«Manlio Rossi-Doria»

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Nella stessa collana:

1. *Qualità e valorizzazione nel mercato dei prodotti agroalimentari tipici*, a cura di F. DE STEFANO, 2000.
2. *L'economia agrobiologia in Campania: un difficile percorso*, a cura di F. DE STEFANO, G. CICIA e T. DEL GIUDICE, 2000.
3. *Istituzioni, capitale umano e sviluppo del Mezzogiorno*, a cura di M.R. CARILLO e A. ZAZZARO, 2001.
4. C. VITALE, *Introduzione alla statistica per le applicazioni economiche*, vol. I. *Statistica descrittiva*, 2002.
5. *Aspetti economici e prospettive della coltivazione della patata in Italia*, a cura di P. LOMBARDI, 2002.
6. C. VITALE, *Introduzione alla statistica per le applicazioni economiche*, vol. II. *Probabilità e statistica*, 2002.
7. *Bibliografia degli scritti di Manlio Rossi-Doria*, a cura di S. MISIANI e M. MONTACUTELLI, 2004.
8. C. COMEGNA, C. PERNA, C. VITALE, *Analisi statistica delle proprietà idrauliche ed idrodispersive dei suoli*, 2004.
9. V. SODANO, *Strumenti di analisi per l'economia dei mercati agroalimentari*, 2004.
10. *Lo sviluppo dei sistemi agricoli locali. Strumenti per l'analisi degli interventi*, a cura di G. MARENCO, 2005.
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12. *L'agricoltura biologica fuori dalla nicchia. Le nuove sfide*, a cura di G. CICIA, F. DE STEFANO, T. DEL GIUDICE, L. CEMBALO.
13. *Income stabilization in agriculture. The role of public policies*, a cura di C. CAFIERO e A. CIOFFI, 2006.

In preparazione:

Il settore del pomodoro trasformato in Italia, a cura di V. SODANO, F. VERNEAU.

O.W. MAIETTA, *L'analisi quantitativa dell'efficienza. Tecniche di base ed estensioni recenti.*

INCOME STABILIZATION IN AGRICULTURE. THE ROLE OF PUBLIC POLICIES

Proceedings of the 86th EAAE seminar
"Agricultural Income Stabilization: what role should public policies play?"
Anacapri, Italy, October 21 – 22, 2004.

edited by
CARLO CAFIERO and ANTONIO CIOFFI

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We were about to send the drafts of the book to the publisher, when we were saddened by the news of the premature death of Professor Claus-Hennig Hanf. Professor Hanf has been an example to generations of agricultural economists, not only in Germany but all over Europe, and we at Portici have had repeated opportunities over the years to benefit from his experience and his passionate concern of the conditions of the European farm sector. We will miss him dearly and we wish to dedicate this book to the memory of his friendship.

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Introduction

In editing this volume we have collected most of the papers presented at the 86th EAAE Seminar entitled "Farm Income Stabilization: what role should public policies play?", held in Anacapri, Italy, on October 21-22, 2004.[1] The book is organized in four sections, reflecting the four main themes around which the Anacapri meeting was organized.

The first session has been concerned with theoretical issues. The papers included in this section explore some of the various aspects that characterize economic analysis of insurance and, more generally, of economic behaviour under uncertainty. The paper by Rasmussen discusses the theoretical advantages of the state-contingent approach in analyzing agricultural production under risk, as compared to the more common expected-utility approach. It is shown that even relatively simple functional forms of the utility function based on state contingent income measures allow for a higher flexibility in describing input substitutability than the most popular functional forms applied in the expected utility framework. This advantage, however, is not readily exploitable in empirical applications, given the high demand on data needed to estimate state-contingent production functions, thus leaving room for further investigation on

[1] The complete list of presentations can be found at the Seminar's web page at: http://www.depa.unina.it/depa/eaaeseminar/eaaeseminar_frameset.htm. In addition to the papers included in this book, the seminar also hosted the presentations of a paper by Luc Christiaensen, Vivian Hofmann and Alexander Sarris, titled "Household Vulnerability and the Demand for Commodity Insurance in Poor Coffee Producing Rural Regions of Tanzania" and of another one by Wouter Zant, titled "Revenue Risk and Consumption Smoothing in Smallholder Agriculture: The Case of Indian Pepper Growers", that the respective authors have preferred not to have published in this proceedings. Also, presentations by Federica Angelucci (co-authored with Paolo Surace) on "Is insurance an appropriate and feasible tool to face market risks in Italy?" and by Olivier Mahul on "The Role of Insurance in the Financing of Agricultural Production Risks: Framework and Case Studies" did not lead to the production of papers suitable for publication.

simulation methods that might be used to define the parameters needed to represent state-contingent production functions in empirical analyses.

In the next paper, Vladislav Valentinov compares the merits of three institutional mechanism for agricultural risk sharing, based respectively on market, governmental provision and mutual organization by farmers, and discusses their implications for agricultural income stabilization in transition economies.

The two papers that follow, by Breustedt and by Capitanio and Cafiero, shed light on the efficiency and incidence of subsidized crop insurance through use of theoretical models. Breustedt focuses on the measure of potential benefits induced by subsidization and shows how such benefits will exceed the direct cost of the subsidy only under very special circumstances, even when assuming a competitive supply of insurance. Capitanio and Cafiero, instead, simulate the effects of the introduction of a premium subsidy in a monopolized crop insurance market and show that it might have no effect on farmers' participation, being captured in increased rents. The two papers together make a strong argument against public subsidization of crop insurance.

The contribution by Bielza, Garrido and Sumpsi focuses on price risk, proposing a model of choice among competing risk management tools. The possibility of choosing among many alternative tools and of combining more than one risk management tool is indeed a very interesting aspect of the analysis of producer's behavior under risk which has not been explored to a great extent until now.

Kobzar and her co-authors, in the paper that closes the first section, measure the correlation structure of yields and prices between farms, and within individual farms over time, using a panel data of Dutch farms, and link the correlation to various farms' characteristics. Their results have important implication for the assessment of the actual benefits of price, yield or revenue stabilization schemes, by recognizing the presence and the extent of phenomena such as the 'natural hedge' generated by the observed negative correlation between yields and prices. Also, the result prove useful to correctly address the possibility of farmers' self insurance and of mutual insurance among farmers.

Section two is concerned with the implications of agricultural price and income risk for economic development. The papers collected here include case studies from many parts of the developing World. The work of Sarris, Conforti and Prakash explores the extent to which futures and option markets might have been used to hedge food price risk by a number of low income food deficit Countries.[2] It shows that, were the observed course of futures and options on wheat be unaffected by the hypothetical hedging of their imports by these

[2] Bangladesh, China, Egypt, India, Indonesia, Mozambique, Nicaragua, Pakistan, The Philippines, Sudan and Tanzania.

Countries, there might have been large monetary gains to be exploited by those wheat importing Countries.

Vakis, Kruger and Mason discuss the experience of Nicaraguan coffee farmers in face of the crisis that hit the market for coffee in the period between 1998 and 2001 and take the opportunity to discuss in depth the links between risk and vulnerability to agricultural poverty.

The next two papers, respectively by Njavro, Par and Hadelan, and by Bokusheva, discuss the merit of various forms of crop insurance in Croatia and in Kazakhstan, providing some instructive examples of pros and cons of adoption of such tool in the condition of transition economies, which might be extended to other Countries.

Section three explores the effects of public policies on farm income risk. The first paper, by Anton and Giner, discusses the production incentives generated by alternative risk management policies in agriculture, considering incentives to price hedging, crop insurance and revenue insurance, in comparison with deficiency payments and direct counter-cyclical payments. The most striking result of their analysis is that no policy expenditure that is oriented to reduce the risk of farming can be considered fully decoupled, something that will likely be brought more and more to the attention of policy makers in the future, especially in contexts such as WTO and EU state aids legislation.

Next, the paper by Carvalho and Godinho tries to ascertain whether the recent CAP reform will have effect on farm income risk by analyzing the result of a mathematical model of a typical Mediterranean farm. An important quality of the paper is that the common argument, according to which the new CAP will cause European farmers to face higher risk, is put under the right perspective by observing that the introduction of a fixed, single payment, in the case study considered, will actually *reduce* overall income risk.

The next two papers tackle very similar issues with reference to two Countries undergoing rapid policy changes. Uysal and Uysal analyze the experience of Turkey in the strenuous course their Country has undertaken towards liberalization and entry into the wider international economic arena, in particular by discussing the consequences on farm incomes of the conditions imposed by the International Monetary Fund, whereas the paper by Lee and Kim discusses the problems that a Country such as Korea will need to confront due to the very rapid process of agricultural policy reform induced by the global standards required by the WTO, and suggests possible policy options. The two papers combined constitute a precious testimony by concerned researchers who try to provide alternatives to a possibly very dangerous *laissez faire* approach that might generate social unrest in two different parts of the World.

The section is closed by Jerzak's analysis of the potential crowding out of private risk management tools that state intervention might cause. The analysis is carried out by first discussing the potential of futures trading in hedging wheat price risk, and then evaluating the experience of Poland between 1998 and 2000, a period which witnessed an initial very promising development of an active futures exchange, followed by its abrupt collapse. The author traces back such collapse to the decision of the Polish Government to increase the intervention price to a level above the equilibrium market price.

The fourth and last section of the volume is devoted to the analysis of private risk management tools. Various opportunities exist for farmers to reduce the negative consequence of uncertain yields and prices, by adopting private instruments such as storage, weather derivatives, insurance contracts and futures markets, and this section analyzes some of the merits and of the problems that markets for such instruments might have in Europe.

The paper by Hanf demonstrate the benefits that could be obtained, in terms of income variability, by exploiting the possibility of easy storage of grains and adopting flexible selling strategies in the German wheat market.

The excellent paper by Berg and colleagues illustrate the theoretical and practical issues involved in the use of weather derivatives for the management of agricultural risks. They also draw on an example from the German potato market to illustrate the conditions that may favour the use of such instrument for risk management.

The next two papers discuss market based crop insurance. Tzouramani and Mattas explore the potential for two possible schemes (yield insurance, and revenue insurance) for two important mediterranean productions such as tobacco and cotton, in Greece, while van Asseldonk and colleagues analyze the potential for marked based crop insurance in the Netherlands. Although the results are highly specific, depending on the condition of the analyzed production sector, both papers' conclusions raise some skepticism on the possibility that market based crop insurance schemes might ever develop in the empirical conditions of the studies, suggesting that other mechanisms might be superior in terms of cost effectiveness for the European farmers.

One of these instruments, potentially suited to hedge commodity price risk, is the futures market. McErlean and Li tackle the somewhat technical issue of analyzing the efficiency of the futures market for wheat in the UK. In other words, they analyze the extent to which futures prices might be used as predictors of the spot price. The main results of the paper is that the efficiency hypothesis cannot be rejected for this particular market, thus adding to the evidence that shows how the futures market does play a role in reducing agricultural price risk in Europe.

The last paper of the section is an analysis of risk perceptions and risk management activities as conducted by conventional and organic dairy farmers in Finland. Flaten and colleagues, through an extended survey of Finnish dairy farmers, shows how traditional production risks are considered less relevant than institutional risk, that is, the one generated by the changing policy environment that surrounds European agriculture.

The general message that can be derived from the papers of this section is that there exist indeed a variety of private instruments that farmers in Europe can use to manage risk, and that any discussion on the potential role of public policies and of the possible benefits of public intervention aimed at stabilizing farm incomes cannot be conducted without a careful and highly specific analysis of the existing private instruments.

Before concluding this introduction, we would like to thank all the people that have contributed to make the 86th EAAE Seminar in Anacapri an instructive and very enjoyable experience.

The first, and most important recognition goes to Olivier Mahul and Cyrus Ramezani, who formed with us the Scientific Committee of the seminar, involved in the difficult task of evaluating and selecting the papers for presentation from the many proposals we received.

Next, we would like to thank Gaetano Marenco, Aleko Sarris, Renos Vakis and, once again, Olivier Mahul, who agreed to chair sessions of the seminar.

A very special thank goes to Brian Wright. With his active participation to the discussions during the Seminar, Brian helped us to tackle the issue of farm income stabilization from the correct perspective.

A warm thanks goes to the staff of the Centro per la Formazione in Economia e Politica dello Sviluppo Rurale, remarkably directed by Antonella Iannuzzi, who bore most of the responsibility for the successful logistic organization in Anacapri.

Finally, the financial support of the University of Naples Federico II, who hosted us at the Centro Internazionale per la Cultura Scientifica of Anacapri, is greatefully acknowledged.

Portici, 16 May 2007.

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Why Government Crop Insurance?

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In setting the stage for this impressive collection of papers, the following paradox merits front and centre placement. On the one hand, there are thousands of economic studies worldwide that show that agricultural research has had sustained, extraordinary returns for about a century. On the other hand, I cannot find one respectable evaluation that shows that any public Multiple Peril Crop Insurance (MPCI) or revenue insurance has ever sustained a positive rate of return. Yet countries worldwide are investing dollars in crop insurance at an increasing rate, when they could have gone to research.

Economists need to keep this paradox in mind. Before asking "how" crop insurance can be used to protect farm incomes, we should ask "why?" The fundamental question is: "Do farmers need government-provided risk protection via insurance?" To try to answer this question, let us first observe that historically, the problem has not been lack of a market. Even publicly-provided markets generate little farmer interest unless heavily subsidized (Hewitt and Wright, 1994). At the same time, it is easy to verify that farmers will often pay for unsubsidized hail insurance coverage, sometimes for fire or lightning cover.

The problem extends beyond moral hazard and adverse selection. A survey by Patrick (1988) on Australian wheat farmers of the Mallee region of Victoria, found that with a coefficient of variation (CV) of prices of approximately 0.4, a CV of yield of approximately 0.4, independent of price, farmers who identify weather as the main risk challenge were unwilling to pay for an actuarially fair local weather index based insurance plan.

One might infer that perhaps Australian farmers are hesitant towards, or ignorant of, insurance in general. But that is not the case. All farmers surveyed by Patrick buy auto and life insurance above minimum levels. Further, they have a proven record of farm risk management. The surveyed farmers have an average age of more than 40 years and entered farming when they were 16 on average. Despite a low level of formal education, they have a more than 20 years average experience in farming in an environment with extremely high price and yield risk.

A plausible reason why they are not willing to pay for insurance is that they have other means to stabilize their consumption: they use savings, they diversify their production (by raising sheep as complements to wheat production, and by having family members work in other sectors), they manage the timing of consumer and producer durable expenditure, and they use loans as last resort. Over time, we could say that they have been selected by the market for their risk management expertise.

Much of the early literature on crop insurance mis-specified what the farmer maximizes, and so over-stated the case for public intervention in insurance. Many studies assumed that:

1. Crop insurance stabilizes y_{it}, where y_{it} is income from farm crop *i* in year *t*.
2. Farmer utility is risk averse in y_{it}.
3. $U(y_{it}) = U(y_t) = U(c_t)$, that is, the utility of the income from a single crop in a single year is equivalent to the utility of the entire income (i.e., neglects the role of diversification of income generating activities) and that the utility of income is equivalent to the utility of consumption (i.e., neglects the role of consumption smoothing activities).

Economic theory suggests that the objective of agents should be that of maximizing the expected utility of the lifetime consumption stream including, perhaps, bequests. If income is variable and savings are available, a change in consumption Δc induced by a change in income Δy is of the same magnitude as $r \Delta y$ where r is the interest rate. This means that, with the exception of true catastrophes, where Δy is very large, the risk premium associated with normal changes of income, being of the order of the square of $r \Delta y$, is negligible. Whereas it is plausible that farmers cannot borrow freely in a formal credit market, it is implausible that they do not save (in fact, without access to credit, they *always* do so when they plant before harvesting!)

A reasonable hypothesis is that the reluctance of farmers worldwide to pay for unsubsidized multi-peril crop insurance is that its value to them is less than even the administrative cost of the program. Good reasons for this include various types of basis risk, and also performance risk, which might imply that the worst state is made even worse with the program.

Yet crop insurance remains a hot policy topic. To fully understand the wide political support for crop insurance programs, a good first question is: "Who benefits from a subsidized crop insurance program?" A list of potential beneficiaries include farm workers, farmers, farm input suppliers, consumers and taxpayers.

Do consumers benefit? In principle, the answer is yes, if output expands and price falls. However, the environmental effects may be negative or positive. For sure, the effects on taxpayers are negative.

In this collection, the focus is, understandably, on the farmers. One fundamental point meriting consideration is the effects of capitalization on the benefits to farmers. Let us assume that crop insurance raises the financial return to the marginal entrant to farming. Assuming a competitive land market, the value of the subsidized crop insurance will be capitalized in the land price and, at the margin, risk benefits will be capitalized as increased land cost.

Hence MPCI does not stabilize farm financial structures in the long run. As land values will rise, the equilibrium debt leverage rises, the profit stream for the entrant leaves no surplus in equilibrium, and therefore entrants will still be vulnerable to residual risk. MPCI cannot provide an effective safety net for farmers in the long run.[1]

Thus once a crop insurance program starts, there is always a need for "more," to handle the new, more leveraged environment.

So who gains? A short list would include:

1. those who were landowners at time of program introduction, who can benefit from the increase in land prices;
2. insurance providers, especially if oligopolistic;
3. politicians who work for them;
4. economists who work for 2. or 3. above by making programs appear to be good or at least defensible policy.

In farm income stabilization policy, a serious problem of time inconsistency arises. The experience of the United States is enlightening to this respect. To promote participation in crop insurance programs, the Government required farmers to waive their rights to disaster assistance if they did not want to buy crop insurance. But when disaster struck, then, the Government demonstrated its inability to enforce farmers' signed waivers of disaster insurance, and to resist offering them disaster payments, especially when wealthy supporters object. (A recent example of a similar inability to commit to judicious policy is the payments made to ex ante "ineligible" Florida orange producers in 2004.)

The dilemma is that Congress wants to stop itself from granting disaster aid, but when a disaster happens, it cannot resist pressure to act by providing aid. Farmers (and others) know this intervention will occur with high probability and therefore the promise not to give aid does not encourage sufficient mitigation investments. Sadly, the ex post need for aid is even more pressing than if no policy was announced!

When Congress recognized this argument, it found a way to use the argument to make things even worse. The creative "solution" of Congress to its own lack of self-control was to increase crop insurance coverage up to more than 70%, so that it would be widely adopted and the pressure for disaster payments would be resisted. In practice, crop insurance expenditure has soared, and disaster payments are still made. The end result 25 years later is an obvious failure. Despite coverage is over 80%, the true loss ratios are around 2:1. The

[1] For evidence that points in this direction, try comparing bankruptcies in farming in Australia (where no subsidized crop insurance program exists) and in the US (where publicly subsidized MPCI have existed since decades.)

program costs around $3b/yr. for crop insurance, with a liability of over $40b. Nevertheless, disaster aid still flourishes. What is worse, it remains discretionary, and therefore uncertain in amount and timing, and so adds another source of risk for farmers. Indeed, in a US survey of "sources of risk" for farmers, it was found that yield, price and the Government were considered the most important.

The above history helps explain why a subsidized crop insurance program is difficult to stop. But, given the evidence, why would a country want to start a MPCI program now? For Europe, an answer may be found in the new WTO rules. Crop insurance provision is included in the "amber box," and alternatives to favour farmers are becoming scarce. The real question to address, therefore, is whether it will survive in the amber box or not.

One promising opportunity for those interested in research, as opposed to program advocacy, is the renewed interest in private index-based disaster coverage worldwide. Index-based cover offers several apparent benefits, including avoidance of traditional problems related to moral hazard or adverse selection, and eminent diversifiability. It will be interesting to see if such programs can be sold to farmers without subsidy, despite the Australian evidence mentioned above. Issues of basis risk, and perhaps lingering concerns regarding index manipulation, deserve attention.

Finally, even if governmental enthusiasm for crop insurance is excessive, economists still have a valid role in documenting their effects, minimizing the waste they cause, and improving their design. The presentations in this conference offer encouraging examples of what the current generation of economists has to offer in addressing these tasks.

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The Changing Role of Public Policies in Farm Income Stabilization

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Up to a few years ago, the attention devoted by European researchers to crop insurance and, more generally, to risk management and income stabilization in agriculture has been –with few notable exceptions– limited. The reason why most agricultural economists and policy analysts in Europe have found little interest in exploring the possible consequences of farm income fluctutations is likely the combination of two aspects. First, the presence of various price stabilizing mechanisms and the high level of support embedded in the Common Agricultural Policy effectively isolated European farmers from most of the vagaries of the international markets, thus greatly limiting the extent of market risk faced by our producers. In addition, in some Member States (most notably Italy and France) a consolidated tradition of public solidarity had been institutionalized through the setting up of special funds whose purpose is to provide ex-post compensation to farmers damaged by unexpected events, thus effectively eliminating large part of the relevant production risk.

Recently, however, things seem to have changed and an increasing public attention is being devoted to the problem of income risk in the European agriculture. Italy, for example, has recently reformed the operating guidelines of its *Fondo di Solidarietà Nazionale*, taking a clear orientation towards increased support to multi peril crop insurance. Between 2001 and 2005, the European Commission, facing increased demands by some Member States, has repeatedly explored the possibility of taking an active role in this field.[1]

With a retrospective look, the seminar organized in October 2004 by the Department of Agricultural Economics and Policy of the University of Naples

[1] In 2001, a working document was issued that analyzes tools for risk management in agriculture, with a special focus on insurance. In 2002 and 2003, two conferences have been held under the Spanish and Greek presidencies of the European Council, discussing the possible role of insurance in the management of catastrophic risk in agriculture. In 2005, the EU Commission has advanced proposals on how to include natural disaster and crises management within the objectives of the reformed CAP where, again, insurance appears to be given a predominant, albeit non exclusive, role.

Federico II, and whose proceeding are included in this volume, seems to have come at the right time.

The title of the seminar: "Farm income stabilization: what role should public policies play?" was intended to draw attention on the possibility of defining a new, broader role for public policies aimed at agricultural income stabilization. Our implicit intention was to try and challenge both the widely held opinion according to which insurance is the best, if not the only suitable instrument for effective risk management in agriculture, and the derived corollary that, given the historic difficulties for private insurance markets to establish in agriculture, an active public intervention in the form of subsidies to insurance premiums is necessary.

In fact, our fear was –and still is–, that to agree with such a view could bring the European Union in a vicious circle from which it will be difficult to escape in the future. As economists, we believe that we can and should do something to help avoiding such a trap. What we can contribute to the policy debate is a clearer vision of the potential benefits and drawbacks of *all* various possible policies (including subsidies to insurance) when they are considered not in abstract, but rather in the real conditions of the current European economy. As a profession, we have perhaps failed to do so when, for example, the merits of one risk management instrument have been assessed in isolation from others (see Cafiero, 2003 for a review), or by erroneously assuming that the welfare consequences of a stabilization policy can be measured in terms of income rather than consumption (Wright, 2006), or by being rather naïve in assuming a competitive structure of the insurance market also on the supply side (Capitanio and Cafiero, 2006).

When analyzing stabilization policies, the crucial aspect we should keep in mind is that the fundamental objective of any stabilization policy ought to be to allow farm families to stabilize *consumption*. This is what would allow them to preserve acceptable living standards even when facing fluctuating incomes. To stabilize income is only one way to achieve a stable consumption flow, and it always comes at a cost. Other means of smoothing consumption exist, which involve use of savings and borrowing. Income stabilization as a direct policy objective, therefore, will have merits only in so far as other ways of stabilizing consumption are even more costly. This might have been the case at the dawn of the Common Agricultural Policies, when credit, financial markets and asset diversification were in fact out of reach for many European farmers, but what about now?

Many of today's European farm families get only a fraction of their total income from farming. In addition, they can rather easily cope with the consequences of fluctuating incomes by use of personal savings and/or by access to credit, a particularly attractive option in periods of low real interest rates. If this allows them to achieve a sufficient stability in the levels of consumption at a limited cost, their willingness to pay for farm income stabilization may be very low (which may contribute to explain the general limited participation of farmers to crop insurance programs). In other words, the cost to farmers of farm income instability may be lower than what commonly implied by the defenders of public income stabilization schemes.

Some would oppose this view, by noting that our argument is valid only for small, non professional family farms, whereas in Europe there is an increasing number of professional, specialized farms, where an individual or a corporate enterprise derives profits exclusively from farming. But, then again, our point is that, even in those cases, it would be greatly mistaken to analyze the problem of income risk management by isolating the operational risk from the more general economic organization of the firm and its integration within the broader economy. This is an issue that, in our view, has not received adequate attention in the analysis of European agriculture. The position of many farms within the agro-food sector is deeply different of what was common fifty years ago. The integration of agriculture within the broad agri-business industry is such that, for example, the consequences of final demand fluctuations are felt much less than before by farmers. Contracting with processors or traders who can and do make active use of derivatives to hedge their price exposure, allow many farmers to set a price for their product well ahead of the time when the actual production will be realized. The observation that European farmers do not appear to make active use of financial derivatives directly is not sufficient to prove that such tools do not have a crucial effect in reducing the economic cost of price uncertainty in agriculture.

There are also other aspects that deserve attention and that too often are neglected in the discussion on agricultural income stabilization schemes. To name just a few, we could consider the role of technological progress and innovation, the role of storage and the political economy of farm policy.

The technological progress in farming, achieved through adoption of genetic, biological, chemical, mechanical, informational and organizational innovations, allows today's farmers to effectively cope with production risk due to natural causes at a much lower cost than just a few decades ago. Also, when storage is feasible and price variation is, to some extent, predictable, the economic cost of price fluctuation is limited, and we should look with suspect to analyses of the effects of price stabilization policies that do not explicitly model *private* storage (see Williams and Wright 1991, ch. 12).

What is perhaps more important, however, is the careful consideration of the *political* environment that surrounds farming. For a long time, economists and politicians have justified the existence of special policies for agriculture precisely because production here is, in principle, riskier than in other sectors of the economy. The fact is that now such policies exist, and they have been very successful in making farming a much more bearable activity than in the past. Today, to continue to put emphasis on the different character of risk in agriculture as compared to other production activities might be at least partially misleading if, at the same time, one fails to consider the special treatment received by agriculture.

The public effort in protecting farm incomes in Europe is still large and income stability, which was explicitly included among the founding objectives of CAP in the Treaty of Rome in 1957, still motivates the existence of several measures, such as subsidization to private storage and other forms of product withdrawal from the market, which have absorbed a total of about € 1 billion from the European Agricultural Guidance and Guarantee Fund (EAGGF) yaerly budget in the recent past.[2] To this amount, we should add the various items that Member States include in their budgets under the headings of participation to subsidized crop insurance programs and to ex-post compensation schemes following exceptional events, which are compatible with the running rules of WTO and of the European norms on competition.

Given such a public effort, which is highly unlikely to be discontinued in the near future, before thinking of implementing new measures we should ask whether there truly is any relevant unhedged consumption risk faced by rural families. Rather than being the result of an objectively assessed increased risk exposure of European farmers, the resurgence of interest on risk in agriculture and, in particular, on the possible role of publicly subsdized insurance could be motivated instead by the political attitude taken by the United States and Canada, which have a consolidated tradition in the field.

But, are we sure that the US one is a virtuous example to follow? Currently, the US Government spends about $3 billions to support Federal Crop Insurance, a program that, while certainly beneficial to farmers,[3] is very costly to the taxpayers, and – what is more important– misses the main point; while the program is in place and is highly subsidized, the US Congress has generously responded to repeated requests of additional *ad hoc* appropriations for compensation of damages to agricultural productions from natural disasters (see Glauber 2004, table 3). Moreover, the compatibility of such a generous treatment of agricultural risk with international trade agreements is being questioned. In a recent complaint that Brazil has presented against the US governmental support to upland cotton producer, subsidies to crop insurance have been included among the allegedly trade-distorting measures. Despite the fact that, in this particular case the WTO panel appointed to evaluate the complaint has concluded that Brazil failed to demonstrate the trade distorting character of US subsidies to crop insurance, the argument is not without merit. A growing literature exists that shows how the presence of insurance subsidies and other risk management

[2] The EAGGF budget outlays arising from all measures intended to promote private storage in 2003 amounted at € 928 mil.

[3] The US Federal Crop Insurance program pays an average of $2.19 in indemnities per each dollar of premiums paid by farmers (Glauber 2004, table 1)

aids do affect production decisions and, therefore, cannot be considered fully decoupled.[4]

Given the experience of the US, we should ask carefully if it makes sense to base the EU intervention aimed at protecting agricultural incomes on subsidized insurance. The question is even more relevant when we consider that the supply of insurance, in many European countries, is far from being competitive. The possibility exists that governmental participation to the premium paid by the farmers might end up in feeding insurance companies' rents, rather than helping farmers to protect their incomes.

From a pragmatic point of view, one might still try to defend the subsidy to crop insurance as being the only viable option. The relevant research question then becomes whether there are indeed other options available to European policy makers to assist farmers in managing their risk. When duly considered, all the evidence indicates that there exist ample and growing opportunities for the development of private risk management in agriculture.

Particularly promising appears, for example, the market for weather derivatives, which may become attractive to various agents, such as providers of public utilities, agroindustrial firms, firms operating in the clothing, recreation and tourism industries, all of which could benefit from the trade of financial derivatives based on weather indexes which are correlated to the economic returns of their activity. Weather derivatives may be very effective in directly hedging most weather-related agricultural production risk, or in hedging the exposure of insurance companies who sell index-based contracts.

One other tool which merits the policy makers' attention is credit. In periods of low real interest rates, access to credit might be the most cost effective way of protecting farmers' standard of living, and therefore a role exist for Governments interested in helping farmers in reducing transaction costs for accessing credit.[5]

In other words, we believe that in the future of the reformed CAP, not just insurance, but also credit and financial markets will provide farmers with a sufficient range of tools to effectively manage their risk, provided the two main obstacles which have hindered their development up to now are removed. The first problem has been the availability of information. There is a fast growing literature that shows how financial derivatives indexed on reliable and easy to measure variables that are correlated to agricultural production might be used to hedge production risk. Despite the existence of many agents that might make use of such instruments, however, active markets for these financial in-

[4] See for example Roberts *et al.* (2004) and Anton and Giner (2006).

[5] Countries such as Canada and Australia have implemented incentive mechanisms to induce a wider use of personal saving in stabilizing income to which we should look with a careful eye, in that they may be more effective and less onerous to the public budget than insurance subsidies.

struments struggle to develop. One likely reason for this state of affairs is the lack of reliable information. A key role for the Governments, in this sense, could be that of providing and/or certifying information on local weather, area yields, prices, and other useful indexes on which contracts might be written and enforced.

The second problem involves the structure of the markets for risk sharing. The effective possibility of sharing risk depends crucially on the possibility of spreading it on the wider possible base, something that might be prevented by the non-competitive structure market. The presence of barriers to entry to the financial, credit and insurance markets, for example, could generate local rent seeking behaviour by the suppliers of such services. In agriculture, the problem is particularly felt since the typically limited size of each individual firm usually prevents farmers from operating directly, for example, on the commodity exchanges or from being able to bargain convenient rates on insurance coverage. However, the possibility to successfully access these markets could be obtained by some form of association, that could allow farmers to reach the minimum size required to reduce the incidence of the fixed costs. The problem is common in insurance markets,[6] in credit, and similar problems might be envisaged in the emerging markets for financial derivatives.

In this, too, a promising role can be foreseen for the public regulator, who might provide the required legal setting and assist farmers' association in developing the required skills to make efficient use of those markets.

In conclusion, we believe that any discussion on the role of public policies intended at assisting farmers' income stabilization should include the wide range of possible private tools that farmers can use (on-farm strategies, insurance, financial and credit markets) and explore ways in which such use can be fostered. Until now, attention has been too narrowly focused on the role of insurance and on the merits of public subsidization. We hope that the works included in this collection might help highlighting some important aspects and contribute to a better informed policy making.

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[6] The Italian legislator was aware of the problem when the *Consorzi di difesa,* farmers' associations through which the financial support of the *Fondo di Solidarietà Nazionale in Agricoltura* is channeled, were created in 1974. The intention was precisely to give farmers sufficient bargaining power to counteract that of insurance companies. Over time, however, the role seems to have been lost, perhaps because the Consorsi have been overwhelmed by the need to try and administer the interests generated by the complex system of insurance subsidies.

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PART ONE

ECONOMIC THEORY OF BEHAVIOUR UNDER UNCERTAINTY AND INSURANCE

Optimizing Production under Uncertainty: Generalisation of the State-Contingent Approach and Comparison of Methods for Empirical Application

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Abstract

In a recent paper Rasmussen (2003) derived criteria for optimal production under uncertainty based on the state-contingent approach developed by Chambers and Quiggin (2000). While the criteria in the 2003-paper were derived for the one variable input case, and for different types of input, the present paper generalises the results to the multi-variable input case. It is further shown that with the output-cubical technology as the basic model, any type of input may be analysed as a special case within the general model framework developed. The main part of the paper is devoted to the problems of empirical application of the state-contingent approach. To empirically apply the optimization criteria derived, one needs specific functional forms of both the state-contingent production functions and the utility function based on state-contingent income measures. The paper shortly reviews the empirical approach normally taken when using the well-known Expected Utility (EU) model and this approach is in turn compared to the more general approach potentially available in the state-contingent model. Comparisons show that the potential benefit of the state-contingent approach compared to the expected utility model is limited by the empirical opportunities. Thus, it is unrealistic to expect production functions to be estimated for all possible states of nature. State-contingent production functions therefore, have to be considered as stochastic production functions. In this case, it is not obvious whether the state-contingent approach is better than the expected utility model, and it is proposed that this is further investigated using Monte-Carlo simulation.

1. *Introduction*

The classical approach to the problem of optimising production under risk/uncertainty is the expected utility model (EU model). The EU-model is, in its basic form, a relatively general model. But as regards empirical application, the tradition has developed over time to the EU-model being the equivalent of a model where utility is maximized as a function of the expected value and variance of profit (Robison and Barry 1987; Dillon and Anderson 1990; Hardaker *et al.* 1997).

This approach to decision making under uncertainty has been severely criticized by Chambers and Quiggin in their book on state-contingent production

(Chambers and Quiggin 2000), as well as in subsequent papers. The main problem being that the traditional approach typically does not consider the interaction between the uncontrolled (uncertain) variables and the decision variables controlled by the decision maker. Furthermore, although Dillon and Anderson (1990) realised the basic need for modelling this kind of interaction, they did not derive criteria for optimal production that went beyond maximizing utility, defined as a function of expected value and variance of profit.

With the state-contingent approach developed by Chambers and Quiggin (2000), the foundation for alternative ways of describing and analysing production under uncertainty were made available. The state-contingent approach has the advantage that it explicitly considers the interaction between controllable inputs and uncontrolled inputs (the uncertain states of nature). In a recent article, Rasmussen (2003) used the state-contingent approach to derive criteria for optimal production (input use) under uncertainty. Criteria were derived for the one variable input case, as well as for different types of input, including state-specific and state-allocable input. While the article illustrates that the state-contingent approach has the merit of being based on well-known marginal principles and optimisation tools, it also indicates that the state-contingent approach has its own weaknesses when it comes to empirical application. Thus, the basic problem of not knowing the decision makers' utility function still exists, and the problem of how to estimate state-contingent production functions has not been solved. Therefore, the question of how to apply the theory of state-contingent production to the real problems of actual decision making still has no clear answer.

The objectives of this paper are to further develop and generalise the criteria for optimal production under uncertainty derived in Rasmussen (2003), and to discuss alternative procedures for empirical application.

In the first part of the paper (Section 2), the criteria derived by Rasmussen (2003) are generalised to the multi-variable input case. Further, it is shown that the output-cubical technology approach criticized by Chambers and Quiggin for not being able to model substitution between state-contingent outputs, is in fact an appropriate vehicle to use, even in the case of state-allocable inputs. It is shown that state-specific and state-allocable inputs are just special cases of state-general inputs, and specific criteria for these two types of input are in fact superfluous; the general criteria derived will cover any type of input.

The second part of the paper (Section 3) focuses on the problems related to empirical application of the state-contingent theory. The state-contingent approach is compared to the Expected Utility (EU) model, both with respect to choice of utility function and description of production technology (production function). In this context, the differences between *state-contingent* and *stochastic* production functions are discussed, and it is proposed that in empirical contexts, it is appropriate to consider *state-contingent production functions* as being themselves *stochastic production functions*.

The paper concludes in Section 4 with a case illustrating the application of the state-contingent approach, in which the results demonstrate the possible consequences of the interaction between application of input and state of nature.

2. *General criteria for optimal production*

Consider a producer who wants to optimize the production of one or more outputs. Both the production and the output prices are uncertain in the sense that yields and prices depend on uncertain future conditions called *states of nature*. The state of nature that determines yields and prices reveals itself only after application/allocation of input. Therefore, production decisions have to be taken without knowing the future state of nature. The only thing known about the future state is that nature will pick one of S possible states of nature. Probabilities of each state of nature may or may not be available, but the decision maker holds - at least implicitly - expectations concerning the frequency with which each possible state of nature will prevail.

The decision-maker wants to maximize the utility function:

$$W = W(\mathbf{q}) = W(q_1, \ldots, q_S) \tag{1}$$

where W is a continuously differentiable non-decreasing, quasi-concave function, and $\mathbf{q} \equiv (q_1, \ldots, q_S)$ is a vector of net-incomes in the S possible states of nature, determined as:

$$q_s = \sum_{m=1}^{M} z_{ms} p_{ms} - \sum_{i=1}^{n} w_i x_i - c^F + k_s \text{ , } (s=1,\ldots, S) \tag{2}$$

where z_{ms} is production of output m in state s, p_{ms} is the price of output m in state s, x_i is the amount of variable input i (i=1,…, n) used in the production of the M outputs, w_i is the price of input i (i=1,…, n), c^F is fixed costs, and k_s is a state-contingent income from other sources.

First consider the case in which no production takes place. In this case, the wealth is determined by the net-income vector:

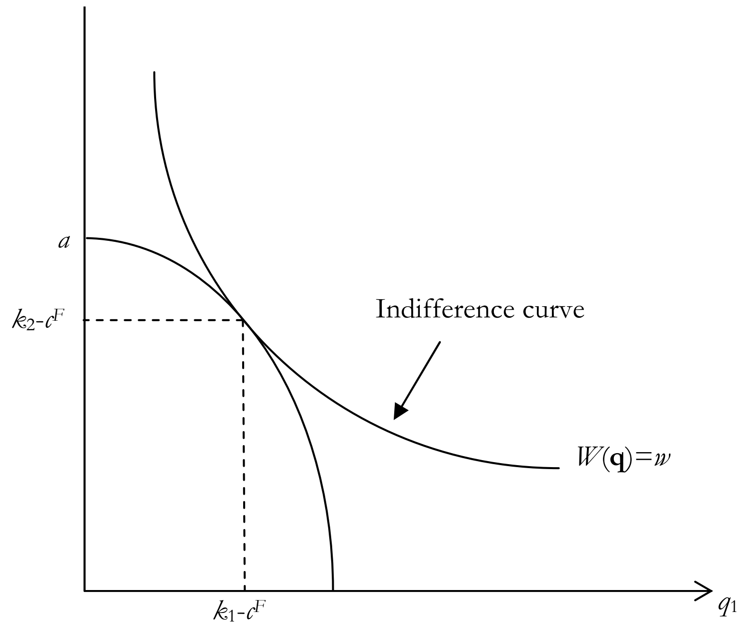
$$q_s = k_s - c^F \text{ , } (s=1,\ldots, S),$$

which is illustrated for S=2 in Figure 1. If we allow financial transactions, then the curve *aa* is the income possibility curve without production. Thus, the choice (k_1-c^F, k_2-c^F) in Figure 1 provides the highest utility possible without production[1].

To supplement the income k_s-c^F (s=1,…, S) the decision-maker may carry out production. The production technology is, as a starting point, given in implicit form as a convex function H: $\mathfrak{R}_+^{M\times S+N} \rightarrow \mathfrak{R}$:

[1] For convenience, it is assumed that *aa* is a quasi-convex function as indicated.

Figure 1. Wealth without production



$$H(\mathbf{z}, \mathbf{x}) = H(z_{11}, \ldots, z_{ms}, \ldots, z_{MS}, x_1, \ldots, x_N) \leq 0 \quad (3)$$

where **z** is a $M \times S$ matrix of state-contingent output of M products ($z_{11},\ldots, z_{MS}$) and **x** is a vector of input ($x_1, \ldots, x_N$), of which the first n elements are variable inputs, and the last $N - n$ elements are fixed inputs. The amount of fixed inputs is restricted by:

$$\sum_{m=1}^{M} x_{jm} - x_j^F \leq 0, \text{ (j = n+1,..., N)} \quad (4)$$

where x_{jm} is the amount of fixed input j allocated to production of output m and x_j^F is the amount of fixed input j.

If a budget restriction applies, then:

$$\sum_{i=1}^{n} w_i x_i - C^0 \leq 0 \quad (5)$$

where C^0 is the given budget.

The production plan which maximizes utility in (1) is determined by the amount of variable inputs ($x_1, \ldots, x_n$), the amount of outputs ($z_{11}, \ldots, z_{ms}, \ldots,$

z_{MS}) and the allocation of the fixed inputs (x_{n+1}, …, x_N) which maximizes the Lagrangian:

$$L = W(q_1,...,q_S) - \mu H(\mathbf{z},\mathbf{x}) - \gamma\left(\sum_{m=1}^{M} x_{Nm} - x_N^F\right) - \delta\left(\sum_{i=1}^{n} w_i x_i - C^0\right) \quad (6)$$

where μ, γ and δ are Lagrange multipliers for the three restrictions (3), (4), and (5), respectively[2].

If H is a continuously differentiable function with non-vanishing derivatives, then the conditions for optimal production may be derived from (6). However, particularly in the case of state-contingent technologies, these assumptions do *not* apply.

To demonstrate, consider the so-called *output-cubical technology* (Chambers and Quiggin 2000, p.p. 53-54) characterizing state-contingent production. A simple example is shown in Figure 2 with one input x and one output z yielding z_1 in state 1 and z_2 in state 2. The output set is Z(x) with the efficient production plan A characterized by output a_1 if state 1 occurs and a_2 if state 2 occurs (and production is efficient).

It is obvious that with this technology, it is not possible to express z_2 as a (differentiable) function of z_1. The derivative is *not* defined in the corner A, and on the vertical part between a_1 and A, the derivative is ∞.

This may also be shown mathematically. The functional relationship describing the technology in Figure 2 may be expressed in implicit form as:

$$H(\mathbf{z}, \mathbf{x}) = H(z_{11}, z_{12}, x) = (x - \max\{b_1 z_1, b_2 z_2\}) = 0 \quad (7)$$

where b_1 and b_2 are parameters.

The H in (7) is not differentiable in z_s (s=1, 2), and that therefore $\partial H/\partial \mathrm{z_s}$ is not defined. Add to this that for the local values of z_s, where H is in fact differentiable, $\partial H/\partial \mathrm{z_s}$ is either 0 or $-b_s$.

When the *technology is output cubical* involving nonsubstitutability between state contingent outputs as shown in Figure 2, then, as shown by Chambers and Quiggin (2000, p. 54), nondecreasing and quasi-concave state-contingent production functions $f_s(\mathbf{x})$ (s=1,…, S) exist, where the output set Z is: $Z(\mathbf{x}) = \{\mathbf{z}: z_s \le f_s(\mathbf{x}), s=1,\ldots, S\}$ and the production function is $f_s(\mathbf{x}) = \max\{z_s\}$.

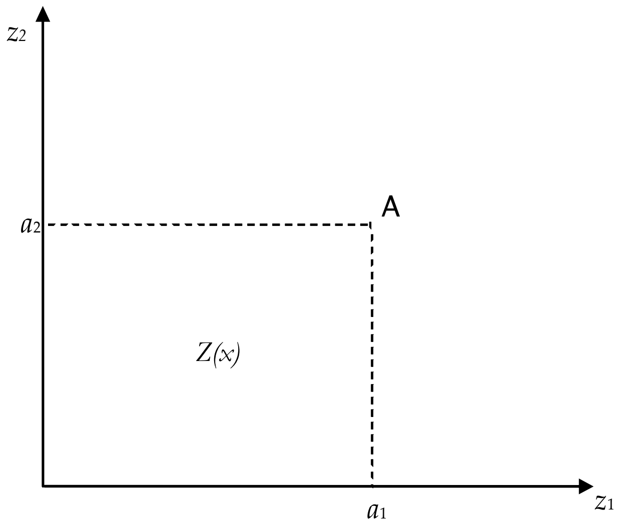
Thus, in this case the production technology $H(\mathbf{z}, \mathbf{x})$ in (3) may be expressed as:

$$H_s(z_s, \mathbf{x}) = z_s - f_s(\mathbf{x}) \le 0, \ (\mathrm{s}=1,\ldots, \mathrm{S}) \quad (8)$$

and the Lagrangean function in (6) thus changes to:

[2] To simplify, the following derivations only consider one output (M=1) and one fixed input x_N (N=n+1).

Figure 2: Output cubical technology



$$L = W(q_1,...,q_S) - \sum_{s=1}^{S} \mu_s H_s(z_s, \mathbf{x}) - \gamma(x_N - x_N^F) - \delta(\sum_{i=1}^{n} w_i x_i - C^0) \qquad (9)$$

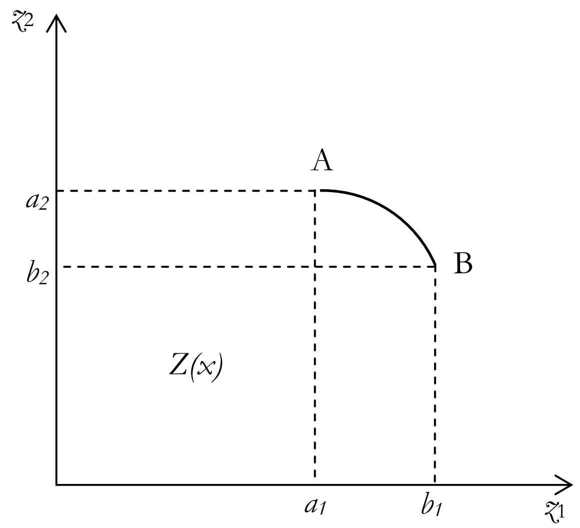
The important question is whether the output-cubical technology covers all relevant technologies available, when producing under risk. Or put in another way; does the technology in the state-contingent case always take the form given in mathematical terms in (8) and shown graphically in Figure 2?

The basic assumption behind the state-contingent model, i.e. that the amount of input (the input vector **x**) allocated to production is finally decided *before* the state of nature (*s*) reveals itself, seems to be sufficient to ensure the existence of output-cubical technology, and therefore the existence of the state-contingent production functions in (8).

However, one case needs *special consideration*. The reason being that some inputs may be what Chambers and Quiggin call *state-allocable inputs*, i.e. inputs, which may be *allocated between states* (Chambers and Quiggin 2000, p.38 ff.). Either in the (narrow) sense that the input in question is allocated to a certain state of nature, and is productive only in the very state of nature to which it has been allocated[3], or in the more general sense that the productivity in each state

[3] This is the definition given by Chambers and Quiggin, illustrated by their example of allocating labour to either building a dam, or applying irrigation (Chambers and Quiggin, 2000,

Figure 3. Substitution between states of nature



of nature depends on *how* the input in question is allocated[4]. This more general form of state-allocability refers to cases where the productivity in each state of nature depends either on the *type of input* used[5], or the *technique used* when applying the input[6].

With state-allocable inputs, decision-makers may in fact substitute between state-contingent outputs by moving along what Chambers and Quiggin call a *state-contingent product transformation curve* (Chambers and Quiggin 2000, Figure 2.5, p. 40 and 51). Also Rasmussen (2003, Figure 6) derives a product transformation curve illustrated as a continuous decreasing concave function in the z_1-z_2 plane, similar to the curve AB in Figure 3 (this paper).

This type of substitutability may be included in the model described so far, by expanding the input vector. Assume for instance that input x_j is a state-allocable input, and that there are S different types of input j or S different

p. 39). Rasmussen (2003) uses the term strictly state-allocable inputs to characterize this type of input to differentiate it from the more general definition.

[4] This more general case includes the Chamber and Quiggin definition as a special case.

[5] Thus, the input "Fertilizers" is considered a *state-allocable* input if one type of fertilizer (type a) is more productive in state 1 than in state 2 and another (type b) is more productive in state 2 than in state 1 (notice, that both types may be productive in both states).

[6] A pesticide is thus termed *state-allocable* if, when applied with a spray-nozzle of *type a*, the pesticide is more productive in e.g. states 1 and 2 than in state 3, and if the pesticide is applied using spray-nozzle of *type b*, the pesticide is more productive in e.g. states 2 and 3 than in state 1.

techniques for applying input j. Then instead of x_j, define new input variables $x_{j1}, \ldots, x_{jS}$, where x_{js} is the amount of input j allocated to state s (s=1,…, S).

Using these new variables as decision variables instead of just x_j, provides the opportunity to move along the state-contingent product transformation curve. Figure 3 illustrates a case where, when all the input ($x=x_j$) is allocated to state 2 ($x_{j2}=x_j$, $x_{j1}=0$), the state-contingent output is A (a_1 in the case of state s=1, and a_2 in the case of state s=2) and where, when all the input x is allocated to state 1 ($x_{j1}=x_j$, $x_{j2}=0$), the state-contingent output is B (b_1 in the case of state s=1, and b_2 in the case of state s=2). Combinations of $x_{j1}>0$ and $x_{j2}>0$ yield state-contingent output somewhere along the curve between A and B.

However, this way of combining different amounts of state-allocable input is not in reality different from combining different amounts of all other inputs.

The conclusion is that output-cubical technology covers the production technology under uncertainty. In the case of some inputs being state-allocable input, then the vector of decision variables should be expanded so that the amount of input allocated to a specific state of nature is considered an individual decision variable (input). In that case, the general model framework of the output-cubical technology illustrated in Figure 2 holds.

The Lagrangean is therefore:

$$L = W(q_1,...,q_S) - \sum_{s=1}^{S} \mu_s H_s(z_s, \mathbf{x}) - \gamma(x_N - x_N^F) - \delta(\sum_{i=1}^{n} w_i x_i - C^0) \qquad (9)$$

Differentiating (9) with respect to x_i, (i = 1,., N) yields the following first order conditions:

$$-w_i \sum_{s=1}^{S} \frac{\partial W}{\partial q_s} + \sum_{t=1}^{S} \mu_t \frac{\partial f_t}{\partial x_i} - \delta w_i \le 0\text{, (i = 1,., n)} \qquad (10a)$$

$$(-w_i \sum_{s=1}^{S} \frac{\partial W}{\partial q_s} + \sum_{t=1}^{S} \mu_t \frac{\partial f_t}{\partial x_i} - \delta w_i) x_i = 0\text{, (i = 1,., n)} \qquad (10b)$$

$$\sum_{t=1}^{S} \mu_t \frac{\partial f_t}{\partial x_N} - \gamma \le 0 \qquad (11a)$$

$$(\sum_{t=1}^{S} \mu_t \frac{\partial f_t}{\partial x_N} - \gamma) x_N = 0 \qquad (11b)$$

Assuming an interior solution ($x_i^* > 0$) and therefore an equal sign in (10a), the conditions in (10) may be expressed as:

$$\frac{w_i}{w_j} = \frac{\sum_{t=1}^{s} \mu_t \frac{\partial f_t}{\partial x_i}}{\sum_{t=1}^{S} \mu_t \frac{\partial f_t}{\partial x_j}}\text{, (i, j = 1,., n)} \qquad (12)$$

where $\partial f_t / \partial x_j$ is the marginal product of input *j* in state *t* (MPP_{jt}).

Differentiating (9) with respect to z_s, (s = 1,…, S) yields the following first order conditions:

$$p_s \frac{\partial W}{\partial q_s} - \mu_s \leq 0 \text{, } (s = 1,\ldots, S) \tag{13a}$$

$$(p_s \frac{\partial W}{\partial q_s} - \mu_s) z_s = 0 \text{, } (s = 1,\ldots, S) \tag{13b}$$

Assuming interior solutions (z_s^* >0) and therefore an equal sign in (13a) implies:

$$\mu_s = p_s \frac{\partial W}{\partial q_s} \tag{14}$$

Inserting (14) in (12) yields:

$$\frac{w_i}{w_j} = \frac{\sum_{t=1}^{S} p_t \frac{\partial W}{\partial q_t} \frac{\partial f_t}{\partial x_i}}{\sum_{t=1}^{S} p_t \frac{\partial W}{\partial q_t} \frac{\partial f_t}{\partial x_j}} = \frac{\sum_{t=1}^{S} \frac{\partial W}{\partial q_t} VMP_{ti}}{\sum_{t=1}^{S} \frac{\partial W}{\partial q_t} VMP_{tj}} \text{, } (i, j = 1,\ldots, n) \tag{15}$$

where VMP_{ti} is $p_t(\partial f_t / \partial x_i)$ i.e. the Value of Marginal Product of input x_i in state *t*.

If one assumes risk neutrality, then (15) reduces to:

$$\frac{w_i}{w_j} = \frac{E(VMP_i)}{E(VMP_j)} \text{, } (i, j = 1,\ldots, n) \tag{16}$$

which expresses that for optimal production, the risk-neutral decision maker should combine variable input in such a way that the relation between the expected marginal products is equal to the relation between prices.

Using (14) in (10a), assuming an interior solution and therefore an equal sign, the condition for optimal production in (10) may also be expressed as:

$$\sum_{t=1}^{S} p_t \frac{\partial W}{\partial q_t} \frac{\partial f_t}{\partial x_i} = w_i (\sum_{t=1}^{S} \frac{\partial W}{\partial q_t} + \delta) \text{, } (i = 1,\ldots, n) \tag{17}$$

which under risk-neutrality reduces to:

$$E(VMP_i) = w_i(1 + \delta) \text{, } (i = 1,\ldots, n) \tag{18}$$

Equation (18) shows that a risk neutral decision maker should add variable input, as long as the expected value of the marginal product is higher than the input price (adjusted for any budgetary restriction)

Assuming interior solutions in both (11a) ($x_N^* > 0$) and (13a) ($z_s^* > 0$), the two conditions may be combined, yielding the following condition for optimal use of fixed input:

$$\sum_{t=1}^{S} p_t \frac{\partial W}{\partial q_t} \frac{\partial f_t}{\partial x_N} = \gamma \tag{19}$$

Under risk-neutrality (19) reduces to:

$$E(VMP_N) = \gamma \tag{20}$$

which tediously expresses that a risk-neutral decision-maker should apply fixed input, as long as the expected value is higher than the shadow price.

If the fixed input is state-allocable, in order for it to be allocated to different states of nature, then, as mentioned previously, the input vector **x** is expanded from (x_1, …, x_n, x_N) to (x_1, …, x_n, x_{N1}, …, x_{NS}), where x_{Nt} (t=1,…, S) is the amount of fixed input x_N allocated to state t. The restriction (4) (with only one output, i.e., M=1, and one fixed input x_N) is adjusted correspondingly, so that in this case:

$$\sum_{s=1}^{S} x_{Ns} - x_N^F \leq 0\,, \tag{21}$$

indicating that the amount of fixed input allocated to the different states of nature, may not exceed the amount of input available.

Including these alterations in the model, the conditions (19) and (20) change to:

$$\sum_{t=1}^{S} p_t \frac{\partial W}{\partial q_t} \frac{\partial f_t}{\partial x_{Ns}} = \gamma\,,\ (s = 1,\ldots, S) \tag{22}$$

Under risk-neutrality (22) reduces to:

$$E(VMP_{Ns}) = \gamma,\ (s = 1,\ldots, S) \tag{23}$$

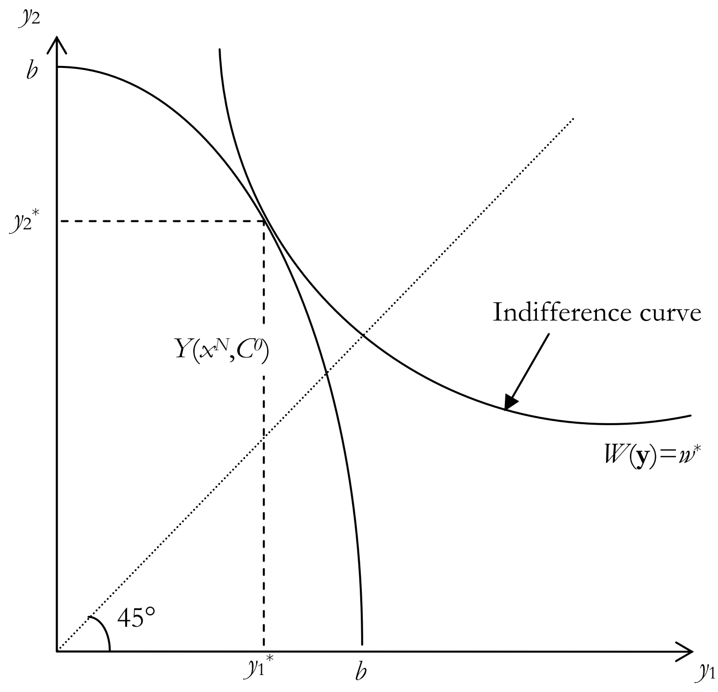
Thus, fixed state-allocable input (input, which may be allocated to specific states of nature) should be allocated between states of nature, so that the expected values of the marginal products are equalized across states.

The result of optimizing production, as derived in (9) – (23), is illustrated in Figure 4 for S=2. Origin of the system of coordinates in Figure 4 corresponds to k_s-c^F (s=1,…, S) in Figure 1, so that the axes in Figure 4 measure *changes in income* compared to the no production alternative illustrated in Figure 1. Thus, the *net-returns* y_s are estimated as (compare with (2)):

$$y_s = \sum_{s=1}^{S} z_s p_s - \sum_{i=1}^{n} w_i x_i\,,\ (s = 1,\ldots, S), \tag{24}$$

and the optimal production plan is the state-contingent net-returns (y_1^*, y_2^*) in Figure 4.

Figure 4. Optimal state-contingent income



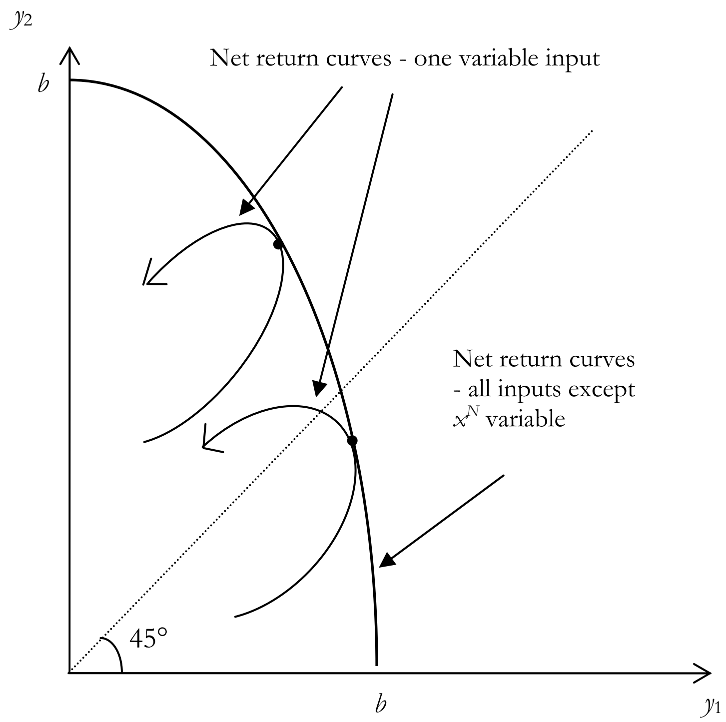
According to the assumptions made earlier, the net return set $Y(x^N,C^0)$ in Figure 4 (the *y*'s below the curve *bb*) is determined by the amount of fixed input (x^N) and the budget (C^0).

To interpret the net-return curve *bb* in Figure 4, compare it with the net-return curve derived in Rasmussen (2003)[7] for the one-variable-input case. In Figure 5, two such one-variable-input net return curves are illustrated with an increasing amount of one variable input in the direction of the arrow, assuming that all other inputs are fixed. The two curves represent different amounts of fixed input.

The net return curve *bb* may now be interpreted as the envelope curve for all possible one-variable-input curves, of which only two are shown in Figure 5. Thus, the implicit assumption behind the net return possibility curve *bb* is that all inputs are used efficiently.

[7] See Rasmussen 2003, Figure 7 and 8 pp. 466-467

Figure 5. Derivation of net return curve



3. *Empirical application*

The criteria for optimal production derived for risk-averse decision-makers (equations (17) and (22)) involve, not only the derivatives of the state-contingent production functions, but also the derivatives of the state-contingent utility function. To implement the criteria derived, i.e. to use the criteria in decision making contexts or to perform comparative static analysis, one therefore needs to know the state-contingent production functions, the state-contingent output prices[8], and the utility function.

Elicitation of the utility function has historically been one of the major problems encountered in the application of the Expected Utility model (EU-

[8] To simplify, only production uncertainty (and not price uncertainty) is explicitly considered in the following.

model)[9]. However, the state-contingent approach does not provide any immediate shortcuts with respect to the demand for identifying risk preferences. And while the endeavours in the literature have focussed on elicitation of von Neumann-Morgenstern (NM) utility functions, the more general preference structure on which the state-contingent approach is based, may even involve further challenges.

However, there are cases in which empirical application is possible without explicit knowledge of the utility function. Such cases exist if there are what Hirshleifer and Riley call Complete Contingent Markets (CCM), i.e. markets for direct trading in state-contingent claims (for instance markets for insurances), or Complete Asset Markets (CAM), i.e. markets for assets, including e.g. financial assets (loans, futures, options, etc.), which may be used to re-allocate state-contingent incomes (Hirshleifer and Riley 1992).

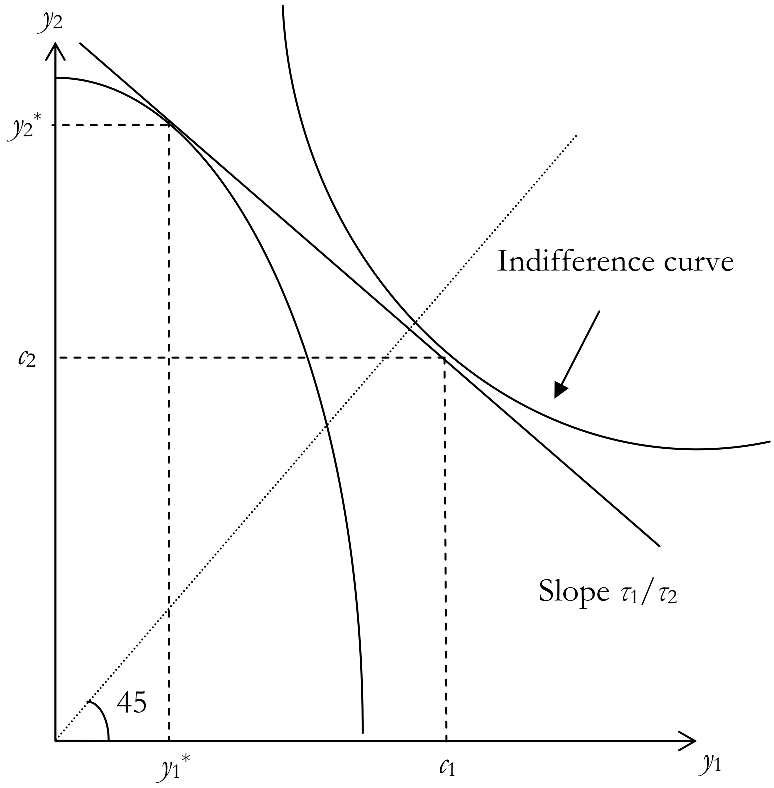
If such markets (and therefore prices of state-contingent incomes) exist, then it is possible to separate the production decision and the consumption decision (Hirshleifer and Riley 1992). The procedure for optimizing production is in this case, to substitute the derivatives of the utility function ($\partial W/\partial y_s$, s = 1,…, S) in (17) and (22) with the relative prices of state-contingent income directly available as market prices (CCM) or indirectly estimated (CAM).

The procedure is illustrated in Figure 6, which corresponds to Figure 4, shown earlier. The relative prices of state-contingent incomes are τ_1/τ_2, and the optimal production therefore provides the net-return (y_1^*, y_2^*). This implies a production plan with higher net-return in state 2 and less net-return in state 1 compared to Figure 4. The optimal state-contingent consumption after trading in the market for state-contingent claims at prices τ_1/τ_2 is (c_1, c_2). (Compare to Hirshleifer and Riley, 1992, Figure 2.5, p. 56).

Although this approach will not be discussed further here, it is without a doubt an approach of increasing importance (Coble and Knight 2002; Allen and Lueck 2002; Pannell *et al.* 2000; Chambers and Quiggin 2002a; Babcock and Hennessy 1996; Quiggin 2002; Chambers and Quiggin 2000). As a basis for empirical work, the approach using direct or indirect markets for state-contingent claims, seems much more promising than using effort to elicitate the decision-makers' utility function. In the ideal case of insurable markets and actuarially fair insurance contracts, the problem of optimizing production in reality boils down to the problem of identifying the production plan that maximizes the expected net-return (Nelson and Loehman 1987). Further, the state-contingent approach is very well suited to this, as indicated by the illustration in Figure 6.

[9] Moschini and Hennessy (2001) give a good review of the published research on identifying risk preferences (the NM-utility function) in the EU-model context.

Figure 6. Separation of production and consumption.



As the objective of this paper is to compare the state-contingent approach with the empirical approaches typically taken in the EU-model context (Hardaker *et al.* 1997), the following analysis will be based on the direct approach, i.e. without considering markets for state-contingent claims. In this case, empirical application involves choosing/estimating an appropriate utility function.

In the following, the EU-model and the more general model based on the state-contingent approach will be compared, and the problems related to empirical application will be discussed. The problems relating to the choice of utility function are discussed in the first subsection. In the next subsection, problems connected to describing the production technology are discussed.

3.1. *Choice of Utility Function.*

3.1.1. *The EU-model*

The popular choice of functional form of the NM utility function in the EU model framework is the negative exponential:

$$v(y) = 1 - e^{-\lambda y} \tag{25}$$

where λ ($\lambda > 0$) is the Arrow-Pratt coefficient of absolute risk aversion, i.e. $\lambda = -v''(y)/v'(y)$. Although this form implies the assumption of constant absolute risk aversion (CARA) which is not usually regarded as a desirable property (Hardaker *et al.* 1997), it has found extensive use in applied analyses of decision making under risk (Allen and Lueck 2002; Pope and Just 1991; Chavas and Holt 1990; Smith *et al.* 2003) due to its mathematical/analytical properties: If y is normally distributed, then the expected utility is a simple function of expected value (E) and Variance (V):

$$W(\mathbf{y}) = E(y) - \frac{\lambda}{2} V(y) \tag{26}$$

More desirable functional forms are the logarithmic:

$$v(y) = \ln(y) \tag{27}$$

which has decreasing absolute risk aversion (DARA), and the power function:

$$v(y) = \frac{1}{1-r} y^{(1-r)} \tag{28}$$

where r is the Arrow-Pratt coefficient of relative risk aversion, i.e. $r = y\lambda$. Like the logarithmic, the power function also has decreasing absolute risk aversion (DARA) and constant relative risk aversion (CRRA). For $r = 1$, the power function (28) reduces to the logarithmic (27).

Also, the quadratic function:

$$v(y) = y - by^2 \tag{29}$$

has been rather popular ($b > 0$), because it implies an EV utility function, i.e.:

$$W(\mathbf{y}) = E(y) - bV(y) - b[E(y)]^2 \tag{30}$$

The properties of the different types of utility functions may be illustrated by deriving the *rate of substitution in utility* of y_s for y_t (RSU_{st}), defined as the slope dy_s/dy_t of an iso-utility curve in state-space[10]. Thus, a utility function $W(\mathbf{y})$ based on the NM-utility function in (25) has the following property:

$$\text{RSU}_{st} \equiv \frac{\partial W / \partial y_s}{\partial W / \partial y_t} = \frac{\pi_s}{\pi_t} e^{-\lambda(y_s - y_t)} \tag{31}$$

A utility function based on the NM-utility function (27) has the following property:

[10] See Dillon and Anderson (1990, p. 125) who use this term to describe the slope in EV-space.

$$\text{RSU}_{st} \equiv \frac{\partial W / \partial y_s}{\partial W / \partial y_t} = \frac{\pi_s}{\pi_t} \frac{y_t}{y_s} \tag{32}$$

Finally, a utility function based on (28) has the following property:

$$\text{RSU}_{st} \equiv \frac{\partial W / \partial y_s}{\partial W / \partial y_t} = \frac{\pi_s}{\pi_t} \left(\frac{y_t}{y_s} \right)^r \tag{33}$$

It follows from (31), (32), and (33) that the marginal rate of substitution (i.e. the amount of income in state *s* that would substitute one unit of income in state *t*) increases, the greater the difference in income in the two states of nature is. Further, it follows directly from (32) and (33) that the marginal rate of substitution in EU-models, based on the logarithmic and power functions, does not change when income in all states are multiplied by a constant (CRRA). A consequence of (31) is that the marginal rate of substitution for exponential function does not change when income in all states is allotted a constant (CARA).

3.1.2. *The general* (*state-contingent*) *form*

In the state-contingent framework, utility functions based on the EU-model may still be applied (Expected Utility is just a special form of the more general utility function).

However, it is appropriate to consider more general functional forms. In this context, one needs to consider what restrictions to place on the utility function.

The most common restriction to place on preferences is that the decision maker is risk-neutral or has risk-aversion. This is the case where the utility function is quasi-concave over stochastic incomes. (Utility functions based on the Neumann-Morgenstern utility functions mentioned in the previous section all fulfil this restriction).

In the general case of the state-contingent framework, preferences only depend on the state-contingent outcomes, and not explicitly on the probabilities as is the case in the EU-model.

Besides the linear utility function (in which case the utility is simply the expected value of net-returns), the simplest functional form describing risk-averse decision makers in the state-contingent framework, is the Cobb-Douglas:

$$W(\mathbf{y}) = a_0 \prod_{t=1}^{S} y_t^{a_t} \tag{34}$$

with $0 < a_t < 1$ to ensure that the function is quasi-concave.

The fact that the relative probabilities are given as the slope of the indifference curve along the bisector (Chambers and Quiggin 2000), i.e.:

$$\frac{\pi_s}{\pi_t} = \left. \frac{\partial W / \partial y_s}{\partial W / \partial y_t} \right|_{y_1 = \cdots = y_S = y}, (s, t \in \Omega) \tag{35}$$

implies, that with a Cobb-Douglas utility function, the relative probabilities are determined as:

$$\frac{\pi_s}{\pi_t} = \frac{a_s}{a_t}, (s, t \in \Omega) \tag{36}$$

Thus, the choice of the parameters of the Cobb-Douglas utility function (a_t, t=1,…, S) is at the same time a choice of the relative (subjective) probabilities implicitly attached to the different states of nature. On the other hand, if the probabilities π_s (s = 1,…, S) have already been determined, then the relative value of the parameters a_s (s = 1,…, S) are determined by (36).

A Cobb-Douglas utility function has the derivative:

$$\frac{\partial W}{\partial y_s} = \frac{a_s}{y_s} W(\mathbf{y}), (s \in \Omega) \tag{37}$$

and therefore the RSU_{st} is:

$$\text{RSU}_{st} \equiv \frac{\partial W / \partial y_s}{\partial W / \partial y_t} = \frac{\pi_s}{\pi_t} \frac{y_t}{y_s} \tag{38}$$

Comparing (38) with (32), one sees that a Cobb-Douglas utility function provides the same marginal rate of substitution (slope of the indifference curve) as an EU utility function, based on the logarithmic form (27) of the NM utility function.

Equation (38) also shows that the Cobb-Douglas utility function implies constant relative risk aversion (CRRA) (the expansion path is a straight line through the origin) and therefore decreasing absolute risk aversion (DARA), which according to Meyer (2002) is a very acceptable assumption.

However, the Cobb-Douglas function is different from the EU model, in the sense that the marginal utility of income in state s (see (37)) not only depends on the relative probability of state s (a_s) and of the net-return in state s (y_s), but also on the net-return in the other states of nature ($W(y)$). In this sense, even the relatively simple Cobb-Douglas functional form potentially provides more flexibility in the description of preferences, than the utility functions based on the popular forms of NM utility functions, mentioned in the previous section.

An even more flexible functional form is the translog:

$$\ln W(\mathbf{y}) = \ln a_0 + \sum_{t=1}^{S} a_t \ln y_t + \tfrac{1}{2} \sum_{s=1}^{S} \sum_{t=1}^{S} b_{st} \ln y_s \ln y_t \tag{39}$$

Notice that the Cobb-Douglas utility function is a special case of the translog utility function ($b_{st} = 0$ for all s, t).

A translog utility function has the following properties (Boisvert 1982):

$$\frac{\partial W}{\partial y_s} = \frac{W(\mathbf{y})}{y_s}(a_s + (\sum_{t=1}^{S} b_{st} \ln y_t)) \tag{40}$$

and therefore:

$$\frac{\partial W / \partial y_s}{\partial W / \partial y_t} = \frac{y_t}{y_s}\left(\frac{a_s + \sum_{t=1}^{S} b_{st} \ln y_t}{a_t + \sum_{t=1}^{S} b_{ts} \ln y_s}\right) \tag{41}$$

As the translog is a relatively general form, one cannot expect it to be well-behaved globally (non-decreasing, quasi-concave, and constant relations between probabilities (i.e. (35)), unless certain restrictions are employed.

To make sure that W is non-decreasing, (40) has to be nonnegative, i.e.:

$$a_s \geq -(\sum_{t=1}^{S} b_{st} \ln y_t)\,,\ (s = 1,\ldots, S) \tag{42}$$

To ensure quasi-concavity the Bordered Hessian matrix should be negative definite.

The translog function is homothetic if and only if:

$$\sum_{t=1}^{S} b_{st} = 0\,,\ (s = 1,\ldots, S) \tag{43}$$

Thus, (43) becomes the condition that the translog utility function in question has CRRA.

Using (35), the following relation exists between the parameters and the probabilities:

$$\frac{\pi_s}{\pi_t} = \frac{a_s + \ln y \sum_{t=1}^{S} b_{st}}{a_t + \ln y \sum_{t=1}^{S} b_{ts}}\,,\ (s, t = 1,\ldots, S) \tag{44}$$

This condition (44) must be valid for any value of y. This is the case only when:

$$\frac{\partial F}{\partial k} = 0\,, \tag{45}$$

where

$$F \equiv \frac{a_s + \ln(ky) \sum_{t=1}^{S} b_{st}}{a_t + \ln(ky) \sum_{t=1}^{S} b_{ts}}\,,\ (k > 0;\ s, t = 1,\ldots, S)). \tag{46}$$

Condition (45) applies only if:

$$a_t \sum_{t=1}^{S} b_{st} = a_s \sum_{s=1}^{S} b_{ts} \text{ , } (s, t = 1,\ldots, S) \tag{47}$$

This restriction (47) - together with the restriction (42) and the condition that the Bordered Hessian is negative definite - thus becomes the general restriction on the translog function to be considered a state-contingent utility function. If the condition (47) is replaced by (43), then the translog utility function is a CRRA utility function.

Risk aversion is ensured when W is quasi-concave.

If the translog is homothetic (i.e., it fulfils (43)), then according to (44) the relation between probabilities is:

$$\frac{\pi_s}{\pi_t} = \frac{a_s}{a_t}, \quad (s, t \in \Omega) \tag{48}$$

which is the same as for the Cobb-Douglas function. This means, that if one chooses a translog functional form of the utility function, concurrently introducing the condition that the utility function has CRRA, then the relative probabilities determine the relation between the *a*-parameters as shown in (48).

To summarize, a Cobb-Douglas utility function in state-contingent income measures yields a utility function with the same degree of flexibility in the state-contingent world as a logarithmic von Neumann-Morgenstern utility function in the Expected Utility world. More flexible functional forms, as for instance the translog, have proven successful in other contexts. But even the flexibility of the translog is limited when one considers the restrictions necessarily placed on state-contingent utility functions.

3.2. *The Production Technology*

Although the basic problems of optimising production under uncertainty are the same, the expected utility model (the EU-model) and the state-contingent model are based on different approaches in describing the technology. While the EU-approach focuses on *the stochastic production function* and estimation of probability distributions of yield (and prices), the state-contingent approach focuses on *state-contingent production functions*, and therefore yields (and prices) contingent on discrete states of nature.

Just (2003) compares the EU-model and the state-contingent model (p. 140). He states that the relative advantage of the two approaches depends on how many moments of the probability distribution it is necessary to estimate, compared to the number of states of nature. He claims that if there are many states of nature, then the state-contingent approach is disadvantaged and that "…most distributions facing farmers have large numbers of potential outcomes (states of nature)" (p.140). For example, most yield and price distributions have a large number of outcomes. In fact, depending on the units used for measuring yields and prices, there may even be thousands of yields and prices, and therefore the same huge number of states to consider.

Although at first sight this point seems important, it also exposes the mistakes one may make if the differences between the two approaches are not carefully considered. While the EU-model typically focuses on the probability distributions of yields and prices, i.e. the *consequences* of the uncertain environment, the state-contingent approach focuses directly on the uncertain environment, i.e. the *states of nature*. Thus, yields and prices are not (as indicated by Just) "states of nature", but rather *consequences* of "states of nature", (e.g. in the case of crop production consequences of the amount of rain or hours of sunshine). In a decision making context, the state-contingent approach is much more appropriate, because it makes explicit that the realized yield of a crop of wheat is a *consequence*, not only of the controllable inputs (the input vector **x**), but also of the *interaction* with the non-controllable inputs, i.e. the "states of nature" (amount of rain, hours of sunshine, etc.).

However, it is not obvious how one *should* empirically approach the problem of facing maybe thousands of discrete states of nature and the demand of estimating, for each of these states of nature, a state-contingent production function usable within the theoretical framework afterwards, as presented in Section 2.

As will be shown in the following, it may not be a question of choosing either the EU-model based on the stochastic production function or the state-contingent model based on state-contingent production functions. In an empirical context, it may be a question of combining the two approaches.

In the following, the focus will be primarily on the state-contingent production function. The EU approach based on the stochastic production function is well known in the literature, and will only be briefly mentioned in the first section to provide comparisons with the state-contingent production function mentioned later.

3.2.1. *The stochastic production function*

The EU-model is typically based on what Chambers and Quiggin (2002b) call *Stochastic Production Functions*, i.e. functions of the type:

$$z_t = f(\mathbf{x}, \varepsilon_t) \tag{49}$$

for instance of the form:

Additive: $$z_t = f(\mathbf{x}) + \varepsilon_t \tag{50}$$

Multiplicative: $$z_t = f(\mathbf{x}) \cdot \varepsilon_t \tag{51}$$

Just-Pope: $$z_t = g(\mathbf{x}) + h(\mathbf{x}) \cdot \varepsilon_t \tag{52}$$

The empirical problem is related to estimating the functions and the probability density function of the error term ε_t, or at least the first two or three moments[11]. The Just-Pope production function form in (52) (Just and Pope 1978) has proven to be especially popular in applied analyses (Moschini and Hennessy 2001), and has been used by, for instance, Larson *et al.* (2002); Smith *et al.* (2003) and Horowitz and Lichtenberg (1994)[12].

3.2.2. *The state-contingent production function*

With the state-contingent model, one of the immediate problems one faces in applied work is how to define the possible states of nature.

In theory, a *state of nature is formally defined as a complete description of the external conditions* (the environment) in the sense that, given a specific state of nature (non-controllable inputs) and a production decision (amount of controllable inputs), then the consequences (outputs or prices) are uniquely determined.

A state may be quantified by a vector of *state-variables* describing the state-space using quantitative variables such as temperature, amount of sunshine, amount of rain, etc. While in theory one can easily imagine a state description being *complete* in the sense that everything relevant has been descrybed/registered, this is typically *not* the case when it comes to empirical application. In practice, it is often impossible to make a complete description/registration of a state of nature. Either because one does not know all the state-variables influencing output, or because the true level of the state-variables is uncertain. In both cases the state description is *incomplete*, and the state-contingent output (the output given a specific registered[13] state of nature) is a stochastic variable.

Consider first the case where the complete state space is the set $\Omega = \{1,\ldots, S\}$. To proceed with the state-contingent approach based on the theory developed in Section 2, one needs estimates of the state-contingent production function for each of the S states of nature. Thus, in the ideal case where the state description is complete, the applied researcher has available the following S *state-contingent production functions*:

$$z_s = f_s(\mathbf{x}),\ (s = 1,\ldots, S) \tag{53}$$

[11] In the EU approach, much energy is used in choosing a type of distribution (Normal, beta, etc) and estimating the parameters, typically the expected value and the variance (Dillon and Anderson 1990; Goodwin and Ker 2002).

[12] For further introduction to the approach in the EU-model, see for instance Dillon and Anderson (1990)

[13] I use the term *registered state* to describe the way in which a state is actually (empirically) registered. If not all relevant state-variables are registered or if the registered level of the individual state-variables is uncertain, then the state description is *incomplete*. A *real state* is the actual state, which exists independently of being registered or not. In the following when I use the term *state*, I mean *registered state* unless explicitly stated.

either in the form of mathematical functions, or in the discrete form as numbers in a table.

In practice this ideal situation rarely exists.

First of all, the *number of possible real states* (*S*) *is often very large*. (This is indeed the case when the variables describing the states of nature, are continuous variables). Therefore, if state-contingent production functions are available, it will in practice typically be for only *some* of the possible real states. To illustrate, consider the simple decision problem of fertilizer application to a crop of barley. The yield of barley four months later depends both on the amount of fertilizer applied now, but also on the real state of nature during the growing season. Assume for simplicity that the real state of nature may be quantified by the amount of sunshine and rain during the growing season. Further assume that the relevant interval of possible amount of rainfall is between 10 and 50 centimetres, and that the relevant interval of the amount of sunshine is between 200 and 800 hours. With only these two state-variables describing the real states of nature, there would – if state-variables are measured in integer units - be 50x600 = 24,000 different states of nature. Imagine that state-contingent production functions are estimated based on experimental yields. Then, even in the unrealistic case that none of the states came out twice, it would take at least 24,000 years to collect enough observations to estimate the 24,000 state-contingent production functions!

Secondly, if state-contingent production functions are in fact available, then they are probably only *estimates* of the true state-contingent production functions, so that the output z_s is a stochastic variable:

$$z_s = f_s(\mathbf{x}, \varepsilon_s),\ (s \in \Omega^E) \qquad (54)$$

where ε_s is a stochastic error term given state *s*, and Ω^E is the set of states for which production functions have been estimated. A state of nature is often characterized by a large number of state-variables. If only a few of these variables are in fact observed/registered when doing the experiments on which the state-contingent production function is based, then the state-description is *incomplete*. The variables registered could be e.g. monthly rainfall and hours of sunshine/month. However, all the other variables influencing the output, may not be observed. These other variables could for instance be wind velocity or CO_2 content of the atmosphere as well as many other variables influencing production. Therefore, even if one were so lucky to replicate production under the (apparently) same conditions (the same amount of rainfall and the same amount of sunshine), one cannot be sure of achieving the same production result (with the same amount of controllable input), because the other (non-controllable) variables may contain alternative values. For this very reason, the state-contingent production for a specific state of nature, (i.e. for a specific registered state of nature, for instance *a* hours of sunshine and *b* centimetres of rain) would be a stochastic variable as indicated in (54), because the *state-description is incomplete*.

Thus, the typical situation facing the applied researcher is that if state-contingent production functions are available at all, it is probably only for a few of the possible real states of nature. And for those real states for which they are available, the state-description is probably incomplete, i.e. has the general form of a stochastic production function shown in (54).

This indeed is the main obstacle to applying the state-contingent approach in an empirical/normative context. Experimental data and farm response data typically do not provide the information necessary to estimate state-contingent production functions. The question is therefore, how the possible advantages of the state-contingent approach may be used when the data necessary to support the approach are often not available.

To illustrate the problem and a possible procedure to deal with it, consider the following *simple example.*

A real state of nature is completely quantified by the level of four state-variables a_1, a_2, a_3 and a_4 (in crop production this could be for instance the amount of rain, the amount of sunshine, concentration of CO_2 in the atmosphere, and wind velocity). Assume for simplicity that there are 10 possible levels of the first state variable a_1 and 3 possible levels of each of the other three state-variables a_2, a_3 and a_4. If any combination is possible, there would therefore be 10×3×3×3=270 possible real states of nature (S = 270). The probabilities connected to each of these possible states may or may not be known.

Assume further that for one reason or another, only the first state-variable (a_1) is systematically being registered when performing the experiments on which estimation of production functions are based. Thus, the states registered refer to the 10 possible levels of state-variable a_1. Finally, assume that production functions have been estimated for only 4 of these 10 possible states, so that of the 10 possible state-contingent production functions $f_1(\mathbf{x}),\ldots, f_{10}(\mathbf{x})$, only $f_2(\mathbf{x})$, $f_5(\mathbf{x})$, $f_6(\mathbf{x})$, and $f_8(\mathbf{x})$ are in fact available. Therefore, the information available as a basis for decision making are the 4 state-contingent poduction functions and the knowledge of the possibility that nature may take one of 270 states of nature and the corresponding probabilities.

Consider first the 4 state-contingent production functions available. The fact that the level of the other 3 state variables a_2, a_3 and a_4 were not registered when the state-contingent production functions were estimated, means that the production in each of the four registered states is a stochastic variable, i.e.:

$$z_s = f_s(\mathbf{x},\gamma_s), \quad (s = 2, 5, 6, 8) \tag{55}$$

where γ_s are state-specific error terms drawn from state-contingent probability distributions that are determined by the variability of other three state-variables that are not registered.

Assume that the probability distribution of each of the four error terms γ_s (s=2, 5, 6, 8) are known (have been estimated). Then the four (state-contingent), stochastic production functions in (55) are, in principle, a description of the technology for 4/10 of the 270 real states, i.e. for the 108 real states.

But what about the technology for the remaining 270-108 = 162 states?

In principle, nothing is at this stage known about the technology for these remaining 162 states.

One way to proceed is to consider each of the estimated state-contingent production functions $f_s(\mathbf{x})$ ($s \in \Omega^E$) as being *representative* of (being an estimate of) – not only state *s*, but also of all possible states of nature in *the vicinity of state s*. In the present example, this means that $f_2(.)$ is considered representative also of state 1 and 3, that $f_5(.)$ is considered representative also of state 4, that $f_6(.)$ is considered representative also of state 7, and that $f_8(.)$ is considered representative also of states 9 and 10. In this way, the four available production functions are used as estimators of the remaining (unknown) production functions.

Obviously this way of estimating the technology for the remaining 6 states, adds another error term, so that in this case:

$$z_s = f_s(\mathbf{x}, \gamma_s, \eta_s), \; (s = 1, 3, 4, 7, 9, 10) \qquad (56)$$

where η_s is an error term with a probability distribution which depends on how much two nearby states in the a_1-dimension resembles each other.

The example illustrates first of all the extreme data requirements necessary to apply the state-contingent approach in its "pure" form. Secondly, it proposes what can be done in the typical second best situation with incomplete date. Finally, it shows that in the real world situation, it is not a matter of choosing between the state-contingent production function and the stochastic production function. It is rather a matter of combining the two.

The example also provides the foundation for describing the relationship between the state-contingent production function and the stochastic production function. The two ways of describing the technology are just special cases of the more general description of the technology in (54). In the special case that $\Omega^E = \Omega$ (production functions have been estimated for *all* possible states), then the error term in (54) vanishes, and the technology description is in the form of (non-stochactic) state-contingent production functions as in (53). In the special case that $\Omega^E = \varnothing$ (available production functions refer to no specific state), then the model (54) reduces to the (pure) stochastic production function in (49).

4. *Example*

In this paper the focus has been on the empirical application of the state-contingent approach. It is therefore appropriate to close the paper, demonstrating the application of the state-contingent theory.

The demonstration is based on the following relatively simple production example[14]. An output z is produced according to the following two state-contingent production functions available:

$$E[z_1] = 3x_1^{0.6}x_2^{0.2}x_3^{0.1} \text{; in state } s = 1 \tag{57.1}$$

$$E[z_2] = 2.5x_1^{0.2}x_2^{0.4}x_3^{0.3} \text{; in state } s = 2. \tag{57.2}$$

where $E[z_s]$ is the expected production in state s.

Input prices are exogenous with the following prices of the three variable inputs x_1, x_2 and x_3:

$$w_1 = 10$$
$$w_2 = 4 \tag{58}$$
$$w_3 = 1.5$$

Expected output prices are also exogenous and there is no price uncertainty, i.e. the output price is the same in states 1 and 2:

$$p_1 = 10$$
$$p_2 = 10$$

Further, the (subjective) probabilities of states 1 and 2 are, respectively:

$$\pi_1 = 0.625$$
$$\pi_2 = 0.375$$

Finally, there is no fixed cost and there is no income from other sources, i.e.

$$c^F = 0$$
$$k_1 = 0$$
$$k_2 = 0$$

Therefore, net-income q_s in state s is the same as net-return y_s in state s. Notice that although the output prices are here assumed to be the same in both states, this need not always be the case. However, to interpret the results, only production uncertainty is considered.

To illustrate the consequences of uncertainty, consider first the case of certainty (perfect information). In the case of perfect information, the decision-maker always knows in advance what state of nature will emerge, and is therefore able to adjust the amount of input to the actual state of nature.

In the *case of certainty*, the objective is to maximize net-income, i.e. the value of output minus variable costs. In state 1 optimization is based on the state-contingent production function (57.1) and in the case of state 2, the optimization is based on the state-contingent production function (57.2). The result of

[14] Although the demonstration is based on a simple text book example, it reveals both the demand for data and the potential strength of the state-contingent approach

Table 1. Optimization of production under uncertainty. An example

	Input x_1 Units	**Input** x_2 Units	**Input** x_3 Units	**Output** Units	**Net-return** y_s ($)
CERTAINTY					
- State 1	275	230	306	459	459
- State 2	610	3 052	6 104	3 052	3 052
(Average)	(401)	(1 288)	(2 480)		(1 431)
UNCERTAINTY					
Risk-neutral	170	272	466	388	388
- State 1				371	222
- State 2				415	664
Risk-averse A	175	237	389	366	376
- State 1				360	322
- State 2				375	466
Risk-averse B	171	253	425	375	385
- State 1				364	276
- State 2				393	566

optimizing[15] production in the certainty case is shown in the first part of Table 1.

The first row of the table shows the optimal amounts of the three variable inputs to be used in the case of state 1. The optimal production is 459 units of output z_1, and the net-return (y_1) is \$459. The second row shows the corresponding information in the case of state 2. In the case of state 2, it pays to apply much more input than in state 1. Especially the amount of the (cheap) input x_3 is increased, because in state 2 this input x_3 is much more productive than in state 1. The production is about 7 times higher (3,052/459) in state 2 than in state 1.

The third row of the table shows the long term use of input and net-return in the case of certainty. The results are estimated by weighing the data in the first two rows by the frequencies of the two states of nature (i.e. 0.625 and 0.375, respectively)

In the *case of uncertainty*, a *risk-neutral decision-maker* applies input according to the criterion (18), i.e. $E(VMP_i) = w_i$ (no budget limitation). The results of optimising production using this criterion are shown in the three rows under the heading “Risk-neutral” in Table 1. Thus, in the case of uncertainty, a risk-neutral decision-maker will apply 170 units x_1, 272 units of x_2, and 466 units of x_3. The expected output is 388 units of z (371 units in the case of state 1, and

[15] All optimizations were carried out using the solver CONOPT3 in GAMS (GAMS Development Corporation 2003)

415 units in the case of state 2), and the expected net-return is \$388 (\$222 in state 1 and \$664 in state 2).

Now, assume that the *decision maker is risk-averse* and has a Cobb-Douglas utility function. As the probabilities are already given in the beginning, the functional form is:

$$W(q_1, q_2) = Aq_1^{0.625h} q_2^{0.375h} \tag{59}$$

where A and h are parameters ($A > 0$, $0 < h < 1.6$). The arguments q_1 and q_2 are expected net-income in states 1 and 2, respectively.

Arbitrarily, choose $h = 0.8$. Further, to identify which of the two states is "good" state, and which is the "bad" state (Rasmussen, 2003), the utility function in (59) is scaled so that the sum of the partial derivatives is 1 for the value **x** chosen by a risk- neutral decision maker. Calculating the sum of the derivatives of:

$$W(q_1(\mathbf{x}^n), q_2(\mathbf{x}^n)) = A \times (q_1(\mathbf{x}^n))^{0.5} \times (q_2(\mathbf{x}^n))^{0.3} \tag{60}$$

where $\mathbf{x}^n$ is the input vector for risk-neutral decision-maker, and where therefore the values of q_1 and q_2 - according to Table 1 - are 222 and 664, respectively, and setting this sum equal to 1, yields the value $A = 3.53$.

Using this value of A in (60) yields $\partial W/\partial q_1 = 0.832 > 0.625 = \pi_1$ and $\partial W/\partial q_2 = 0.167 < 0.375 = \pi_2$. Therefore, according to Rasmussen, 2003, state 1 is a "bad" state of nature, and state 2 is a "good" state of nature. Thus, receiving one more dollar in state 1 would provide more utility than the probability of this state of nature, and vice versa with state 2.

When the *decision-maker is risk-averse*, the criterion for optimizing is given earlier in condition (17). Applying this condition to a decision-maker with a utility function as in (59) with h=0.8 and A=3.53, yields the production plan shown in the three rows under the heading "Risk-averse A" in Table 1.

As one would expect, the optimal production is lower for a risk-averse decision-maker than for a risk-neutral decision maker. As risk-neutral decision-maker produces an expected output of 388 units of z, while a risk-averse decision-maker produces an expected output of 366 units.

However, what is more interesting is that the risk-averse decision-maker uses *input in another combination* than the risk-neutral decision-maker. Notice especially that while a risk-averse decision-maker reduces input x_2 and x_3 compared to a risk-neutral decision-maker, the use of input x_1 is increased (from 170 to 175 units). The reason being that in this example, input x_1 is much more productive in state 1 than in state 2. And as state 1 is the "bad" state of nature, it becomes "attractive" to use relatively more x_1 and to reduce x_2 and x_3, which are not as productive in the "bad" state of nature as in the "good" state of nature.

To further illustrate the flexibility of the state-contingent model approach, assume now that the income from other sources (k_s) changes. Instead of being

0 (zero) in both states as originally assumed (k_1=0; k_2=0), it now changes so that it is $200 in state 1 ($k_1$=200) but still zero in state 2 (k_2=0).

The results of optimizing production under this condition are shown in the last three rows of Table 1 under the heading "Risk-averse B". With the basic income being $200 higher in state 1, the optimal combination of input changes. The application of input x_1 decreases, while the application of x_2 and x_3 increases compared to the "Risk-averse A" situation. The result is that net-return in state 1 is substituted for net-return in state 2 (the net-return reduces from 322 to 276 in state 1 and increases from 466 to 566 in state 2). Thus, the model allows for substitution between state-contingent incomes through changing combination of input.

The results in Table 1 also underline another important aspect concerning optimizing production under uncertainty. By comparing the *use of input under uncertainty* with the *average use of input under certainty* (numbers in parenthesis in the third row), one sees that the optimal amount of input is *not* the amount one would apply on *average* if the two states were known in advance. If fact, the example shows that there may be very large difference. Interesting is also the fact that the expected net-return in the case of uncertainty, is considerably lower than the average net-return if the state of nature was known in advance. In the present example the expected net-return under uncertainty is even less than if one was certain that the bad state (state 1) would emerge every time (both the risk-neutral ($388) and the risk-averse ($376 and $385) provide less net-return than the $459 in the "bad" state (state 1)).

Although it is difficult to generalize from the specific results of this relatively simple example, it has demonstrated the power of the state-contingent approach.

5. *Conclusion*

In this paper I have derived criteria for optimal application of variable and fixed input in the multiple input - one output case based on the state-contingent approach. It has been shown that with the output-cubical technology as the basic model, any type of input may be analysed as special cases within the general model framework developed.

Applications of the criteria derived imply that state-contingent production functions and utility functions, based on state-contingent income measures – or at least the derivatives of these functions – are known. As most of the empirical work concerning optimizing production under risk has historically been based on the expected utility model, the approach based on the state-contingent approach implies new challenges. Both with respect to modelling the utility function, as well as with respect to choosing functional forms and procedures for estimating state-contingent production functions. In the paper it is shown that even relatively simple functional forms of the utility function based on state-contingent income measures, involve a higher flexibility in describing input substitution than the popular functional forms applied in the expected utility framework. Concerning production technology, the relation between the state-contingent production function and the stochastic production function normally applied in expected utility models has been analysed, and it is shown that the two ways of describing the production technology are just special cases of a more general description in the form of stochastic, state-contingent production functions.

The main conclusion concerning empirical application is that it is unrealistic to expect that production functions may be estimated for all possible states of nature. Instead, one has to accept that state-contingent production functions may be estimated for only a few states of nature. It is proposed that when this is the case, each of the state-contingent production functions available is considered being a stochastic production function.

This leaves the question of whether the state-contingent approach is better than the expected utility model when it comes to empirical application. While the state-contingent approach has clear advantages if state-contingent production functions are available for all states of nature, it is not clear whether this is the case if one has available (or is able to estimate) only a few *stochastic*, state-contingent production functions. It is proposed that this question be further investigated using e.g. Monte-Carlo simulation.

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The Institutional Mechanisms of Agricultural Insurance and Their Applicability in Transition

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Abstract

The objective of the paper is to compare the major institutional mechanisms of agricultural insurance (market, government, civil society) in order to find out how the mutual substitution of the mechanisms can serve to overcome their limitations. The major identified limitations include: for the market mechanism - opportunism and poor insurability of systemic risks; for the government mechanism - opportunistic behavior of the insured producers, agency problems in the implementation of public programs, high potential for bureaucratization and excessive complexity of insurance programs. The incentive problems of the civil society mechanism mainly do not include those that are characteristic for both markets and governments. However, this mechanism possesses problems specific to cooperative organizations. These problems have been shown to originate from high social capital-dependence of the civil society mechanism, which means that while these problems are able to significantly increase transaction costs of civil society mechanism, the actual size of these transaction costs depends on the availability of social capital in the respective communities. The economic context of transition to market has been shown to create additional constraints on market and government mechanisms and opportunities for the civil society mechanism. The optimal role of the government therefore is to invest in social capital in order to reduce the transaction costs of the civil society mechanism.

1. *Introduction*

The fundamental characteristic of the world with positive transaction costs is that institutions matter for economic performance. The conditions of bounded rationality, opportunistic behavior, uncertainty and unpredictability of business environment dictate the need to pay significant attention to designing the appropriate incentive structures of economic interaction with the purpose to attenuate the rational incentives of individuals to maximise their own welfare at the expense of downgrading the welfare of the economic system to which they belong. The task of designing the optimal incentive structures of interacting agents is particularly important for agricultural insurance activities, which are characterized by high potential for opportunistic behavior in the face of bounded rationality and uncertainty.

Specifically, the study of incentive attributes of different institutional mechanisms of agricultural insurance is important for the following reasons. First, the incentive attributes affect the effectiveness and efficiency of such mechanisms. Although the number of factors affecting the performance of specific insurance instruments can be large, it is important to remember that ultimately the performance is determined by the extent to which the incentives of major stakeholders match together.

Second, the incentive attributes determine the feasibility of different institutional mechanisms of agricultural insurance. Although certain income stabilization instruments (such as farm income insurance contracts and forward and futures markets in the EU) may seem to be efficient and effective, they may still remain relatively unpopular with agricultural producers, unless they fully correspond to the comprehensive sets of relevant incentives.

Third, the comparative incentive characteristics of different institutional mechanisms determine the structures of their optimal combination, in particular with respect to how market-based instruments, such as hedging and use of financial instruments, can be combined with the public insurance and price stabilization policies (e.g. storage policies in the EU). Particularly interesting and relatively underemphasized question relates to the role of cooperative and mutual organizations of agricultural producers in stabilizing their incomes.

Agricultural insurance is especially important for transitional economies, where agricultural incomes are low and their fluctuations therefore can have particularly destructive effects. This dictates the need to examine the implications of the transitional context for the performance, feasibility, and optimal combination of different institutional mechanisms of insurance, which also depends on the configuration of incentives of major stakeholders.

The paper explores the broad institutional mechanisms of agricultural insurance and is aimed at the theoretical identification and comparison of their incentive attributes, which affect their performance, feasibility and optimal combination in conditions of both well-developed and transitional economies. The paper is structured as follows. Sec.2 provides an overview of the available institutional mechanisms of agricultural insurance; Sec.3 uses the example of insurance to find out how their incentive attributes affect their performance, feasibility, and optimal combination; Sec.4 examines the implications of these conceptual findings for the transitional conditions; Sec.5 contains concluding remarks.

2. *The institutional mechanisms of agricultural insurance: an overview*

Just like any other type of economic activity, agricultural insurance activities can be performed through a variety of institutional mechanisms based on different types of incentive structures. Three broad institutional mechanisms of this kind can be identified:

- **market**, which presupposes that insurance is organized through the achievement of clearing prices between producers seeking to reduce their risks and agents offering the needed insurance services;
- **government**, which presupposes that insurance is organized with the help of public expenditures allocated as a result of interaction of a variety of political agents;
- **civil society**, which presupposes that insurance activities are delivered by organizations, owned and operated by agricultural producers themselves.

The operation of insurance markets requires that both agricultural producers and suppliers of insurance should be both willing and able to work together. Although the smoothly functioning markets are able to provide the efficient allocation of resources, these restrictive conditions often preclude the achievement of efficient outcomes through the market mechanism. In particular, the existence of insurance markets is limited only to situations where a number of conditions are fulfilled:

- information is symmetric;
- risks are independent;
- number of exposure units is large;
- chances of loss are calculable;
- actual losses occurring are determinable and measurable;
- potential losses must be seen by the policy as significant, still the premia must be economically affordable (Skees and Barnett 1999).

Moreover, the operation of a market is based on a certain institutional framework, which may be not fully developed and require a certain length of time to build, which may be particularly true for the transitional conditions.

The use of government mechanism of agricultural insurance is represented by governmental involvement in insurance markets either through offering insurance services or subsidizing insurance services of private firms.

The civil society mechanism of agricultural insurance presupposes the operation of cooperative (mutual) organizations offering insurance services to farmers, including agricultural cooperatives operating on a pooling basis. The development of this mechanism, both in the EU Member States and in transitional economies, seems to be significantly outdistanced by the extent of application of the two other ones. Nevertheless, there are a number of successful examples of cooperative insurance in the EU. For instance, in the Netherlands mutual insurance schemes have been developed for contagious disease outbreaks both in crops and livestock (ibid: 30). The Commission has also proposed the setting up of similar organization structures in the Member States intended to stabilize revenue in the pig sector (European Commission 2000, quoted in European Commission 2001: 30). An important role in stabilizing farm incomes may also belong to other cooperatively organized financial institutions, such as cooperative banks.

The cooperative principles in agricultural insurance may be used not only by agricultural producers but also by private insurance companies which may choose to create the insurance pools in order to jointly provide insurance for certain risks. Insurance pools offer a number of advantages: they can cover new and unknown risks, catastrophic risks, infrequent risks (to which the law of large numbers does not apply), as well as risks which can only be covered by applying special know-how; risks can be spread more value, lowering the need for and cost of reinsurance. Two categories of pools exist: co-insurance pools (as e.g. AGROSEGURO in Spain) and co-reinsurance pools (European Commission 2001: 29).

Each of the above-mentioned institutional mechanisms has powerful limitations, with the consequence that certain mechanisms are likely to be feasible only for certain specific risk reduction problems. It seems however that a general authoritative evaluation of what kinds of problems should be addressed by what mechanisms is not possible because the conditions in which agricultural producers find themselves are strongly embedded in regional and local institutional contexts. However, it would be possible to identify a set of incentive problems characteristic for each institutional mechanism, and associate these problems with the nature of specific risks, which would give an idea about the relative benefits and costs of different mechanisms for a well-specified situation. The elaboration of the incentive problems of institutional mechanisms will be the object of the next section.

3. *Comparing the institutional mechanisms*

The objective of this section is to analyze the major incentive problems of the market, government, and civil society institutional mechanisms in order to find out how the mutual substitution of the mechanisms can serve to overcome these problems.

3.1. *The incentive problems of the institutional mechanisms*

The insurance area of farm income stabilization provides a particularly appropriate field for studying the incentive problems, since informational asymmetries leading to opportunistic behavior in the form of adverse selection and moral hazard are particularly well expressed here. Different stakeholders of insurance, such as agricultural producers, private insurance companies, and public officials, have specific vested interests in the organization of the agricultural insurance system. Depending on particular configurations of rights and responsibilities in the system, their interests may exhibit various degrees of harmony and convergence, affecting the overall effectiveness of insurance activity.

An example of the suboptimal configuration of incentives is provided by the recent experience (1995-1998) of the CAT programme in the US agricultural insurance system. The efficiency of the program was questioned on the grounds that it has failed in providing the intended safety net, while it has produced significant underwriting profits for the insurance industry (OIG 1999a, quoted in European Commission 2001: 67). With this program more money went to the insurance companies than to producers helping them to recover from insured losses (OIG 1999c, quoted in European Commission 2001: 68). Since the public reinsurance left only minimal risks to the involved private companies, they had little reason to effectively monitor risky policyholders, to deny claims of questionable losses, as well as to improve their own practices and performance (OIG 1999a, 1999b, 1999c, quoted in European Commission 2001: 68).

3.1.1. *The market mechanism*

A major incentive problem constraining the development of insurance industry, well-described in the literature, is *the significant potential for opportunistic behavior in the form of adverse selection and moral hazard*. In his classic 1970 paper, Akerlof identified the destructive effects of the information asymmetry problems on the efficiency of markets in second-hand cars. The inability of buyers to determine ex ante the true attributes of proposed cars and the respective risk of acquiring lemons, coupled with the motivation of sellers to sell poor quality cars, resulted in the demise of the market itself. The problem of moral hazard exists when the probability of occurrence of a given state of the world is influenced by one of the parties to a contract but when the behavior of this contractor cannot be observed (Ricketts 2002: 34). The potential for opportunistic behavior therefore limits the extent to which the market mechanism can be used to deliver the insurance services needed by agricultural producers.

Another challenge for insurance activities is created by the incentive problems emerging due to *poor insurability of systemic risks*. Mahul (2001) proposes that crop risks should be decomposed into systemic and idiosyncratic components, only the latter of which should be covered by insurance. Goodwin/Smith (1995) (quoted in Bokuschewa/Heidelbach 2004) suggest that systemic risks can be covered by means of reinsurance in the global insurance market. Many researchers however adhere to the view that neither reinsurance nor capital markets cannot effectively deal with systemic risk and public policy interference is therefore necessary (see e.g. Skees *et al.* 1997, Cutler and Zeckhauser 1997, Miranda andGlaubner 1997, quoted in Bokuschewa and Heidelbach 2004).

3.1.2. *The government mechanism*

The following three incentive problems of organization of agricultural insurance programs occur only within the public sector – agency, rent seeking, and motivational side-effects of disaster aid. Accordingly, these problems only serve to deepen the disadvantages of the government institutional mechanism with respect to those of markets and civil society.

The effectiveness of public involvement in agricultural insurance is essentially determined by the fact that public officials hold no residual claims in the overall performance of the insurance programs, thus giving rise to the emergence of *principal-agent relationship in the implementation of public programs*. Consequently, the incentives of public official to search for economically optimal insurance contract configurations as well as to maximise the efficiency of administering the respective programs must be limited; at least more limited, than is the case with private suppliers of insurance. Although there are important disciplining mechanisms, such as possibilities for promotion and dismissal, the salaries of public officials are only very loosely, if at all, related to the efficiency of transactions that they conduct or mediate, which creates for them a significant margin of work efforts, on which they can safely economize without subjecting themselves to the risk of sanctions.

The agency character of public involvement in agricultural insurance is evidently not unrelated to the fact that the public supply of insurance (as well as other income stabilization) services may be also guided by political, rather than economic, considerations. Such products may be insufficiently tested and may undermine the soundness of the insurance system. To give an example, the US Risk Management Agency has been recently accused of insufficient research before implementing crop insurance policies, which resulted in unreasonably high yield figures in certain programmes, such as cotton and corn, as well as poorly written policies for some specialty crops (OIG 1999b, quoted in European Commission 2001: 70).

Another incentive problem of public involvement in agricultural insurance, also not unrelated to its agency character, is high potential for bureaucratization and excessive complexity of insurance programs, leading to the emergence of rent-seeking activities (Skees 1999b, 2000, quoted in European Commission 2001: 70). Rent seeking activities are possible on the part farmers (in trying to manipulate the insurance program tools to cover unjustifiably high risks), private insurance companies (in trying to obtain greater share of public funds intended as support for agricultural producers), as well as political actors seeking to increase their political weight by promoting the public delivery of insurance services meeting certain political demand but not necessarily well-tested and substantiated.

An incentive problem inherent in the disaster aid delivered by the government is that awareness of the possibility of disaster aid might reduce sensitivity of farmers towards risks and crowd out the private initiatives (European Commission 2001: 36). The private initiatives adversely affected by ad-hoc aids include both private suppliers of insurance and cooperative organizations. Although the need for disaster aid could be minimized if the private insurance system (including these both categories) would work efficiently, in reality this is evidently not the case.

3.1.3. *The civil society mechanism*

In most developed and transitional economies, the civil society mechanism of insurance and, more generally, farm income stabilization, so far remains significantly underrepresented in comparison to the market and government mechanisms. Evidently this must be explained with the major limitations of this mechanism, possibly outweighing the limitations of its institutional alternatives. Cooperative organizations are in fact known to have a number of incentive problems. Whereas these incentive problems are largely independent of the specific area of business activities, they are able to affect the effectiveness and efficiency of any activities as long as they are organized on the basis of the cooperative principles.

The incentive problems of cooperation include: common property problem (the members' equity contribution may not be proportional to the distribution of resulting benefits); horizon problem (members can capture benefits from their investment only over the time horizons of their expected membership in the organization, which causes bias toward short-term investment and/or underinvestment); monitoring problem (decision management is allocated to decision specialists who are not residual claimants); influence cost problem (some groups of members may have opposing interests and engage in costly lobbying activities); decision problem (large number and heterogeneity of members complicate the reaching of a consensual decision) (Borgen 2003). These incentive problems give grounds to consider the civil society mechanism as relatively 'expensive' in terms of transaction costs in comparison to the market and government mechanisms.

It has to be emphasized however that in contrast to the incentive problems of the market and government institutional mechanisms, the above mentioned problems of cooperatives are not necessarily present in every organization based on the cooperative principles. Whereas the severity of the incentive problems may vary across the institutional mechanisms, the specific functions that they perform, as well as space and time coordinates, this variation seems to be particularly pronounced for the civil society mechanism. Consequently, the incentive problems of cooperatives by themselves still provide an insufficient basis for evaluating the feasibility the civil society mechanism in comparison to the other ones.

3.2. *The substitutability of institutional mechanisms*

As has been shown above, different institutional mechanisms of agricultural insurance exhibit diverse sets of incentive problems, which limit the possibilities for their effective realization. The mechanisms, however, are characterized by non-identical sets of problems, the actual acuteness of which may also vary on the situational basis. This gives rise to the theoretical possibility of mutual substitution of institutional mechanisms, since certain insurance functions which are infeasible in the framework of one institutional mechanisms due to significant incentive problems may well be feasible through the other mechanisms which is not in the given context constrained by major incentive or other limitations. The theoretical possibility of this substitutability can be identified by considering the extent to which the above-mentioned incentive problems of each institutional mechanism are or are not characteristic for the remaining mechanisms. To be sure, this possibility is only theoretical; its actual feasibility significantly depends on the political, economic, and institutional contexts. Nevertheless, the theoretical possibility is an important prerequisite of the practical feasibility.

The first identified problem, relating to significant potential for opportunistic behavior in the form of adverse selection and moral hazard, is ultimately based on the non-identity between buyers and sellers of insurance. Whenever these agents are not represented by the same persons, the combination of antagonism of interests and information asymmetries will result in the high probability of opportunism. However, although this problem has been mainly discussed as characteristic for insurance markets, it should be equally characteristic for insurance services undertaken by public agencies, since their suppliers and recipients will be again represented by different groups of individuals.

The fundamental characteristic of civil society mechanism is the mutual self-help orientation, which presupposes that individuals who need a certain service organize its production and/or delivery to themselves. Suppliers and recipients are therefore identical, which reduces the incentives for opportunistic behavior. Although the civil society mechanism is also subject to limitations of its own, discussed in Sec.3.1.3, it can be used to provide insurance services where the danger of opportunism makes markets and governments infeasible or less effective (unless its own limitations in a given context are weaker than the opportunism problem).

The possible incentive problems of civil society mechanism are particularly attenuated in those cases where members of cooperative organizations are personally familiar with each other. This knowledge is an important asset which is unavailable to other alternative suppliers of insurance and which creates a possibility for distinct economic advantages of cooperative organization. Namely, whereas uncertainty about the future behavior of business partners may give rise to higher prices for the products and services rendered, reduction of this uncertainty due to the mutual knowledge of each other will make the high prices unnecessary.

This point was demonstrated by Bonus (1986) in his transaction cost analysis of local credit cooperatives in rural areas of Germany at the time of Raiffeisen. The author argued that the urban banks did not possess the required information about the creditworthiness of small-scale farmers, merchants, and businessmen living there, and therefore could not offer them the required loans. The supply of loans was therefore monopolized by the local usurers, who invested significant resources in acquiring (learning) this information. The inhabitants of these areas, however, managed to internalise the loan supply transactions by creating local credit cooperatives, which effectively utilized the pool of local information and the intimate knowledge that members had of each other and charged on this basis acceptable interest rates. Essentially the same logic was used to explain the emergence of central cooperative banks – local cooperative banks required a reliable partner, for which role the urban banks were poorly suited. Local banks, again on the basis of pool of local information available to them, internalised these transactions by creating a central bank, owned by the local banks themselves. The basic argument of Bonus (1986: 335) is that 'the main benefits of collective organization derived by cooperatives are achieved by internalising crucial transactions into a firm jointly owned by the holders of transaction-specific resources, who thereby avoid potential threats to the quasi-rent of their investment by outside opportunists'. Accordingly, agricultural producers requiring insurance services can also internalise the required transactions and in this way protect themselves from potential opportunism which is unavoidable in both market and government institutional mechanisms.

The second incentive problem of the market mechanism, which dictates the need to use other mechanisms, is poor insurability of systemic risks. Whereas with respect to the systemic risk problem the government institutional mechanism has advantages over market, the role of civil society seems to be more uncertain. For a local-based civil society organization, e.g. small mutual insurance company, systemic risks certainly present a major problem. However this problem can be overcome by cooperatively organized co-insurance and co-reinsurance pools. Since such pools are organized by insurance companies (i.e., not by actors who demand insurance, but rather supply it), they represent an interesting mixture between the market and civil society mechanisms. It is theoretically possible that systemic risk problem can be also addressed by the civil society mechanism in its pure form, i.e., avoiding the participation of insurance suppliers and including only agricultural producers, by means of creating federative cooperative insurance organizations. The membership of federative insurance cooperative would be represented by local-based centralized cooperatives ('centralized' here means that their members are only agricultural producers, but not lower-level cooperatives). In contrast to centralized cooperatives, the federative ones are able to diversify risks across a number of regions.

To be sure, such federative cooperatives are rarely empirically observed. In most countries, the existing agricultural insurance cooperatives are mainly local-based, rather than federative, and importantly supplemented (in many cases outdistanced) by the market and government institutional mechanisms. Nevertheless, they do represent at least a theoretically possible method of dealing with systemic risks. Consequently, with respect to ability to address this problem the civil society mechanism can be believed to occupy an intermediate place between markets and governments.

As shown above, the limitations of the government mechanisms include agency problems in the implementation of public programs and high potential for bureaucratization of insurance programs, leading to the emergence of rent-seeking activities, as well as motivational side-effects of governmental disaster aid. The first two of them are caused by the fact that public officials do not have residual interests in the quality of fulfilment of their functions, since their salaries are within a significant margin independent of it. Since similar absence of residual interests is evidently not characteristic the market and civil society mechanisms, they can be believed to be able to substitute the government mechanism, when these incentive problems present the major bottleneck. The third problem of the government mechanism is also evidently not relevant for markets and civil society.

To summarize the discussion of substitutability, civil society seems to be a mechanism most equipped to deal with the problems of markets and governments. The reason why civil society does not become the dominant mechanism of insurance evidently lies in the fact that its own incentive problems grow prohibitively large as it is applied to a growing number of tasks. The naturally emerging questions are: 1) under what conditions do these problems emerge?; 2) can government prevent their formation? These questions are considered in the following sections.

3.3. *The concept of social capital-dependence of the civil society mechanism*

The general reason for the existence of incentive problems of the civil society mechanism lies in the fact that its operation needs to be supported by large amounts of social capital, i.e. this mechanism, in contrast to other ones, exhibits high social capital-dependence. Consequently, the limitations of the civil society mechanism emerge as a consequence of insufficient availability of social capital to match its high social capital-dependence (see Valentinov 2004 forthcoming). Arguably, if the right amount of social capital would be always there, civil society would represent the dominant mechanism of insurance. The shortage of social capital can be caused, e.g., by the expansion of membership base, which technically complicates the required communication processes, and the emergence of heterogeneities between members, which might hamper the process of collective decision-making.

The high social capital-dependence of the civil society mechanism has a number of implications for comparing the organizational attributes of the three institutional mechanisms. First, the performance of the civil society mechanism will be more sensitive to the type of inter-personal relations between people involved, than would be the case with the other mechanisms. This is a source of both strengths and limitations in comparison to performance of markets and governments. Second, the mutual knowledge of each other by members of cooperative (i.e. civil society-based) organizations gives rise to reputational effects, which reduce the incentives for opportunistic behavior. Third, the objectives of

Table 1: Comparative analysis of institutional mechanisms

Criterion	**Institutional mechanism**		
	Civil society	**Government**	**Market**
Basic motive	Mutual self-help	Career reward	Profit
Importance of inter-personal relations	Critical	Non-critical	Non-critical
Incentives for opportunism	Eliminated	Exist	Exist
Major limitation	High requirements of social capital	High bureaucratic costs	Opportunism

Source: Own presentation.

individual actors acting within the civil society mechanism are directed not at individual gain, as is the case with markets and governments (respectively in the forms of profit and career reward), but at the mutual self-help.

To summarize, the major limitations of the three mechanisms can therefore be formulated as high social capital-dependence for civil society, high bureaucratic costs for governments, and high danger of opportunism for markets (see Table 1). Where one of these limitations presents the major bottleneck, other institutional mechanism should be used.

4. *Implications for transition*

The objective of this section is to show that the economic context of transition has a number of characteristics which importantly affect the feasibility of different institutional mechanisms of agricultural insurance.

4.1. *Characteristics of transitional situation*

Whereas the current states and evolutionary paths of transitional economies are rather diverse, several principal characteristics of the transitional situation, broadly relevant for Central and East European countries, can be identified.

The first characteristic is that a number of markets are institutionally underdeveloped and therefore function imperfectly, if at all. This may be caused by the absence of the required legislation or any other formal institutional structures. But even in the case that the required formal institutions are in place, the development of markets may be hindered by the lacking informal institutions, which are known to require relatively longer time to change. This explains the institutional incompleteness of insurance markets in transitional conditions.

The further characteristic of transitional situation is the presence of important differences between the levels of profitability of agriculture and the rest of the economy. Since the opportunities to make profits in agriculture are more limited than in other sectors, agricultural producers are relatively more limited in their ability to pay insurance premiums. This circumstance will reduce the motivation of private suppliers of insurance to deal with agriculture. This may additionally constrain the operation of private insurance systems based on the market institutional mechanism.

These two characteristics suggest that the use of market instruments of agricultural insurance in transitional conditions is more complicated, than in the case of developed market economies. Theoretically, these limitations can be overcome by means of substituting markets by the remaining institutional mechanisms of government and civil society.

Another important characteristic of transition, however, is the significant scarcity of governmental budgets, which limits the feasibility also of the government mechanism. In transition, the government cannot assume the performance of important insurance-related activities not only and not so much because of potential bureaucratic inefficiencies but rather due to sheer financial limitations. The use of government mechanism, therefore, will be also more limited in transitional than in developed market economies.

Is the feasibility of civil society mechanism in transition also limited by certain transition-specific factors? One general limitation seems to be relevant: the system of central planning did not promote the development of trust among people, and can be considered to have generated more bonding, than bridging, social capital; e.g. Paldam/Svendsen (2001) point out the negative effects of 'grey/black' networks of communist origin on the effectiveness of the transitional process. This would reduce the feasibility also of the civil society institutions in their diverse forms. However, the civil society mechanism has a number of transition-specific advantages, which are explored in the following section.

4.2. *The advantages of the civil society mechanism*

The objective of this section is to show that although the development of civil society institutions in transitional conditions is constrained by the above-mentioned incentive problems, the transitional context also facilitates the development of these institutions in a number of ways.

First, producer-owned organizations aimed at stabilizing farm incomes will provide the insurance services at cost, in contrast to alternative private suppliers who will be interested in charging a certain margin, which in effect explains their motivation to offer these services. The economic possibility of avoiding the extra costs of insurance by means of excluding the profit component is created by the fact that such civil society-based organizations have an important informational asset not available to outsiders – mutual familiarity of members with each other. As was shown in Sec.3.3, the existence of reputational effects will motivate members not to behave opportunistically, and the higher probability of the expected positive behavior can be capitalized into lower prices for insurance services. By minimizing in this way costs to producers, the civil society mechanism has an advantage over the market mechanism.

Second, agricultural producers are better informed about the idiosyncratic details of their situation than any outside stakeholders. Whereas private suppliers of insurance may undertake some efforts to become better informed about the nature of demand that they have to satisfy, the same is not to the same extent true of public officials. Public officials are imperfectly informed about the details of the situations in which agricultural producers find themselves and in view of the absence of residual interests will undertake only limited efforts to fill in these information gaps. Therefore, when the knowledge of idiosyncratic details is important for the successful delivery of insurance functions, the civil society mechanism has advantages over both government and market mechanisms (the latter may be able to overcome this information problem, but only at extra costs to producers in the form of the enhanced profit margins to compensate for the risk emerging due to the lack of the required information).

Third, an important advantage of the civil society mechanism is that the undertaking of activities within its framework depends more on the efforts of producer themselves than on the actions of public officials or initiatives of private suppliers of insurance. This means that the producers do not have to wait until public officials or private suppliers acknowledge the importance of a certain problem to the extent of expending resources in the attempt to contribute to its solution. Since the required civil society institutions are created and maintained by producers themselves, in using these institutions the producers enjoy a significant amount of independence, which would be unachievable for them in the framework of the other institutional mechanisms.

4.3. *The role of public policy*

Such advantages of the civil society mechanism as the presence of residual interests of key stakeholders in high performance of the respective organizations, first hand information about specific agricultural insurance opportunities, coupled with minimization of costs to producers make it preferable, from the viewpoint of maximizing producers' welfare, that every insurance task is solved by means of the civil society instruments. However, the incentive problems of the civil society mechanism give rise to its prohibitively high transaction costs, which would result in the optimality of a certain mix of mechanisms, rather than the overarching use of only one of them.

In this connection it is important to remember the argument in Sec.3.3, pointing to significant variability of negative effects of the incentive problems of the civil society mechanism, depending on the availability of social capital. In the cases when the amount of actually available social capital is sufficient, the transaction costs of the civil society mechanism would stay in reasonable limits. It means that, although the government cannot change the underlying incentive problems of the civil society mechanism, it can lower its transaction costs by means of investing in social capital in the communities concerned. Such role of the government can be realized in the following ways:

Maximum delegation of decision-making responsibilities to the grass-roots level, as the growing recognition of individual responsibility encourages the grass-roots social capital-based activities. Such policy attitude forms the logical basis for the development of the civil society mechanism, since agricultural producers will expend efforts for it only in the case when the respective organizations are treated seriously and respectfully by governmental policy-making bodies.

Dissemination of information about the civil society mechanism and its potential role in agricultural insurance. Being based only on bottom-up actions, the operation of this mechanism critically depends on the way that the rank-and-file people understand its role. Eliminating cultural path-dependency effects, educating agricultural producers in the principles of market economy, and transforming their patterns of self-perception (from more passive to more active) are important tasks of governmental and also non-governmental advisory, consulting and extension structures.

Creating an effective infrastructure, whereby agricultural producers and other stakeholders of agricultural insurance have better chances of reaching consensual positions through an access to a favorable interaction environment. Promoting formal and informal communication is an effective way to invest in social capital.

Finally, an important issue is developing trust in the governmental policy itself. Opportunistic or inconsistent behavior on the part of government can compromise the idea of civil society, which requires not only trust among individual economic agents, but also trust in the government as a reliable partner. Agricultural producers should be well-educated as to the current policy objectives and the strategies used to achieve them. Partnerships, established by the civil society-based organizations with ministries of agriculture, might play a crucial role in motivating the producers to create and join such structures. In general, governmental departments, responsible for agriculture, and the civil society-based organizations should position each other as strategic partners.

Taking into account the above-mentioned characteristics of the transitional situation, it can be concluded that whereas the choice in Western conditions might be between various institutional mechanisms of agricultural insurance, the respective choice for the transitional conditions can often be between civil society-based performance or non-performance.

5. *Conclusions*

Agricultural insurance activities can be performed through the institutional mechanisms of market, government, and civil society, whereas each of them exhibits a number of incentive problems. In particular, the use market mechanism is limited by opportunism problems and poor insurability of systemic risks; the government mechanism, while having better ability to deal with the systemic risks, cannot solve the problem of opportunistic behavior on the part of the insured. In addition, it is beset with agency problems in the implementation of public programs; high potential for bureaucratization and excessive complexity of insurance programs, leading to the emergence of rent-seeking activities; as well as negative motivational side-effects of disaster aid.

The incentive problems of the civil society mechanism mainly do not include those that are characteristic for both markets and governments. However, this mechanism possesses problems specific to cooperative organizations, such as common property problem, horizon problem, monitoring problem, influence cost problem, as well as decision-making problems. These problems have been shown to originate from high social capital-dependence of the civil society mechanism, which means that while these problems are able to significantly increase transaction costs of civil society mechanism, the actual size of these transaction costs depends on the availability of social capital in the respective communities.

The economic context of transition to market has a number of characteristics having important implications for the feasibility of different institutional mechanisms of agricultural insurance. The use of the market mechanism of agricultural insurance is limited by their frequently observed institutional underdevelopment and insignificant opportunities of making profits on agriculture; the use of the government is also limited by budget constraints. The civil society mechanism, on the other hand, has important advantages, such as the presence of residual interests of agricultural producers in high performance of the respective organizations, limited incentives for opportunism, first-hand information about specific insurance opportunities, minimization of costs to producers, as well as the fact that the undertaking of activities within its framework depends more on the efforts of producer themselves than on the actions of public officials or initiatives of private suppliers of insurance.

The optimal role of the government, therefore, is to invest in social capital in order to reduce the transaction costs of the civil society mechanism. The investment in social capital can be performed in the following general forms: maximal delegation of decision making responsibilities; information, educational and advisory work; developing a communication infrastructure for agricultural producers and related stakeholders; and building trust in governmental policy itself.

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A Qualitative Cost-Benefit Analysis of Crop Insurance

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Abstract

Extending an approach of Duncan and Myers we analyse if a crop insurance should be subsidized because systemic risk prevails or because the agricultural production decisions are distorted or show divergences. However, there seem to be only very special circumstances encouraging subsidization. Moreover, there is strong evidence that upward distorted prices and negative external effects in production cause too much insurance coverage in equilibrium. From numerical simulations we can show the increase in optimal production due to insurance. However, these benefits are private and, therefore, they are supposed to induce private willingness to pay. Summing up, this analysis gives more support in favor of non-subsidization of crop insurance than of subsidization.

1. *Introduction*

In the real world, public interventions are well known in crop insurance markets. However, the academic world focuses on optimally designed insurance contracts from a private point of view (e.g. Mahul; Vercammen) and on what Chambers calls "insurability" of the agricultural risks. In this sense, Duncan and Myers find "subsidized reinsurance […] can encourage establishment of a crop insurance market […] and increasing the size of subsidy will encourage additional farmer participation" (p. 849). However, "there is no guarantee that these economic benefits [of the subsidy] will exceed the cost of the subsidy" (p. 849). We want to contribute to this literature with a first simple cost-benefit analysis of subsidization of crop insurance markets with risk averse insurers, systemic risk, transaction costs and symmetric information. Since the benefits heavily depend on the agricultural product market and its production risk, we have to additionally analyze the insurability of the agricultural production risk when insurance and production decisions may be distorted and are made simultaneously.

To keep the analysis simple, we concentrate on what one might call index insurance schemes to ensure symmetric information. The payments of these insurance contracts are not based on the actual yield of insured producers but "on exogenous and easily observable variables which are likely to be closely correlated with yields for producers participating in the schemes" (Chambers and Quiggin, p. 320), for example these variables may be based on an area yield or on a weather index. Because of the exogeneity, these insurance schemes do not face problems of asymmetric information. We model an insurance market with risk-averse agents and stochastic agricultural production. From the insurance supply and demand functions we will detect possible divergences and distortions that may justify public interventions. Also, the insurance's impact on the agricultural product market is considered.

The paper is structured as follows. After presenting a short literature review the model is examined in terms of supply and demand functions as well as market equilibrium and the issue of insurability. A qualitative cost benefit analysis for the insurance market and for the agricultural market follows, before conclusions about subsidization and further research are presented to close the paper.

2. *Literature review*

Markets for agricultural insurance contracts are often analyzed in the literature because of asymmetric information that may cause adverse selection and moral hazard (Ahsan, Ali and Kurian, Nelson and Loehman). Chambers generalizes results of Nelson and Loehman and introduces the term "insurability", i.e. the emergence or existence of commercial agricultural insurance, which he applies to the problem of moral hazard in contrast to Duncan and Myers who focus on insurability when systemic risk is present and reinsurance is available. In fact, we apply their approach to primary crop insurance only but extend it by allowing for endogenous decisions on uncertain agricultural production that can be affected by divergences or price distortions.

Ahsan *et al.*, Nelson and Loehman as well as Duncan and Myers refer to subsidization of crop insurance or reinsurance as well as Siamwalla and Valdes and Hennessy, Babcock and Hayes who only analyze budgetary and producer welfare effects of revenue insurance. Only Siamwalla and Valdes give at least a qualitative normative economic evaluation of subsidization for crop insurance. They find a social gain by turning down the supply function on the agricultural market due to the risk reducing effect of the insurance. However, the benefits of an additional turning due to subsidization cannot exceed its costs.[1] Thus, they reject subsidization of crop insurance. The three papers mentioned before only discuss subsidization intuitively or show that it increases insurability (Ahsan *et al.*, Duncan and Myers). Our main contribution is a qualitative cost-benefit analyses of crop insurance. In addition, we extend the existing literature

[1] However, their way of modeling the costs of additional turning the supply function seem to be questionable.

by analyzing the impact of divergences and distortions on the insurability of agricultural risk and by analyzing the impact of an insurance market on an agricultural product market. However, we restrict our analysis to symmetric information crop insurance schemes, i.e. index crop insurance.

Index crop insurance contracts are extensively studied in the literature. Miranda cites Halcrow from the 1940's with a first promotion for an index crop insurance that uses the area yield as the underlying index to avoid problems of asymmetric information. Miranda gives a first empirical analysis for soybean producers, which is followed by two works about wheat farmers by Smith, Chouinard and Baquet, as well as by Mahul and Vermersch. All authors conclude that area yield insurance may offer reasonable risk reduction for farmers. The optimal private design of such insurance contracts is examined in Mahul followed by a work of Vercammen.

3. *The model*

We use the approach of Duncan and Myers (DM) who model a crop insurance market and the related reinsurance market to analyze the insurability of agricultural risks in the presence of systemic risk and subsidization. We omit an explicit reinsurance market. Instead, we extend their model by choosing insurance and production decisions simultaneously. However, we show that all of their results hold for our analysis.

We start with assumptions on the agents' preferences and on the agricultural technology as well as on the insurance scheme. Afterwards we will derive the supply and the demand for insurance and present the market equilibrium.

3.1. *Assumptions*

We assume agents following a mean-variance preference function as in Duncan and Myers, U for farmers and V for non-farmers.

$$U = \mathrm{E}\left[y\right] - 0.5\, r\ \mathrm{var}\left[y\right] \tag{1}$$

with y = income, r = coefficient of absolute risk aversion, E[.] = expectation operator, and var[.] = variance operator.

We assume the same risk aversion for farmers and non-farmers in contrast to Duncan and Myers who assume the insurance firms' risk aversion being one half of the farmers' risk aversion. They argue that insurance firms are larger and more diversified than farmers. However, in our view the firms do not have a utility function but the firms' shareholders. We assume a number of F farmers who are identical in each of R Regions and N identical non-farmers. N is sufficiently large to abstract from the possibility of an insurance's bankruptcy.

The yield per farmer in a period follows a stochastic production function of the Just and Pope type:

$$q_{\varepsilon} = q + \sqrt{k}q\ \varepsilon \tag{2}$$

i.e., it is the sum of planned production q and a stochastic term ε multiplied by a constant and the planned production. The ε has a zero mean and variance of one. The production variance follows with $\sigma^2_\varepsilon = kq^2, k > 0$. To keep the analysis easily tractable we assume a quadratic cost function $C_q = (a/2)\ q^2$. These functions are equal for all farmers but not the actual ε in a period.

The standardized indemnity payments i_r for a region r are based on an index e_r, for example an area yield or a regional weather index that is appropriately transformed to the scale of the agricultural yield. Under full coverage, the insurance pays $p(\bar{e}_r - e_r)$ to the farmer if $e_r < \bar{e}_r$. The price of the agricultural product is denoted p and it is assumed to be exogenous and non-stochastic. Each farmer purchases one insurance contract.

$$i_r = \frac{\max\left[\overline{e}_r - e_r, 0\right]}{\mathrm{std}\left[\max\left[\overline{e}_r - e_r, 0\right]\right]} \tag{3}$$

with $\overline{e}_r$ = strike value, max[.] = maximum operator.

The risk premium π per farmer is endogenous and represents the price for risk sharing per farmer. The coverage level is denoted by $\varphi>0$. The farmers are offered insurance contracts based on different e_r. The correlation $\sigma_{i\varepsilon}$ between i and ε is negative and identical for each farmer. It represents the insurance's effectiveness. The correlations among indemnity payments of farmers in different regions σ_{ii} are positive and identical representing the systemic risk among regions.

3.2. *Supply of insurance*

Each non-farmer holds an identical share in one of identical insurance companies. All payment flows are directly incorporated into the non-farmer's preference function. For simplicity, variable administrative costs are modeled in the farmer's income and fixed costs are discussed later on.[2] Thus, a non-farmer's income in period t is

$$y_t^{non} = y_n + \frac{RF}{N}\varphi\left(\pi + p\left(\mathrm{E}[i] - i_t\right)\right). \tag{4}$$

Assuming independence among non-agricultural income y_n and the risk premium π we get a non-farmer's preference function:

[2] A long-rum competitive equilibrium can be introduced following DM. However, introducing a reservation preference level (see also Appelbaum and Katz) for the insurers only shifts the supply function upwards or is incorporated in the conditions for insurability below.

$$\begin{aligned} V &= \mathrm{E}[y_n] + \frac{RF}{N}\varphi\pi - 0.5\ r\left(\mathrm{var}[y_n] + \varphi^2 p^2\left(\frac{RF}{N^2}\sigma_i^2 + (\mathrm{R}^2 - \mathrm{R})\frac{F^2}{N^2}\sigma_{ii}\sigma_i^2\right)\right) \\ &= \mathrm{E}[y_n] + \frac{RF}{N}\varphi\pi - 0.5\ r\left(\mathrm{var}[y_n] + \frac{RF}{N^2}\varphi^2 p^2\left(1 + (\mathrm{R}-1)F\sigma_{ii}\right)\right) \\ &\approx \mathrm{E}[y_n] + \frac{RF}{N}\varphi\pi - 0.5\ r\left(\mathrm{var}[y_n] + \frac{RF}{N^2}\varphi^2 p^2\left(1 + RF\sigma_{ii}\right)\right) \end{aligned} \tag{5}$$

Assuming *R* sufficiently high and maximizing V with respect to the coverage level φ yields the supply function for insurance coverage φ^S

$$\begin{aligned} &\frac{\partial V}{\partial\varphi} = \frac{RF}{N}\pi - r\ \frac{RF}{N^2}p^2\varphi\left(1 + RF\sigma_{ii}\right) \overset{!}{=} 0 \\ &\Rightarrow \varphi^S = \frac{N}{rp^2\left(1 + RF\sigma_{ii}\right)}\pi \end{aligned} \tag{6}$$

The second order condition for a maximum is satisfied because $-r\ p^2RF/N^2 < 0$. Solving for π and multiplying by φ gives the marginal revenue function which can be easily interpreted.

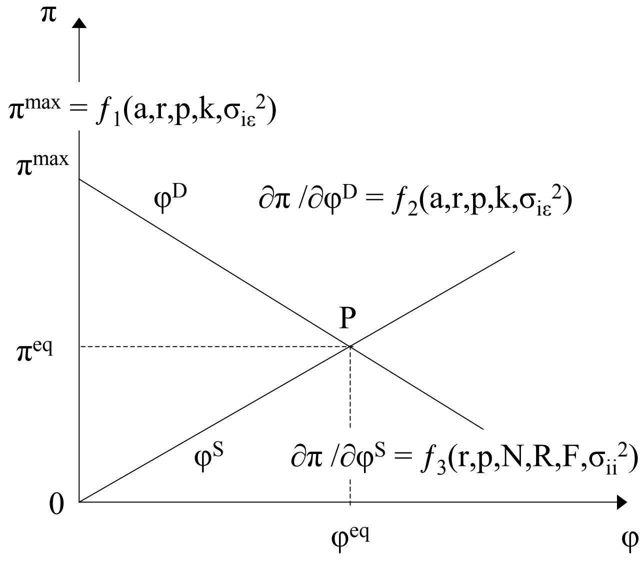
$$\pi\varphi^S = \frac{rp^2\varphi^{S2}\left(1 + RF\sigma_{ii}\right)}{N} \tag{7}$$

The marginal revenue for risk bearing at the optimum has to compensate for the risk an insurer takes $rp^2\varphi^{S2}$ and for the systemic risk that the insurers generate by pooling the risks of farmers across regions.

The supply function (6) shares DM's result 4 (p. 850) that "proportional reinsurance does not expand the opportunity set of available equilibria" because the supply function starts from the origin irrespective of its parameters. Proportional reinsurance means that "insurance firms share a specified proportion of both policy premiums […] and indemnities with the reinsurer" (p. 849). Subsidized reinsurance in the sense of DM means that the portion of premiums an insurance company pays to the reinsurer is smaller than the portion of indemnities it receives.

DMs' result 5 (p. 850) that "if an equilibrium exists under catastrophic risk and proportional reinsurance, then an increase in proportional reinsurance reduces the equilibrium premium [and] increases the equilibrium coverage level" holds, too. If the insurer shares a portion $1 > a > 0$ of both premium and indemnities with the reinsurance company then φ^S is multiplied by $1-a$ because the risk term, i.e. the denominator of (6), is divided by $(1-a)^2$ and the risk premium is divided by $1-a$ only. The demand for insurance is unaffected by the reinsurance. Graphically, the supply function in figure 1 rotates clockwise. Thus, (6) also explains DM's result 7 that for an existing equilibrium "an increase in the reinsurance subsidy reduces the equilibrium premium, [and] increases the equilibrium coverage level" (p. 851).

Figure 1. Equilibrium in the insurance market



3.3. *Demand for insurance*

The benefit of insuring has two intuitive components for the farmer. Firstly, he gives away a portion of his production risk. Secondly, the insurance might reduce the marginal risk of his output quantity and, thus, the insurance might increase the optimal planned production. Without insurance his optimal planned yield q^* can be easily derived by maximizing U defined as:

$$\begin{aligned} & U = p\mathrm{E}[q+\varepsilon] - C_q - 0.5rp^2\sigma_\varepsilon^2 \\ & \Rightarrow U = pq - \frac{a}{2}q^2 - 0.5\ rp^2kq^2 \\ & \Rightarrow \frac{\partial U}{\partial q} = p - aq - bq \overset{!}{=} 0 \qquad \Rightarrow q^* = \frac{p}{a+b} \end{aligned} \tag{8}$$

with $b=rp^2k$ as the marginal disutility due to risk for an additional output quantity. Thus, $aq+b$ is the marginal disutility of an additional planned output quantity. To ensure that a higher price results in a higher planned production we restrict

$$\frac{\partial q^*}{\partial p} = \frac{a + rp^2k - 2rp^2k}{\left(a + rp^2k\right)^2} = \frac{a - rp^2k}{\left(a + rp^2k\right)^2} > 0 \Leftrightarrow a > rp^2k = b \tag{9}$$

Omitting subscripts for regions, the farmer's income with insurance in t can by described by

$$y_t^{farm} = p\left(q+\varepsilon_t\right)-\frac{a}{2}q^2 - C_{ins} - \varphi\left(\pi + p\left(\mathrm{E}\left[i\right]-i_t\right)\right) \tag{10}$$

with C_{ins} = variable administrative costs equal per farmer or insurance contract.

DM model the insurance costs as constantl per unit of coverage, something that in our view seems less realistic because administrative costs are closer related to the amount of contracts than to the coverage. Alternative approaches incorporating insurance costs are to be discussed. For example, insurance costs may increase with a higher coverage level if indemnity payments can be higher in a period than the accumulated premiums minus indemnities of former periods (Raviv; Chambers).

Assuming independence among deviations from planned production, costs and risk premium we get the farmer's preference function

$$\begin{aligned} U_{ins} &= pq - \frac{a}{2}q^2 - C_{ins} - \varphi\pi - 0.5\ r\ \mathrm{var}\left[p\left(\varepsilon+\varphi i\right)\right] \\ &= pq - \frac{a}{2}q^2 - C_{ins} - \varphi\pi - 0.5\ r\ p^2\left(kq^2+\varphi^2+2\varphi\sigma_{i\varepsilon}\sqrt{k}q\right) \end{aligned} \tag{11}$$

Differentiating with respect to the planned production and to the coverage level $\varphi>0$ and setting equal to zero gives:

$$q = \frac{p - rp^2\varphi\sigma_{i\varepsilon}\sqrt{k}}{a+b} \tag{12}$$

$$\varphi = -\sigma_{i\varepsilon}\sqrt{k}q - \frac{\pi}{rp^2} \tag{13}$$

Equation (13) represents the demand function for insurance coverage under exogenous production. It follows the inverse demand function

$$\pi = -rp^2\sigma_{i\varepsilon}\sqrt{k}q - rp^2\varphi\,. \tag{14}$$

Combining (12) and (13) gives the demand and inverse demand functions under endogenous production decisions, respectively

$$\varphi^D = -\frac{\sigma_{i\varepsilon}\sqrt{k}p}{a+b\left(1-\sigma_{i\varepsilon}^2\right)} - \frac{a+b}{a+b\left(1-\sigma_{i\varepsilon}^2\right)}\frac{\pi}{rp^2} \tag{15}$$

$$\Leftrightarrow \pi^D = -rp^2\sigma_{i\varepsilon}\sqrt{k}q^* - rp^2\varphi^D\frac{a+b\left(1-\sigma_{i\varepsilon}^2\right)}{a+b}\,. \tag{16}$$

The second order conditions for a maximum hold because

$$\frac{\partial^2 U_{ins}}{(\partial q)^2} = -a - rp^2 k < 0 \quad ; \quad \frac{\partial^2 U_{ins}}{(\partial \varphi)^2} = -rp^2 < 0 \quad ; \quad \frac{\partial^2 U_{ins}}{\partial q \partial \varphi} = rp^2 \sigma_{i\varepsilon} \sqrt{k}$$
$$\text{Hessian} = \frac{\partial^2 U_{ins}}{(\partial q)^2} \frac{\partial^2 U_{ins}}{(\partial \varphi)^2} - \left(\frac{\partial^2 U_{ins}}{\partial q \partial \varphi} \right)^2 = \left(-a - rp^2 k\right)\left(-rp^2\right) - \left(rp^2 \sigma_{i\varepsilon} \sqrt{k}\right)^2 \tag{17}$$
$$\text{Hessian} = arp^2 + r^2 p^4 k \left(1 - \sigma_{i\varepsilon}^2\right) > 0$$

Multiplying (16) by φ yields

$$\varphi^D \pi^D = r\left(-p^2 \varphi^D \sigma_{i\varepsilon} \sqrt{k} q^* - p^2 \varphi^{D2} \frac{a + b\left(1 - \sigma_{i\varepsilon}^2\right)}{a+b} \right). \tag{18}$$

The farmer's marginal expenditure for insuring at the optimum must be equal to the marginal utility of sharing the risk of the optimal production without insuring minus the disutility of the indemnity payments' variance $rp^2\varphi^{D2}$ multiplied by the optimal production without insurance relative to the optimal production under insurance coverage if no risk premium has to be paid (see (8) and (25)).

3.4. *Market Equilibrium*

Following DM the market equilibrium premium with exogenous production can be derived from (6) and (13)

$$\varphi^S = \frac{N}{rp^2\left(1 + RF\sigma_{ii}\right)} \pi = -\sigma_{i\varepsilon} \sqrt{k} q - \frac{\pi}{rp^2} = \varphi_{ex}^D$$
$$\Leftrightarrow \pi_{ex}^{eq} \left(\frac{N}{rp^2\left(1 + RF\sigma_{ii}\right)} + \frac{1}{rp^2} \right) = -\sigma_{i\varepsilon} \sqrt{k} q \tag{19}$$
$$\Leftrightarrow \pi_{ex}^{eq} = -\frac{\sigma_{i\varepsilon} \sqrt{k} q r p^2 \left(1 + RF\sigma_{ii}\right)}{N + 1 + RF\sigma_{ii}}$$

The equilibrium coverage level with exogenous production follows

$$\varphi_{ex}^{eq} = -\frac{N\sigma_{i\varepsilon} \sqrt{k} q}{N + 1 + RF\sigma_{ii}} \tag{20}$$

The equilibrium risk premium π^{eq} under endogenous production results from setting the supply (6) and demand (15) functions equal

$$\pi^{eq} = -\frac{rp^2 \sigma_{i\varepsilon} \sqrt{k} p \left(1 + RF\sigma_{ii}\right)}{N\left(a + b\left(1 - \sigma_{i\varepsilon}^2\right)\right) + (a+b)\left(1 + RF\sigma_{ii}\right)} \tag{21}$$

The equilibrium coverage level φ^{eq} is

$$\varphi^{eq} = -\frac{\sigma_{i\varepsilon} \sqrt{k} p}{\left(a + b\left(1 - \sigma_{i\varepsilon}^2\right)\right) + (a+b)\left(1 + RF\sigma_{ii}\right) N^{-1}} \tag{22}$$

This equilibrium supports Duncan and Myers' result 3 that for an existing equilibrium without reinsurance "a marginal increase in catastrophic risk increases the equilibrium premium" because the numerator in (21) increases relatively more than the denominator and "a marginal increase in catastrophic risk. reduces the equilibrium coverage level". The latter can be easily seen from (22).

Until now, we have assumed that $\varphi>0$. Thus, we have to find the conditions which ensure $\varphi>0$ or, as Chambers calls it, "insurability".

3.5. *Insurability*

Farmers and non-farmers will share risk or, in other words, the risks are insurable, if farmers and non-farmers are both not worse off with risk sharing than without.

For farmers, the following condition must hold:

$$\begin{aligned} \Delta_U &= U^*_{ins} - U^* = p\Delta_q - \frac{a}{2}\Delta_{q^2} - C_{ins} - \varphi\pi - 0.5\ r\ p^2\left(k\Delta_{q^2} + \varphi^2 + 2\varphi\sigma_{i\varepsilon}\sqrt{k}\Delta_q\right) \geq 0 \\ &\Rightarrow p\Delta_q - \frac{a}{2}\Delta_{q^2} - 0.5\ r\ p^2\left(k\Delta_{q^2} + \varphi^2 + 2\varphi\sigma_{i\varepsilon}\sqrt{k}\Delta_q\right) \geq C_{ins} + \varphi\pi \end{aligned} \tag{23}$$

with $\Delta_q = q_{ins}^* - q^*$, $\Delta_q^2 = q_{ins}^{*2} - q^{*2}$, and q_{ins}^* = optimal production with insurance (see (25)).

The left hand side is a farmer's total utility from insuring. Subtracting $\varphi\pi$ we get his surplus from insuring which at least has to compensate the administrative insurance costs.

For non-farmers we need

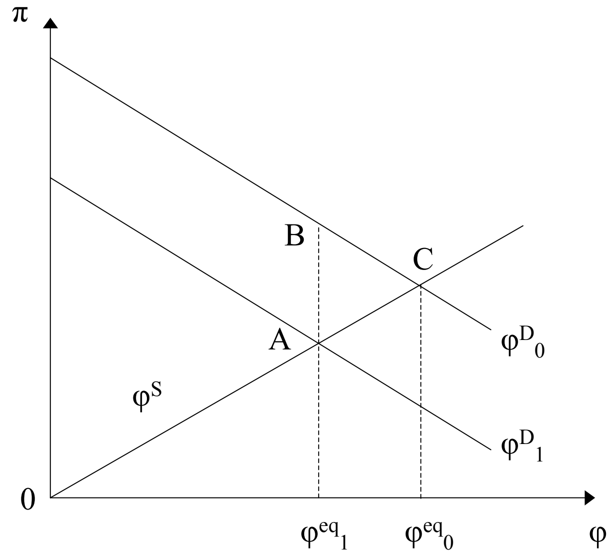
$$\begin{aligned} \Delta V &= \frac{RF}{N}\varphi\pi - C_{ins}^{fix} - 0.5\ r\ \frac{RF}{N^2}\varphi^2 p^2\left(1 + RF\sigma_{ii}\right) \geq 0 \\ &\Rightarrow \frac{RF}{N}\varphi\pi - 0.5\ r\ \frac{RF}{N^2}\varphi^2 p^2\left(1 + RF\sigma_{ii}\right) \geq C_{ins}^{fix} \end{aligned} \tag{24}$$

with C_{ins}^{fix} are fixed costs of the insurance per non-farmer, i.e. per shareholder of the insurance companies.

The left hand side of the inequality in (24) is a non-farmer's surplus from insuring and may not fall below the fix costs of insurance per non-farmer. DM's result 5 still holds because proportional reinsurance reduces the positive term on the left hand side relatively more than the second term. This relationship also supports result 6 of Duncan and Myers that "an increase in the reinsurance subsidy helps facilitate equilibrium […], thereby expanding the opportunity set of available equilibria" (p. 851). Even without fixed costs (24) confirms DM's result 1 that "an insurance market equilibrium can fail to exist under catastrophic risk" (p. 848) and their result 2 that an increase in systemic risk decreases the set of equilibria.

Proportional and fixed insurance costs do not affect the equilibrium coverage level since they depend on the number of contracts offered and on the insurance company as a whole, respectively. Thus, farmers or insurers have an

Figure 2. Total surplus under insurance costs proportional to coverage or fix per contract



incentive to transfer at least a portion of their surplus minus their costs to the other group in the market if this group‘s surplus is too small to cover the related fixed costs. Therefore, we will not analyze if (23) and (24) hold but if the total surplus in the market can cover both proportional insurance costs per contract and fixed insurance costs.

3.5.1. *Insurance costs*

Not surprisingly, the set of equilibria, i.e. the insurability, increases with lower insurance costs. Since the insurance costs as well as the risk premium claimed by the insurers are not affected by reinsurance due to the assumption of constant absolute risk aversion DM's result 4 that proportional reinsurance does not expand the set of equilibria still holds. Assuming variable costs being proportional to the number of farmers instead of DM's costs being proportional to the coverage level increases the total surplus as can be seen from figure 2. The demand function is shifted downwards when insurance costs are paid per unit coverage instead of being paid per contract. Thus, the total surplus minus insurance costs is reduced by the triangle ABC.

3.5.2. *Endogenous production*

Endogenous production increases insurability. The supply function is not affected but the demand function. Since the maximum risk premium (compare (14) and (16)) does not change and the maximum coverage level (compare (13) and (15)) increases and because the demand function is still linear endogenous production increases the total surplus on the insurance market.

3.5.3. *Upward distorted product price*

The total surplus and thus the insurability increases due to a higher price since the partial derivative of the total surplus with respect to the price is positive.

3.5.4. *External effect in marginal costs*

If we assume negative external effects of agricultural production the marginal costs are too low from a social point of view, in other words the parameter a is too small. The supply function is not affected. The inverse demand function is shifted and turned upwards when negative externalities are not incorporated into the marginal costs (see equation (27) in the Appendix). Thus, negative external effects in production increase insurability.

3.5.5. *External effect in production variance*

In the parameter k there seem to be only small divergences in plant production, e.g. increasing the risk of dangerous insects on one field may affect the neighbor's yield, too. However, if we think of animal disease that may become epidemics there may be significant negative externalities in k. They increase the insurability because the inverse demand function is shifted and turned upwards (see (16)).

It has been shown that our model reproduces the main results of Duncan and Myers. However, important changes have to be stated. We do not need their assumption of different risk aversion among agents. Insurance costs being independent of the coverage level, endogenous production, upward distorted prices, and negative external effects of agricultural production increase insurability compared to DM. We now extend the Duncan and Myers approach to a qualitative cost benefit analysis.

4. *Cost-Benefit Analysis*

4.1. *Insurance market*

Public intervention in the market modeled above can only increase the social welfare if there are divergences or distortions in the supply (6) or demand function (15) or in the conditions for insurability (23) and (24).

For all functional relationships we can reject divergences in the number of farmers, regions, or non-farmers. There cannot be any divergences in the technical parameters describing the correlation of indemnity payments and yield as well as the systemic risk represented by the correlation of indemnity payments among regions, either. If there is a divergence between the private risk aversion and the social risk aversion may depend on the point of view. On the one hand, risk aversion is an individual's preference what precludes a divergence by definition. On the other hand, sharing a risk by all members in a society may reduce the individual risks significantly (Arrow and Lind). However, if this is also true for agricultural production risk, it follows that all risks of voluntary economic activity should be shared publicly. This conclusion is in sharp contrast to the common arguments for market economies since risks would be externalized. Economic decisions would be made without risk considerations and the risk would affect persons who are not incorporated into the decision making process. Thus, we argue that there is no divergence in the risk aversion.

4.1.1. *Upward distorted product price*

The price for agricultural output may be distorted or it may not cover all benefits from agricultural production. If we assume for the EU that output prices are upward distorted and the non-market benefits from agriculture are less at the margin than the upward distortion and other subsidies (e.g. direct payments) we have a price that is too high. An upward distorted product price turns the supply function upwards while the maximum coverage level and the maximum risk premium of the demand function increase (see (15) and (16)). In total, from (28) in the Appendix follows that there is too much coverage in equilibrium from a social point of view.

4.1.2. *External effect in marginal costs*

If we assume negative externalities in the agricultural production process represented in a smaller parameter a than without negative externalities the demand function is shifted and turned upwards (see (27) in the Appendix). Consequently, there is too much risk sharing in the insurance market from a social point of view. If we assume positive externalities of agricultural production (e.g. preserving the landscape due to agricultural land use) a factor subsidy like arable area payments seem to more efficient since they reduce the marginal costs directly.

4.1.3. *External effect in production variance*

In the parameter k there seem to be only small divergences in plant production, e.g. increasing the risk of dangerous insects on one field may affect the neighbor's yield, too. However, if we think of animal disease that may become epidemics there may be significant negative externalities in k. The insurance equilibrium would be too high from a social point of view because the inverse demand function is shifted and turned upwards (see (16)) with a smaller k. Positive external effects seem hardly to exist for the individual production variance.

4.1.4. *Insurance costs*

Turning to the last parameters of our analysis the insurability may be too small if we have positive externalities in the insurance costs. However, there seem to be only limited issues such as public good characteristics when the insurance company collects information such as regional yields or implements a close meshed net of stations collecting weather data. But, these externalities can be probably better taken into account by interventions in these information markets or in the collection services than by interventions on the crop insurance market (see also Nelson and Loehman).

From 4.1 to 4.5 follows that the impact of divergences and distortions on the insurability can be significant.

4.2. *Agricultural product market*

Since an increase in production may be a benefit from crop insurance we analyse the changes in the agricultural supply when an insurance market exists. The optimal planned production changes with purchasing insurance. It is labelled $q_{ins}{}^*$ and comes from solving (12) and (13) for q.

$$\begin{aligned} q^*_{ins} &= \frac{p + rp^2 k\sigma^2_{i\varepsilon} q^*_{ins} + \sigma_{i\varepsilon}\sqrt{k}\pi}{a+b} \\ \Rightarrow q^*_{ins} &= \frac{p + \sigma_{i\varepsilon}\sqrt{k}\pi}{a + b\left(1-\sigma^2_{i\varepsilon}\right)} \end{aligned} \tag{25}$$

The optimal production with an insurance market in equilibrium is higher than without insurance $q^* = p/(a+b)$ because the impact of the marginal risk b is reduced. However, this effect is partially compensated as the risk premium reduces the marginal revenue (for proof see Appendix (29)).

Since the partial effects of the parameters on the change of optimal agricultural supply are very complex with the equilibrium insurance premium we present numerical simulations of the optimal planned output with and without insurance.[3] The functions (8) and (25) and the insurance premium in equilibrium are shown in figure 3. The marginal costs are a hundred times higher in the first column than in the second one. For all settings k is set to unity.[4] The settings in the first row with systemic risk, a high risk aversion and a very effective insurance ($-\sigma_{i\varepsilon} = 0.4$) serve as references for the analysis.

The effectiveness of insurance determines ceteris paribus the shift in the supply function. A correlation between deviations from planned production and indemnity payments of minus 10% results in an unobservable small increase in supply. If the marginal costs are high relative to risk aversion we can observe a similar effect in the third graph in the column of the right. The remaining settings with high or small marginal costs of production, with or without systemic risk show a higher supply due to insurance with a maximum increase of around 10%. Thus, potential welfare gains due to crop insurance are obvious. However, the increase in supply due to the risk reduction causes will-

[3] Young, Vandeveer and Schnepf show the supply increasing effect of the crop insurance subsidization on US agricultural production. Risk considerations are not incorporated in their analysis.

[4] Variation in k does not give additional insight. The difference in production increases for small prices with a higher k but the maximum relative increase does not change considerably.

ingness to pay of the farmers for insurance. Consequently, there is private demand for insurance and private insurers may offer insurance. The private benefits of insurance are an argument against subsidized insurance and additional public benefits are hard to find.

In upward distorted agricultural markets, the more elastic supply even increases the welfare loss due private production being larger than socially optimal production. The potential welfare gains in figure 3 would decrease.

We have to conclude that divergences and distortions that occur in European agricultural markets probably increase the insurability of crop risk and also increase the coverage in equilibrium. Some other divergences can probably more efficiently reduced by other instruments than subsidized crop insurance. Thus, the analysis at this stage of modeling gives no support for subsidization.

5. *Conclusions*

Extending an approach of Duncan and Myers we can reproduce their results for endogenous production decisions and the same risk aversion for farmers and insurers. Therefore, we can analyze conditions for subsidization of index crop insurance. These conditions can only hold if the insurance market or if the agricultural production decisions are distorted or show divergences. However, there seem to be only very special circumstances encouraging subsidization.

Moreover, there is strong evidence that upward distorted prices and negative external effects in production cause too much insurance coverage in equilibrium. From numerical simulations we can show the increase in optimal production due to an insurance. However, these benefits are totally private and, therefore, they are supposed to induce private willingness to pay. Summing up, this analysis gives more support in favor of non-subsidization of crop insurance instead of subsidization.

However, shortcomings of the analysis have to be taken into account for the interpretation of the results and they show need for further research. In our view, the assumption of constant absolute risk aversion is very restrictive under European circumstances of distorted prices[5] and direct payments. The insurability is probably overstated. However, it will probably increase when prices and direct payments are reduced in the near future. But even then, arguments for insurance subsidies are hard to find unless the planted area decreases because of risk considerations and this decrease is accepted to have negative externalities.

[5] However, the restriction that a higher price results in higher optimal production restricts the effect of distorted prices to a range of constant risk aversion that is consistent with decreasing absolute risk aversion.

Figure 3. Planned production and risk premium under different settings

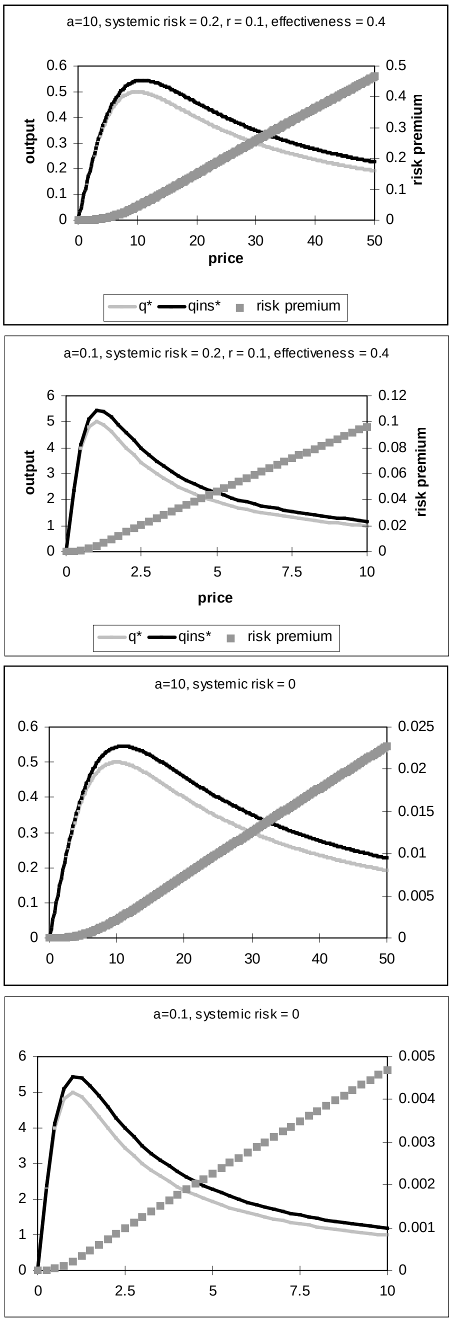
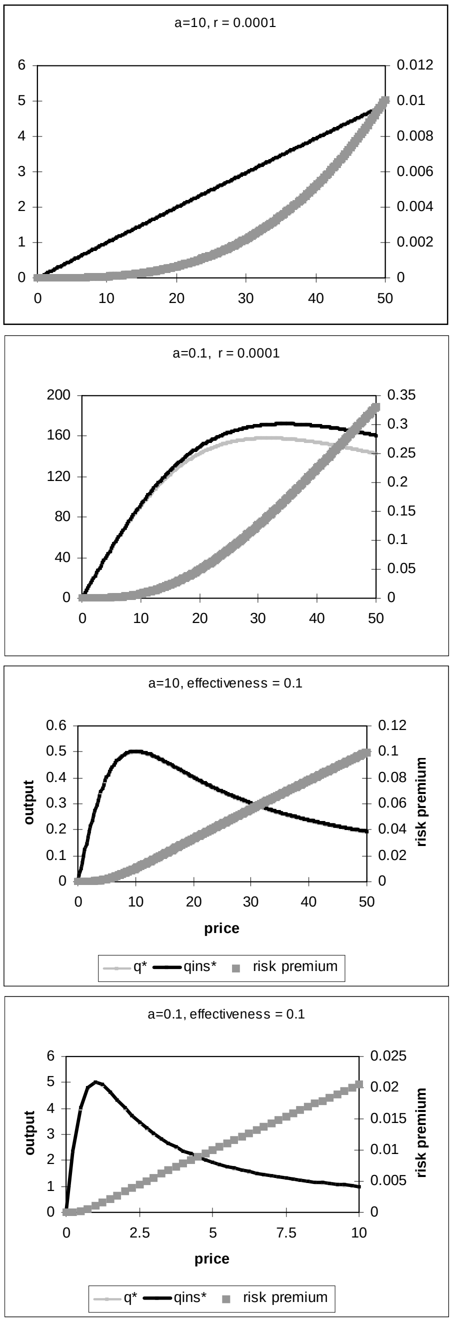


Figure 3 (continued)



Effectivenes = – σ_{ie}, systemic risk = σ_{ii}, risk premium is π^{eq}, k = 1.

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Appendix

Equilibrium coverage level:

$$\varphi^{D} = -\frac{\sigma_{i\varepsilon}\sqrt{k}\,p}{a+b\left(1-\sigma_{i\varepsilon}^{2}\right)} - \frac{a+b}{a+b\left(1-\sigma_{i\varepsilon}^{2}\right)}\frac{\pi}{rp^{2}}$$

$$\Rightarrow \varphi^{eq} = -\frac{\sigma_{i\varepsilon}\sqrt{k}\,p}{a+b\left(1-\sigma_{i\varepsilon}^{2}\right)} + \frac{a+b}{a+b\left(1-\sigma_{i\varepsilon}^{2}\right)}\frac{\sigma_{i\varepsilon}\sqrt{k}\,p\left(1+RF\sigma_{ii}\right)}{N\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)+\left(a+b\right)\left(1+RF\sigma_{ii}\right)}$$

$$\Rightarrow \varphi^{eq} = -\frac{\sigma_{i\varepsilon}\sqrt{k}\,p}{a+b\left(1-\sigma_{i\varepsilon}^{2}\right)} + \frac{\sigma_{i\varepsilon}\sqrt{k}\,p\left(1+RF\sigma_{ii}\right)\left(a+b\right)}{\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)\left(N\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)+\left(a+b\right)\left(1+RF\sigma_{ii}\right)\right)}$$

$$\Rightarrow \varphi^{eq} = \frac{\sigma_{i\varepsilon}\sqrt{k}\,p\left[\left(a+b\right)\left(1+RF\sigma_{ii}\right)-\left(N\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)+\left(a+b\right)\left(1+RF\sigma_{ii}\right)\right)\right]}{\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)\left(N\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)+\left(a+b\right)\left(1+RF\sigma_{ii}\right)\right)}$$

$$\Rightarrow \varphi^{eq} = \frac{\sigma_{i\varepsilon}\sqrt{k}\,p\left[\left(a+b\right)\left(1+RF\sigma_{ii}\right)-\left(N\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)+\left(a+b\right)\left(1+RF\sigma_{ii}\right)\right)\right]}{\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)\left(N\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)+\left(a+b\right)\left(1+RF\sigma_{ii}\right)\right)}$$

$$\Rightarrow \varphi^{eq} = \frac{-\sigma_{i\varepsilon}\sqrt{k}\,pN\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)}{\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)\left(N\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)+\left(a+b\right)\left(1+RF\sigma_{ii}\right)\right)}$$

$$\varphi^{eq} = -\frac{\sigma_{i\varepsilon}\sqrt{k}\,p}{\left(a+b\left(1-\sigma_{i\varepsilon}^{2}\right)\right)+\left(a+b\right)\left(1+RF\sigma_{ii}\right)N^{-1}} \tag{26}$$

Parameter *a* in the marginal costs:

$$c = -rp^2 \sigma_{i\varepsilon} \sqrt{k} q^* = -rp^2 \sigma_{i\varepsilon} \sqrt{k} \frac{p}{a+b}$$

$$\frac{\partial c}{\partial a} = -\frac{0 - rp^3 \sigma_{i\varepsilon} \sqrt{k}}{(a+b)^2} < 0$$

$$d = -rp^2 \frac{a + b\left(1 - \sigma_{i\varepsilon}^2\right)}{a+b} \tag{27}$$

$$\frac{\partial d}{\partial a} = -\frac{rp^2 (a+b) - rp^2 \left(a + b\left(1 - \sigma_{i\varepsilon}^2\right)\right)}{(a+b)^2} = -\frac{rp^2 \left(a + b - a - b\left(1 - \sigma_{i\varepsilon}^2\right)\right)}{(a+b)^2}$$

$$= -\frac{rp^2 b \sigma_{i\varepsilon}^2}{(a+b)^2} < 0$$

The demand for insurance is shifted up and rotated counterclockwise if *a* decreases.

Partial derivative of the equilibrium coverage level with respect to product price

$$\varphi^{eq} = -\frac{\sigma_{i\varepsilon} \sqrt{k} p}{\left(a + b\left(1 - \sigma_{i\varepsilon}^2\right)\right) + (a+b)\left(1 + RF\sigma_{ii}\right) N^{-1}}$$

$$\frac{\partial \varphi^{eq}}{\partial p}$$

$$= -\frac{\sigma_{i\varepsilon} \sqrt{k} \left(\left(a + b\left(1 - \sigma_{i\varepsilon}^2\right)\right) + (a+b)\left(1 + RF\sigma_{ii}\right) N^{-1}\right) - \sigma_{i\varepsilon} \sqrt{k} p \left(2rpk\left(1 - \sigma_{i\varepsilon}^2 + \left(1 + RF\sigma_{ii}\right) N^{-1}\right)\right)}{\left(\left(a + b\left(1 - \sigma_{i\varepsilon}^2\right)\right) + (a+b)\left(1 + RF\sigma_{ii}\right) N^{-1}\right)^2}$$

$$= -\frac{\sigma_{i\varepsilon} \sqrt{k} \left(a + b\left(1 - \sigma_{i\varepsilon}^2\right) + (a+b)\left(1 + RF\sigma_{ii}\right) N^{-1}\right) - 2\sigma_{i\varepsilon} \sqrt{k} b \left(1 - \sigma_{i\varepsilon}^2 + \left(1 + RF\sigma_{ii}\right) N^{-1}\right)}{\left(a + b\left(1 - \sigma_{i\varepsilon}^2\right) + (a+b)\left(1 + RF\sigma_{ii}\right) N^{-1}\right)^2} > 0$$

$$\Rightarrow 2\sigma_{i\varepsilon} \sqrt{k} b \left(1 - \sigma_{i\varepsilon}^2 + \left(1 + RF\sigma_{ii}\right) N^{-1}\right) > \sigma_{i\varepsilon} \sqrt{k} \left(a + b\left(1 - \sigma_{i\varepsilon}^2\right) + (a+b)\left(1 + RF\sigma_{ii}\right) N^{-1}\right)$$

$$\Leftrightarrow 2b\left(1 - \sigma_{i\varepsilon}^2 + \left(1 + RF\sigma_{ii}\right) N^{-1}\right) < a + b\left(1 - \sigma_{i\varepsilon}^2\right) + (a+b)\left(1 + RF\sigma_{ii}\right) N^{-1}$$

$$\Leftrightarrow 2b\left(1 - \sigma_{i\varepsilon}^2\right) + 2b\left(1 + RF\sigma_{ii}\right) N^{-1} < a + b\left(1 - \sigma_{i\varepsilon}^2\right) + (a+b)\left(1 + RF\sigma_{ii}\right) N^{-1}$$

$$\Leftrightarrow b\left(1 - \sigma_{i\varepsilon}^2\right) + b\left(1 + RF\sigma_{ii}\right) N^{-1} < a + a\left(1 + RF\sigma_{ii}\right) N^{-1}$$

$$\Leftrightarrow b\left(1 - \sigma_{i\varepsilon}^2\right) + (b - a)\left(1 + RF\sigma_{ii}\right) N^{-1} < a \tag{28}$$

Note that $a > b$ from (9) and that $\sigma_{i\varepsilon} < 0$.

Proof: Planned production increases with purchasing insurance

$$
\begin{aligned}
& q_{ins}^{*} - q^{*} = \frac{p + \sigma_{i\varepsilon}\sqrt{k}\pi}{a + b\left(1 - \sigma_{i\varepsilon}^{2}\right)} - \frac{p}{a + b} > 0 \\
& \Leftrightarrow \frac{p\left(a + b\right) + \sigma_{i\varepsilon}\sqrt{k}\pi\left(a + b\right)}{\left(a + b\left(1 - \sigma_{i\varepsilon}^{2}\right)\right)\left(a + b\right)} > \frac{p\left(a + b\left(1 - \sigma_{i\varepsilon}^{2}\right)\right)}{\left(a + b\left(1 - \sigma_{i\varepsilon}^{2}\right)\right)\left(a + b\right)} \\
& \Leftrightarrow p\left(a + b\right) + \sigma_{i\varepsilon}\sqrt{k}\pi\left(a + b\right) > p\left(a + b\left(1 - \sigma_{i\varepsilon}^{2}\right)\right) \\
& \Leftrightarrow \sigma_{i\varepsilon}\sqrt{k}\pi\left(a + b\right) > -\sigma_{i\varepsilon}^{2} p b \\
& \Leftrightarrow \sqrt{k}\pi\left(a + b\right) < -\sigma_{i\varepsilon} p b \\
& \Leftrightarrow -\sqrt{k}\left(a + b\right)\frac{rp^{2}\sigma_{i\varepsilon}\sqrt{k}\,p\left(1 + \mathrm{RF}\sigma_{ii}\right)}{N\left(a + b\left(1 - \sigma_{i\varepsilon}^{2}\right)\right) + \left(a + b\right)\left(1 + \mathrm{RF}\sigma_{ii}\right)} < -\sigma_{i\varepsilon} p b \\
& \Leftrightarrow \left(a + b\right)\frac{rp^{2}k\left(1 + \mathrm{RF}\sigma_{ii}\right)}{N\left(a + b\left(1 - \sigma_{i\varepsilon}^{2}\right)\right) + \left(a + b\right)\left(1 + \mathrm{RF}\sigma_{ii}\right)} < rp^{2}k \\
& \Leftrightarrow \frac{\left(a + b\right)\left(1 + \mathrm{RF}\sigma_{ii}\right)}{N\left(a + b\left(1 - \sigma_{i\varepsilon}^{2}\right)\right) + \left(a + b\right)\left(1 + \mathrm{RF}\sigma_{ii}\right)} < 1
\end{aligned}
\tag{29}
$$

Public Intervention in the Management of Agricultural Risk: Who Benefits from Insurance Subsidies?

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Abstract

Analyses of agricultural insurance failures often assume the existence of competitive supply, tracing the reasons for high insurance cost and limited farmers' participation to informational problems and suggesting the need for premium subsidization in order to increase participation. In this paper we explore the incidence of public subsidies to agricultural insurance premia when supply is non-competitive. Through use of a highly stylized model of an insurance market, it is shown that a monopolistic supply would capture most of the subsidy as rents, thus eliminating the potential incentive towards wider farmers' participation. The model is applied to a panel of Italian farms to demonstrate the limited effect that a subsidy would have in promoting use of an hypothetical all-risk yield insurance.

1. *Introduction*

The management of risk in agriculture and the role of insurance have long been at the center of researchers and policy-makers attention. A review of the recent literature consistently shows the failure of private markets for agricultural insurances and their lack of sustainability in absence of any public intervention.

Reasons for such failures are usually sought in either informational problems or in some form of limited rationality by the potential buyers. The most explored issues are: asymmetric and incomplete information, with the resulting problems of adverse selection and moral hazard, and systemic risk, which raises the need for reinsurance and consequent higher cost of insurance provision (Miranda and Glauber, 1997; Just, Calvin and Quiggin, 1999). Also, some mention the inability of farmers to precisely assess the benefits derived from crop insurance as one other possible reason for the limited demand.

Although all the arguments have some merit, these reasons are not fully convincing, and are definitely not exhaustive of the list of possible causes of the observed conditions of insurance markets in agriculture throughout the World.[1]

One more convincing explanation for the limited interest to multiperil crop insurance is simply that farmers can manage risk by engaging in other actions – such as by diversifying production, managing savings, acessing credit and financial markets, and so on – and therefore the potential demand for crop insurance is lower than what commonly believed (Wright and Hewitt, 1994).

One aspect, however, that has been virtually always neglected by the literature on agricultural insurance is the possible non competitive structure of the insurance market. After all, a market equilibrium where high prices and limited participation prevail could simply be the result of monopolistic pricing behaviour. The true failure of agriculture insurance markets, in other words, could simply be due the lack of competition on the supply side.

From a social welfare point of view, this issue deserves special consideration whenever public intervention is involved, as it is often the case in agricultural insurance. Many governments throughout the World have paid or still pay high subsidies to sustain agricultural insurance (a short list includes: USA, Canada, Spain, Italy, Greece, Japan, Sweden, Brazil and India) and it is thus legitimate to ask who might benefit more from such type of public intervention.

The effects of a subsidy on the premiums and the distribution of the benefits are deeply different under different competitive structures of the market. If suppliers can exercise market power, it is easily conceivable that part of the subsidy would be captured as monopoly rents, thus limiting the incentives on farmers' participation. How much of the subsidy is going to be captured as rents and what the effects on actual farmers' participation are, however, remain empirical questions that need to be answered on a case by case basis.

Starting from this consideration, this paper aims at studying the effects of an hypothetical policy intended to sustain agricultural insurances through a subsidy on premiums, under the hypothesis of two extreme forms of the supply: perfect competition and monopoly and using an highly stylized model. The paper is organized as follows. First, a simple model of the market for an all-risk insurance contract is presented (section 2). Section 3 presents the results of the empirical application of the model on a sample of Italian farms. Section 4 concludes.

[1] That the informational problems alone cannot justify the limited participation to insurance markets is indirectly demonstrated, for example, by noting that contracts aiming at the control of moral hazard and adverse selection, such as area-based contracts and contracts with deductibles, have long existed in insurance markets also for agricultural coverage.

2. *A simple model of an all-risk yield insurance*

2.1. *Market equilibrium*

Let us assume a set of N farms specialized in the production of a single product. $y_{i,t}$ is the unit (per hectare) yield of the i-th farm in period t. The farm's yield varies for reasons beyond the farmer's control, so that there exists a potential demand for insurance. Abstracting from price and interest rate[2], and given a temporal horizon T, the present value of the monetary gross returns from insuring one hectare of the crop with a contract that guarantees a minimum yield ψ to the i-th farm is the following:

$$PV_i(\psi) = \sum_{t=1}^{T} \max\{0, \psi - y_{it}\} \tag{1}$$

A risk-neutral farmer would be willing to pay a per hectare annual premium at most equal to the average expected benefit:

$$WTP_i(\psi) = PV_i(\psi)/T. \tag{2}$$

A simple insurance contract can be defined by the pair (π, ψ), where π is the premium and ψ is the guaranteed yield. Total demand for this type of insurance will be equal to the sum of the individual demands by farmers whose willingness to pay is equal or exceeds π. Given the distribution of farms in terms of individual yield productivity and a level of guaranteed yield, we can derive the market demand for insurance, measured in hectares, by summing up, for each value of the premium, the total area of farms whose willingness to pay is higher or equal to the required premium:

$$D(\pi, \psi) = \sum_{i=1}^{N} \gamma_i h_i \tag{3}$$

where h_i is the area of the i-th firm and $\gamma_i = 1$ if $WTP_i(\psi) \geq \pi$, 0 otherwise.

For any conceivable yield distribution, it will be:

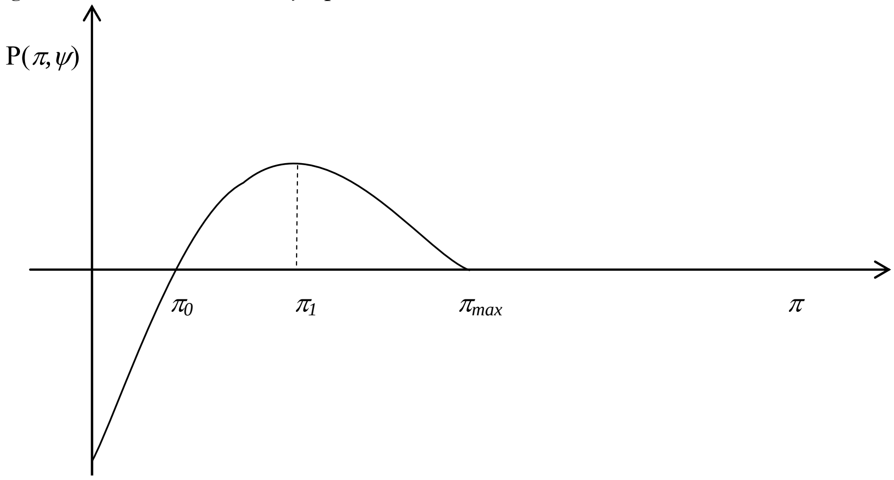
$$\partial D(\pi, \psi)/\partial \pi < 0, \text{ and } \partial D(\pi, \psi)/\partial \psi > 0.$$

For a given sample of firms, an insurance contract will determine revenues (given by the premiums paid by farmers) and costs (indemnity payments) for the insurance industry. The net profits of the insurance industry (abstracting from administrative costs) over the relevant time horizon will be:

$$P(\pi, \psi) = \sum_{i=1}^{N} \sum_{t=1}^{T} \gamma_i h_i \left[\pi - \max\{0, \psi - y_{it}\} \right]. \tag{4}$$

[2] Price is unity, which allows us to express all values in physical units, i.e., quintals per hectare (q/ha). There is no time discount rate.

Figure 1: Insurance industry's profits.



The actual form of this function depends on the distribution of yields. We predict that, when plotted against π, it shall assume an inverted U-shape (figure 1). Initial values of profits are certainly negative, corresponding to zero values for the revenues (when $\pi = 0$, all farmers would sign the contract, with no revenues for the insurance company) and the highest possible amount of indemnities to be paid. As the value of the premium increases, some farms will refrain from signing the contract, and therefore the value of indemnities to be paid will fall, whereas the value of revenues for the insurance industry will grow thanks to the payments by those who remain in the contract. Net profits for the insurance industry will reach a maximum at the premium π_1 in figure 1. At higher levels of the premium, the firms who remain in the market will be those with higher risk, with the consequence that the total amount of indemnities to pay will decrease more slowly than the amount of premiums collected. A market will be sustainable if the maximum of the curve in figure 1 corresponds to non negative profits.

Intuitively, we can define two possible equilibriums depending on the competitive structure of the supply of insurance, shown in figure 1. With full information and no barriers to entry, the equilibrium premium will be the lowest value compatible with positive profits (π_0) given that new firms would offer contracts with the same guarantee level at a lower premium, whenever there are profit opportunities. In a monopolistic market, that is, whne there is no competitive threat by potential entrants, the equilibrium premium will be the one that maximizes profits (π_1).

2.2. *The introduction of a subsidy*

The simple model outlined above can be used to simulate the effects of the introduction of a subsidy paid by the government, so that the effective premium paid by farmers will be $\tilde{\pi} = (1\text{-}s)\pi$, where s is the subsidy expressed as a percentage of the market premium.

With the introduction of the subsidy, the demand for insurance will change: a farmer will participate whenever his willingness to pay exceeds the effective premium $\tilde{\pi}$ and the market demand will be:

$$\tilde{D}(\pi,\psi,s) = \sum_{i=1}^{N} \tilde{\gamma}_i h_i \tag{5}$$

where:

$$\tilde{\gamma}_i = \begin{cases} 1 & \text{if} \quad WTP_i(\psi) > \tilde{\pi} \equiv (1-s)\pi \\ 0 & \text{otherwise} \end{cases}$$

How this might change the profit function for the insurance industry is not clear: the higher participation will increase both the premiums received by the insurer and the amount of indemnities paid. The ultimate change in the insurance industry's profit function depends on the distribution of yields across farms.

4. *Distributional effects of insurance subsidies*

4.1. *Data description*

In order to analyze the effects of the introduction of a subsidy on the premium of an all-risk insurance on yields, we have utilized a panel of farms taken from the RICA dataset for the Italian Emilia Romagna region. We have focused on wheat producing farms of the mountainous area in that region.[3] From the RICA database, we selected only farms which have been included in the sample for at least eight years over the period from 1980 to 1997[4]. This gives us a total of 141 farms. Given the structure of the RICA dataset, the sample of farms is not constant. Every year a different set of farms is recorde; nevertheless, we selected years when there were at least 24 farms (Table 1).

The mean annual yield within the sample does not show any clear trend; the values are close to the overall mean value of 60.5 q/ha over the entire period.

[3] The choice of the crop and the area has been determined by the need to have a dense enough panel of farms, recorded for a sufficient number of years to allow for a reliable characterization of the individual yield variation.

[4] The sample we have used does not include observations for the year 1983.

Table 1. The sample

Year	number of farms	average yield (q./ha)
1980	26	58.1
1981	40	62.6
1982	62	65.8
1983	N.A.	N.A.
1984	92	59.8
1985	103	57.2
1986	109	60
1987	116	66.5
1988	110	61.6
1989	105	51.3
1990	100	62.7
1991	90	64
1992	82	65.4
1993	75	61.6
1994	66	64.6
1995	56	58.3
1996	36	58.4
1997	24	50.2
Total(*)	141	60.5

(*)This is the total number of different farms included in the sample, each of which appears in at least eight years.

Somehow exceptional years are 1989 and 1997, when the yield is about 20% lower than the overall mean; the highest value of 66,5 q/ha is obtained in 1987.

4.2. *Results*

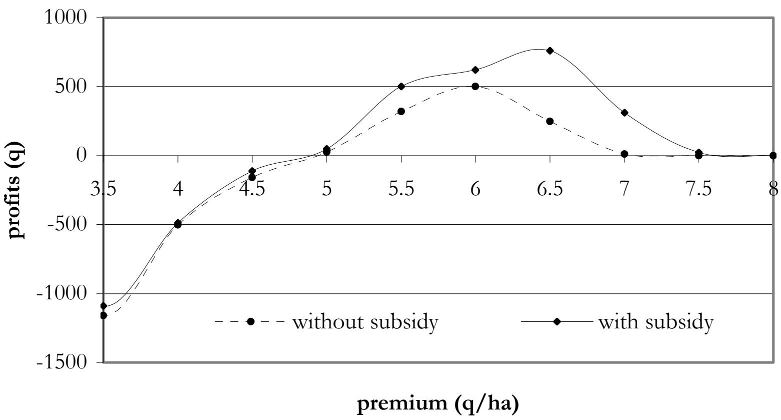
Starting from the observed distribution of yields we calculate the willingness to pay of each farm for a contract defined through the level of guarantee, ψ, and the premium, π. Then, selecting – for each value of the premium – the farms whose willingness to pay is higher than the premium, we build the aggregate demand function and the insurance industry's profit functions for the market represented by the sample of RICA farms.

Figure 2 reports the case of a contract that guarantees the individual hystoric average yield, with and without a 10% subsidy on the premium.[5]

Without the subsidy, the equilibrium premium would be of about 5 q/ha (or 8.2% of the mean yield of the sample) in a competitive market, and of 6.1 q/ha

[5] This contract is somewhat similar to the Actual Production History (APH) product delivered in the US under the Federal Crop Insurance regulation. Other contracts might be devised that guarantee the average area yield, or that include deductibles by guaranteeing only a fraction of the average yield, or where the indemnity payment is triggered only by losses which exceed a certain fraction of the average yield. These contracts are easy to implement in our model, and we have done so. The qualitative results are the same of the APH contract we focus in this paper.

Figure 2 - Performance of the contract based on historic individual yields



(i.e., 10% of the mean yield) under monopolistic supply. 29 firms (out of 141) would sign a contract at a premium of 5 q/ha, while only 12 would do so for a premium of 6.1 q/ha.

The introduction of a 10% subsidy to the premium would shift the industry's profit function as depicted in the figure. The value of the market clearing premium in competitive conditions will not be changed, remaining at around 5.0 q/ha, although participation will increase from 29 to 46 farms, due to the lower effective premium paid by farmers. Assuming monopolistic supply, the effect would be much different: the equilibrium premium will increase from 6.1 to 6.5 q/ha (an increase of 6.5 %) and participation would increase by only 2 farms, from 12 to 14 farms.

5. *Discussion and conclusions*

If nothing else, the variability of meteorological conditions and their effects on agricultural production should imply the existence of a potential demand for crop insurance. Despite this potential, active markets for agricultural insurance have long existed only for a limited number of perils (most notably hail and fire) and, where they has lasted beyond experimental stages, multi peril crop insurance programs has done so only by virtue of crucial and high public support.

The agricultural economic literature usually explains this stylized fact with the effects of asymmetric and incomplete information, the heterogeneity of risk exposure and with the systemic nature of many agricultural risk. These technical

Table 2. The effect of a 10% subsidy on the premium

	Competition		Monopoly	
	w/o subsidy	with subsidy	w/o subsidy	with subsidy
Equilibrium premium (q/ha)	5.0	5.0	6.1	6.5
(as a % of average yield)	*(8.2%)*	*(8.2%)*	*(10%)*	*(10.7%)*
Participating farms (N)	29	46	12	14
(as a percentage of the sample)	*(20.6%)*	*(32.6%)*	*(8.5%)*	*(9.9%)*

problems of the agricultural insurance would imply that coverage could be so onerous for farmers, up to the point of preventing operation of effective markets. Under these circumstances, public intervention aimed at reducing the cost of insurance for farmers could indeed be crucial for the development of a market. From the public interests point of view, the benefits of a widespread use of multi peril insurance in agriculture would be that of being able to share with private insurance companies part of the financial burden imposed by the need to compensate farmers for damages due to natural causes. The available evidence, however, seems to point against the merit of such an argument, especially for the case of the United States, where increasing subsidies to insurance premiums have been accompanied by increasing expenditure for ad hoc compensatory payments (Glauber, 2004).

In this paper, we advance one other possible reason for why premium subsidization might not be effective in inducing wider participation by farmers and therefore in reducing the need for ex-post compensation of damages.

Our highly stylized model describes how the incidence of a premium subsidy might differ depending on the competitive structure of the supply of insurance. It also allows us to predict the effect of the introduction of a subsidy under the ideal conditions of absence of informational problems.

By using a panel of farms from Italy, we show first that, if the market were competitive, a 10% subsidy on the premium might indeed induce a sizeably wider participation by farmers. The reason is simple: competition would guarantee that the subsidy would be fully appropriated by farmers and the reduced cost would justify the use of multiperil insurance also by relatively low risk farms. If, for any reason, competition in insurance supply is prevented, the market clearing premium would be higher, and a market would be sustained only by the higher risk farms. If introduced, a subsidy would be partly captured as a higher premium and therefore participation will only be marginally affected (in the example we present, the increase in market premium would capture more than 60% of the subsidy).

Despite the simple nature of our exercise, which abstracts from any consideration related to informational problems, there is an important conclusion we can draw from our study. A subsidy to the premium might promote the demand and use of all-risk insurance coverage in agriculture, only provided there is sufficient competition among supplier of insurance so that the subsidy results in effective reduction of the cost of coverage to farmers. Under less than perfect competition, part of the subsidy will be captured as rent through an increase of the prevailing market premium, with the consequence that it will not come up to the original expectations of promoting farmers' participation.

The key point we would like to stress is that the introduction of a subsidy as a policy instrument to promote wider use of insurance in agriculture is likely to be ineffective. First, it does not directly address informational asymmetries and strategic behaviour by farmers and/or insurers, and therefore the overall cost to the society of sharing agricultural risk is not reduced. Moreover, the presence of such informational problems would only exacerbate the problems and the distorted incidence of a subsidy under non competitive conditions. On the other hand, if a market for risk sharing is sufficiently transparent to allow for effective competition among suppliers of insurance coverage, then a public subsidy on the premium paid by farmers might induce wider participation.

The main lesson we should derive from all this is that, before even thinking of introducing a subsidy on the premium, any intervention aimed at promoting farmers' participation to insurance markets should focus first on promoting competition among insurance providers, and only when supply is made sufficiently competitive, further attempts at reducing informational asymmetries and opportunistic behaviour might be beneficial to farmers.

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Optimal Choice of Management Instruments to Cope with Price Risk[1]

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Abstract

This article offers an analysis of the choice between two alternative risk management instruments. We model farmers' behaviour by optimising the certainty equivalent, formulated as a mean-variance model. The paper provides analytical solutions for a number of choice problems that combine instruments with and without basis. The results of the model are expressed as the demands for hedging with futures, forward contracts and insurance. We find an analytical and easy-to- apply solution of the more general case of a choice of two risk management instruments with different basis risk. We show that this model nests other problems previously analysed in the literature.

1. *Introduction*

Commodity price instability is one of the primary sources of farmers' risk (Musser and Patrick). A number of risk management instruments are available for managing price risks. Some of these instruments are futures and option contracts, forward contracts, and revenue and price insurance (Hardaker, Huirne and Anderson; Hardwood *et al.*). Most of these instruments provide means for dealing with short-term price volatility, while others, like some types of insurance, are useful for managing inter-season price variability. Price risk management instruments have been thoroughly studied from both theoretical and empirical standpoints (Hardaker, Huirne and Anderson; Moschini and Hennessy; Gardner and Rausser, 2001a and 2001b).

In practice, it is not easy to ascertain what actual benefits each risk management instrument delivers to farmers. Many studies show that farmers are quite reluctant to purchase insurance policies or trade with futures contracts in agri-

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cultural exchanges. It is this recognition that prompts the interest in looking at the demand for risk management instruments.

The demand for a single instrument has been examined at length in the literature. However, farmers are commonly given a wider choice of more than one risk management instrument. Access to a second or third instrument can influence the demand for the ones that were initially available. Yet, the analytical context of the optimal choice of various instruments has not received a lot of attention in the literature. Several articles have looked at the choice of two instruments based on different variables, one of which is free of basis risk (perfectly correlated with the farmer's relevant variable) (Lapan, Moschini and Hanson; Frechette 2000; Mahul 2003b). The more generic case, in which the two available instruments are based on different variables with basis risk, would provide more insight into the different problem variants. This was what Moschini and Lapan did for the particular case of futures and options (Expected Utility EU model) and for futures and straddles (both EU and mean-variance (M-V) model). The objective of this article is to characterise the demand for any two alternative risk management instruments with basis risk.

To this end, the certainty equivalent based on the mean-variance model (M-V) will be applied to the case of two different futures contracts. We shall also analyse the case in which a generic price insurance contract (similar to an option contract) is one of the available instruments in the knowledge that the insurance indemnity is a truncated variable. Although some authors warn against the use of the M-V model when there are truncated variables (Lapan, Moschini and Hanson; and Moschini and Lapan), it can provide a good approximation of the expected utility optimum and gives more analytical insight (see among dozens references Wolf; García, Adam and Hauser; Simaan; Guvele; Poitras and Heany).

The study offers theoretical results on the demand for two instruments. These results are open to a number of comparative statics analyses that yield testable hypotheses and can be applied to many practical examples. According to the transformation of truncated variables proposed by Chavas and Holt, analytical results can be calculated for the case of insurance, with no need to resort to numerical simulations.

The paper is organized as follows. A literature review of the simultaneous demand for two price risk management tools is presented in section 2. Then, our theoretical analysis is developed in section 3. First, the model's assumptions are presented, and then the general case of the demand for two different futures contracts with basis risk is developed. Next, the case of futures and price insurance is analysed. Lastly, for comparative purposes, the particular case of one instrument with no basis risk, in this case a forward contract sale is analysed, the other instrument being price insurance. We then report just one example of comparative statics analysis, looking at the effects of the agent's risk averseness on the demand for the instrument. To close section 3, the Chavas and Holt transformation is completed to show how the theoretical results can be directly applied to a truncated variable with no need for simulations. The concluding section summarises the main contributions of the paper.

2. *Literature review*

The context of this article is on the problem of farmers' choice when there are two instruments available with different basis risk. This is the case of two different futures contracts with basis risk, a futures contract with basis risk and price insurance, or futures with basis risk and options (this is by far the best documented case in the literature). Lapan, Moschini and Hanson have looked at the case of futures and option markets, finding that optimal hedging only requires futures, options being redundant. In this case, optimal hedging is equivalent to the slope of the regression between the local and futures prices, just as if only futures were available. Lapan, Moschini and Hanson in 1991 thus conclude that options play a role due to the real market biasedness and are used just for speculative purposes. However, a complete analytical solution was not reached until Moschini and Lapan published their work (1995). They solved the expected utility (EU) model analytically under yield risk and concluded that the joint risk across prices and yields gives options a hedging role. This means that, even in an unbiased market, risk aversion can lead a farmer to hedge with options. They also conducted a M-V analysis to which we shall refer in section 3.3. Coble, Heifner and Zuniga; and Mahul (2003a) found empirically the optimal hedging strategy with futures and options, when both yield and revenue insurance are also available.

The case of two instruments, one with and the other one without basis risk, is in fact a particular case of two instruments having different basis risks. For example, apart from analysing the demand for unbiased futures and options, Lapan, Moschini and Hanson looked at the optimal futures and straddles positions for a biased market where there is no basis risk ($p=f$). This, added to the assumption that the covariance between futures and straddles is zero, leads to some mainly qualitative conclusions about these speculative positions.

This case has been more thoroughly analysed by Frechette and Mahul (2003b) using the mean-variance model. Frechette looks at the demand for hedging with futures in two different markets, a local market with the farmer's spot prices, and a more remote market where there is basis risk. Mahul (2003b) analyses the demand for hedging with futures with basis risk and for an insurance policy that guarantees the maximum price covering 100% of potential losses. This insurance policy is in fact equivalent to a cash forward sale that secures the highest possible price, where the price distribution is not truncated.

3. *Theoretical analysis*

3.1. *The model*

We assume farmers behave as maximisers of the certainty equivalent, defined by the standard mean-variance model:

$$CE = E(W) - \frac{A}{2}V(W),$$

where A is absolute risk aversion and $E(W)$ and $V(W)$ represent expected wealth and wealth variance.

Farmer's wealth, $\widetilde{W}$, under the assumption that the farmer grows only one crop, is given by:

$$\widetilde{W} = W_0 + \widetilde{p}\,q - C(q) \tag{1}$$

where, W_0 is the initial wealth; $\widetilde{p} \cdot q$ represents revenue, with $\widetilde{p}$ being the local stochastic price and q the deterministic harvested production. $C(q)$ accounts for the production costs. If there are two different available instruments, 1 and 2, farmer's wealth is given by:

$$\widetilde{W} = W_0 + \widetilde{p}\,q - C(q) + \phi_1 q \widetilde{\Pi}_1 + \phi_2 q \widetilde{\Pi}_2 \tag{2}$$

where ϕ_1 and ϕ_2 stand for the demand for instruments 1 and 2, expressed in terms of what proportion of q each risk management instrument contains; and $\widetilde{\Pi}_1$ and $\widetilde{\Pi}_2$ represent the instrument payoffs. In the following sections, we will lay down the specific payoff formulae for each type of instrument. Throughout the article we will use the following notation:

- F and I denote the "futures contracts" and "insurance" instruments, respectively.
- p, f, i are all stochastic variables denoting local prices, futures prices and insurance indemnities, respectively.
- C_F and C_I denote the costs of instruments F and I.
- E_p, E_f, E_i (V_p, V_f, V_i) represent the expected value (variance) of local prices, futures prices and insurance indemnities.
- Cov_{pf}, Cov_{pi}, Cov_{if} denote the covariances
- N_1 and N_2 denote the mathematical expectations of $\widetilde{\Pi}_1$ and $\widetilde{\Pi}_2$.

3.2. *Demand for two futures contracts*

Lapan and Moschini compare the analytical results of an expected utility (EU) model and a mean variance (M-V) model for the case of just one futures contract. The results of both models are the same when just prices are random, but differ when yields are also considered as a random variable. Since we are only considering price randomness, we do not expect our results to be different from the EU model.

The certainty equivalent of the problem is given by[2]:

$$CE(W(\phi_1,\phi_2)) = W_0 + E_p q - C(q) + \phi_1 q N_1 + \phi_2 q N_2$$

$$-\frac{A}{2}q^2\left[V_p + \phi_1{}^2 V_1 + \phi_2{}^2 V_2 - 2\phi_1 Cov_{p1} - 2\phi_2 Cov_{p2} + 2\phi_1\phi_2 Cov_{12}\right] \quad (3)$$

Upon maximising CE with respect to ϕ_1 and ϕ_2, we get the solution denoted by Case 1 in Table 1[3].

The solution of Case 1 has the classical terms of M-V: the speculative or wealth component, and the hedging or risk component. Note, however, that there are three key covariances, (Cov_{p1}, Cov_{p2}, Cov_{12}). These are the covariances of the two instruments with local prices, and the covariance of the instruments with each other.

Our results are consistent withJust and Pope's, although their focus is on the optimal acreage among two crops. Using a mean-variance model, and denoting the acreage allocated to crops 1 and 2 as ϕ_1 and ϕ_2, their optimal solution for crop 1 is expressed by:

$$\phi_1 * = \frac{N_1 V_2 - N_2 Cov_{12}}{A(V_1 V_2 - Cov_{12}^2)} \quad (4)$$

This solution is quite similar to that of Case 1, except in that there is no second addend in Just and Pope's. This is due to the fact that Cov_{p1} and Cov_{p2} (covariances of each futures price with local prices) are zero in Just and Pope's problem.

3.3. *Demand for futures and insurance*

The optimal hedging ratio and optimal coverage level of price insurance are quite similar to, but differ slightly from the optimal hedging ratios in two different futures markets. As insurance indemnity is represented by a truncated variable, these results should only be considered as an approximation or rough calculation of the EU demand. As Moschini and Lapan show, the M-V and EU analytical results differ. However, their differences are not the same for all instruments based on truncated variables, as we will show later in this section. Also, in this case the comparative statics for risk aversion yields more insights and a few testable hypotheses that will be analysed in section 3.4.

Following the above notation, futures and insurance results are given by $\widetilde{\Pi}_F = f_0 - \widetilde{f} - C_F$ and $\widetilde{\Pi}_I = \widetilde{i} - E_i - C_I$. The certainty equivalent is given by:

[2] All proofs are available from the authors upon request

[3] Notation shown in section 3.1

Table 1. Instrument's Demand Results

Case 1. Two basis risk instruments: 2 Futures markets (1 and 2)	
Market 1	Market 2
$\phi_1 * = \dfrac{N_1 V_2 - N_2 Cov_{12}}{Aq[V_1 V_2 - Cov_{12}{}^2]} + \dfrac{Cov_{p1} V_2 - Cov_{p2} Cov_{12}}{V_1 V_2 - Cov_{12}{}^2}$	$\phi_2 * = \dfrac{N_2 V_1 - N_1 Cov_{12}}{Aq[V_1 V_2 - Cov_{12}{}^2]} + \dfrac{Cov_{p2} V_1 - Cov_{p1} Cov_{12}}{V_1 V_2 - Cov_{12}{}^2}$

Case 2. Two basis risk instruments: A futures market (F) and price insurance (I)	
Futures market	Price insurance
$\phi_F * = \dfrac{N_F V_i + N_I Cov_{if}}{Aq[V_i V_f - Cov_{if}{}^2]} + \dfrac{Cov_{pf} V_i - Cov_{pi} Cov_{if}}{V_i V_f - Cov_{if}{}^2}$	$\phi_I * = \dfrac{N_I V_f + N_F Cov_{if}}{Aq[V_i V_f - Cov_{if}{}^2]} - \dfrac{Cov_{pi} V_f - Cov_{pf} Cov_{if}}{V_i V_f - Cov_{if}{}^2}$

Case 3. One BR and one 0-BR instruments: A cash forward contract (FC) and price insurance (I)	
Cash forward contract	Price insurance
$\phi_{FC} * = \dfrac{N_{FC} V_i + N_I Cov_{pi}}{Aq[V_i V_p - Cov_{pi}{}^2]} + 1$	$\phi_I * = \dfrac{N_I V_p + N_{FC} Cov_{pi}}{Aq[V_i V_p - Cov_{ip}{}^2]}$

$$CE(W(\phi_F, \phi_I)) = W_0 + E_p q - C(q) + \phi_F q N_F + \phi_I q N_I - \frac{A}{2} q^2 \left[V_p + \phi_F^2 V_f + \phi_I^2 V_i - 2\phi_F Cov_{pf} + 2\phi_I Cov_{pi} - 2\phi_F \phi_I Cov_{fi} \right] \quad (5)$$

The solution to this problem[4] is reported in Table 1 under Case 2. A few signs in these results differ from the results for Case 1, because indemnities are negatively correlated to local prices. We conclude that the model of two futures contracts with basis risk also applies to other types of risk management instruments. Furthermore, we stress a key difference from Moschini and Lapan's futures and straddles results. Using the M-V model, they found out that the

[4] All proofs are available from the authors upon request

choice for one instrument "is not affected by the bias in the other" (see Moschini and Lapan, p. 1038). This contrasts sharply with our results, and also with their EU model results. On analysing their results in further detail we can conclude that, under the assumption of no production risk, theirs could be considered a particular case of our more general result, where Cov_{12}=0. This means that their result does not reflect the influence of one instrument's bias on the other due to the particular characteristic of straddles, that is, a mutual covariance with futures equal to zero under the assumption of symmetry of the futures price distribution.

The fact that the correlation of both instruments affects the optimal choice has potencially policy implications. This is the case when price insurance policies are based on 'indices' that are more or less pegged to futures prices. In this case, farmers' choice will be influenced by the relative weight of the futures within the 'index' composition. We have several examples of this, such us the Spanish potato insurance 'index', where the Amsterdam's futures prices play a minor role, and mainly several US revenue insurance products, for which futures prices are the only price source. If both instruments are highly correlated, they will be perceived by farmers as substitutes. Should one instrument become more heavily subsidised in the framework of a safety net policy, farmers would generally respond with a larger demand for this instrument, reducing the demand for the other.

3.4. *Comparative statics*

Case 2 investigates the influence of farmers' risk preferences on the demand for instruments through the following comparative statics analysis.

$$\frac{\partial \phi_F *}{\partial A} = -\frac{N_F V_i + N_I Cov_{if}}{A^2 q[V_i V_f - Cov_{if}^{\ 2}]} \tag{7}$$

$$\frac{\partial \phi_I *}{\partial A} = -\frac{N_I V_f + N_F Cov_{if}}{A^2 q[V_i V_f - Cov_{if}^{\ 2}]} \tag{8}$$

The denominator is always positive. On the contrary, the covariance of futures and insurance indemnities, Cov_{if}, is most plausibly negative, because the covariance of futures and local prices is expected to be positive and the covariance between local prices and indemnities is negative. Furthermore, it is fair to assume as well that purchasing price insurance and hedging with futures entails some costs ($N_F < 0$ and $N_I < 0$). The first set of comparative statics results are reported in Table 2.

Thus, there are cases in which more risk aversion would be followed by greater demand for both instruments, lower demand for both instruments and greater demand for just one instrument and lower for the other.

Table 2. Comparative Statics Results for the Absolute Risk Aversion Coefficient

Condition	**Sign of** $\frac{\partial \phi_F *}{\partial A}$	**Sign of** $\frac{\partial \phi_I *}{\partial A}$
$\lvert N_F V_i \rvert > \lvert N_I Cov_{if} \rvert$	>0	?
$\lvert N_F V_i \rvert < \lvert N_I Cov_{if} \rvert$	<0	?
$\lvert N_I V_f \rvert > \lvert N_F Cov_{if} \rvert$	?	>0
$\lvert N_I V_f \rvert < \lvert N_F Cov_{if} \rvert$	?	<0

To get further insight from the analysis, we consider that futures and insurance are just two generic instruments 1 and 2, and we hypothesise that the costs of both instruments are equal. Then, we would get the following results:

if $|\sigma_1| > |\rho\sigma_2|$, then $\frac{\partial \phi_2 *}{\partial A} > 0$, and sgn ($\frac{\partial \phi_1 *}{\partial A}$) is undetermined;

if $|\sigma_1| < |\rho\sigma_2|$, then $\frac{\partial \phi_2 *}{\partial A} < 0$, and sgn ($\frac{\partial \phi_1 *}{\partial A}$) is undetermined.

The meaning of the above results becomes clearer if we analyse two extreme values of the instrument correlation:

If $|\rho| \approx 1$ then $\sigma_1 > \sigma_2 \Rightarrow \frac{\partial \phi_2 *}{\partial A} > 0$ and $\frac{\partial \phi_1 *}{\partial A} < 0$. Hence if two instruments are similar and strongly correlated, more risk aversion will induce more demand for the instrument with lesser variance (instrument 2), and a lower demand for the riskier one (instrument 1).

If $|\rho| \approx 0$ then $\frac{\sigma_1}{\sigma_2} > 0 \Rightarrow \frac{\partial \phi_2 *}{\partial A} > 0$ and similarly $\frac{\sigma_2}{\sigma_1} > 0 \Rightarrow \frac{\partial \phi_1 *}{\partial A} > 0$, which means that the instruments are not substitutes. Therefore, more risk aversion would be followed by a greater demand for both instruments.

Both results seem quite logical, so we can deduce that, in this case, results are going to depend on the value of N_F, N_I and on the substitutability of the instruments.

Going on with the partial derivatives analysis, if both futures and insurance have positive expected gains ($N_F > 0$ and $N_I > 0$), the signs of the above partial derivatives will be the opposite.

Lastly, N_F and N_I having opposite signs can match up with a case where the subsidy covers the loading factor and part of the fair premium ($N_F < 0$ and $N_I > 0$). The following result holds irrespectively of the magnitude of the product of N_F and N_I with variances and covariances, namely:

$$\frac{\partial \phi_F *}{\partial A} > 0 \text{ and } \frac{\partial \phi_I *}{\partial A} < 0 .$$

The meaning of this result is as follows. Clearly, a risk neutral agent would insure up to the maximum possible amount, because $N_F < 0$ and $N_I > 0$, and would not hedge with futures. However, as risk aversion grows, farmers' behaviour will be driven not only by the instruments' expected results, but also by their risk reduction potential. Therefore, more risk averse farmers will find a more balanced combination of the instruments. This should be taken into account when designing insurance subsidised policies that target especially less favoured farmers. There is the risk that the less risk averse producers will benefit from most subsidies, while the target group, with greater risk aversion, will find other less profitable though more risk reducing instrument combinations, which are less supported by the government.

3.5. *Cash forward sale and price insurance*

For comparison purposes, we shall next analyse the case when only one instrument has basis risk. Our model will illustrate the case of a price insurance and of a cash forward sale based strictly on the farmers' local prices. Let the benefits of insurance (*I*) and cash forward contract (*FC*) be given by $\tilde{\Pi}_{FC} = p_0 - \tilde{p} - C_{FC}$ and $\tilde{\Pi}_I = \tilde{i} - E_i - C_I$. The certainty equivalent is:

$$CE = W_0 + E_p q - C(q) + \phi_{FC} q N_{FC} + \phi_I q N_I$$
$$- \frac{A}{2} q^2 \left[V_p (1 - \phi_{FC})^2 + \phi_I^2 V_i + 2(1 - \phi_{FC}) \phi_I Cov_{pi} \right] \quad (6)$$

The solution for ϕ^*_{FC} and ϕ^*_I is reported in Table 1 under Case 3.

These results are equivalent to Mahul's (Mahul, 2003 b). Comparing these results with the general results, for example with the results for futures and price insurance (Case 2), we note that the "hedging" or risk related components have become "1" for the forward contract demand and "0" for the price insurance demand. This is because the forward contract is free of basis risk. In fact, Case 3 is a particular case of the more general results expressed in Case 2. This can be checked by transforming futures into the cash forward contract in Case 2 equations in Table 1, by substituting $V_f = V_p$, $Cov_{pf} = V_p$ and $Cov_{fi} = Cov_{pi}$.

We can see that where there are no costs nor subsidies and the forward contract guarantees the expected price, ($N_{FC} = 0$ and $N_I = 0$), then agents will clearly prefer the forward contract over insurance ($\phi_{FC}* = 1$ and $\phi_I* = 0$). This is because forward contracting reduces the variance-risk to zero, while insuring does not completely eliminate risk.

3.6. *Cash forward sale and price insurance according to Chavas and Holt's approach*

As some of the key parameters of price insurance, such as the mean, variance and covariances of indemnities are unknown, if we wanted to apply our results to a real case, indemnities would need to be empirically simulated. However, Chavas and Holt proposed a method to determine the parameters of a truncated variable, based on another non-truncated variable. We will follow their procedure for the cash forward sale and price insurance case. We will make the assumption that prices follow a normal density function in the knowledge that the literature directs analysts to assume either lognormal distributions (Samuelson; Black; Wilson and Fung; Lapan and Moschini; Babcock and Hennessy; Meuwissen, Huirne and Hardaker) or a combination of normal and lognormal distributions (Roberts, Goodwin and Coble; Goodwin, Roberts and Coble).

Bearing these cautions in mind, Chavas and Holt's truncated variable would correspond to our insurance indemnity, $\tilde{i}$; the untruncated variable would be the guaranteed price minus the local price, P_g- $\tilde{p}$; and Chavas and Holt's parameter, *h,* is given by (as proved in Appendix 1):

$$h = \frac{E_p - P_g}{\sigma_p}$$

The moments of $\tilde{i}$, based on parameter *h*, are computed in appendix 1.

$$\tilde{W} = W_0 + \tilde{p}\, q - C(q) + \phi_{FC}\, q\, (p_0 - \tilde{p} - C_{FC}) + \phi_I\, q\, (\tilde{i} - E_i - C_I) \qquad (9)$$

As shown in appendix 1, the expected wealth and the wealth variance are:

$$E(W) = W_0 + E_p\, q - C(q) + \phi_{FC}\, qN_{FC} + \phi_I\, qN_I \qquad (10)$$

with $N_I = E(\tilde{i} - E_i - C_I) = P_g - E_p + \sigma_p[f(h) + hF(h)] - E_i - C_I$, and

$$V(\mathrm{W}) = q^2\, V_p\, \left[1 + \phi_{FC}^2 - 2\phi_{FC} + \phi_I{}^2\, K - 2\phi_I\, (1 - F(h)) + 2\, \phi_{FC}\phi_I (1 - F(h))\right]. \qquad (11)$$

K is a parameter that represents the relationship between the price and indemnity variances ($K = V_i/V_p$) and its formula is given in appendix 1. We compute ϕ_{FC} and ϕ_I to maximize *CE*(*W*) = *E*(*W*) – 0.5 *A* *V*(*W*). First- and second-order conditions are verified, and we finally get:

$$\phi_{FC}{}^* = \frac{N_{FC} K - N_I (1 - F(h))}{A\, q\, V_p \left[K - (1 - F(h))^2\right]} + 1 \qquad (12)$$

$$\phi_I{}^* = \frac{N_I - N_{FC}(1 - F(h))}{A\, q\, V_p \left[K - (1 - F(h))^2\right]} \qquad (13)$$

This shows that Chavas and Holt's procedure provides a means to get an analytical solution to the problem that dispenses with numerical simulations of the variances and covariances of indemnities. Moreover, since $KV_p = V_i$ and $-(1-F(h))V_p = Cov_{pi}$, if they are substituted in equations 12 and 13, we get the same expressions as we did before (Case 3 in Table 1).

4. *Conclusions*

This paper offers a comprehensive analysis of the optimal choice of two alternative instruments to manage commodity price risks. The theoretical analysis is based on a general certainty equivalent optimisation model using the mean variance (M-V) model. Different combinations of instruments and modelling assumptions lead to a number of problem variants that are presented in reference to previous results detailed in the literature.

We conclude that all combinations of risk management instruments (RMIs) are just particular cases of the most general case that is embodied by two RMIs both with basis risk, a case that can be illustrated by two futures contracts with different basis risk. Thus, the results for all cases are slight modifications of this general result.

We have shown that, in the general case of two available RMIs with basis risk, the demand for one RMI depends upon the expected costs or profits of this and the other RMI, on the agent's risk preferences, on the variances of the instruments' associated random variables, and also on the correlations, not only of the farmer's prices with each RMI-associated variable but also on the mutual correlations of the two RMI variables. This finding has a policy implication in the case of insurance based on indexes that are partially or totally pegged to futures prices, such as the revenue insurance programs in the U.S. Insurance subsidising has an effect on the demand of futures contracts, which is dependent (increasing) on the weight of futures in the insurance index.

The general result applies, as we have said, to the comparison of two different futures contracts in the same market or for two different futures markets. But it also applies to other instruments with basis risk, albeit with some slight variations. Greater differences arise when one instrument has basis risk and the other does not, which would be the case of a cash forward sale. If one of the instruments is an insurance contract or option-like product, some cautions, stemming from the truncation of the relevant ramdon variable, should be taken into account. Nevertheless, while this might not provide an EU consistent exact solution, it can give a good approximation in the case of insurance. The Chavas and Holt (1992) transformation for truncated variables provides a means to get an analytical solution to the problem that dispenses with numerical simulations of indemnity variances and covariances.

Generally, our results provide a simple and easy-to-apply analytical solution of the demand problem and they also allow for an interesting analysis of comparative statics. This is illustrated by the analysis of the effects of risk aversion on the demand for two instruments, such as futures and insurance. From this we conclude that this effect varies depending on the expected payoff values of both RMIs and on their substitutability. For instance, when an instrument's expected payoff is positive – due to intense subsidisation –, we find that more risk aversion will generally be followed by lower demand for the instrument. Thus, insurance policies that target especially risk averse or less-favoured farmers should be carefully tailored to ensure that they are delivered to the target group, and not to more favoured producers.

The paper's analyses can be furthered in a number of ways: (i) using the expected utility model instead of the M-V model, (ii) considering other random variables, mainly yields, and (iii) exploring the optimal choice of various crop-specific instruments in a context where crop diversification is possible. Nevertheless, our results have proved useful for simple numerical applications to real cases (see Bielza, 2004 and Bielza *et al.* 2004).

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Appendix 1. Computing the parameters of variable 'indemnity' as a function of local prices (following Chavas and Holt, 1990)

We compute $E\left(\tilde{i}\right)$, $V\left(\tilde{i}\right)$ and $Cov\left(\tilde{p}, \tilde{i}\right)$ as a function of parameters $E\left(\tilde{p}\right)$ and $V\left(\tilde{p}\right)$. Let $\tilde{d}$ be the difference variable between local price and guaranteed price: $\tilde{d} = P_g - \tilde{p}$, $E\left(\tilde{d}\right) = P_g - E_p$, and $V\left(\tilde{d}\right) = V_p$. Insurance indemnity, $\tilde{i}$, is a truncation of the variable $\tilde{d}$:

$$\tilde{i} = \begin{cases} \tilde{d} & \text{if } \tilde{d} > 0 \\ 0 & \text{if } \tilde{d} \leq 0 \end{cases}$$

We now compute the parameters of the truncated variable following Chavas and Holt (1990), generating the variable h:

$$h = \frac{0 - \lfloor P_g - E_p \rfloor}{\sigma_p} = \frac{E_p - P_g}{\sigma_p} \tag{A14}$$

With E_p and σ_p, denoting the expected value and the standard deviation of variable $\tilde{p}$:

$$E(\tilde{i}) = E_i = P_g - E_p + \sigma_p \left[f(h) + hF(h) \right] \tag{A15}$$

$$V(\tilde{i}) = V_i = V_p \left[1 - F(h) + hf(h) + h^2 F(h) - f(h)^2 - h^2 F(h)^2 - 2f(h)hF(h) = V_p K \right] \tag{A16}$$

Let K be the term in brackets, so that K represents the ratio of the relevant variances ($V_i = V_p K$).

To evaluate the covariance between price and indemnity, we first compute the parameters of the truncated variable 'guaranteed price' or insured price $\tilde{p}_a$. Based on the insured price, we compute the parameters of "indemnity" ($\tilde{i}$). First, $\tilde{p}_a$ is defined as follows:

$$\tilde{p}_a = \begin{cases} P_g & \text{if } \tilde{p} < P_g \\ \tilde{p} & \text{if } \tilde{p} \geq P_g \end{cases}$$

Again, following Chavas and Holt (1990):

$$h' = \frac{P_g - E_p}{\sigma_p} = -h$$

so that:

$E(p_a) = E_p + \sigma_p \left[f(h') + h' F(h') \right]$ and

$$V(p_a) = V_p \left[1 - F(h') + h' f(h') + h'^2 F(h') - f(h')^2 - h'^2 F(h')^2 - 2f(h')h' F(h') \right]$$
$$= V_p K'$$

We now compute the functional relations between $E(\tilde{i})$ and $E(\tilde{p}_a)$, and between $V(\tilde{i})$ and $V(\tilde{p}_a)$. Since $h' = -h$; $F(h) = 1 - F(h')\, h'$ and $f(h) = f(h')$, we have: $E(\tilde{p}_a) = E_p + \sigma_p \left[f(h) - h(1 - F(h)) \right]$

$$V(\tilde{p}_a) = V_p \left[F(h) - hf(h) + h^2(1 - F(h)) - f(h)^2 - h^2(1 + F(h)^2 - 2F(h)) + 2f(h)h(1 - F(h)) \right]$$
$$= V_p \left[F(h) - hf(h) - h^2 F(h)) - f(h)^2 - h^2 F(h)^2 + 2h^2 F(h) + 2hf(h) - 2f(h)hF(h) \right]$$
$$= V_p \left[-1 + 2F(h) + K \right]$$

Therefore: $K' = -1 + 2F(h) + K$

We now compute $Cov\left(\tilde{p}, \tilde{i}\right)$

By definition: $\tilde{p} + \tilde{i} = \tilde{p}_a$. Computing the variances,

$V\left(\tilde{p} + \tilde{i}\right) = V\left(\tilde{p}_a\right)$, $\quad V(\tilde{p}) + V\left(\tilde{i}\right) + 2\,Cov\left(\tilde{p}, \tilde{i}\right) = V\left(\tilde{p}_a\right)$,

$V\left(\tilde{p}\right) + V\left(\tilde{p}\right)K + 2\,Cov\left(\tilde{p}, \tilde{i}\right) = V\left(\tilde{p}\right)\left(-1 + 2\,F\left(h\right) + K\right)$

$2\,Cov\left(\tilde{p}, \tilde{i}\right) = V\left(\tilde{p}\right)\left(-1 + 2\,F\left(h\right) + K - 1 - K\right)$

Therefore:

$$Cov\left(\tilde{p}, \tilde{i}\right) = V\left(\tilde{p}\right)\left(-1 + F\left(h\right)\right) \tag{A17}$$

Farm Level Yield, Price and Cost Variations

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Abstract

In this study, farm revenue variability is analysed within and between farms. Within-farm analysis is conducted by examination the variance-covariance structure of revenue components (i.e. yields and prices). Between-farm analysis refers to farm revenue variability that is affected by differences in business and financial characteristics. The method is applied to a panel data set of 109 Dutch arable farms based on the period 1990–1999 including nine major crops. The within-farm results show that the coefficients of variation (CV) of prices exceeded CV values of yields. A high number of the within-farm correlation coefficients were significant (75 out of 144) for both price-price and yield-yield correlations. Positive yield correlations were most frequently observed. Negative price correlations were found only between cereal crops and root crops. Negative correlation values were observed only between yield and price of the same crops. Cereals have lower yield-price correlation compared to the root crops. In overall the variance-covariance structure differed substantially between farms. The results have considerable impact on farm portfolio analysis, where usually within-farm variability of crops is ignored. Between-farm analysis indicated that the geographical location, farmer's age, farmer's education level and variable cost had significant impact on revenue variability. The leverage ratio, off-farm income and land area were also significant and had inverse relations with the total farm revenue variability.

1. *Introduction*

Risk management involves the selection of methods for countering all types of risks in order to meet the decision-maker's goal taking into account his or her risk-attitude. The portfolio modelling approach is often used to indicate the consequences of alternative risk management strategies. Markowitz (1952), in his classical work, defined portfolio analysis as "security selection". At the same time he footnoted that a good portfolio is more than a long list of good stocks and bonds. The word portfolio refers to a mix, or combination, of assets enterprises or investments (Brealey and Myers, 2000). In application to risk analysis for agricultural businesses, the concept of assets is usually broadened to include crop and livestock enterprises, acquisition of machinery, buildings, and land, hiring labour, financing alternatives, consumption and tax activities, and investments in financial assets. A portfolio analysis starts with information concerning individual farming activities. Then the consequences of integrating the activities in different ways are analysed using portfolio analysis in terms of expect income and variability of income. The actual variability can be associated with farm specific business and financial characteristics. Although the farms in the same area operate under similar market and weather conditions, due to the specific farm and farmer characteristics, all farmers need to manage their risks differently.

The aim of this study is to conduct an individual farm revenue analysis (i.e. within-farm analysis) and to examine the difference between farms based on the farm managerial effect and farm structural effect. This paper analyzes the relationship between revenue coefficient of variation and business structural variables (such as: cultivated area size, regional location, farmer's age and education, company type, relationship between owners, variable costs and off-farm income) and a financial structural variable (leverage ratio). The study consists of four main parts. First, revenue components (crop yields and prices) of historical data are de-trended. In the second part the coefficients of variation are calculated as an indicator of relative risks for yields and prices. The third part estimates the within-farm correlations of yields and prices. In the last part, the regression analysis is performed to estimate the relation of farm revenue and farm characteristics (business and financial).

2. *Method*

Because the variables of interest tend to change over time in a more or less consistent and predictable way, yield and price variables were de-trended to account for technical progress and inflation (Barry et al, 2000, p. 315-318). Price has been de-trended by Paasche equation (Mas-Colell, 1995), using the consumer price index as deflator.

Yields are de-trended by using two main models: linear and multiplicative.

The linear model is defined either by the linear function,

$$y_{qit} = \alpha_{qi} + \beta_{qi1} t + \varepsilon \, , \tag{1.a}$$

the second degree polynomial function,

$$y_{qit} = \alpha_{qi} + \beta_{qi1} t + \beta_{qi2} t^2 + \varepsilon \, , \tag{1.b}$$

or the third degree polynomial function,

$$y_{qit} = \alpha_{qi} + \beta_{qi1} t + \beta_{qi2} t^2 + \beta_{qi3} t^3 + \varepsilon \, . \tag{1.c}$$

all with $\varepsilon \approx N(0, \sigma^2)$.

The multiplicative model is defined also by either the linear function

$$\log(y_{qit}) = \alpha_{qi} + \beta_{q1} t + \varepsilon \, , \tag{2.a}$$

the second degree polynomial function,

$$\log(y_{qit}) = \alpha_{qi} + \beta_{qi1}t + \beta_{qi3}tr2 + \varepsilon \quad , \qquad (2.b)$$

or the third degree polynomial function

$$\log(y_{qit}) = \alpha_{qi} + \beta_{qi1}t + \beta_{qi2}t^2 + \beta_{qi3}tr3 + \varepsilon \qquad (2.c)$$

If the multiplicative method is used, the function can be inverted as: $y_{qit} = e^{\ln(y_{qit})}$

The multiplicative has been used only when heteroskedasticity was found to be present in the linear model (Verbeek, 2002, p. 80). Both the linear and multiplicative models consist of three different functional forms: linear, second and third degree polynomial (equations 1.a–1.c and 2.a–2.c). This method allows for differences in the systematic changes during the period (Oskam, 1991) and provides the best data fit into the model.

where y_{qit} is yield unit of activity q on farm i in year t, α_{qi} is the regression constant for activity q on farm i, t is time ($t=1,.T$), β_{qi} is the systematic change in yield of crop q on farm i over the period (it is assumed that the trend caused by technological change among other things will continue in future), ε is a random error and $tr1$, $tr2$ and $tr3$ are the transformed functions of t, which equal (Murdoch, 1966):

$$trN = t^N - \frac{t^N * t^{N-1}}{t^{N-1} * t^{N-1}} * t^{N-1} - \frac{t^N * t^{N-2}}{t^{N-2} * t^{N-2}} * t^{N-2} \qquad (3)$$

where N can be 1, 2 or 3.

To evaluate the variability of yields and prices within a farm, the coefficients of variation (CVs) are calculated. CV is an indicator of the amount of variability relative to the amount of expected yield or price.

$$CV_{qi} = \frac{\sqrt{s_{qi}^2}}{\bar{b}_{qi}} \qquad (4)$$

where:

- CV_{qi} is a q crop yield or price coefficient of variation of farm i;
- $\bar{b}_{qi}$ is the mean value of crop q yield or price, respectively, on farm i; and
- s_{qi}^2 is the variance of crop q yield or price for farm i.

The variances (s^2), covariance's (Q) and correlations (ρ) of yields and prices are calculated as (Lien, 2002):

$$s_{qi}^2 = \frac{\sum_{i=1}^{n} \sum_{t=c_i}^{d_i} \left(b_{qit} - \hat{b}_{qit}\right)^2}{n-1} \qquad (5)$$

$$Q_i(q,p) = \frac{\sum_{i=1}^{n}\sum_{t=c_i}^{d_i}\left(b_{qit} - \hat{b}_{qit}\right)\left(b_{pit} - \hat{b}_{pit}\right)}{n-1} \tag{6}$$

$$\rho_{qpi} = \frac{Q_i(q,p)}{s_{qi} \times s_{pi}} \tag{7}$$

where:

- $\hat{b}_{qit}$ is predicted regression value for mean output per unit of activity q on farm *i* in year *t*;
- *n* is number of observations per farm;
- c_i is the first year with an observation on farm *i*;
- d_i is the last year with an observation on farm *i*;
- s_{qi}^2 is activity *q* variance of output per unit;
- $Q_i(q,p)$ and ρ_{qp} are covariance and correlation between crops *q* and *p*, respectively on farm *i*.

Degrees of freedom in equations (5) and (6) are (*n*-1), where *n* is the number of observations and 1 is the degree of freedom lost in estimating the time trend.

In addition, farm total revenue is calculated by multiplying the deflated yield and price values for each crop, each then multiplied by the corresponding proportion of cultivated area and summed across crops. Afterwards coefficient of variation of the revenue ($CV(R_i)$) were calculated. Differences in revenue variability between-farm were explained by the following input variables: leverage ratio (*Lev*), variable costs (*VarCost*), farm planted area (*Land*), farm location (*Loc*), farmer's age (*Age*), education level (*Edu*), company type (*ComTy*), relationship between owners (*Rel*), off-farm income (*OffInc*), as presented in equation 8:

$$\text{Var}(R_i) = f(Lev_i, VarCost_i, Land_i, Loc_i, Edu_i, ComTy_i, Rel_i, Age_i, OffInc_i) \tag{8}$$

3. *Materials*

The input data concerning farm business and financial structure were obtained from the Farm Accounting Data Network (FADN) data set. The FADN data are a unique panel data set, which includes crop-level information per farm. For the analysis, 109 arable farms were selected from the 718 available farms with at least seven years of observations in the period 1990-1999 in The Netherlands. The used land area of these farms did not change over the observed period. The farms had grown at least four crops every year during the observed period among the following eight most extensively grown crops in The Netherlands: winter wheat, spring barley, sugar beet, onion seed, carrots, table potatoes, potatoes for processing, seed potatoes and grass seed. There-

Table 1: Description statistics of yield and price of crops

Product	N. of farms	Revenue component	Mean	Std. Dev	Median
Winter wheat	92	yield (kg/ha)	7461	2313	7957
		price (€/kg)	0.18	0.03	0.17
Spring barley	86	yield (kg/ha)	5945	1015	6104
		price (€/kg)	0.17	0.02	0.17
Sugar beet	99	yield (€/ha)	62179	8712	62483
		price (€/kg)	0.06	0.00	0.06
Carrot	26	yield (€/ha)	66829	15212	69452
		price (€/kg)	0.11	0.07	0.08
Potato consumption	64	yield (€/ha)	45623	12968	45254
		price (€/kg)	0.23	0.06	0.23
Potato for seed	44	yield (kg/ha)	36078	5255	36337
		price (€/kg)	0.23	0.06	0.23
Onion for seed	48	yield (kg/ha)	49066	9831	47698
		price (€/kg)	0.10	0.06	0.09
Grass seed	45	yield (kg/ha)	1407	300	1416
		price (€/kg)	1.22	0.20	1.22

fore, farms could have had different sizes, cropping sets and management strategies. The data set included detailed information for these arable crops over time. Prices for the crops were derived at the individual farm level.

The measured components of the farm revenue per crop were yield [kg/ha] and price [€/kg]. The numbers of yield and price observations, their uncorrected means and standard deviations are presented in Table 1. In addition, medians are presented because this measure of central tendency is more robust to errors of extreme data points than means (Pindyck, 2000).

The independent variables of the regression analysis (equation 8) are divided into two parts: the variables describing the business structure of the farm and the variables describing the financial structure of the farm. The variables describing business structure are the following: variable costs, farm regional location, company type, relationship between owners, farmer age and off-farm income:

- The variable costs (*VarCost*) are measured as the sum of the variable costs of all the produced crops on the farm. These costs include storage, transport, energy, pesticides, fertilisers, manure and seeding materials, but not the costs of contract work.
- Land area (*Land*) is a total cultivated land area of the farm.
- Location (*Loc*) is measured by dummy variables.
- Eight main agricultural regions in The Netherlands are included. They are partly based on the soil type and partly on the traditional aspects of farming in that particular area (CBS, 1991). The majority of the farms are from the following areas: *A* (29%), *B* (27%) and *C* (24%). The rest of the farms are

Figure 1: Agricultural regions in The Netherlands

distributed as follows: 11% of the farms are from *D*, 10% from *E*, 4% from *F*, 3% from *G* and 1% from *H* (Figure 1).

- Farmer's age (*Age*) is measured as farmer's year-of-birth. One third of the farmers (30%) was born before 1940, 67% of the farmers were born between 1941 and 1960; the rest (3%) was born after 1961. However, to account for a possible non-linearity effect, this variable is included as a quadratic function of age ($Age+Age^2$).
- Farmer education level (*Edu*) is a dummy variable based on the level of farmer's agricultural education. The majority of the farmers (66%) had a high or secondary level of the agricultural education, some of them (28%) have a lower-level agricultural education, and others (6%) do not have special agricultural education.
- Company type (*ComTy*) is a dummy variable that indicates three main types of the Dutch farming: family farming, association (partnership firm), incorporated firms or limited liability firms. Most of the farms (63%) are family farms, 25% are partnership farms and only 1% are Incorporated or limited firms (Inc. or Ltd.).
- The relationship between owners (*Rel*) is a dummy variable that indicates the type of family relationships within the farm. In the current data set the following family relations are presented: independent manager (58%), fa-

ther with son or son-in-law (28%), brothers or brothers-in-law (6%) and other family relationships (8%).

- Off-farm income (*OffInc*) depicts farm income earned from other sources than farming.
- Leverage (*Lev*) is included as a financial variable measuring farm solvency (Barry, 2001). It is the ratio of total farm debt to farm equity and it measures the farm's total obligations to creditors as a percentage of the farm total equity capital. Since financial information of the beginning and end of the year is available in the data set, the values of farm debts and equities have been calculated as the average of begin-and-end balance of each year (Barry, 2000; pp. 98-114).

4. *Results*

4.1. *Price and yield de-trending*

Prices have been de-trended and applied to further analysis using the price indexes that were calculated based on the data of the Dutch Central Bureau of Statistics (CBS, 1990-2002). Yields de-trending was done by different models (see equations 1-2). Table 2 presents the best-fitting yield de-trending approach for each crop over all the farms. From the table it can be seen that the multiplicative method gives the best fit for winter wheat, sugar beet and onion seed. For the other crops the linear method gives a better fit. The third column of the table includes the number of observations and the goodness-of-fit (R_{adj}^2 and F-test) for each model. The significance of each parameter is evaluated by the t-test statistics. In the case of winter wheat, for example, 2140 observations are used for de-trending. The R_{adj}^2 measure indicates that the function explains 60% of the variation; the F-test value equals 5.00 and is significant at a level of 1%. The regression parameters are reflected by α and β coefficients. They have also been tested at the 1% significance level using the t-test. Since the multiplicative method has been used for de-trending of this crop the α-value should be inverted (footnote of equation 2) to reflect the real value. So, farmers have a de-trended production of winter wheat of 5,540 kg/ha constantly.

4.2. *Revenue components estimation*

Because it is impossible to present all 109 variance-covariance matrixes (one for each farm), we choose to present the mean values of the correlation matrix and coefficients of variation (Table 3).

4.2.1. *Coefficient of variation*

On the diagonal of Table 3, the coefficients of variation (equation 4) are presented. It can be seen that the within farm CV of wheat yield, for example, over the period 1990-1999 equals 0.34. The CV values of winter wheat, carrot

Table 2: Results of yield de-trending

Product	Type of function	Statistical properties	Estimated parameters α	β_1	β_2	β_3
Winter wheat	third degree orthogonal polynomial	n=580 R_{adj}^2=0.60 F=5.00 p<0.01	8.62 p<0.01	0.13 p<0.01	-0.02 p<0.01	-0.001 p<0.01
Summer barley	linear	n=320 R_{adj}^2=0.56 F=4.70 p<0.01	7297.55 p<0.01	61.84 p<0.03		
Sugar beet	quadratic orthogonal polynomial	n=625 R_{adj}^2=0.60 F=5.70 p<0.01	11.2 p<0.01	-0.06 p<0.01	-0.004 p<0.01	
Carrot	third degree polynomial	n=96 R_{adj}^2=0.45 F=2.54 p<0.01	128826.61 p<0.01	-26379.67 p<0.01	4366.19 p<0.01	-246.07 p<0.01
Potato (for consumption)	quadratic polynomial	n=375 R_{adj}^2=0.49 F=5.02 p<0.01	41194.83 p<0.01	3339.79 p<0.03	-399.90 p<0.03	
Potato (for seed)	quadratic polynomial	n=284 R_{adj}^2=0.44 F=4.20 p<0.01	26171.42 p<0.01	567.45 p<0.01	-43.83 p<0.01	
Onion seed	Orthogonal linear	n=170 R_{adj}^2=0.52 F=3.92 p<0.0001	10.78 p<0.01	0.01 p<0.05		
Grass seed	third degree orthogonal polynomial	n=233 R_{adj}^2=0.42 F=3.09 p<0.01	6.84 p<0.01	-0.06 p<0.01	0.02 p<0.01	0.002 p<0.01

and consumption potato are lower. The corresponding values are 34%, 29% and 27%, respectively, while the CV values for most other yields are below 25%. The CVs of prices are more widely dispersed: with extremely low values for sugar beet (2%) and extremely high values for carrot (134%) and onion seed (70%). The rest of the CVs price values are around 20%.

4.2.2. *Correlation values*

Yield-price correlations: Above the diagonal of Table 3, the correlation coefficients are presented (equation 7). There are 41 significant correlation coefficients from the possible 64. The table shows that, for example, the correlation between yield and price of wheat is –0.05. Only negative correlations between yield and price of the same crop were found. These results illustrate an inverse relation between yield and price within crops: increases in the expected yields of

Table 3: Correlation matrix (off diagonal) and coefficient of variation (diagonal) including all farms

Coefficient of variation		**Wheat**		**Barley**		**Beet**		**Carrot**		**Potato cons.**		**Potato seed**		**Onion seed**		**Grass seed**	
		yield	price	yield	price	yield	price	yield	price	yield	price	yield	price	yield	price	yield	price
Wheat	yield	0.34	**-0.05**[a]	**0.33**	**0.11**	**0.31**	-0.02	0.15	-0.16	**0.27**	**-0.14**	**0.27**	**-0.26**	**0.15**	**-0.50**	0.35	**-0.19**
	price		0.15	**-0.07**	**0.98**	**0.34**	**-0.58**	**0.28**	-0.19	**0.19**	**-0.31**	-0.01	**-0.17**	0.05	**-0.18**	0.13	-0.07
Barley	yield			0.17	**-0.03**	**0.37**	**-0.12**	0.18	**-0.33**	**0.22**	**-0.23**	**0.20**	**-0.26**	**0.26**	**-0.42**	0.08	0.06
	price				0.16	**0.27**	**-0.42**	0.19	0.01	0.12	**-0.30**	**-0.22**	**-0.28**	0.02	-0.12	**0.18**	0.08
Beet	yield					0.15	**-0.32**	**0.25**	**-0.24**	**0.46**	**-0.31**	**0.26**	**-0.32**	**0.32**	**-0.14**	**0.16**	**0.14**
	price						0.04	-0.04	0.16	**-0.30**	**0.69**	-0.10	**0.41**	**-0.18**	**0.31**	0.02	-0.03
Carrot	yield							0.29	**-0.44**	0.15	-0.24	0.09	-0.14	**0.30**	**-0.33**	**0.42**	-0.09
	price								1.34	-0.14	**0.28**	-0.12	**0.44**	**-0.31**	**0.33**	**-0.56**	**0.52**
Potato cons.	yield									0.27	-0.38	**-0.29**	**0.33**	**0.50**	**-0.36**	0.03	-0.01
	price										0.24	**-0.27**	**0.55**	**-0.35**	**0.37**	-0.15	0.01
Potato seed	yield											0.13	**-0.29**	**0.25**	**-0.31**	0.11	0.04
	price												0.20	**-0.47**	**0.50**	0.02	-0.06
Onion seed	yield													0.22	**-0.38**	0.14	-0.09
	price														0.70	-0.03	0.07
Grass seed	yield															0.21	**-0.40**
	price																0.22

[a] The correlation coefficients that are different from zero at a significance level of 5% or less are written in **bold**.

these crops are associated with decreases in their respective prices. On the whole, cereals have the lowest correlation values compared to the other crops. The yield-price correlation values of other crops vary from the lowest value of potato seed (-0.29) to the highest value of carrot (-0.44). The reason of the positive yield-price correlations between different crops (8 from the significant 34) could be that yields and prices of these crops are affected by the same weather and market conditions. The rest of the significant correlations were negative.

Yield correlations: As it can be seen from the table, positive yield correlations between different crops are observed in most cases (18 from possible 19 significant). For example, yields of wheat and barley have a positive correlation of 0.33. The results indicate that crops are subjected to the same production and weather influences: a high yield of one of them is associated with a high yield of another one. Only one negative significant correlation value is observed between yields of table potato and seed potato.

Price correlations: There are 11 positive price correlation coefficients between different crops from possible 18 significant values. For example, winter wheat price is highly positive correlated with summer barley price (0.98). Negative correlations are found between all possible pairs of the prices of cereals and sugar beet, cereals and consumption potato and cereals and potato seed. There is also a negative correlation between the prices of onion seed and winter wheat. Other significant correlations were positive. Possible price correlations indicate that crop prices are subject to the same market conditions.

Table 4: Regression results of farm revenue variability estimation

Variables	Coefficients	t-value	Significance[(a)]
Intercept	-628.94	3.57	**
Lev	-2.61	-2.06	**
OffInc	-0.14	8.88	**
VarCost	2.99	13.22	**
Land	-2.45	-3.39	**
Age	-0.02	-4.34	**
Loc A	2.23	-3.37	**
Loc B	4.26	1.65	*
Loc C	-14.83	1.93	*
Loc D	-19.21	-6.13	**
Loc E	-4.78	-3.83	**
Loc F	5.70	0.25	
Loc H	-6.37	-0.68	
Edu			
Low-level education	0.22	2.60	**
ComTy			
Association	-7.17	-3.56	**
Inc or Ltd.	2.42	1.93	*
Rel			
No relation	2.05	4.62	**
Other family relation	2.04	0.95	

[(a)] * indicates statistical significance at 5% level; ** at 1% level

4.3. *Farm revenue variability estimation*

A summary of the regression analysis (Equation 8) is provided in Table 4. The F-statistic of the model was significant at the 95% confidence level and the coefficient of determination R_{adj}^2 equaled 75%. The significance of the coefficients was estimated by the t-value at a significant 5% level or less. A highly educated farmer with son (father-son family relation) managing an independent farm (as a company type) in the region G was chosen as the reference group. From the results of the farm revenue CV estimation it can be seen that the leverage ratio had an inverse relation to the total farm revenue variability: farms with greater solvency had lower revenue CV while farms with relatively greater obligations to creditors had a lower CV of revenue. The same held for the land area and off-farm income. Thus the higher the proportion of the land area and off-farm incomes, the lower the revenue variability could be expected to be.

High variable costs were associated with higher farm revenue variability. Farmer's age had an inverse influence on revenue variability: older farmers had less variable revenues. As can be seen, the majority of farm location dummy-variables were significant in the model and had considerable influence on the revenue variability. Farmers with a higher education level had slightly lower CV of revenues than their less educated colleagues. Concerning the company type, family farms had more stable revenues than partnerships or farms with managers. The variable for relationships between owners indicated that brothers had higher revenue variability, while father-son and other types of family-based farms had less variable revenues.

5. Conclusions

In this paper Dutch crop revenue variability is considered from two different points of view: within a farm and between farms. The within-farm analysis focussed on revenue components. The results indicate that it is important to estimate the correlation structure on the individual farm level, since there is a considerable difference between the farms. For instance, positive yield and price correlations were most common at the farm-level basis of the aggregated data set. However, in a number of cases, negative correlation values between yield and price of the same crops were observed at the farm-level; this demonstrates the importance of knowing the farm specific situation in optimising risk management decisions.

Between-farm analysis quantified the relation between business and financial variables on the one hand and revenue variability on the other hand. A significant relationship between revenue coefficient of variation and farm structural characteristics is found in our survey. The leverage ratio, off-farm income, and land area all tended to reduce farm total revenue variability: larger values of these variables were shown to be associated with lower values of revenue variability. Also farmer's age had an inversely relation with the revenue variability. This regression coefficient is quite low, but it has a significant influence on the model. A slight positive relation of education level at the model is observed: better-educated farmers have less variable revenues.

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PART TWO

RISK POLICIES FOR ECONOMIC DEVELOPMENT

The Use of Futures and Options to Insure Wheat Import Price Risks by Low Income Food Deficit Countries

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Abstract

The paper considers the problem of insuring the price risks of wheat imports of low income food deficit coutnries (LIFDCs), as a way to insure one part of their external commodity risks, and a contribution to their sustainable development. Econometric analysis of wheat import unit values of LIFCDs suggests that they are closely related to international wheat export reference prices. These in turn are closely related to the Chicago Board of Trade (CBOT) futures prices, suggesting that CBOT is a good hedging market for all wheat importing countries. Simulations for a set of LIFDCs that account for a large share of the LIFDC wheat imports are conducted for the periods 1995-2002 and 1986-2002 with actual CBOT futures and options data to explore the feasibility of hedging monthly wheat imports of LIFDCs. It is shown that rules based on futures as well as options provide considerable opportunities for hedging. It is also shown that pooling the price risks of all countries together provides superior hedging opportunity. This suggests that multilateral arrangements to hedge LIFDC cereal import price risks maybe viable, and maybe a crucial contributor to overall sustainable development strategies.

1. *Introduction*

Sustainable development implies that development efforts and growth are not interrupted by unforeseen events and crises. However, it is exactly such unpredictable events that many times oblige governments to focus on short run management of the crises, and abandon longer term development strategies. It is for this reason that management of external and internal shocks is important for sustainable development. Developing commodity dependent countries are particularly vulnerable to this kind of boom and bust, and it is for this reason that the issue of commodity market instability has been prominent in international development debates.

Given the unpredictability and large price variations of internationally traded commodities, and given that many developing countries depend on them for foreign exchange, as well as food imports, there has been a long history of discussions, research, proposals, and actions concerning measures to alleviate the adverse consequences of such risks. Such discussions seem to resurge with greater force every time there is either a major world commodity boom or slump. Despite, however, the long standing concerns and discussions, and several actions aimed at dealing with the problem, the risks faced by developing countries seem to be as large today as they were 50 years ago.

Agricultural producers around the world are exposed to a variety of income uncertainties, both market related, such as price variations, as well as non-market related, such as unstable weather patterns. It is well known that such uncertainties induce substantial income risks, and these can be particularly detrimental to small and/or poor producers in developing countries. It is also well known that farmers have developed several ways for dealing with the various risks they face. The consensus, nevertheless, appears to be that despite the variety of risk management strategies adopted by poor households in developing countries there is substantial residual income and consumption risk.

Recent empirical evidence suggests that commodity price instability is detrimental to overall macroeconomic growth (Collier and Dehn, 2001; Dehn, 2000). This implies that countries need to manage their trade related commodity risks, if they are to ensure sustainable development. The provisions of safety nets or insurance mechanisms is thus crucial to poverty alleviation, as well as growth.

That commodity dependence is important for several countries is not in doubt. There are more than 50 developing countries that depend on three or fewer commodities for more than half of their export earnings. All Highly Indebted Poor Countries (HIPCs) depended in 1997 for more than half of their merchandise export earnings on commodities.

The first best way for any entity to deal with ex-ante unpredictable commodity risks is to establish a risk management or insurance strategy. Individual agricultural producers the world over seem to do this either through formal or informal channels, and depending on the instruments and possibilities available to them. These developments have changed drastically the risk management strategies of developed country commodity dependent entities. Apart from few exceptions, however, there has been minimal use of market based risk management instruments by developing country entities. The major problem of low income commodity dependent countries (LICDC) are not price or quantity variations per se, but rather major unforeseen and undesirable departures from expectations.

There have been two main ways through which commodity dependent countries and donors, as well as the international community, have attempted to deal with commodity market instability. The first concerns attempts at direct intervention in the commodity markets with the purpose of altering the price distribution of the relevant commodities. This group of efforts includes all the various international commodity agreements, national and international buffer stock schemes, and various other mainly national efforts aimed at production control. While most of the international commodity agreements have failed (Gilbert, 1996), and are currently not in the international agenda, there are still many national policies that attempt to control domestic agricultural commodity markets in many developing as well as developed economies.

The second way that has been employed to deal with commodity market instability is through ex-post compensation to those countries whose export earnings or import bills were adversely affected by commodity market fluctuations. Prominent among these schemes are the European Union's (EU) STABEX and SYSMIN instruments aimed at the ACP[1] countries. The other such existing scheme is the International Monetary Fund's (IMF) Compensatory and Contingency Financing Facility (CCFF).

The underlying rationale for compensatory schemes like STABEX is the belief that unanticipated undesirable shocks to export earnings (negative shocks) of a low income developing country destabilise government budgets and investment expenditures, as well as the real incomes of producers of the relevant commodities, and hence are detrimental to growth. Thus, the compensation was given primarily to governments of ACP countries experiencing adverse shocks, with the idea that the governments would utilise the funds for compensation of producers, or development of the relevant sector, or other related development needs. The compensation under STABEX has covered agricultural, fishery, and forest products, but not commodities of importance to EU producers. Hence the STABEX has not covered all developing countries that are heavily commodity dependent for export earnings, and not all the products of the eligible countries. On the import side, the IMF's CCFF has provided only loans, and not transfers.

Given the inadequate performance of most stabilization and ex-post compensation schemes, there is a need for new approaches to dealing with commodity price risks. The purpose of this paper is to contribute to this need, by examining the feasibility of hedging the cereal import price risks of food import dependent low income developing countries, using modern market based risk management instruments.

A recent FAO study (Gürkan, Balcombe and Prakash, 2003) has indicated that between the mid-1980s and 1990s, the least developed countries (LDCs[2]) were under economic stress when importing the food they needed to maintain their national food security. The food they imported gradually reached, on average, about 12 percent of their apparent food consumption by the end of the millennium. While this is not necessarily bad, as it maybe due to domestic production restructuring along comparative advantage lines, the study showed that

[1] This group is composed of 77 developing countries that were formerly colonies of various EU member States.

[2] There are 49 developing countries, currently classified by the World Trade Organization (WTO) as well as by the United Nations as "Least Developed"

throughout this period, the growth in these countries' commercial food import bills consistently outstripped the growth of their GDP as well as total merchandise exports. Relief was at hand only during the past few years, when international prices of many food commodities reached historical lows because of a confluence of diverse factors. The study has also revealed that these countries have faced large and unanticipated price 'spikes' that exacerbated their already precarious food security situation. Indeed, it was discovered that variations in import unit costs of many important food commodities contributed to around two-thirds of the variation in their commercial food import bills. Coupled with substantial declines in food aid flows over the same period, these developments have meant significant increase in the vulnerability of these countries.

In light of the above developments, it seems that the problem of managing the risks of food imports is increasing in importance, and is already a major issue for several low income food deficit countries (LIFDCs[3]).

The issue of food import risk for LIFDCs has been discussed extensively for some time, especially since the commodity crisis of the early 1970s, and several proposals for international food insurance schemes have appeared (for an early review see Konandreas, et. al, 1978). The issue of financing of food imports by LIFDCs figured prominently in the discussions leading to the Uruguay Agreement (which, among other things, led to the creation of the World Trade Organization, WTO), and gave rise to the "*Decision on measures concerning the possible negative effects of the reform programme on least-developed and net food-importing developing countries"***,** also known as the Marrakesh Decision. In the Marrakesh Decision, Ministers recognized "that as a result of the Uruguay Round certain developing countries may experience short-term difficulties in financing normal levels of commercial imports and that these countries may be eligible to draw on the resources of international financial institutions under existing facilities, or such facilities as may be established, in the context of adjustment programmes, in order to address such financing difficulties."

Pursuant to the Marrakesh Ministerial Decision on Measures Concerning the Possible Negative Effects of the Reform Programme on Least-Developed and Net Food-Importing Countries, 17 net food-importing countries made a proposal for the establishment of a "revolving fund" to ensure that adequate financing is available to LDCs and NFIDCs during times of high world market prices. However, this fund requires resources, which may not be available from donors.

Food import risks have not been a big part of the recent policy debate, both internationally as well as nationally. The reasons are several. First, there have been ample supplies of basic foods commercially available for export from de-

[3] According to the FAO definition, that is also used by the rest of the United Nations, there are currently 86 developing countries that are classified as low income food deficit countries. This list is updated annually.

veloped and other cereal exporting countries, at prices that have been secularly declining. Second, despite the fact that there have been some price spikes in recent years, the crisis situation of the early-mid 1970s has not occurred since then. Third, food aid, while declining, has continued to flow, alleviating many of the immediate concerns.

Nevertheless, there is a range of new problems and issues that are arising, which suggest that the issue of food imports may loom large in the near and medium term future. First, given the secular decline in prices of many primary commodities on which several LIFDCs are dependent for export revenues, these countries are becoming increasingly unable to meet commercial food import demands, despite secular declines in the prices of basic foods. In addition, and given simultaneous dependence on commodity exports, price instability is becoming a problem not only on the export but also on the import side. As different commodity prices do not move together, the likelihood of high import prices, in the face of low export prices, is real, and presents new challenges for policy. International price volatility has not declined, and if anything has remained at high levels.

Second, given the abolition or restructuring of many domestic food marketing bodies, domestic food prices in many countries have become very volatile, and the price variations, especially seasonal ones, have been larger in many cases than international ones, reflecting weaknesses in domestic marketing structures, and lack of adequate transmission. At the same time, surges in cheap food imports of basic foods have on occasion created difficult situations for many developing country producers. This suggests that the link between food imports and domestic food markets is not a perfect one, and can be problematic in cases of international price spikes, as well as severe domestic production shocks.

Third the increased volatility of domestic food markets may lead to irreversible effects on domestic production but also nutrition in many countries. This because not only production structures may change, but also investments, migration, and food consumption patterns maybe affected. The effects of domestic and international price volatility have macroeconomic dimensions and impacts in commodity dependent countries. These are becoming even more so in countries that depend on food imports.

Fourth, the liberalisation of domestic markets, and the continuing instability of international markets, creates considerable risks for LIFDCs, which, unless dealt with, can lead to food insecurity and increased vulnerability of the poor. However, the development of a variety of risk management instruments in international markets, such as futures and especially options for basic food commodities, presents opportunities for managing the risks that LIFDCs face in a more organised and cost effective manner.

It thus becomes important to examine whether there are nationally based strategies to deal with the food import risk management problem. This paper deals with this issue, by examining how a number of LIFDCs would have fared in the past, had they adopted easy to implement, market based risk management strategies. Such an approach has been suggested before by Sarris (2000 and 2003b), but in his simulations he used insurance rules based on cash prices and not on actual futures or options prices.

The only other paper in the literature to deal with a similar issue with actual futures prices is the one by Faruqee, Coleman and Scott (1997). In their analysis of Pakistan's wheat imports, however, they utilized data for only one year, and this opens their analysis to the criticism that their positive results (which favoured the use of financial instruments) could have depended on the specificity of the particular year, or the particular import pattern of that country. Furthermore, they only used a particular hedging rule, and did not explore alternatives.

In this paper we consider the wheat imports of several of the major LIFDCs, and examine in a counterfactual manner, the possible benefits or losses that they could have incurred over a past period of time, had they combined their cash imports with easy to apply and transparent hedging strategies, using futures and options. We use actual import as well as futures and options data to implement the simulations, and explore a variety or rules.

Section 2 below discusses some issues concerning food imports of developing countries. In section 3 the methodology of the analysis, as well as our data are presented. In section 4 we explore econometrically the world wheat market and in particular the relationship between the import prices of the selected countries, and the reference international prices, as well as the prices in Chicago, the largest futures and options market in the world. In section 5 we present the results of our simulations for individual countries, while in section 6 we explore results when all countries are pooled together. In the final section we summarize our results and the policy conclusions.

2. *Issues relevant to food imports of LIFDCs*

In the context of the WTO discussions concerning follow-up to the Marrakesh Decision, the WTO fourth Ministerial Conference in Doha, established an Inter-agency Panel[4] with the objective, among others, *".to explore ways and means for improving access by least developed and net food importing developing countries*[5] *to multilateral programs and facilities to assist with short term difficulties in financing normal levels of commercial imports of basic foods.*". This panel has produced a report in June 2002

[4] The agencies represented include the World Bank, the IMF, the International Grains Council, FAO, and UNCTAD.

[5] The WTO group of net food importing developing countries (NFIDCs) comprises 22 developing countries that are WTO members. While most of these countries are also in the FAO group of 86 LIFDCs, the large difference is due to the fact that many LIFDCs are not WTO members.

(WTO, 2002). In the same context FAO has sponsored a study carried out by UNCTAD to explore the mechanisms for financing imports of basic foodstuffs (FAO, 2003).

The FAO study contains an extensive discussion of the current state of food import trade by developing countries. It notes that while state entities still play a very important role in the export of some basic foods in some LIFDCs, food imports have been mostly privatised in recent years, although there are exceptions, and in some countries state agencies operate in alongside private importers.

The biggest problem highlighted by the report is that private traders in LIFDCs do not always have access to import finance, unless they are part of an international group. Furthermore, financing conditions for food imports differ considerably across countries and products. Since credit relations involve the issues of who provides the finance, and who takes the risk, credit relations and hence food imports can be constrained by finance capacity as well as risk-taking capacity. It is pointed out that in both areas there are severe constraints in developing countries. These may imply higher interest rates for food import financing, and a disproportionate shift of the burden of risk to developing countries, if there is limited risk bearing capacity between developed country financiers and developing country counterparties as well as between developing country banks and their local trading clients. Both constraints imply smaller food imports with direct consequent implications for domestic food availability, and domestic prices, as well as food security. The report suggests that the major constraint is risk bearing capacity, rather than absolute lack of finance. There appears to be no empirical study to date of how credit and risk bearing capacity constraints affect the level of food imports in LIFDCs.

The major problem with risk, is that developing country private clients, whether they are importers or banks, are generally considered as risky counterparts by developed country traders and banks. It is in this context that the notions implicit in this paper and earlier ones must be examined. While in Pakistan's case examined by Faruqee *et al.* (1997) it was government agencies that did the importing, and hence straightforward to examine hedging strategies by them, in the case of LIFDCs whose food import trade is all in private hand, one must think of which could be the agency implementing the risk management strategies that are analysed here. It will certainly not be the individual traders, as these in most cases are too small and credit constrained to do it. It must rather be some financial branch of the government, such as the Central Bank, or some other relevant public financial institution on behalf of either the ministry of agriculture, or some similar authority responsible for the smooth flow of domestic food supplies. If it is a central or other publicly controlled bank, then the hedging strategies outlined here could be visualized as financial hedging strategies by the financial institution in its provision of credit to the domestic food importing agents (private as well as public). As the relevant domestic credit would be directly linked to imports, the hedging strategies can be viewed as basic financial risk management by the financial institution extending or guaranteeing such credit. It is in such a context that the simulations and analysis presented here must be viewed.

The report of the Inter-Agency panel (WTO, 2002) in fact recommended (page 35) that futures and options be used to reduce the risk of food importers, with the idea that this could protect consumers could be protected in this fashion by world market price increases. However, the panel did not examine relevant strategies, or their potential in terms of gains from standard trading practices.

3. *Methodology, assumptions, and data*

Consider either a food importing authority of a developing country, or a corresponding financing authority, which extends financing, or guarantees financing for all the food imports of a country. For the sequel we will not be concerned with the particular institutional character of the agent that does the financing or guarantee, or imports for that matter. We will refer to an "agency" as the institution that does both the actual importing as well as the hedging, knowing fully well that in an actual country situation, the relevant import related and financing functions may be split among various institutions. This assumption is made, in order to concentrate on the hedging strategies, rather than on the specific institutional arrangements in any food importing country.

A narrowing of the analysis will be made by concentrating only on wheat imports. The reason is practical, as well as related to our resource constraints. Wheat is one of the widely traded cereals, has well established cash, futures and options markets, and is imported by many LIFDCs. Of course, many LIFDCs import more than just wheat. Depending on the country food imports may include maize, rice, other cereals, as well as other staples. It is not clear, whether there is any short term substitution between the various types of food imported by a given country. In any case we will examine the wheat part of food imports only, assuming implicitly that the presence of the hedging would not affect the short term quantities imported of wheat. This, of course, may not be correct, as the capacity to manage risks better may increase the possibilities as well as the amounts of food imports. This, however, is beyond the objectives of this paper.

The problem posed is the following. In the course of a year, the agency will need to import certain amount of wheat for delivery to the country's border in given months. We shall assume that the agency knows the amounts to be imported in every month several months ahead. This assumption is necessary in order to justify the need for hedging. If this knowledge is available only with a short lag, say one month, then there is no point in hedging, as it normally takes about a period of about more or less one month or so (depending on the distance, other trade related specificities etc. between the exporter and the importer) from the actual ordering of some wheat, until the shipments arrive at the port or entry point of the importing country. Hence in such a case the optimal strategy would be to order only on a cash basis. However, in most countries, the total requirements or demand for cereal and other food imports, as well as the likely pattern of imports, will be known some time in advance by traders, as well as other market participants, especially after domestic production conditions become clear. Of course, the assumption is not perfectly valid, as the monthly requirements may not be exactly known many months in advance. In such a case, of course, the optimal hedging strategy maybe to hedge a smaller amount than the "forecasted" or "expected" amounts. As we do not have any estimates or data on the forecasted, or expected amounts imported in given months, we will assume that the actually observed imports were known perfectly some months in advance.

For our analysis we chose out of all the LIFDCs, eleven that have been the major wheat importers over the past 20 years, and with a view to geographical representation. These are in alphabetical order, Bangladesh, China, Egypt, India, Indonesia, Mozambique, Nicaragua, Pakistan, Philippines, Sudan, and Tanzania. Between them they accounted for 54 percent of the wheat imports of all LIFDCs in the period 1980-2002. These countries are indicated in table 1, along with statistics indicating their wheat importing shares relative to that of all LIFDCs as well as the world.

Consider now the problem of insuring the price risk for the amounts of wheat that are known will be imported some months ahead. The method that will be studied is transactions through futures or options. The futures are cheaper than options, but options are better as they provide one sided insurance. The objective of the study is to simulate a variety of rules, to examine whether the private markets could have offered in the past possibilities for price insurance by LIFDCs.

The data available to us is the following. First we know the actual imports of wheat for all LIFDCs on an annual basis (both calendar as well as crop (July-June) crop year) for a period going back to the 1960s. Secondly we have monthly wheat import data for all LIFDCs by origin of imports since 1995 from the International Wheat Council (IWC). Our actual wheat futures and options data is obtained from the Chicago Board of Trade (CBOT) and is daily from 1986. Our analysis will simulate the insuring actions of the agency. This will involve buying futures or call[6] options at a given point in time, ahead of the

[6] A call option on wheat gives the buyer the right but not the obligation, to buy a certain amount of wheat (specified in the standard option contract) at a given prespecified "strike" price. The buyer pays a price for this right, the option price. If the actual price of wheat at the time of the "exercise"of the option, is above the strike price the option holder gains the difference, while if the actual price is below the strike price the option holder gains nothing, and will not exercise the option, and loses the amount paid for the option in the beginning. In actual markets the right

physical wheat contracting, and selling them at some later point, namely when the actual physical transaction for wheat imports is concluded.

The actions of the agency will try to insure the price risk of its physical purchases. It will be assumed that the cash orders for wheat imported in a given month are placed one month in advance. This appears reasonable in light of the norms of the trade. This implies that the prices at which wheat imports will be valued and eventually paid, are prices of one month ahead of the actual physical arrivals at the border.

In order to implement the simulations, given that we have all the daily data available for futures and options the agency must decide on the rules to follow. The following parameters must be specified.

- The day of the year on which the contract (future or option) is bought
- What contract to buy (namely for which month to buy a future or option contract).
- How much quantity to buy of the contract.

In addition in the case of options the decision must be made at what strike price to buy a call option.

We will simulate the following types of rules (strategies)

Rule 1. Hedging only with futures contracts

Under this set of rules, basically similar to what Faruqee did, we assume that the agency buys futures 3,6,9 and 12 months in advance of the date when it needs to contract the actual delivery. This actual contract date is assumed to be one month before the needed monthly physical import delivery as per the seasonal trend needs, which as indicated above we assume are known. In other words suppose that according to the needs, the importing agency needs to physically import 100 000 tons of wheat in December. This implies that the physical quantities must be ordered one month before. Hence the actual contract for physical delivery in December will have to be placed in November, and this implies that the price at which the transaction will be made, and the payment made (or the loan obtained) is the November price. Hence the need is for hedging the November transaction and payment. Under the 3 month rule indicated above, the agency will buy futures contracts for amounts totaling 100 000 tons in August. The futures contract at which the futures transaction will be made will be the one traded as close to (and after) the date of needed purchase as possible. In the example here, the actual forecasted transaction is in November, and the nearest traded futures contract is the December contract,

is not for a physical amount of wheat, but for a futures contract usually traded in the same market. This then makes the option contract a "derivative" contract, as its value "derives" from the value of the underlying futures contract. However, as futures markets, especially for cereals are hedging markets for the physical traders, the futures markets are closely related to the real markets.

hence the agency will buy December wheat futures in August (namely in the 11-3=8th month), and sell it in November. Under the six month rule the agency would purchase the December future in May (11-6=5) and sell it in November, and so on for the for the 9 month and the 12 month rules.

It will be assumed that the agency can buy futures contracts for the exact amount that it will need to import. This is an approximation as the actual futures contracts are available only for fixed lump amounts (for instance the standard CBOT wheat futures contract is for 5000 bushels[7] or about 130 metric tons) but it is possible through brokers and traders to obtain futures for whatever amount the agency may wish, for a small extra fee.

Once the month of purchase is agreed the agency must decide the exact day in the month which it will make the transaction (both purchase and later sale). For the simulations reported below it has been assumed that this is the day closest to the middle of the month. For sensitivity analysis we also assumed alternatively that the transactions take place in the beginning of the month, and at the end of the month. The same strategy is applied month after month. It is finally assumed that the cost of buying or selling futures is 0.15 $ per ton, just as was assumed in Faruqee et. al. (1997).

Rule 2. Hedging with options

The simulation under this scenario will involve examining how the examined LIFDC would have fared if it had followed hedging its past imports with call options.

Everything that was said above for futures concerning the dates at which the contracts are bought and the dates of expiration, also holds for the simulations with call options. The only difference is that in this case the strike price also has to be determined. The rule here is that the strike price will be parameterized as $(1+a)\ p^f_{t,t+k}$ where $p^f_{t,t+k}$ denotes the futures price observed in month t for the nearest month after the period $t+k$ when the actual transaction will be made (k can be 3,6,9,12). As indicated above the future contract chosen is for the month closest (but after) the month in which the actual order of the wheat will be made. The parameter α is the proportion above this future price for which insurance is sought. Hence if $a = 0.1$, the call option bought implies that if the future price goes above 1.1 times the current future price (namely the strike price), then the difference between the actual higher futures market price and this strike price will be paid to the buyer of the option, namely the agency.

In the simulations the calculations involve two steps. The first is the calculation of the net gain or loss associated with trading in futures and call options; the second is the comparison of such net gain (or loss) with a commercial wheat import bill for each of the eleven countries, chosen.

[7] In CBOT one bushel of wheat is 36.7437 kg

The first step was based on data retrieved from the archives of the Chicago Board of Trade (CBOT), and particularly on the daily data for the settlement prices of futures contracts, for the strike price of call options, and for the related premium. For options, in each relevant trading day a net gain (loss) was calculated by considering firstly the difference between the strike price as indicated above, and the nearest futures settlement price. When this difference turned out to be positive, the net gain (or loss) was calculated by deducting the options price that was paid initially from it, while if the difference is null or negative, only the options price is accounted as a loss. In other words, given that N is the net gain or loss, P_s is the strike price of the call option, and P_{NF} is the nearest available future settlement price, and PR is the price of the call option, the calculation was based on the following condition

$$N = \begin{cases} (P_{NF} - P_S) - PR & for(P_{NF} - P_S) > 0 \\ -PR & for(P_{NF} - P_S) \leq 0 \end{cases}$$

Net gains and losses were calculated for different hedging rules, that were defined in terms of the time horizon of the future contract (the k in the earlier discussion), in terms of the parameter α, and in terms of three alternative trading dates, namely at the beginning of each month, around the 15th of each month, and at the end of each month. Each hedging rule was calculated with reference to one of these three trading days of each month. The rules are transparent and easy to apply.

An example is in order. Suppose that in a given trading day of the 8th month of the year, namely August 15th, the agency purchases a call option with α = 0.1 and k = 3. This means that the call option expires in November (month 8+3), when the actual contract for the physical wheat shipment that is to be delivered in December will be made. Suppose that in August 15, the December future is quoted at 90.9 (say US Dollars per ton, although the actual quoted price is in cents per bushel). With α = 0.1 the desired strike price at which the call option will be bought is P_s = 100 = (1.1 times 90.9). As in the actual options market options are not available for all strike prices, the actual strike price at which the call option is bought is the one quoted that is nearest to the desired price of 100. Assume that this is 98.0. Suppose that the cost of buying this call is PR= 12.0. The calculation of gain undertaken examines the December future price on November 15 (we take the settlement price on November 15 or the nearest trading day to November 15). Suppose that this price has moved upward beyond expectations, to P_{NF} = 120. In this case the option will be exercised, and the net gain will be N= (120 - 98) - 12 = 10. Suppose now that price growth expectations have not fully materialized, so that the December future on November 15th has only reached P_{NF} = 95. In this case the option will *not* be exercised, and the net loss accounted for will be N= - 12.

In the second step of the simulation, we compare the net gains and losses, with the actual cost of imports. This is calculated by assuming that the actual imports are contracted at a price which is a weighted average of the three monthly reference world export wheat prices, namely the export unit values of wheat in Australia, Argentina, and US Gulf. The weights are the shares of imports that are obtained from North America, South America and Oceania respectively that are available from the detailed monthly data that we have from the IWC. The monthly export price data was retrieved from the IMF's International Financial Statistics.

It should be underlined that this is an approximate and theoretical wheat import bill that was built up exclusively to compare it with the cost implied by the importation of the same amount while hedging price risks in the CBOT. In other words, what matters here is the size of the net gain or loss that could have been made by the selected countries should they have hedged price risk with futures or options over the sample period, relative to the cost of importing the same amounts in the same period through purely commercial transactions. Clearly the cost of transport is not included in the calculations of the reference cost of imports.

4. *Price relations between border prices and world reference as well as Chicago prices*

The previous section discussed the methodology of simulations of wheat import hedging strategies, but did not delved into the question of whether the Chicago wheat market is an effective hedging medium for the wheat importing developing countries. The objective of this section is to examine whether the Chicago Board of Trade futures prices and hence those of the related options are indeed effective reference prices for hedging wheat imports of the selected developing countries. To this end, the transmission of price signals is first analyzed between the wheat import unit values of the selected countries and three world reference prices for the same commodity, namely the US Gulf price for hard winter ordinary no 2 wheat, and the export unit values for Australia and Argentina as reported in the IMF International Financial Statistics. Subsequently, the relation between these three world reference prices and the future settlement prices published for wheat by the Chicago Board of Trade is analyzed. As will be shown, all the examined prices show a considerable degree of common movements in the long run, albeit less so in the short run.

All price series utilized are reported or transformed into common units, namely US$ per metric ton, in order to abstract from effects of exchange rate movements. Furthermore, all prices analyzed were utilized in their logarithmic transformation. This was done, so as to be able to interpret estimated parameters as price transmission elasticities.

Data for import unit values of all LIFDCs are available from FAO on an annual basis (both calendar since 1960, as well as in July-June crop year terms from 1980). The reference prices utilized are in monthly terms, hence both calendar and crop season averages can be computed. The relation between annual border prices and the three world reference prices was first analyzed with a pooled time series-cross section regression using calendar year prices. All the countries' import unit values were regressed on the reference prices by including country specific effects according to

$$pd_{it} = \alpha + \beta T + \gamma pw_t + \sum_{i=1}^{I-1} \delta_i D_i + \varepsilon_{it} \tag{1}$$

where *pd* are the countries' (log) import unit values in time t, *pw* is the (logarithm of the) world reference price (which will be one of the three reference prices indicated above), D_i are dummy variables for each of the *i* countries, T is a time trend, and *I* is equal to the number of countries considered, namely 11 [8].

Results, which are indicated in table 2, are quite similar for the three world reference prices. They all show a high transmission elasticity with respect to the import unit values, with high goodness of fit indicators. The three prices appear to be transmitted to import unit values by similar degrees, although the US Gulf No. 2 red winter ordinary price exhibits a slightly higher coefficient. Country specific effects captured by the dummy variables, that can be interpreted as specific transmission elasticities, are quite similar across the three world reference prices. They are all significantly different from zero, apart from those for Egypt, Indonesia and Pakistan. These country specific effect reflect factors such as distance, effects of seasons on the countries' wheat imports, and other unobservable country specific effects.

These results are derived in a static framework, and they imply that overall the international wheat reference prices are good determinants of wheat import unit values. Given the static nature of the results, it may be worthwhile, to checking whether a dynamic relation between the involved prices yields more insights. To this end, price relations where analyzed with the econometric approach proposed in Rapsomanikis *et al.* (2003). First, the dynamic properties of the series involved have been investigated, through standard tests for the presence of unit roots in the data, aimed at understanding their order of integration. Two different tests were applied: the Augmented Dickey-Fuller (ADF) test, and the Phillip-Perron (PP) test[9], both by including a time trend and a constant term[10].

[8] This procedure is similar to the one adopted in Mundlak and Larson (1992) and in Morissett (1998), except that in our case policy variables and the changes in exchange rates are not explicitly considered, as they are not needed since all prices are expressed in the same currency, and as only border prices are considered.

[9] As is well known, the first test is a parametric one, based on the estimation of an AR(*n*) model, in which what is tested is the null hypothesis that the coefficients of the lagged dependent variables are unitary, against a one sided alternative that they are strictly smaller than one; the former identifies a random walk, while a coefficient higher than one would imply an explosive behaviour. The Phillips-Perron test is conceptually similar to the ADF, but it is based on an

Both tests suggest that the series for annual import unit values and the three corresponding world reference prices are $I(1)$, as they accept the absence of unit roots in the levels, while they reject it in first differences. Given that the results of the order of integration suggest that the annual time series are all integrated with the same order, for each import unit value, the following Auto Regressive Distributed Lags (ARDL) model was estimated (all prices are in log forms):

$$pd_t = a + \tau T + \sum_{j=1}^{J} \beta_j pd_{t-j} + \sum_{k=0}^{K} \gamma_k pw_{t-k} + e_t \qquad (2)$$

in which J and K were chosen through the minimization of the Akaike information criterion. The presence of a long run relationship between pd and pw was tested by computing the parameters of the long run relation between border and world prices $pd_t = \lambda_0 + \lambda_1 pw_t + u_t$, which is derived from (2) under the assumptions that $pd_t = pd_{t-k} \forall k$ and $pw_t = pw_{t-j} \forall j$. These assumptions imply that

$$\lambda_0 = \frac{a}{1-\sum_j \beta} + \frac{\tau T}{1-\sum_j \beta};$$

$$\lambda_1 = \frac{\sum_k \gamma_k}{1-\sum_j \beta_j}, \text{ and}$$

$$u_t = \frac{e_t}{1-\sum_j \beta_j}$$

In order to take into account the adjustment taking place around the long run equilibrium, the ARDL model (2) has also been estimated in the corresponding Error Correction (ECM) specification, which is as follows:

$$\Delta pd_t = a + \delta T + \rho[pd_{t-1} - \lambda_1 pw_{t-1}] + \sum_{j=1}^{J} \beta_j^* \Delta pd_{t-j} + \sum_{k=0}^{K} \gamma_j^* \Delta pw_{t-k} + h_t \qquad (3)$$

The above relation, in which the long run parameter λ_1 is the same as the one calculated from the ARDL model in (2), allows to distinguish between the short run adjustment parameter $\rho = (1 - \sum \beta_j)$ known as the ECM coefficient, and the long run parameter λ_1. Estimates for these two parameters are reported in Table 3 for each country's import unit values in relation to each of the three world reference prices.

AR(*1*) model, in which the same test on the coefficient of the lagged variable is performed by correcting the usual *t*-statistic with a (non parametric) estimate of the spectrum of the error term.

[10] Detailes results for these tests are not reported for brevity, but they can be made available upon request.

For each country the results are quite similar across the three world reference prices. Compared to the static relation, the lag structure yields transmission coefficients significantly different from zero for all countries. For Indonesia a significant coefficient arises only in relation to the US Gulf price, while there is no evidence of a long run equilibrium with the other two international prices. Several long run coefficients show a significant degree of over transmission of price signals (coefficients larger than 1), therefore the ECM short-run adjustment coefficients tend to be relatively high. Some of these ECM coefficient – notably those for Bangladesh and Sudan in relation to the Australia and Argentina reference prices, and that for Tanzania with respect to the US price - are exactly equal to 1, indicating that there are no significant lags of the dependent variable in the relation. For China, Egypt, Indonesia and India, the size of the coefficients is closer to unity in the relation with the Australian price, while for Bangladesh this is the case with the US price; the geographical proximity may contribute to explain this evidence for Asian countries.

The same approach was adopted in order to investigate the relation between the monthly price series of the three wheat world reference prices and the Chicago futures settlement prices. As futures do not exist for all months, the CBOT price that was considered as the reference for the world prices was assumed to be the one for the nearest available futures contract. As in the analysis of annual prices, the dynamic properties of the series where first investigated. All the involved prices exhibited stationarity in the levels, with consistent evidence from both the PP and the ADF tests[11]. Given that also in this case the resulting order of integration is the same for all monthly price series involved for both the PP and ADF tests, the ARDL model and the corresponding ECMs were estimated as indicated above in equation (2). The relevant values of the ρ and λ_I coefficients are reported in Table 4.

All three prices appear closely related to the Chicago futures, given that the λ_I coefficients are all significant and close to 1. The US Gulf price shows, as expected, the closest to unity value for the long run coefficient, while the Argentinian price appears as the relatively more distant. The ECM short run parameter, instead, appears higher for the Australian price compared to the other two.

Altogether, these results indicate that there is a considerable amount of transmission of price signals between the Chicago future market and the average prices actually paid for importing wheat into the selected countries. In turn, this allows us to safely assume that the Chicago futures market could be a viable trading marketplace in which risk in import prices may be hedged by the

[11] Also in this case, results are not reported for brevity, but they can be made available upon request. Given the previous results of the unit rood tests, moreover, it should be mentioned that for the three world reference prices, the results of the unit root test change markedly by reducing the size of the sample and changing the frequency of the data.

selected countries. Of course, since our models are dynamic, the relationship between the reference export prices and the CBOT prices is not too strong contemporaneously, as it extends over several periods. In other words a shock in CBOT will not be transmitted fully to the various export prices in the same month, but only over time it will be fully transmitted. This implies a more complicated optimal hedging strategy than one based on simple contemporaneous correlations (in level or difference form) as is usually done, and as was done by Faruqee *et al.* (1997). For instance it may imply that the hedging for price risk for given desired import shipment may need to be done by allocating different portions of the desired hedged quantity to several futures contracts. It is, however, beyond the purpose of this article to examine the optimal (and most likely complicated) hedging strategy in the presence of a dynamic relation between the price of interest to the importing country and the CBOT price.

5. *Results of hedging strategies with futures and options*

The results of simulating the simple hedging rules described in Section 3, for each country are presented in Tables 5 to 15. The simulations were run over the longest periods for which appropriate data was available. Two periods were in fact simulated. The first was July 1995 - December 2002, during which actual monthly import quantities of wheat were available. The second period was November 1986 - December 2002. This is the longest period for which we have available daily options data. Since we do not have the actual monthly imports for the importing countries for the period 1986-1994, we derived them by the following method. First the actual average seasonal monthly import profiles for each country (in terms of the share of total annual imports that are imported in any particular month) were constructed from the observed data of 1995-2002. These average profiles are indicated in figure 1. Then these average seasonal import patterns were applied to the annual data, prior to 1995, to generate the longer monthly series. It is because of this method that we report two different periods in the simulations.

For each one of the two respective periods, the wheat import bills were calculated by the method indicated earlier, and are given in the upper left cell of each table, as they are the same for each simulation over a given period.

As mentioned previously, the simulations were run for three different trading days in a month, but the results appear to be quite similar with respect to the timing of the trades. Therefore, results are reported only for the midpoint in each month.

For all types of simulations, namely both with the options as well as with the futures, net profits (negative if losses), in absolute terms, and as a percentage of the import bill, were calculated for each country and are indicated in the tables for different values of α and k.

Before we discuss the results we may discuss the timing of the simulations. We expect the results to depend on the period of simulation chosen. This is especially so, since our simulations cover a relatively short period, namely a period of 16 years at most. This is evident also from the behaviour of the wheat reference prices that is exhibited in figure 2. It can be seen that between 1986 and 1994 world wheat prices were relatively stable, while in 1996-97 they experienced a peak, which subsided after that.

The second consideration, as well as expectation is that the longer the time period for the simulation, the lower should be the profit from hedging with futures alone. The reason is that over a long period the behaviour of futures is not any different than the behaviour of cash prices. In fact futures tend to reflect the information available at any given time, and hence are not good predictors of subsequent cash prices, especially for longer lead times.

The simulation results concerning hedging with futures bear these two expectations out. It can be seen that the results (net profits over simple cash importing) depend considerably on the period chosen. It can also be seen that in all cases the results of hedging only with futures decline considerably when the longer simulation period is considered, as expected. For the shorter period of simulations (1995-2002), all importing countries would have made considerable profits if they had hedged all their imports with futures. Finally in all case it appears that all countries would have made more profits if they hedged their subsequent imports with a longer lead time. In fact the profits of hedging imports with futures 12 months in advance are in all cases substantially larger than the profits of hedging 3,6, and 9 months in advance. For instance, applying a futures horizon of 12 months, India and Mozambique record simulated gains of 16 percent over the period July 1995 to December 2002. This appears consistent with the notion that trading with futures involves taking more price risk than trading with call options, which in turn implies a higher probability of a net gain.

The results are quite different for hedging with options. First, it is clear that the simulations over longer periods produce better results. In fact, while the net profits in the simulations for the shorter period are negative in several cases, they turn out to be positive for the second longer simulation period. This is to be expected as the second period includes a long period of price decline (from 1997 to 2001), which, if insured to with options would have surely resulted in losses because in most of the years the options would not have been exercised, and only the premiums would have been paid.

An interesting conclusion from the simulations of options hedging is that the value of the insurance parameter α matters a lot as expected, but furthermore, net profits are larger the larger α is. This means that it is more beneficial to an importing country to insure the rather improbable events of price spikes, namely large unexpected price increases.

The other result, is that it appears that in the case of hedging with options, the lead time that gives the best results for most countries is around 9 months ahead of the actual order time. It is not clear why this should be the case, but it certainly offers clear hints concerning optimal hedging strategies.

As a percentage of import bills, net profits across all countries fall in the range of -5 percent to 7 percent of the import values, and most values appear dispersed around zero, indicating in general a small magnitude of loss or gain for the countries being simulated. China yields the highest net gains, in the order of 7.2 percent in the instance when wheat imports are insured with a strike price 5 percent above the futures price with a 12 month lead period. Bangladesh shows the largest net gains after China, under similar hypotheses surrounding k and α. Other countries that show relatively high simulated net gains, include Egypt and Sudan, with profits which reach 4 percent and 3 percent of the value of imports respectively.

By contrast, some countries experience negative returns, regardless of the hedging rule, particularly India and Tanzania. Indeed, the frequency of losses in the simulations, despite their magnitude being small, far outweighs the frequency of profits. Moreover, it is noted that net outcomes vary widely across different hedging parameters. Nevertheless, at least three regularities seem to hold for a number of the countries. Firstly, profits tend to increase with k, that is, the longer the horizon over which a country hedges risk, the higher the net return. Secondly, the higher the level of α, the higher the net return, in other words, the higher the price at which insurance is sought, the higher the likelihood of a net gain. Thirdly, simulations run over the longer period (November 1986 – December 2002) appear to yield generally higher profits relative to those simulated in the July 1995 – December 2002 period: in other words, the longer the period over which trading in options at the CBOT is conducted, the higher the probability of a net gain.

6. *Results of pooled import hedging rules*

The above results concerned each country individually, and it was seen that despite some overall patterns there is considerable heterogeneity across countries. The heterogeneity of monthly imports noticed in figure 1 suggests that there may be a role for pooling the import risks of the studied countries. In fact figure 3, which averages the import profiles of all 11 countries, suggests a much more even pattern of monthly food import requirements that for any country individually.

Table 16 reports the results of similar simulations as for the individual countries, but under the assumption that the sum of all monthly imports of the 11 countries are hedged together. In other words the underlying assumption is that there is an international agency that insures every country's monthly wheat imports, and then aggregates all monthly import requirements, and places hedges in the futures or option markets for the sum of all imports.

The results are remarkably better in this case. When the multilateral agency hedges only with futures, it would have made considerable profits in the period 1995-2002, which as indicated above, could have been the result of the particular behaviour of the market during this relatively short period. Over the longer period, however, the profits largely vanish, with the exception of rules that dictates hedging with a 12 month lead time.

When, however, hedging with options is simulated, and for the longer simulation period, the agency experiences small but positive profits in almost all cases. This suggests that pooling of the import hedging requirements for food importing developing countries is a profitable activity. This also suggests that there may be an externality in wheat import price risk hedging, in the sense that insurance sought individually by each country will be less efficient than insurance sought collectively.

7. *Concluding remarks*

The results of this paper suggest that hedging wheat importing countries import with options and futures in the CBOT exchange appears, as a viable strategy for the LIFDCs countries to engage in. The profits that can be made are positive especially over a long period of time. While the results suggest that each country could engage in hedging individually, it was shown that pooled hedging has a much higher chance of generating net profits. Of course the profits considered were purely monetary. There may be additional benefits deriving from the insurance. For instance the overall quantity of imports may increase, thus resulting in higher domestic food supplies, and perhaps better domestic food security. This is an aspect that will, of course, contribute to sustainable development.

The existence of substantial transmission of price signals for the commodity chosen among the major export markets and CBOT, confirmed that the CBOT offers a viable hedging market for wheat import for all countries.

The larger benefits from the pooled simulations suggest that a multilateral agency doing the insurance on behalf of all LIFDCs would not only be viable, but also could lower the overall cost of such insurance, first by the larger profits obtained, which could be passed on the LIFDCs as discounts on the insurance premiums, or by economies of scale in option and future purchases.

However, there are some *caveats* to the be taken into account when considering the results of the simulations. Firstly, given the importance of the countries involved in global wheat imports, one may question whether their involvement in the CBOT may influence the price determination process in the exchange. Secondly, as mentioned, the simulations are based on a comparison with purely commercial transactions in the spot market, whereas it is known that for many of the selected countries concessional transactions are a considerable share of cereal imports. Thirdly, from the simulations it appears that the sample period and the seasonal import pattern may make a difference to outcomes in the CBOT market. This probably calls for a more extensive research, that might involve more products and more markets.

The implications of the analysis for sustainable development are that many of the low income food deficit countries could benefit considerably from instituting food import expenditure insurance schemes of the type suggested in this paper. Even if the monetary benefits are zero or small, the indirect benefits can be large. They involve the insurance that there will be enough food to feed all those in need, and hence the assurance for many developing countries that they will not have to reallocate development funds to deal with short term food crises. This, in turn could lead for a more orderly pattern of public investments and hence potentially faster growth.

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Appendix: Tables and Graphs

Table A1: Countries selected for the simulations

	Avg. wheat imports 1980-2003 (000mt)	Share in LIFDC wheat imports (%)	Share in World wheat imports (%)	Avg. cereal imports 1980-2003 (000mt)	Share of wheat in LIFDC cereal imports (%)
Bangladesh	1 540	3.5	1.5	2 061	2.3
China, mainland	6 794	15.4	6.7	9 771	10.1
Egypt	6 601	15.0	6.5	9 181	9.8
India	767	1.7	0.8	1 242	1.1
Indonesia	3 116	7.1	3.1	4 594	4.6
Mozambique	157	0.4	0.2	495	0.2
Nicaragua	100	0.2	0.1	181	0.1
Pakistan	1 635	3.7	1.6	1 387	2.4
Philippines	2 125	4.8	2.1	2 581	3.2
Sudan	671	1.5	0.7	789	1.0
Tanzania	128	0.3	0.1	295	0.2
LIFDC	44 089	54	23	67 154	35
World	101 151	100		212 373	

Table A2: Transmission between international reference prices and the nearest CBOT future price. (monthly data - sample: Jan 1973 - Dec 2002)

		dependent variables	PWUS	PWAR	PWAS
regressor					
nearest future price at CBOT	λ_1	coefficient	0.92	1.38	1.16
		t-ratio	17.07	5.90	9.67
	ρ	coefficient	-0.14	-0.15	-0.24
		t-ratio	-5.03	-3.02	-8.36

PWUS=US Gulf No.2 wheat price (IMF, IFS Statistics)
PWAS=Australia wheat price (IMF, IFS Statistics)
PWAR=Argentina wheat price (IMF, IFS Statistics)
Source: authors' calculations

Table A3: Transmission between international reference prices and pooled import unit values (pooled sample of annual data 1961-2001)

	dependent variables								
	PLP			PLP			PLP		
regressors	variable	coefficient	*t-ratio*	variable	coefficient	*t-ratio*	variable	coefficient	*t-ratio*
	C	0.67	*4.29*	C	1.01	*6.90*	C	0.92	*6.37*
	T	0.00	*4.00*	T	0.01	*6.40*	T	0.00	*1.68*
	DCHN	0.13	*2.64*	DCHN	0.13	*2.61*	DCHN	0.13	*2.66*
	DEGY	0.04	*0.75*	DEGY	0.04	*0.74*	DEGY	0.04	*0.75*
	DIND	0.30	*6.35*	DIND	0.30	*6.16*	DIND	0.30	*6.31*
	DINS	-0.01	*-0.29*	DINS	-0.01	*-0.19*	DINS	0.00	*-0.09*
	DMOZ	0.09	*1.89*	DMOZ	0.09	*1.87*	DMOZ	0.09	*1.91*
	DNIC	0.33	*6.82*	DNIC	0.33	*6.77*	DNIC	0.33	*6.91*
	DPHL	0.12	*2.50*	DPHL	0.12	*2.47*	DPHL	0.12	*2.51*
	DPKT	0.08	*1.61*	DPKT	0.08	*1.59*	DPKT	0.08	*1.62*
	DSUD	0.19	*3.96*	DSUD	0.19	*3.91*	DSUD	0.19	*3.98*
	DTNZ	0.24	*4.97*	DTNZ	0.24	*4.90*	DTNZ	0.24	*5.00*
	PWUS	**0.84**	***23.39***	**PWAR**	**0.77**	***22.87***	**PWAS**	**0.81**	***23.67***
R^2		0.77			0.77			0.77	

where:
PLP = pooled calendar year wheat import unit values from Bangladesh (BDH), China (CHN), Egypt (EGY), India (IND), Indonesia (INS), Mozambique (MOZ), Nicaragua (NIC), Philippines (PHL), Pakistan (PKT), Sudan (SUD), Tanzania (TNZ);
D*** = dummy variables for the import unit values of the above mentioned countries;
PWUS = US Gulf No.2 hard winter ordinary wheat price (IMF, IFS Statistics);
LWAS = Argentina wheat price (IMF, IFS Statistics);
LWUS = US Gulf No.2 hard winter ordinary wheat price (IMF, IFS Statistics)
Source: authors' calculations

Table A4: Transmission between international reference prices and single import unit values (annual data - sample: 1961 – 2001)

regressors		dependent	PCHN	PBDH	PEGY	PIND	PINS	PMOZ	PNIC	PPKT	PPHL	PSUD	PTNZ
PWUS	λ	coefficient	1.10	0.54	1.31	1.36	1.45	1.12	1.35	1.33	1.07	1.02	0.81
		t-ratio	*3.76*	*5.86*	*7.00*	*3.86*	*2.47*	*6.33*	*10.67*	*7.44*	*11.57*	*40.28*	*6.61*
	ρ	coefficient	-0.28	-0.80	-0.59	-0.42	-0.45	-0.59	-1.01	-0.68	-0.61	-0.81	-1.00
		t-ratio	*-2.23*	*-5.64*	*-6.26*	*-3.03*	*-3.15*	*-5.55*	*-5.14*	*-5.93*	*-8.87*	*-2.43*	*n.a.*
PWAR	λ	coefficient	1.12	0.49	1.20	1.20	0.71	1.00	1.21	1.47	1.07	1.02	0.82
		t-ratio	*8.94*	*7.03*	*5.69*	*2.61*	*1.35*	*5.31*	*7.72*	*4.24*	*11.20*	*60.11*	*8.25*
	ρ	coefficient	-0.47	-1.00	-0.36	-0.32	-0.38	-0.55	-0.78	-0.40	-0.65	-1.00	-1.26
		t-ratio	*-3.60*	*n.a.*	*-2.76*	*-2.26*	*-2.36*	*-4.84*	*-4.93*	*-4.41*	*-8.73*	*n.a.*	*-5.69*
PWAS	λ	coefficient	0.99	0.47	1.10	1.15	0.77	1.01	1.20	1.32	0.94	1.05	0.81
		t-ratio	*6.18*	*5.99*	*6.07*	*2.57*	*1.52*	*5.92*	*8.38*	*5.66*	*11.65*	*53.27*	*6.31*
	ρ	coefficient	-0.34	-1.00	-0.41	-0.33	-0.39	-0.61	-0.84	-0.50	-0.73	-1.00	-0.99
		t-ratio	*-2.72*	*n.a.*	*-2.78*	*-2.13*	*-2.46*	*-5.04*	*-4.76*	*-5.55*	*-7.72*	*n.a.*	*-5.76*

Wheat Import unit values for: PCHN= China; PBDH=for Bangladesh; PEGY=for Egypt; PIND=for India; PINS=for Indonesia; PMOZ= Mozambique; PNIC= Nicaragua; PPKT=Pakistan; PPHL=Philippines; PSUD=Sudan; PTNZ= Tanzania
PWUS=US Gulf No.2 hard winter ordinary wheat price (IMF, IFS Statistics)
PWAS=Australia wheat price (IMF, IFS Statistics)
PWAR=Argentina wheat price (IMF, IFS Statistics)
Source: authors'calculations

Table A5: Results for Bangladesh

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
1,578,870	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-25,197	-1.60	-33,496	-2.12	-29,040	-1.84	-51,996	-3.29
α = -0.02	-21,246	-1.35	-28,858	-1.83	-26,401	-1.67	-42,378	-2.68
α = 0.00	-18,850	-1.19	-25,928	-1.64	-22,984	-1.46	-37,876	-2.40
α = 0.05	-12,263	-0.78	-19,737	-1.25	-13,816	-0.88	-27,211	-1.72
α = 0.10	-8,251	-0.52	-14,580	-0.92	-8,955	-0.57	-26,401	-1.67
α = 0.15	-4,148	-0.26	-5,555	-0.35	-3,610	-0.23	-15,873	-1.01
α = 0.20	-1,163	-0.07	-5,147	-0.33	-29	0.00	-13,402	-0.85
α = 0.25	-1,246	-0.08	-29,040	-1.84	10,218	0.65	-5,091	-0.32

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
3,515,073	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-15,724	-0.45	1,999	0.06	37,189	1.06	153,020	4.35
α = -0.02	-8,978	-0.26	-1,593	-0.05	47,402	1.35	149,239	4.25
α = 0.00	-9,989	-0.28	-2,062	-0.06	48,669	1.38	152,162	4.33
α = 0.05	-4,134	-0.12	-1,191	-0.03	51,730	1.47	176,095	5.01
α = 0.10	1,095	0.03	8,646	0.25	40,960	1.17	12,928	0.37
α = 0.15	51,050	1.45	70,244	2.00	24,108	0.69	-15,873	-0.45
α = 0.20	78,210	2.22	12,244	0.35	31,285	0.89	-13,402	-0.38
α = 0.25	8,948	0.25	37,189	1.06	35,079	1.00	-5,091	-0.14

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
1,578,870	US$ 000	% On Bill
k=3	40,001	2.53
k=6	68,659	4.35
k=9	87,202	5.52
k=12	152,979	9.69

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
3,515,073	US$ 000	% On Bill
k=3	15,988	0.45
k=6	10,356	0.29
k=9	-23,536	-0.67
k=12	64,454	1.83

Table A6: Results for China

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
4,465,964	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	32,699	0.73	9,529	0.21	54,427	1.22	-97,325	-2.18
α = -0.02	30,743	0.69	17,734	0.40	58,590	1.31	11,570	0.26
α = 0.00	30,823	0.69	19,216	0.43	66,745	1.49	23,870	0.53
α = 0.05	23,950	0.54	17,698	0.40	89,980	2.01	28,756	0.64
α = 0.10	14,881	0.33	11,036	0.25	100,078	2.24	22,192	0.50
α = 0.15	18,663	0.42	48,218	1.08	166,126	3.72	-7,836	-0.18
α = 0.20	22,197	0.50	44,077	0.99	197,196	4.42	-6,582	-0.15
α = 0.25	14,927	0.33	54,427	1.22	270,970	6.07	-2,346	-0.05

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
17,595,023	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	70,826	0.40	235,324	1.34	357,849	2.03	1,126,024	6.40
α = -0.02	103,885	0.59	187,495	1.07	430,375	2.45	1,155,303	6.57
α = 0.00	87,254	0.50	162,215	0.92	431,864	2.45	1,161,839	6.60
α = 0.05	87,167	0.50	128,725	0.73	422,322	2.40	1,265,350	7.19
α = 0.10	83,524	0.47	163,368	0.93	373,303	2.12	163,606	0.93
α = 0.15	453,660	2.58	630,402	3.58	296,826	1.69	-7,836	-0.04
α = 0.20	661,390	3.76	174,004	0.99	331,767	1.89	-6,582	-0.04
α = 0.25	104,184	0.59	357,849	2.03	380,478	2.16	-2,346	-0.01

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000): 4,465,964	US$ 000	% On Bill
k=3	33,633	0.75
k=6	91,290	2.04
k=9	98,253	2.20
k=12	686,302	15.37

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000): 17,595,023	US$ 000	% On Bill
k=3	-78,763	-0.45
k=6	-198,651	-1.13
k=9	-404,734	-2.30
k=12	756,493	4.30

Table A7: Results for Egypt

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
7,082,904	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-79,407	-1.12	-145,997	-2.06	-138,631	-1.96	-236,555	-3.34
α = -0.02	-62,527	-0.88	-117,151	-1.65	-126,941	-1.79	-167,262	-2.36
α = 0.00	-54,071	-0.76	-103,736	-1.46	-110,228	-1.56	-135,241	-1.91
α = 0.05	-29,797	-0.42	-79,458	-1.12	-63,019	-0.89	-104,887	-1.48
α = 0.10	-16,797	-0.24	-62,070	-0.88	-32,476	-0.46	-100,914	-1.42
α = 0.15	-3,584	-0.05	-28,055	-0.40	18,688	0.26	-67,639	-0.95
α = 0.20	2,565	0.04	-18,894	-0.27	43,276	0.61	-56,415	-0.80
α = 0.25	543	0.01	-138,631	-1.96	80,743	1.14	-20,187	-0.29

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
15,121,022	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-32,506	-0.21	21,060	0.14	73,838	0.49	458,423	3.03
α = -0.02	-860	-0.01	18,133	0.12	115,280	0.76	475,104	3.14
α = 0.00	-5,380	-0.04	14,243	0.09	123,882	0.82	501,274	3.32
α = 0.05	13,310	0.09	11,680	0.08	152,982	1.01	595,064	3.94
α = 0.10	29,221	0.19	49,117	0.32	153,347	1.01	55,345	0.37
α = 0.15	202,912	1.34	270,582	1.79	135,022	0.89	-67,639	-0.45
α = 0.20	300,931	1.99	65,587	0.43	169,695	1.12	-56,415	-0.37
α = 0.25	39,841	0.26	73,838	0.49	182,166	1.20	-20,187	-0.13

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
7,082,904	US$ 000	% On Bill
k=3	143,482	2.03
k=6	281,167	3.97
k=9	379,809	5.36
k=12	861,330	12.16

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
15,121,022	US$ 000	% On Bill
k=3	57,230	0.38
k=6	63,111	0.42
k=9	21,153	0.14
k=12	691,416	4.57

Table A8: Results for India

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
1,129,076	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-28,273	-2.50	-46,938	-4.16	-45,367	-4.02	-51,385	-4.55
α = -0.02	-22,616	-2.00	-39,343	-3.48	-40,796	-3.61	-49,349	-4.37
α = 0.00	-20,281	-1.80	-35,768	-3.17	-37,904	-3.36	-41,368	-3.66
α = 0.05	-14,461	-1.28	-27,136	-2.40	-27,360	-2.42	-28,158	-2.49
α = 0.10	-9,891	-0.88	-19,955	-1.77	-19,186	-1.70	-24,963	-2.21
α = 0.15	-6,250	-0.55	-9,057	-0.80	-11,846	-1.05	-7,643	-0.68
α = 0.20	-3,955	-0.35	-5,889	-0.52	-6,574	-0.58	-6,152	-0.54
α = 0.25	-2,394	-0.21	-45,367	-4.02	-3,510	-0.31	-259	-0.02

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
2,307,901	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-26,464	-1.15	-40,137	-1.74	-55,999	-2.43	7,419	0.32
α = -0.02	-21,930	-0.95	-37,842	-1.64	-36,275	-1.57	6,170	0.27
α = 0.00	-23,204	-1.01	-38,085	-1.65	-34,738	-1.51	14,119	0.61
α = 0.05	-21,666	-0.94	-33,892	-1.47	-22,473	-0.97	35,884	1.55
α = 0.10	-15,029	-0.65	-25,912	-1.12	-11,635	-0.50	-34,513	-1.50
α = 0.15	25,145	1.09	33,002	1.43	-14,076	-0.61	-7,643	-0.33
α = 0.20	40,509	1.76	-5,623	-0.24	-9,031	-0.39	-6,152	-0.27
α = 0.25	-1,953	-0.08	-55,999	-2.43	-4,762	-0.21	-259	-0.01

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
1,129,076	US$ 000	% On Bill
k=3	51,177	4.53
k=6	75,858	6.72
k=9	114,389	10.13
k=12	182,788	16.19

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
2,307,901	US$ 000	% On Bill
k=3	39,904	1.73
k=6	61,401	2.66
k=9	65,592	2.84
k=12	322,875	13.99

Table A9: Results for Indonesia

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
4,608,765	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-54,190	-1.18	-76,084	-1.65	-128,014	-2.78	-156,667	-3.40
α = -0.02	-43,694	-0.95	-57,654	-1.25	-118,898	-2.58	-112,667	-2.44
α = 0.00	-38,885	-0.84	-48,074	-1.04	-106,696	-2.32	-90,445	-1.96
α = 0.05	-22,991	-0.50	-32,698	-0.71	-75,736	-1.64	-74,963	-1.63
α = 0.10	-14,752	-0.32	-20,056	-0.44	-59,455	-1.29	-70,361	-1.53
α = 0.15	-4,221	-0.09	-17,268	-0.37	-45,832	-0.99	-43,624	-0.95
α = 0.20	329	0.01	-14,474	-0.31	-28,534	-0.62	-37,210	-0.81
α = 0.25	-1,729	-0.04	-128,014	-2.78	9,155	0.20	-16,437	-0.36

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
7,442,241	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-19,064	-0.26	3,880	0.05	-34,540	-0.46	69,336	0.93
α = -0.02	-5,332	-0.07	10,944	0.15	-20,813	-0.28	91,939	1.24
α = 0.00	-5,677	-0.08	14,069	0.19	-11,010	-0.15	111,496	1.50
α = 0.05	3,554	0.05	16,145	0.22	10,194	0.14	154,251	2.07
α = 0.10	7,486	0.10	29,186	0.39	18,576	0.25	18,901	0.25
α = 0.15	55,975	0.75	72,324	0.97	14,881	0.20	-43,624	-0.59
α = 0.20	83,986	1.13	21,814	0.29	39,609	0.53	-37,210	-0.50
α = 0.25	13,056	0.18	-34,540	-0.46	63,859	0.86	-16,437	-0.22

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
4,608,765	US$ 000	% On Bill
k=3	75,643	1.64
k=6	154,122	3.34
k=9	260,065	5.64
k=12	624,689	13.55

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
7,442,241	US$ 000	% On Bill
k=3	27,778	0.37
k=6	50,594	0.68
k=9	95,841	1.29
k=12	536,870	7.21

Table A10: Results for Mozambique

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
197,647	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	24	0.01	-6,037	-3.05	-3,339	-1.69	-5,726	-2.90
α = -0.02	147	0.07	-5,291	-2.68	-3,050	-1.54	-4,672	-2.36
α = 0.00	64	0.03	-4,760	-2.41	-2,444	-1.24	-3,969	-2.01
α = 0.05	-180	-0.09	-3,956	-2.00	-1,139	-0.58	-3,074	-1.56
α = 0.10	-188	-0.09	-3,454	-1.75	-221	-0.11	-2,885	-1.46
α = 0.15	7	0.00	-1,930	-0.98	2,050	1.04	-2,035	-1.03
α = 0.20	279	0.14	-1,305	-0.66	3,335	1.69	-1,747	-0.88
α = 0.25	127	0.06	-3,339	-1.69	4,095	2.07	-807	-0.41

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
371,202	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	1,336	0.36	-2,551	-0.69	1,318	0.36	5,883	1.58
α = -0.02	1,747	0.47	-2,421	-0.65	1,954	0.53	6,104	1.64
α = 0.00	1,504	0.41	-2,226	-0.60	2,457	0.66	6,753	1.82
α = 0.05	1,056	0.28	-2,117	-0.57	3,268	0.88	8,727	2.35
α = 0.10	811	0.22	-1,519	-0.41	3,186	0.86	-1,264	-0.34
α = 0.15	3,521	0.95	3,094	0.83	3,815	1.03	-2,035	-0.55
α = 0.20	5,397	1.45	161	0.04	4,938	1.33	-1,747	-0.47
α = 0.25	1,026	0.28	1,318	0.36	5,349	1.44	-807	-0.22

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
197,647	US$ 000	% On Bill
k=3	937	0.47
k=6	6,982	3.53
k=9	8,408	4.25
k=12	31,874	16.13

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
371,202	US$ 000	% On Bill
k=3	-986	-0.27
k=6	2,188	0.59
k=9	-629	-0.17
k=12	30,659	8.26

Table A11: Results for Nicaragua

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
103,313	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-2,087	-2.02	-2,019	-1.95	-995	-0.96	-3,610	-3.49
α = -0.02	-1,639	-1.59	-1,739	-1.68	-896	-0.87	-2,818	-2.73
α = 0.00	-1,442	-1.40	-1,360	-1.32	-743	-0.72	-2,737	-2.65
α = 0.05	-1,016	-0.98	-981	-0.95	-454	-0.44	-1,895	-1.83
α = 0.10	-827	-0.80	-740	-0.72	-132	-0.13	-1,691	-1.64
α = 0.15	-531	-0.51	-378	-0.37	777	0.75	-1,216	-1.18
α = 0.20	-369	-0.36	-252	-0.24	1,169	1.13	-1,024	-0.99
α = 0.25	-233	-0.23	-995	-0.96	1,656	1.60	-355	-0.34

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
269,802	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-1,250	-0.46	-107	-0.04	1,507	0.56	5,743	2.13
α = -0.02	-524	-0.19	-368	-0.14	1,892	0.70	5,803	2.15
α = 0.00	-577	-0.21	-183	-0.07	1,980	0.73	5,794	2.15
α = 0.05	-225	-0.08	-77	-0.03	2,244	0.83	7,733	2.87
α = 0.10	-121	-0.04	423	0.16	1,982	0.73	614	0.23
α = 0.15	2,743	1.02	4,011	1.49	2,155	0.80	-1,216	-0.45
α = 0.20	4,276	1.58	1,055	0.39	2,773	1.03	-1,024	-0.38
α = 0.25	461	0.17	1,507	0.56	2,937	1.09	-355	-0.13

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
103,313	US$ 000	% On Bill
k=3	2,506	2.43
k=6	2,023	1.96
k=9	4,060	3.93
k=12	12,866	12.45

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
269,802	US$ 000	% On Bill
k=3	830	0.31
k=6	-1,023	-0.38
k=9	-554	-0.21
k=12	13,211	4.90

Table A12: Results for Pakistan

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
2,291,590	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-18,025	-0.79	-39,764	-1.74	-85,365	-3.73	-105,650	-4.61
α = -0.02	-15,332	-0.67	-28,151	-1.23	-81,834	-3.57	-74,372	-3.25
α = 0.00	-12,113	-0.53	-23,106	-1.01	-71,872	-3.14	-55,697	-2.43
α = 0.05	-3,996	-0.17	-10,837	-0.47	-49,644	-2.17	-42,954	-1.87
α = 0.10	1,831	0.08	-4,229	-0.18	-38,681	-1.69	-39,471	-1.72
α = 0.15	6,768	0.30	3,542	0.15	-25,643	-1.12	-14,105	-0.62
α = 0.20	7,552	0.33	1,989	0.09	-18,616	-0.81	-11,442	-0.50
α = 0.25	3,453	0.15	-85,365	-3.73	8,852	0.39	-798	-0.03

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
5,057,507	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-12,294	-0.24	-14,470	-0.29	-49,166	-0.97	29,521	0.58
α = -0.02	-5,628	-0.11	-9,788	-0.19	-43,172	-0.85	47,634	0.94
α = 0.00	-6,903	-0.14	-9,531	-0.19	-33,482	-0.66	63,702	1.26
α = 0.05	567	0.01	-1,056	-0.02	-15,921	-0.31	97,052	1.92
α = 0.10	6,670	0.13	5,961	0.12	-6,678	-0.13	11,547	0.23
α = 0.15	64,269	1.27	76,424	1.51	9,868	0.20	-14,105	-0.28
α = 0.20	93,742	1.85	23,722	0.47	23,404	0.46	-11,442	-0.23
α = 0.25	16,054	0.32	-49,166	-0.97	42,982	0.85	-798	-0.02

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
2,291,590	US$ 000	% On Bill
k=3	17,069	0.74
k=6	100,819	4.40
k=9	203,302	8.87
k=12	278,493	12.15

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
5,057,507	US$ 000	% On Bill
k=3	1,451	0.03
k=6	63,490	1.26
k=9	153,920	3.04
k=12	216,400	4.28

Table A13: Results for Philippines

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
2,729,993	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-33,211	-1.22	-63,914	-2.34	-64,871	-2.38	-84,944	-3.11
α = -0.02	-26,395	-0.97	-53,292	-1.95	-60,306	-2.21	-65,409	-2.40
α = 0.00	-22,976	-0.84	-45,610	-1.67	-52,352	-1.92	-51,714	-1.89
α = 0.05	-13,703	-0.50	-35,436	-1.30	-33,752	-1.24	-43,601	-1.60
α = 0.10	-8,299	-0.30	-25,690	-0.94	-24,265	-0.89	-41,777	-1.53
α = 0.15	-2,584	-0.09	-12,388	-0.45	-10,002	-0.37	-30,727	-1.13
α = 0.20	-49	0.00	-9,166	-0.34	-1,152	-0.04	-26,281	-0.96
α = 0.25	-482	-0.02	-64,871	-2.38	14,246	0.52	-11,037	-0.40

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
4,703,090	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-9,154	-0.19	-13,213	-0.28	-7,473	-0.16	48,534	1.03
α = -0.02	-73	0.00	-9,900	-0.21	-130	0.00	55,351	1.18
α = 0.00	-84	0.00	-6,876	-0.15	6,625	0.14	67,436	1.43
α = 0.05	4,262	0.09	-5,871	-0.12	18,881	0.40	93,636	1.99
α = 0.10	5,706	0.12	2,860	0.06	21,934	0.47	9,875	0.21
α = 0.15	37,439	0.80	44,237	0.94	27,237	0.58	-30,727	-0.65
α = 0.20	55,709	1.18	14,531	0.31	38,184	0.81	-26,281	-0.56
α = 0.25	10,171	0.22	-7,473	-0.16	45,870	0.98	-11,037	-0.23

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
2,729,993	US$ 000	% On Bill
k=3	55,509	2.03
k=6	106,772	3.91
k=9	162,834	5.96
k=12	396,983	14.54

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
4,703,090	US$ 000	% On Bill
k=3	25,620	0.54
k=6	40,268	0.86
k=9	50,393	1.07
k=12	363,199	7.72

Table A14: Results for Sudan

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
943,361	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-12,678	-1.34	-13,077	-1.39	-17,682	-1.87	-24,405	-2.59
α = -0.02	-10,585	-1.12	-10,476	-1.11	-15,721	-1.67	-20,170	-2.14
α = 0.00	-9,702	-1.03	-9,550	-1.01	-13,989	-1.48	-16,352	-1.73
α = 0.05	-6,252	-0.66	-7,930	-0.84	-8,549	-0.91	-13,138	-1.39
α = 0.10	-4,235	-0.45	-6,078	-0.64	-6,205	-0.66	-13,958	-1.48
α = 0.15	-1,969	-0.21	-4,637	-0.49	-2,478	-0.26	-10,958	-1.16
α = 0.20	-1,307	-0.14	-3,617	-0.38	-239	-0.03	-9,235	-0.98
α = 0.25	-849	-0.09	-17,682	-1.87	6,543	0.69	-3,951	-0.42

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
1,492,408	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-7,625	-0.51	-62	0.00	2,143	0.14	30,371	2.04
α = -0.02	-5,028	-0.34	161	0.01	5,808	0.39	30,551	2.05
α = 0.00	-5,120	-0.34	-103	-0.01	6,317	0.42	33,838	2.27
α = 0.05	-2,894	-0.19	-654	-0.04	10,203	0.68	40,742	2.73
α = 0.10	-1,441	-0.10	2,203	0.15	9,544	0.64	896	0.06
α = 0.15	9,859	0.66	14,578	0.98	7,902	0.53	-10,958	-0.73
α = 0.20	15,191	1.02	2,225	0.15	10,699	0.72	-9,235	-0.62
α = 0.25	842	0.06	2,143	0.14	15,048	1.01	-3,951	-0.26

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
943,361	US$ 000	% On Bill
k=3	15,210	1.61
k=6	27,095	2.87
k=9	38,142	4.04
k=12	97,752	10.36

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
1,492,408	US$ 000	% On Bill
k=3	7,010	0.47
k=6	7,536	0.50
k=9	4,153	0.28
k=12	66,323	4.44

Table A15: Results for Tanzania

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
227,860	**US$ 000**	**% On Bill**	**US$ 000**	**% On Bill**	**US$ 000**	**% On Bill**	**US$ 000**	**% On Bill**
α = -0.05	-3,377	-1.48	-6,421	-2.82	-6,570	-2.88	-5,825	-2.56
α = -0.02	-3,023	-1.33	-5,742	-2.52	-6,201	-2.72	-5,596	-2.46
α = 0.00	-2,665	-1.17	-5,170	-2.27	-5,769	-2.53	-5,271	-2.31
α = 0.05	-1,757	-0.77	-4,408	-1.93	-3,960	-1.74	-4,720	-2.07
α = 0.10	-1,230	-0.54	-3,576	-1.57	-2,845	-1.25	-4,677	-2.05
α = 0.15	-677	-0.30	-2,541	-1.12	-2,145	-0.94	-4,070	-1.79
α = 0.20	-522	-0.23	-2,015	-0.88	-1,862	-0.82	-3,388	-1.49
α = 0.25	-386	-0.17	-6,570	-2.88	-2,415	-1.06	-1,281	-0.56

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
315,784	**US$ 000**	**% On Bill**	**US$ 000**	**% On Bill**	**US$ 000**	**% On Bill**	**US$ 000**	**% On Bill**
α = -0.05	-2,927	-0.93	-5,359	-1.70	-5,205	-1.65	-162	-0.05
α = -0.02	-2,427	-0.77	-4,947	-1.57	-4,543	-1.44	-377	-0.12
α = 0.00	-2,183	-0.69	-4,542	-1.44	-4,146	-1.31	-105	-0.03
α = 0.05	-1,301	-0.41	-3,931	-1.24	-2,392	-0.76	1,072	0.34
α = 0.10	-779	-0.25	-2,899	-0.92	-1,605	-0.51	-3,514	-1.11
α = 0.15	1,450	0.46	29	0.01	-1,300	-0.41	-4,070	-1.29
α = 0.20	2,527	0.80	-1,245	-0.39	-946	-0.30	-3,388	-1.07
α = 0.25	118	0.04	-5,205	-1.65	-1,665	-0.53	-1,281	-0.41

Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
227,860	**US$ 000**	**% On Bill**
k=3	1,527	0.67
k=6	10,286	4.51
k=9	8,902	3.91
k=12	25,783	11.32

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
315,784	**US$ 000**	**% On Bill**
k=3	684	0.22
k=6	8,579	2.72
k=9	6,559	2.08
k=12	27,158	8.60

Table A16: Results for the aggregate of the 11 countries

Profit / Loss on Options (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):	k=3		k=6		k=9		k=12	
25,355,216	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-223,721	-0.88	-424,218	-1.67	-465,447	-1.84	-824,088	-3.25
α = -0.02	-176,166	-0.69	-329,963	-1.30	-422,454	-1.67	-533,123	-2.10
α = 0.00	-150,099	-0.59	-283,847	-1.12	-358,237	-1.41	-416,799	-1.64
α = 0.05	-82,465	-0.33	-204,879	-0.81	-187,448	-0.74	-315,845	-1.25
α = 0.10	-47,758	-0.19	-149,392	-0.59	-92,343	-0.36	-304,906	-1.20
α = 0.15	1,473	0.01	-30,049	-0.12	86,084	0.34	-205,727	-0.81
α = 0.20	25,557	0.10	-14,693	-0.06	187,970	0.74	-172,878	-0.68
α = 0.25	11,729	0.05	-465,447	-1.84	400,551	1.58	-62,551	-0.25

Profit / Loss on Options (Mid Month:Nov-86 to Dec-02)

Est. Bill (US$ 000):	k=3		k=6		k=9		k=12	
61,431,083	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill	US$ 000	% On Bill
α = -0.05	-54,845	-0.09	186,364	0.30	321,463	0.52	1,934,112	3.15
α = -0.02	54,851	0.09	149,875	0.24	497,778	0.81	2,022,822	3.29
α = 0.00	29,640	0.05	126,919	0.21	538,416	0.88	2,118,306	3.45
α = 0.05	79,696	0.13	107,759	0.18	631,039	1.03	2,475,607	4.03
α = 0.10	117,143	0.19	231,435	0.38	602,914	0.98	234,422	0.38
α = 0.15	908,023	1.48	1,218,928	1.98	506,439	0.82	-205,727	-0.33
α = 0.20	1,341,868	2.18	308,474	0.50	642,376	1.05	-172,878	-0.28
α = 0.25	192,747	0.31	321,463	0.52	767,342	1.25	-62,551	-0.10

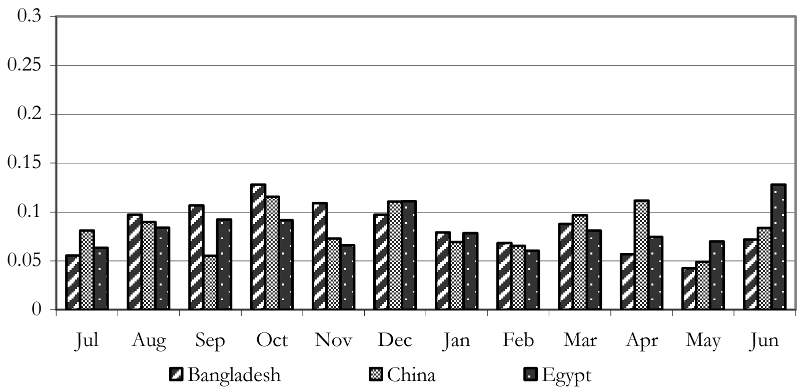
Profit / Loss on Futures (Mid Month: Jul-95 to Dec-02)

Actual Bill (US$ 000):		
25,355,216	US$ 000	% On Bill
k=3	436,693	1.72
k=6	925,070	3.65
k=9	1,365,366	5.38
k=12	3,351,839	13.22

Profit / Loss on Futures (Mid Month: Nov-86 to Dec-02)

Est. Bill (US$ 000):		
61,431,083	US$ 000	% On Bill
k=3	96,746	0.16
k=6	107,849	0.18
k=9	-31,843	-0.05
k=12	3,089,058	5.03

Figure A1: Average monthly distribution of wheat imports (1995 to 2002). (Shares of total annual imports imported in a given month)



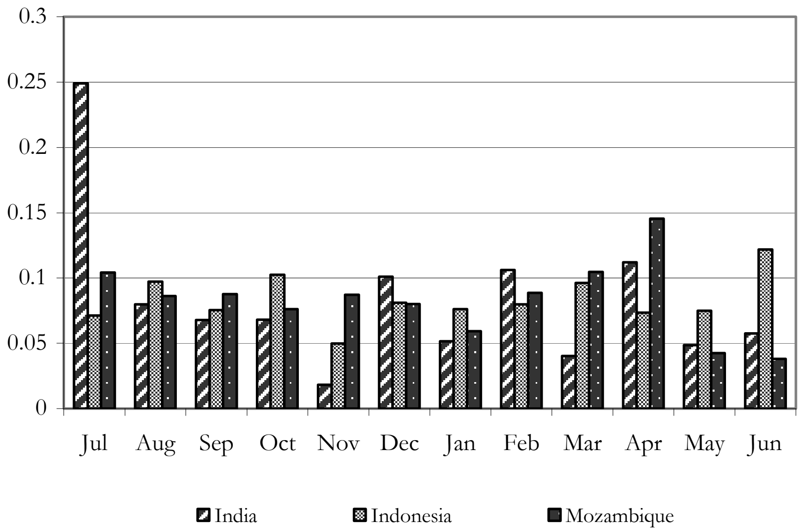
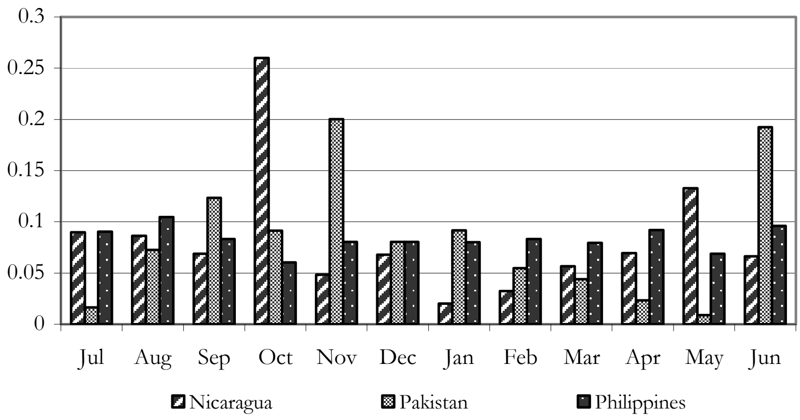


Figure A1: (continued)



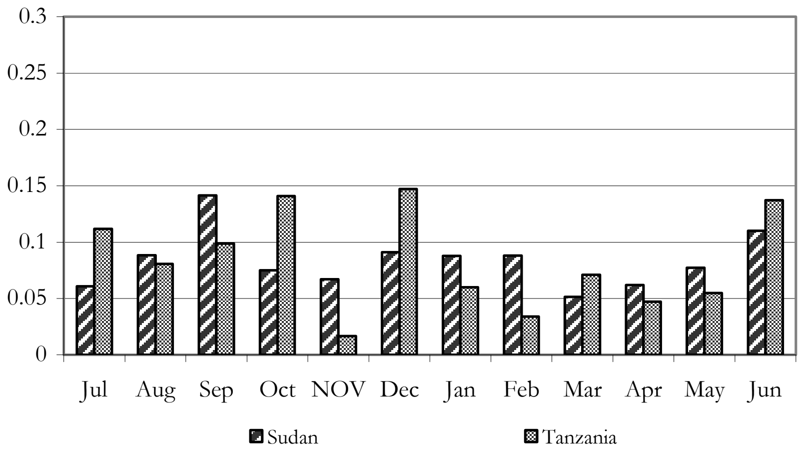


Figure A2: World wheat reference prices (in US$ per metric ton)

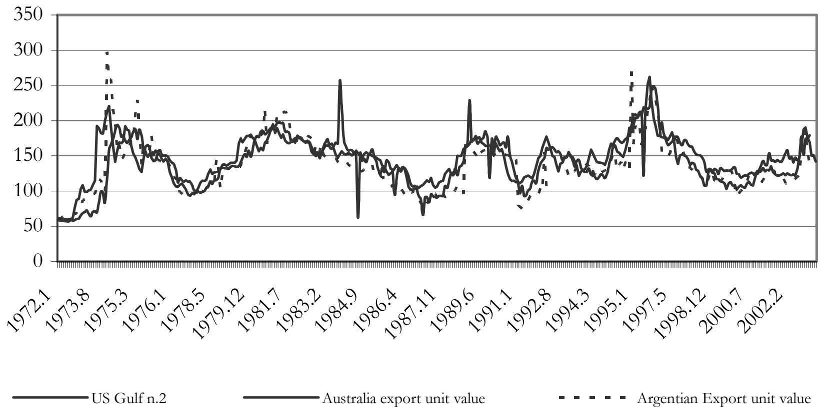
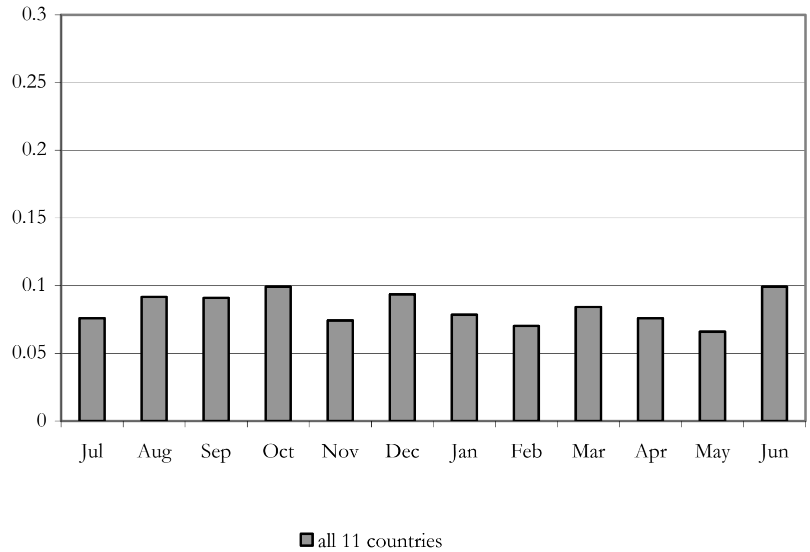


Figure A3: Average aggregate monthly distribution of wheat imports for all 11 countries together (1995 to 2002)



Shocks and Coffee: Lessons from Nicaragua

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Abstract

Using household level panel data from Nicaragua, this paper explores the impact of the recent coffee crisis on rural households engaged in coffee production and coffee labor work. Taking advantage of the panel structure of the data, a number of findings emerge: (i) while overall growth between 1998 and 2001 was widespread in rural Nicaragua, coffee households saw large declines in various socioeconomic outcomes; (ii) among coffee households, it is small farm households that were affected the most and not poor labor households as previously expected; (iii) even though coffee households used various risk management strategies to address the shock, it was pre shock, ex-ante strategies (like income diversification) that were the most effective in allowing coffee households insulate against the shock. By contrast, the coffee households that used ex-post coping instruments did not manage to mitigate the adverse impact as well, with additional potential long run implications via extensive uses of harmful coping strategies (like increases in child labor); and (iv) the coffee shock affected upward mobility and downward poverty vulnerability of coffee households. Such findings seem to confirm the widespread impact of shocks on overall household behavior and indicate the importance of incorporating risk management in the policy agenda of poverty reduction.

1. *Introduction*

Coffee is by far the most important crop for the Nicaraguan economy. It is the highest source of agricultural export revenues in Nicaragua. Specifically, during the last 5 years, coffee exports have averaged $140 million (24 percent of total export earnings).[1] It is estimated that total employment in coffee produc-

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[1] Source: Banco Central de Nicaragua. *Indicadores Economicos Mensuales*. www.bcn.gob.ni

tion accounts between 20 and 40 percent of the rural labor force,[2] and that more than 65% of those employed in the sector are seasonal workers.[3]

Nonetheless, for the last few years the coffee industry has been undergoing a worldwide structural change. The entry of a number of new producers in the late nineties (such as Vietnam), as well as technological improvements leading to increases in production in Latin American countries (e.g. Brazil) have dramatically increased production and as such, international coffee prices have been severely depressed.

The collapse in prices has resulted in significantly lower revenues for coffee producers in Nicaragua. Between 1998 and 2001, average price received by coffee exporters decreased from $151 to $59 per hundredweight - a decrease of 61%.[4] By 2001, the price received by coffee producers (between $45 and $50 per hundredweight) was barely sufficient to cover production costs, which are estimated to be $35, $45, and $55 (per hundredweight) for low, medium and high-technology farms.[5]

This has seriously affected the Nicaraguan coffee economy. Many farmers have been forced to reduce and even abandon coffee production altogether. In addition, there is concern about the social impact of the crisis on the coffee laborers. Initial estimates suggested that 35,000 permanent and more than 100,000 seasonal coffee plantation workers may have lost their coffee jobs.[6]

Still, the lack of in depth empirical evidence to understand the magnitude of the crisis impedes informed policy formation. Not only there is a need to better measure the impact of the shock but also identify the households that were affected the most and explore the various strategies utilized by these households to prevent, cope and mitigate the adverse effect of the crisis. A better understanding of these issues will be crucial in designing appropriate instruments for policy response.

This paper addresses these gaps in knowledge. Using a household panel data that was collected in two periods (1998 where prices were relatively high and 2001 when they were at their lowest) and by specifically exploring the sample heterogeneity to distinguish between coffee and non-coffee households, the paper describes the evolution of household-level socio-economic welfare measures between the two periods and explores the various mechanisms and strategies employed to deal with the crisis.

[2] From LSMS data on employment and agricultural production, about 20 percent of the rural labor force is estimated to be directly employed in the coffee sector while MAGFOR (2002) estimates this to be 40 percent.

[3] Inter American Development Bank (2001). The remaining 35% are permanent farm workers or farm owners.

[4] Government of Nicaragua, Ministry of Industry and Commerce (MIFIC) and Center of Export Transactions. These refer to international prices.

[5] Cfr. Footnote 3.

[6] Ibid.

The paper is divided as follows: the next section describes the data and the various typologies and classifications used to define the coffee sector. An evaluation of the impact of the coffee crisis on a number of socio-economic outcomes is examined in section III, while section IV explores risk management strategies available to affected households. Section V addresses how the coffee shock may have influenced poverty mobility and vulnerability while a discussion of public policy interventions to address the crisis is presented in section VI. Section VII concludes.

2. *Data, coffee typology and a baseline profile of coffee households*

2.1. *Data sources and coffee typology*

The main data source is from the *Living Standards Measurement Surveys* (LSMS) collected in Nicaragua in 1998 and 2001. The first survey was implemented in the summer of 1998, while the second during the summer of 2001. By then coffee prices had reached more than 60 percent of their 1998 level (Figure 1). More than 4,000 households were surveyed each year, and approximately 3,000 of those surveyed in 1998 were also interviewed in 2001. Taking advantage of the panel nature of the data, 2,993 panel households are identified for which data on aggregate consumption and income exists in both years. Since the main focus is to understand the impact of the coffee crisis (a mainly rural phenomenon), the analysis is limited largely to rural households only and focuses on a final rural panel data of 1,355 households.[7]

In order to understand the impact of the coffee shock on households, a number of definitions are used to define how a household relates with coffee. The first definition focuses on household employment activities and classifies a household between "coffee" and "non coffee" based on whether any member of a household worked in the coffee sector, either as a wage earner or as a producer. Specifically, a household is defined as:

- *non-coffee* if it was not involved in any coffee activities in either year;
- *exiting coffee* if it was only involved in coffee activities in 1998;
- *entering coffee* if it was only involved in coffee activities in 2001;[8] and

[7] Preliminary analysis also included urban households to assess whether or not to incorporate them in the analysis. While it is likely that seasonal migration from urban to rural regions occurs during coffee harvests, the household survey reveals that most of this migration occurs within rural areas. In addition, since isolating the impact of the coffee crisis per se is a challenging issue, focusing on rural areas alone facilitates this by eliminating any systematic biases in welfare and other socioeconomic changes that could be due to urban-specific shocks.

[8] While observing households enter the coffee sector during this period is counterintuitive, there are two possible explanations: (i) households were already in coffee before the first survey but did not have coffee income reported in 1998 due its perennial nature; (ii) households entered immediately after the 1998 survey, when coffee prices were still high. Of the 117 households that

- *coffee* if it was involved in coffee activities both years.

The rural panel classifies 293 households involved in coffee activities in at least one of the years of the survey (Tables 1 and 2). This represents 24 percent of the rural panel households out of which one third (8 percent of the rural panel) remained in the coffee sector over the period.[9]

The first definition further distinguishes *coffee households* between "labor" and "farm". This additional division is crucial as one of the key questions that this study tries to address is how the impact of the crisis compares among different types of coffee households. Using this distinction, there are 31 coffee-labor households and 59 coffee-farm households that remained in coffee both periods (Table 2). It is important to note that this latter category corresponds mainly to small-scale family farms with an average farm-size of 13 hectares and median of 5.6 hectares.[10]

A third typology defines coffee households based on their activity during the baseline year. Since households may have entered or exited the coffee sector as a response to the shock, attributing changes in various outcomes such as poverty and consumption to the coffee shock cannot be separated from the strategy to "exit" or "stay" in coffee. In this sense, the two definitions above are "endogenous" to the outcome, which poses a challenge in measuring the coffee shock's impact. While this is not always the case, classifying households based on the first year's (1998) affiliation to coffee is used in the empirical analysis as an instrument for the two previous definitions:

non-coffee if it was not involved in any coffee activities in 1998;
coffee labor if it was involved in coffee labor activities in 1998; and
coffee farm if it was involved in coffee farming activities in 1998

Based on this definition, in 1998 there were 108 coffee-labor households, 108 coffee-farm households and 1139 non-coffee households (Table 2).

A final broader coffee classification that also serves for robustness checks is established using a geographical based index of coffee intensity. The small sample size of coffee households using the previous definitions raises a concern about empirical inferences that could be made. In addition, given that there are possibly spillover effects between the coffee and non-coffee sectors, it is important to be able to assess the impact of the coffee crisis on a more heteroge-

entered the coffee sector between 1998 and 2001, 62 are labor households and 55 are small farmers.

[9] While these are weighted estimates using the rural panel, none of the two surveys was designed to represent coffee households at the national or any sub-national level, and as such these estimates should only be treated as indicative.

[10] As neither of the two household surveys was designed to represent coffee households at the national or any sub-national level, any conclusions should not be interpreted strictly as representing all coffee households in Nicaragua.

Box 1: Typology of rural coffee households

Household definitions			Regional definition
1	2	3	4
Any household member affiliated in coffee sector: using			Coffee production intensity in municipality
both years	both years	initial year 1998	
Non-coffee both years Coffee-exit Coffee-enter Coffee both years	Both years: Coffee-labor Coffee-farmer	Non-coffee Coffee-labor Coffee-farmer	Low intensity region Medium intensity region High intensity region

Sources: Nicaragua LSMS 1998 and 2001; and National Agricultural Census 2001.

neous group of households irrespective of their direct involvement in coffee.[11] As such, using the 2001 *Censo Nacional Agropecuario* (Agricultural Census), a municipality-level intensity of coffee production is defined as the share of land dedicated to coffee cultivation. The benefit of such geographical definition is that it addresses the concerns above and serves as robustness check for the results obtained from the household definitions but can also look at the geographical aspects of the impact (if any). Using the distribution of coffee intensity three coffee regions are defined (low, medium, high).[12] Based on the regional coffee definition, 288 households (21 percent of the rural panel) reside in the high coffee region (Table 3). Box 1 summarizes the four definitions above.

3. *Assessing the impact of the coffee shock*

3.1. *Baseline profile: 1998*

The rural panel suggests that coffee labor households were among the poorest rural groups during 1998, while coffee farmers were the wealthiest. In particular, coffee labor households were the poorest group based on consumption and income levels as well as land assets (Table 4).[13] In fact, practically all coffee

[11] For example, while the coffee crisis may directly affect the incomes of agricultural workers, producers and anyone else involved in the production and marketing chain of coffee, it may also affect the local non-coffee economy via lower demand for other goods or increases in the labor supply for non-coffee jobs.

[12] A municipality is defined as *Low coffee intensity* if less than 1.3 percent of the farmland is dedicated to coffee (corresponding to the first 3 quintiles of the coffee intensity variable); *medium coffee intensity* is a municipality where 1.4-10.7 percent of farmland is used for coffee production (corresponding to the fourth quintile of the coffee intensity variable); and *high coffee intensity* is a municipality where 10.8 percent or more of the total farmland is dedicated to coffee production.

[13] All group comparisons presented in this paper are statistically significant at the 90 percent level or more unless otherwise noted.

labor households were poor (Table 6). By sharp contrast, coffee farmers were by far the better-off group before the crisis in terms of welfare and wealth, even compared to non-coffee households. Still, coffee farmers were the least diversified in terms of income sources (with almost 80 percent of their income derived from farming), suggesting that they would be potentially less able to protect themselves from a coffee shock.

3.2. *Impact on poverty*

Overall, the years between 1995 and 2001 are characterized by high economic growth in Nicaragua. Real GDP averaged annual growth rates of about 5 percent between 1995 and 2001, while GDP per capita grew at a rate of 2.1 percent per year.[14]

Partially in response to economic growth, overall poverty declined over this period. In particular, between 1998 and 2001, overall poverty in Nicaragua declined by 4 percent to a headcount rate of 46 percent (Table 5). Even though poverty is still an overwhelmingly rural phenomenon (as more than two-thirds of the Nicaragua's poor live in rural areas), poverty rates declined faster in rural areas than in urban areas. In 2001, 64 percent of the rural were poor (a decline of six percent from 1998), compared with only 29 percent among the urban population (a decline of less than 2 percent). Similarly, almost 25 percent of the rural population was classified as extreme poor in 2001 (a decline of 15 percent from 1998), while only six percent were extreme poor in urban areas (a decline of less than 2 percent).

Nonetheless, the rural panel reveals that coffee-sector households did not benefit from these advances.[15] In particular, the poverty rate among households involved in the coffee sector in both years increased by 1.8 percentage points to more than 75 percent (Table 5 and Figure 2). Similarly, households that entered the coffee sector before 2001 observed a moderate decline in poverty of almost two percent. By contrast, poverty rates among households not involved in coffee in both years and among households that exited coffee after 1998 decreased by more than ten percentage points to 55 and 63 percent, respectively. In fact, attributing (naively) the poverty rates differences between coffee and non-coffee households on the coffee shock alone would suggest that the crisis resulted in a poverty increase of 11.9 percentage points.

Similarly, reduction in extreme poverty was not shared among households involved in coffee activities. While extreme poverty decreased by 47 percent among non-coffee households, and by about 22 percent in households that entered and exited coffee, it increased by 5 percent among households involved in

[14] Cfr. footnote 1.

[15] Note that from this point forward, all comparisons refer to the panel estimates.

coffee in 1998 and 2001. A similar trend was observed with the regional coffee definition.[16]

Still, differentiating between farm and labor households within the coffee sector reveals that while both were affected negatively farm households were hit the most. In fact, only coffee farm households experienced increases in poverty rates (seven percent). By contrast, poverty among labor households decreased by four percent even though it did at a lower rate compared to non-coffee households (Tables 5 and 6). This implies that while coffee labor households were poorer as noted earlier, the coffee crisis shock affected them less compared to coffee farm households. Understanding and comparing the various coping strategies between the two groups is therefore crucial.

The regional coffee definition confirms the above patterns. During both 1998 and 2001, poverty in the high coffee intensity region was high compared to low and medium coffee intensity regions (Table 5 and Figure 3). Poverty rates among households in high coffee intensity regions remained above 75 percent while among households in low and medium intensity regions decreased by 13 and 6 percentage points, respectively. These trends and the corresponding impact of the coffee shock on poverty rates using this definition (a suggested impact of 11.7 percentage points) are both consistent with the household definitions discussed above.

3.3. *Consumption*

Between 1998 and 2001, real consumption per capita in rural areas increased an average of 11.7 percent, or 470 Cordobas (Table 7). This increase was driven mainly by an increase in consumption of non-food items (e.g., non-durable household goods, clothing, transportation, etc.) of 28.1 percent (or 9.4 percent per year). By contrast, average food consumption practically remained the same, increasing by less than 1 percent over the three-year period.

In contrast, households that were involved in the coffee sector in both years experienced significant declines in per capita consumption. While consumption per capita increased 15 percent among non-coffee households, it decreased more than 16 percent among coffee households (Table 7 and Figure 4). Households that exited coffee production between 1998 and 2001 experienced an increase of consumption of 15 percent, whereas consumption remained unchanged among households that entered the coffee sector after 1998.

Consistent with the poverty trends above, the consumption decline was more severe among farm as opposed to labor coffee households. Consumption

[16] Extreme poverty declined in all regions, but the increase was more than 5 times greater among low-intensity coffee regions (56 percent) vis-à-vis high-intensity coffee regions, where extreme poverty fell by 10 percent.

per capita decreased more than 25 percent among farm households while consumption among coffee labor households remained the same (Table 9).

Similar patterns are observed using the regional coffee definition. In particular, total consumption per capita in low-intensity coffee areas increased by almost 16 percent between 1998 and 2001, in contrast with a 3 percent decrease in high-intensity regions (Figure 5).[17] This finding is consistent with the evolution of poverty within these regions.

The drop in overall consumption of coffee households was driven by a decline in food consumption. Decomposition of consumption per-capita into its food and non-food components allows the identification of the source in consumption changes. For non-coffee households, while food consumption was similar between 1998 and 2001, the non-food component increased by more than 30 percent (Figure 4 and Table 5). Conversely, while coffee households experienced drops in both consumption components, the largest drop was in food consumption (23 percent). Similar patterns hold using the regional coffee definition.

3.4. *Income*

Mirroring the previous patterns, coffee households experienced large declines in incomes. Overall, between 1998 and 2001 real rural incomes per capita increased by 30 percent. Still, comparisons using the coffee definitions reveal distinct differences for each subgroup. For example, income per capita increased by 40 percent for non-coffee households (Table 8 and Figure 6). Similar increases are found in the low intensity coffee region. By sharp contrast, households involved in coffee in both periods suffered a decrease in per capita income of more than 25 percent.

Nonetheless, coffee farm households were hit the worst. In fact, while they had the highest average incomes per capita in 1998, by 2001 it was among the lowest. Using the household coffee definition, income per capita for coffee farm households was 6,031 Cordobas, compared to 3,697 for non-coffee households in 1998 (Tables 8 and 9). This pattern completely reversed in 2001 with coffee farm households experiencing a 40 percent decrease in incomes while non-coffee households saw a 40 percent increase in incomes. On the other hand, incomes for coffee labor households changed little between the 2 periods (Table 9), to a large part reflecting the price effect on agricultural income.

3.5. *Health and Education*

Child malnutrition remained unchanged within coffee regions between 1998 and 2001. Despite the fact that overall, incidences of various malnutrition

[17] This decrease was not statistically significant.

measures such as stunting, wasting and underweight showed improvement during the period (national declines of 35, 11, and 73 percent, respectively), these gains were not enjoyed equally by children of all regions.[18] As figures 7 and 8 reveal, the Central Rural region - where more than 80 percent of Nicaragua's coffee production is concentrated - the incidence of underweight children changed very little while for chronic malnutrition (stunting) actually appears to have slightly increased. Both malnutrition incidences for the Central Rural region were the highest in the country during both periods and these trends suggests that the coffee crisis had a negative effect on the nutritional status of children younger than 5 years in the region (in the sense of at not enjoying the gains experienced elsewhere).

In educational outcomes, despite large increases in enrollment rates at both the primary and secondary levels, overall, primary enrollment rates among coffee households fell and secondary enrolment rates hardly changed between 1998 and 2001. Among non-coffee households, primary net enrollment rates increased from 78 to 86 percent (Figure 9). By contrast, enrollment rates among households involved in the coffee sector in both periods decreased from 77 to 72 percent. At the same time, secondary net enrollment rates almost doubled among non-coffee (to 40 percent), while remaining essentially unchanged among coffee-sector households over the period (at around ten percent; Figure 10). While not attributing these differences solely on the coffee crisis, it is possible that these patterns reflect harmful coping strategies among coffee households. The next session addresses this issue in more detail.

In summary, descriptive statistics suggest that households related to coffee activities did not benefit from an otherwise period of growth in Nicaragua. In fact, most socio-economic indicators for these households have worsened between 1998 and 2001, a period that saw coffee prices declined by more than half. While accurately quantifying the impact that the coffee shock may have had is challenging, the big magnitude cast little doubt that the coffee shock had a strong impact on coffee farm households and to a smaller effect coffee labor households. The next section explores the various strategies that these households used to mitigate, cope or prevent the shock and the extent by which informal insurance mechanisms to smooth consumption were available.

[18] Stunting (height-for-age) reflects chronic malnutrition, which results from years of retarded skeletal growth and is associated with poor economic conditions; wasting (weight-for-height) captures deficiencies in fat tissue and indicates food loss from a short-term, emergency situation; and underweight (weight-for-age) combines the previous two measures and reflects total malnutrition. A child (of usually 5 years or less) is considered "stunted", "wasted" or "underweight" if his/her corresponding anthropometric measure is two or more standard deviations below the median of the internationally recognized reference population. Also see Marini and Gragnolati 2002, and Chawla 2001.

4. *Risk management strategies and responding to shocks*

4.1. *Do households self-insure?*

The role of risk and insurance on household behavior is well documented in the literature.[19] As poor households make consumption decisions in uncertain environments, they face many risks: idiosyncratic risks that affect a specific household (illness, death, unemployment); or covariate risks that affect everyone within a particular region or group (droughts, hurricanes, terms of trade shocks or macroeconomic volatility). The question as to whether some households are better able to use formal or informal mechanisms to minimize the impact of such risks on their consumption is therefore key in designing policies that provide insurance or safety nets mechanisms.

The previous section revealed that coffee households were adversely affected by the coffee shock in terms a number of different welfare dimensions. In the context of the coffee shock a number of questions arise: were affected households able to protect against the negative income decline? How does their ability to insure (or not) compares with non-coffee households? Are there differences among coffee households?

A number of empirical approaches have been used that address these questions of self-insurance and consumption smoothing. The most common is to fit an equation that looks at how changes in consumption correlate with income changes.[20] The typical specification is derived from a consumption equation of the initial form:

$$\ln C_{it} = \alpha + \beta \ln Y_{it} + \gamma X_{it} + \eta_i + \omega_{it} \qquad (1)$$

where $\ln C_{it}$ is the log of consumption per capita of household i in period t, $\ln Y_{it}$ is the log of income at time t, X_{it} is a vector of socio-economic characteristics, α, β and γ are parameters to be estimated, η is a household fixed effect and ω_{it} is an i.i.d. error term.

By differencing equation 1 (between the two years), the specification becomes:

$$\Delta \ln C_i = \alpha + \beta \Delta \ln Y_i + \gamma \Delta X_i + \omega_i \qquad (2)$$

where Δ denotes changes over the two periods of the respective variables. Estimating equation 2 will give unbiased estimates of the coefficients.

The basic test of consumption insurance is the extent to which household income co-varies with consumption. If households are fully insured against income shocks, then changes in income do not affect consumption and $\beta = 0$.

[19] For example, Alderman and Paxson (1992), Townsend (1994), Jalan and Ravallion (1999).

[20] See Townsend (1994), Ravallion and Chaudhuri (1997) and Grimard (1997) for some examples.

The extent to which β differs from zero indicates how insulated (or exposed) a household's consumption is to income shocks.[21]

In the case of the coffee shock, an additional empirical challenge is to correctly model the coffee crisis since it is covariate shock that only affects a subgroup of the population. Specifically, it is important to be able to test for differentiated impacts on consumption among different types of households, based on whether they participated in coffee activities or resided in a coffee region (as defined earlier). Nonetheless, two of the coffee definitions are endogenous in the sense that the decision to enter, exit or stay in coffee is endogenous to consumption changes. As such, the final empirical strategy implemented here is to estimate coffee-group specific models using equation 2. That is, for each coffee classification, a consumption changes is regressed on income changes (ΔY) and household size changes (ΔX).[22] This avoids the endogeneity issue since the only interest is to test the specific group's ability to self-insure.[23]

The overall results reject the full insurance hypothesis. Estimating Equation (1) suggests that more than fourteen percent of an income shock is passed onto current consumption (Table 10).[24] These effects are similar by estimating this on food and non-food consumption.

Estimation of equation 2 using coffee-specific models suggests that income shocks have a heterogeneous impact among different rural subgroups. For example, using the first two coffee definitions, given an overall impact of income shocks on consumption that is similar for coffee and non-coffee households, the former are significantly less able to self-insure (Table 10). Specifically, for every dollar of income decrease, coffee-labor households decrease consumption by 22 cents while coffee labor households by 20 cents.

Comparing self-insurance abilities for food consumption, the results indicate that coffee-labor households are vulnerable to insuring food consumption while coffee-farm households are not. Specifically, more than 43 percent of an income shock among coffee-labor households is passed through food consumption decreases. By contrast, among coffee-farm households, the effect is not significant suggesting that income shocks do not translate into food consumption decreases. To the extent that coffee-labor households were the poor-

[21] The intercept α captures aggregate income risk.

[22] This is a similar estimation strategy adopted by Jalan and Ravallion (1999).

[23] An alternative approach would be to estimate an augmented equation 2 using coffee dummies interacted by income changes to test the full insurance model and exploring differentiated insurance ability among various coffee categories. This approach has the advantage of using the entire sample, which is attractive due to the small sample sizes of coffee categories using the specification of equation 2. While estimating this specification resulted in similar results, they are not reported due to concerns on the endogeneity of some of the coffee classifications.

[24] These magnitudes are consistent with the ones typically found in the literature. See also Skoufias and Quisumbirng (2002).

est in both periods, these findings imply that they were also the most vulnerable to income risks. As such in improving insurance mechanisms and risk reduction in rural Nicaragua, special attention on the poorer and more vulnerable populations (such as coffee labor households) may be a priority. This finding is consistent with literature from other countries that suggest that the poorest households are also those least able to smooth consumption (Jalan and Ravallion 1999).

The ability to insure non-food consumption against income shocks is smaller among coffee-farm households. For example, among households that remained in coffee farming in both periods, non-food consumption changes decreased by 34 cents for every dollar decrease in income. A similar pattern is observed using the other coffee household definition (even though the overall magnitude is smaller).

Interestingly, households that exited and entered the coffee sector seem to be able to "insure" against income fluctuations. The non-significance of the income coefficient for both groups suggests that these households were better able to insulate their consumption from income shocks (Table 10).[25] While for households that exited the coffee sector, this could be suggesting that mobility and adaptability to changing economic conditions may be important in determining how households insure against shocks, it is unclear as to why that may be the case for household that entered coffee (but the small sample sizes for both groups may explain these results). Nonetheless, as discussed below, income diversification in non-agricultural activities seems to have allowed some households to stabilize consumption patterns. Understanding the process of coffee entering or exiting may therefore be important.

4.2. *Risk management strategies*

Exposure to risk in general does not necessarily translate in adverse outcomes. In fact, if households have access to a sufficient portfolio of options that can allow them to manage the realization of risk (the shock), then exposure to risk is not an issue. This is not the case in most cases and the results above do suggest that rural households in Nicaragua are not able to fully protect themselves against risk exposure.

As such, a better understanding of the various risk management strategies employed by rural households to cope with risks is important. Typically it is useful to separate such strategies into ex-ante and ex-post (Holzmann and Jorgensen 2000). Ex-ante mechanisms address what households (and to that extent, public and private instruments) can do to reduce or prevent the occurrence of risks and mitigate the impact of risk if an adverse event occurs. Some examples of ex-ante mechanisms are crop insurance, exiting a risky occupation,

[25] Similar results were obtained with changes in food and non-food consumption.

income diversification. On the other hand, ex-post mechanisms address the ability of households to respond after a risk has been realized (for example taking children out of school or selling assets). Exploring whether these risk management strategies and mechanisms exist or vary across different households is also instrumental for policy design.

This section explores what strategies, if any, have allowed rural households to address exposure to various risks, with emphasis on the coffee shock. To facilitate the analysis, in addition to ex-ante and ex-post strategies, risk management strategies are further grouped in: (i) labor market adjustments; (ii) precautionary savings; and (iii) informal insurance. In principle, all three strategies can be both ex-ante and ex-post. Finally exiting the coffee sector as a response to the shock is also considered as a coping strategy.

Empirically, there are a number of approaches to explore the role of various risk management mechanisms on household welfare. Typically, data on a household's response as a result of realized risks can be used to assess the existence and use of the various mechanisms mentioned above. Since the Nicaragua survey did not collect such information a few alternative methodological strategies are implemented. Denoting $\boldsymbol{Z}$ to be a vector of potential risk management instruments available to the household the initial period (for example assets, labor supply), the first approach entails estimating a consumption growth model of the form:

$$\Delta \ln C_i = \delta_0 + \delta_1 X_i + \delta_2 Z_i + v_i \qquad (3)$$

where X_i and Z_i are as previously defined above, δ_0, δ_1, and δ_2 are parameters to be estimated and v_i is an i.i.d. error term.

Estimating equation 3 can allow indirect inferences on the existence of a particular risk management instrument vis-à-vis consumption growth. Specifically, testing whether a specific instrument $\boldsymbol{Z}$ is correlated with consumption growth over the period is interpreted as weak evidence of a positive role for that instrument in addressing risk. For example, finding a positive relationship between the initial level of remittances and consumption growth is interpreted as evidence that migration was a potentially important strategy for households (and possibly against exposure to risk). As with the insurance models above and due to the similar endogeneity concerns, equation 3 is estimated for each of the coffee definitions separately so as to assess the existence of risk management instruments among each specific subgroup. The results are presented in Tables 11 through 19, the dependent variable being the change in total, food, and non-food consumption, respectively.

A second approach is to directly test whether a household used a specific coping instrument. Empirically this can be implemented by estimating a probability model of the form:

$$\text{Prob}(\Delta Z_i = 1) = f\left(\sum_{k=1}^{K-1} \theta_k \text{ Coffee}_{ik} + \xi_i\right) \quad (4)$$

where ΔZ_i denotes a positive use of that risk management instrument. For example, ΔZ_i could be the change in a household's child labor allocation over the period. In this case, by differentiating among households based on their affiliation with coffee activities, a positive θ for say, coffee laborers, would suggest that these households were more likely to engage in harmful coping mechanisms such as child labor due to the coffee shock. To further explore coping abilities among coffee households, equation 4 is also estimated controlling for whether a household was poor in 1998, capturing heterogeneous coping ability between poor and less poor coffee households. The results for these estimations are presented in Tables 20 through 23.

The results from both approaches described above, complimented by descriptive statistics are summarized below.[26]

4.3. *Labor market adjustments*

Household diversification in non-agricultural activities plays an important role for rural welfare and coping with shocks. Non-coffee households that were more income diversified in 1998 (measure by the number of different agricultural and non-agricultural income sources in the household) were more likely to experience consumption growth (for example Tables 11, 13 and 14).[27] By contrast, diversification among coffee labor and farm households did not affect consumption growth. One important distinction that may explain these patterns is the observation that while non-coffee households were diversified in both agricultural and non-agricultural activities, coffee households were mainly "diversified" only within the agricultural sector (Tables 4 and 8, Figures 11-13). As such, these patterns suggest that access to non-agricultural activities may be a key instrument for both risk mitigation and consumption growth in general.

Consistent with the above, examination of income portfolio adjustments indicates that households that increased non-agricultural incomes faired better. For example, among households that exited coffee over the period, the main income increases were due to increases in non-agricultural income (Table 8 and Figure 13). In addition, while coffee labor households who exited coffee mainly diverted their efforts to non-agricultural labor (wage) activities, coffee farm households that exited coffee shifted labor to non-agricultural enterprises (self-

[26] All models discussed in this section also control for municipality level fixed effects, and whether the household resides in a hurricane Mitch affected municipality, the other covariate shock during this period.

[27] This is consistent with Beneke and Gonzalez-Vega (2000) who find positive effects of income diversification on income growth in El Salvador.

employment). This is indicative of the constraints for poorer households (coffee labor) to take advantage of higher return occupations in the non-agricultural sector. Nonetheless, the fact that these households did exit coffee highlights the importance of understanding the determinants of both upward income mobility and the ability to diversify into non-agricultural activities.

The empirical results also imply that coffee households engaged in harmful coping activities via increases in child labor, directly affecting school enrollment. Over the period of the study, child labor incidence increased in rural Nicaragua by 24 percent (Figure 14). While this incidence has decreased among coffee households (Figure 14), the average total weekly hours worked by children among coffee households significantly increased compared with a decrease for child workers in non-coffee households (Figure 16 and 17).[28] In addition, households residing in the high coffee intensity region were significantly more likely to increase child labor (Table 21). Consistent with these trends, school attendance decreased among children in coffee households while it increased for non-coffee households (Figures 9, 10 and 18).

The use of child labor as a coping strategy was more prevalent among coffee farm households. In particular, even though children working in labor and farm households both worked more and went to school less, the impact in terms of increases in hours worked was stronger among coffee farm households (Figure 16 and 17). This is also confirmed by looking at the results in equation 4 that imply that coffee farm-households were up to 21 percent more likely than non-coffee households experience child-labor increases (Tables 20 and 21). These patterns raise serious issues about the need of policy interventions that can protect children's human capital against adverse shocks.

While partial evidence seems to suggest that remittances are important for consumption smoothing, migration per-se does not seem to be a widespread strategy adopted among coffee households. While the empirical results of equations 3 suggest that both coffee and non-coffee households receiving remittances in 1998 were more likely experience non-food consumption growth (Tables 13, 16 and 19), the results from the coping equation 4 imply that migration was not a coping strategy implemented by coffee households (Tables 20-23).[29]

4.4. *Precautionary savings*

In addition to adjustments to income portfolios, precautionary savings can help households cope with shocks allowing them to liquidate available assets.

[28] The labor force participation among coffee households may be due to a shrinking demand for labor, corroborated by the higher unemployment rate among coffee households (Figure 15).

[29] Nonetheless, migration as a coping strategy was suggested during various informal interviews in rural Nicaragua and it consistent with similar studies such as Beneke and Gonzalez-Vega (2000) who find that the existence of international migrants within a household was correlated with higher income growth during a downturn in agricultural production in El Salvador.

Still, coffee labor households were the most asset-poor among all households in rural Nicaragua. As such, their ability to use such assets to cope with shocks was limited. By contrast, coffee farmers during 1998 were among the wealthier households in terms of asset holdings. Exploring the changes of various assets like land or livestock indicates that some of these assets were used as coping mechanisms, still in a limited way (Figures 19-22).

Furthermore, equation 4 suggests that poor farmers were less likely to use assets in response to the coffee shock. By differentiating between coffee poor and non-poor households based on their 1998 classifications, the results suggest that poor coffee farmers were 13 percent less likely to sell land and 9 percent less likely to sell (or consume) cattle compared to non-poor coffee farm households (Table 21). Interestingly, poor coffee households were more likely to experience decreases in the number of poultry owned, suggesting partial coping via own animal consumption (Tables 20, 21 and Figure 21). These trends overall indicate the importance of assets and highlight the limited capacity among poorer households to use physical assets as a major coping strategy.[30]

4.5. *Informal insurance*

The use of informal insurance mechanisms can be another instrument by which household may use to address shocks. For example, informal social networks established by households through memberships in civic, religious, or neighborhood organizations can provide them an alternative source of resources in the event of an adverse shock. In addition, strong ties with migrant household members of relatives may result help in the form of remittances or informal gifts during crises.

The empirical analysis shows that at least partially, the role of family networks is important. As discussed earlier, remittances (used as a proxy for the existence of a family network) were positively correlated with non-food consumption growth for both coffee labor and labor households (Table 16). The impact seems to be stronger for coffee labor households implying that informal coping mechanisms may be more important for the poorer coffee households.

4.6. *Exiting coffee*

As indicated earlier, a significant number of households in the survey exited the coffee sector during this period. This "exit option" was higher among coffee laborers partially explained by the short run inability of coffee farmers to exit the coffee sector due to their land commitment to the coffee production (Table 24). The observation that households that exited coffee did overall bet-

[30] This finding is similar to results in Conning, Olinto and Trigueros (2000) who find that households owning land or other productive assets were better able to protect their income during economic downturns.

ter in terms of (socio)-economic outcomes suggests that that it would be useful to explore the attributes of those exiting in order to understand the characteristics associated with higher mobility to get out of coffee. While the data does not permit the distinction between those households that exited coffee due to lack of jobs or farm business failure with those that have used exit as a risk management strategy, a model exploring a number of initial (1998) characteristics and how they correlate with the exit decision of the following is estimated as follows:

$$\text{Prob}(ExitCoffee_{i,2001} \mid Coffee_{i,1998} = 1) = \lambda_0 \cdot W_i + \lambda_1 \cdot Coffee_k \beta + \lambda_2 \cdot (W_i' \cdot Coffee_k) + \pi_i \tag{5}$$

where *W* is a vector of initial (1998) household and regional attributes and $Coffee_k$ is a dummy identifying coffee farmers capturing a differentiated impact of an attributing between coffee labor and farm households. As earlier, λ_0, λ_1 and λ_2 are parameters to be estimated while π_i is an i.i.d. error term. The estimation also uses municipality level fixed effects. Table 25 presents the results.

Assets, wealth status and income diversification in non-agricultural jobs are important correlates with a household's ability to exit coffee. Less poor households were more likely to exit coffee suggesting that poorer households are less mobile. In addition, conditional on whether a household is a coffee laborer or farmer, higher consumption increases the probability for coffee laborers to exit coffee compared to farm coffee households (see also Figure 25). Similarly, while farm households were less likely to exit (since by definition their land investment in the production process is fixed), after controlling for land size, larger farmers were more likely to exit the coffee sector, indicating that if land can be interpreted as wealth, assets are important in allowing households engage in new activities. Finally, coffee households that were more income diversified in non-agricultural activities were more likely to exit coffee. This is consistent with the earlier findings that show that the ability to enter the non-agricultural sector has been key in mitigating the negative shocks of the shock.

Access to credit is associated with a higher probability to exit coffee. The role of credit can be crucial in mitigating the impact for shocks by both helping to cope and diversify in other activities. Credit has a stronger impact on the probability to exit coffee among labor coffee households as opposed to farmers, perhaps highlighting the lack of assets among coffee labor households.

Finally, a number of attributes describing the local economic context are correlated with exiting coffee. For example, distance to Managua or residing within the coffee region are both negatively correlated with the probability to exit coffee. Both of these attributes capture the existence of non-coffee activities and opportunities (in addition to controlling for the shock for the latter). Interestingly, residing in a region affected by hurricane Mitch also decreases the probability of exiting the coffee sector, presenting an example of the adverse effect of multiple shocks on households.[31]

While separating the decision to exit from a forced exit is challenging, these findings seem to indicate the critical importance of assets and opportunities on upward mobility and coping capacity. They reinforce the fact that in the presence of shocks, those households that can protect themselves using instruments that either detach them from exposure to risk or minimize its impact if the risk is realized, are better able to cope.

4.7. *The role of ex-ante risk management*

To summarize the results in this section, coffee households have used a mixture of coping mechanisms in response to the coffee crisis. While harmful coping mechanisms such as increases in child labor and - to a lesser extent - selling or consuming physical and animal assets were utilized among coffee households, a number of ex-ante management instruments such as exiting coffee, receiving remittances or income diversification were also used (Table 26).

While a formal test cannot explicitly compare the two, the findings suggest that households that used ex-ante as opposed to ex-post mechanisms were better insulated from the coffee shock. For example, since much of the explanatory variables in the consumption growth models are all based on the initial pre-crisis household income strategies, their positive role on consumption growth can be interpreted as the realization of ex-ante risk management actions taken by these households. For example, by diversifying the income sources or having migrant members before the coffee shock, coffee households were better able to mitigate the adverse impact of the crisis. Similarly, higher education (using the maximum level of education in the household in 1998) was associated with a four percent increase in consumption growth, which -while not testable - is consistent with the hypothesis that human capital may have allowed households to mitigate the negative impact from the crisis by either finding higher return occupations or increasing farm efficiency. Comparing the effectiveness of ex-ante and ex-post strategies is beyond the scope of this study. Still, the dominant role of ex-ante strategies among coffee households for consumption smoothing and the observation that households that predominantly used ex-post coping mechanisms did worse suggests that, at least qualitatively, ex-ante strategies have been more effective.

5. *Shocks, vulnerability and mobility*

The previous sections outlined the extent by which the coffee crisis has affected rural households and explored the various mechanisms affected house-

[31] Hurricane Mitch hit the region in October 1998, right after collection of the first survey.

holds utilized to cope with the shock. While households do not seem to be able to fully insure against unanticipated income fluctuations, a number of coping strategies were used among rural coffee households that mitigated the impact of the coffee shock. For households affected by the coffee crisis, a heterogeneous set of mechanisms such as ex-ante income diversification or ex-post increases in child labor have allowed households to deal partially with the shock.

Nonetheless, prioritizing among the identified strategies and mechanisms explored above is a complex task. For example, the results suggest that the coffee shock had a bigger impact on farmers rather than labor households. Still, coffee farmers had the lowest poverty rates, highest level of assets while labor households are chronically poor. As such, further exploring the linkages between shocks and poverty dynamics may allow building a more comprehensive policy agenda.

5.1. *Poverty dynamics*

To this end, this section provides an analysis on the impact of shocks on poverty dynamics. Specifically, two questions are addressed: (i) has the coffee shock increased household vulnerability to decreases in welfare; and (ii) did the ability of households to escape poverty (mobility) changed due to the shock?

In the case of rural Nicaragua, poverty is dynamic. For example, between 1998 and 2001, almost a third of non-coffee households moved in and out of poverty (Table 27, Figures 23 and 24). In addition, non-coffee households were less likely to exit poverty (upward mobility) than falling into poverty, consistent with the overall poverty rate decreases observed during this period.

In addition, a number of interesting patterns related to the coffee shock emerge with respect to poverty changes. First, while almost a third of coffee farm households experienced similar movements in and out of poverty compared with the overall trends above, they were more likely to enter poverty (Table 27). In addition, coffee labor households were virtually trapped in chronic poverty. Almost 90 percent of coffee labor households remained in poverty and experience little upward mobility.

Coffee households were also more likely to experience a consumption decrease. Only ten percent of non-coffee experienced a fall in their "ranking" in terms of consumption quintiles (Table 28). This compares with a quarter of coffee labor households and half of the coffee farmers. In addition, comparing households based on whether consumption in general decreased over the period, while almost 40 percent of non-coffee household experienced consumption decreases, more than two thirds of coffee farm households and 56 percent among coffee labor households suffered a drop in consumption.

These results indicate that the coffee shock may have affected coffee households' ability to enter or exit poverty. Further exploring how the coffee shock may have affected these dynamics is addressed below.

5.2. *Vulnerability to poverty*

Vulnerability is a dynamic concept capturing the probability that a household will experience a negative loss in its welfare (Holzmann 2001). The main idea of vulnerability is that it measures a household's ability to insure or protect against exposure to risk. In fact, while exposure per se is not sufficient to infer vulnerability, observing a differential behavior among exposed households or between exposed and non-exposed households is indicative of the degree that a household will suffer welfare losses in the event of the risk being realized, therefore measuring its vulnerability to risk exposure.

For the purposes of the study, three definitions for vulnerability are used: (i) the likelihood that a household's consumption fell below the poverty line during the two periods covered by the data; (ii) the probability that a household's experienced a decrease in its consumption level; and (iii) the probability that a household's initial ranking based on consumption quintiles decreased. To address the first definition, the following model of the probability that a household - which was not poor in 1998 - entered poverty in 2001 is estimated:

$$\mathrm{Prob}(C_{i,2001} < PovLine_{2001} \mid Poor_{1998} = 0) = \sum_{k=1}^{N-1} \varsigma_k \cdot Coffee_k + \rho \cdot X_i +_i \psi \cdot Z + \tau_i \tag{6}$$

where $Coffee_k$, X_i and Z_i are as defined earlier, τ_i is an i.i.d. error term. In addition, while ς_k tests whether a household's exposure to the coffee crisis increase the probability (and therefore vulnerability) to fall into poverty, ρ and ψ reveal the extent where a number of household attributes are correlated with vulnerability to poverty.[32]

Similarly, using the second definition, the probability that household i experienced a fall in consumption level is given by:

$$\mathrm{Prob}(C_{i,2001} < C_{i,1998}) = \sum_{k=1}^{N-1} \varsigma_k \cdot Coffee_k + \rho \cdot X_i + \psi \cdot Z_i + \tau_i \tag{7}$$

while for the last definition, the probability that a household's consumption ranking fell can be estimated using:

$$\mathrm{Prob}(Quintile_{i,2001} < Quintile_{i,1998}) = \sum_{k=1}^{N-1} \varsigma_k \cdot Coffee_k + \rho \cdot X_i + \psi \cdot Z_i + \tau_i \tag{8}$$

[32] To control for municipal-level characteristics related to the coffee crisis, the regression also includes the municipality-level intensity in coffee production.

The results from these models are presented in Table 29.

Households residing in the coffee region were more vulnerable to welfare losses, suggesting that the coffee shock increased vulnerability. While participation in the coffee sector (using the initial coffee classification) did not have statistically significant effect in household's vulnerability to welfare loss, the regional coffee definition suggest that households in the coffee region were more likely to experience a fall in consumption (Table 29). This finding implies that exposure to the coffee shock risk has increased vulnerability to welfare losses among exposed households.

Exploring further the concept of vulnerability to poverty and consumption loss, a number of interesting points arise. For example, higher levels of education significantly reduce vulnerability to poverty. This reinforces the importance of human capital accumulation as an ex-ante instrument to minimizing vulnerability. In addition, residing in a municipality affected by hurricane Mitch increases the probability that a household will experience reductions in welfare. Again, this confirms the hypothesis that shocks negatively influence poverty dynamics, in this case vulnerability.

5.3. *Upward mobility*

An alternative exercise in understanding poverty dynamics is to explore the factors that are correlated with households' mobility to exit poverty. To address this, a model of the probability that a household exited poverty in 2001 conditional on being poor in 1998 is estimated:

$$\text{Prob}(C_{i,2001} > PovLine_{2001} \mid Poor_{1998} = 1) = \sum_{k=1}^{N-1} \varsigma_k \cdot Coffee_k + \rho \cdot X_i +_i \psi \cdot Z + \tau_i \quad (8)$$

where the regressors are the same as in equation 6 and 7. The results are discussed below.

Households residing within coffee regions were less likely to exit poverty. Mirroring the results on vulnerability, while the household-level classifications of affiliation in coffee activities were not significant, this finding illustrates the aggregate impact of the exposure to the coffee crisis in upward mobility (Table 29).

A number of other factors are correlated with the ability to exit poverty. First, income diversification increases the probability to exit poverty (Table 29). This provides empirical support to the current policy efforts to promote diversification in rural areas, as it indicates that it is not only a successful coping strategy (among coffee farmers) but also important in enhancing upward income mobility (MAGFOR 2003; Varangis *et al.* 2003). It is also important to point out, however, that the diversification measure used here refers to income from different sources (agriculture, non-agriculture, wage and self-employment), and not to diversification in agricultural production. Indeed, an alternative specification using crop diversification found no significant correlation with poverty dynamics.

In addition, households receiving remittances were more likely to exit poverty. This result indicates that migration as a strategy to access higher-return opportunities, is important for economic mobility and reinforces the role of social capital and informal networks in poverty alleviation. Furthermore, both human capital (education) and physical (land) assets were also positively correlated with exiting poverty. Finally, distance from Managua is inversely related to the ability to exit poverty. To the extent that this captures the local economic environment, it shows that more isolated areas offer fewer income options for households.

To summarize the poverty dynamics analysis vis-à-vis the coffee crisis, predicted probabilities to fall or escape poverty are calculated. First, households affiliated with the coffee sector were the most vulnerable to decreases in welfare and least mobile to exit poverty compared to non-coffee households, suggesting that the coffee crisis has indeed affected their mobility and vulnerability (Table 30). These results are robust as they hold independent of the coffee definition or typology used.[33]

Finally, while coffee laborers –the poorest rural group in the survey - were the most adversely affected with respect to vulnerability and mobility with respect to poverty, coffee farmers were mostly affected in terms of the probability to experience consumption declines. These results, suggest that while for coffee farmers the shock may have been more transitory in nature, it may have accentuated poverty traps among the chronically poor coffee laborers. This raises the need for distinct policy interventions for each of the two groups.

6. *Public response to the coffee crisis*

While Government and private support for the coffee sector was significantly delayed in Nicaragua, a number of programs addressing the coffee crisis have since been established. A short summary is presented below.

6.1. *Debt restructuring*

By 2002, coffee-farm debts totaled approximately US$105 million in Nicaragua.[34] As the ability of coffee farmers to repay these loans diminished, it presented a potential crisis in the country's already stressed financial system. As

[33] The probability to exit poverty among non-coffee households is not statistically significant with that of coffee-farm households using the initial coffee classification.

[34] Nicaraguan Coordination and Strategy Secretariat of the Presidency (SECEP).

such, the Government intervened by promoting, coordinating and providing funds for different debt-restructuring programs.

These programs varied according to the type of debt held by a coffee producer, with the following main restructuring categories being created: (i) debts to solvent commercial banks (US$55 million – 684 cases); (ii) debts to bankrupt commercial banks (US$32 million – 665 cases); (iii) debts to micro-finance organizations (US$6 million – 7,520 cases); and (iv) debts to exporting firms (US$12 million – 2,300 cases). The first two categories targeted mainly medium and large coffee farmers (with farms sizes of at least 20 manzanas), the third focused on small farmers (5 manzanas or less) while the final category did not distinguish based on farm size. It is important to note that the majority of the government restructuring schemes (more than 80 percent) has focused on large coffee farmers.

As of May 2003, 100% of the debts in categories (i) and (iii) had been resolved, where the Government played an active role. While the Government did not get involved in re-structuring producers' debts to exporting firms (category iv), these appear to be getting resolved in an efficient manner by the stakeholders (usually an exporting firm and a producer).

6.2. *Social protection interventions*

The Government of Nicaragua implemented a "Food-for-work on Coffee Farms" program through the Ministry of Agriculture (MAGFOR). The program took place in 2002 in 21 coffee municipalities, costing US$574,336 and providing family food rations to 8,212 households: 6,317 of them were small coffee farm owners (6 manzanas or less), and 1,895 were coffee farm workers. Participating households received the food complement in exchange for working on various activities on coffee farms.[35]

6.3. *Indirect benefits from existing (non-coffee specific) programs*

A number of existing public programs may have indirectly mitigated the impact of the coffee crisis. First, the Government's "Libra por Libra" program which started in 2002 has led to higher productivity of small farmers' production of basic grains for own-consumption via the disbursement of genetically improved and certified seeds for basic grain production, and technical assistance. An estimated 72,000 small farmers, many of which reside in coffee regions have participated in the program. During 2003, and in part due to the coffee crisis, MAGFOR doubled the amount of seed distributed in some coffee regions (MAGFOR 2003).

[35] Prior to this program, the Government financed a small scale workfare program benefiting 300 coffee workers (representing about 1,000 family members) in 2001.

In addition, the "Red de Proteccion Social", a conditional cash program in Central Nicaragua that supplements poor rural households' incomes seems to have mitigated the adverse impact of the coffee shock. In particular, a recent impact evaluation of the program finds that program beneficiary households involved in the coffee sector have faired better in a number of socio-economic outcomes compared to non-participating coffee households (Maluccio 2003).

6.4. *Support from other agencies*

USAID financed a US$2.5 million coffee relief, food-for-work initiative in 2002. The program's objectives was to provide relief to unemployed coffee laborers, provide incentive to coffee farmers to continue employing their full-time labor force on a full-time basis, ensure that essential crop maintenance is performed and provide limited support to rehabilitate public infrastructure. An estimated 13,394 coffee laborers in ten coffee municipalities benefited from the USAID program.

Finally, the German government's assistance agency (KDR) financed a large infrastructure project to increase the supply of potable drinking water in the departments of Jinotega and Matagalpa. This project was initiated in 2001, and it generated approximately 10,000 to 15,000 temporary jobs, potentially coffee laborers.

While the programs described above may have temporarily alleviated some of the adverse impacts of the coffee crisis, it is unclear as to whether they have fully addressed its structural nature. In fact, none of the coffee-specific programs discussed above seem to have had a long-term objective but instead aimed at addressing the short run coping capacity of affected households. In addition, the majority of the public resources were targeted in a regressive way, mainly directed to medium and large coffee farmers.

7. *Moving forward: lessons for constructing a policy agenda*

Using household level panel data from Nicaragua, this paper explores the impact of the recent coffee crisis on rural households engaged in coffee production and coffee labor work. Taking advantage of the panel structure of the data, a number of findings emerge: (i) while overall growth between 1998 and 2001 was widespread in rural Nicaragua, coffee households saw large declines in various socioeconomic outcomes; (ii) small coffee-farm households were affected the most, and not poor labor households as previously expected; (iii) among the various risk management strategies coffee households used to address the shock, pre-shock, ex-ante strategies (like income diversification) were more effective in allowing coffee households insulate against the shock. By contrast, the coffee households that used ex-post coping instruments did not manage to mitigate the adverse impact as well, with additional potential long run implications via extensive uses of harmful coping strategies (like increases in child labor); and (iv) the coffee shock affected upward mobility and downward poverty vulnerability.

Based on the finding above, a number of lessons emerge in terms of pushing forward the policy agenda related to the coffee crisis and shocks in general. They are discussed below.

Understand the shock and those affected

Initial attention on the coffee crisis focused on the impact of the shock on labor employment. The analysis shows that it was small coffee farmers, rather than poor coffee laborers, that appear to have experienced the most serious effects from the crisis. This was partly due to the fact that while labor workers were mobile in moving from coffee employment to other low paying labor jobs, coffee farm households were stuck in long-term perennial investments with little flexibility to complement their incomes.

These insights have important implications about the choice of a short-run safety net one could potentially consider. While shocks that result in open unemployment are typically addressed through workfare programs by providing support to unemployed workers until renewed labor demand draws them back into the labor market, the fact the laborers were able to substitute for potential labor losses via alternative low paying job opportunities seems to imply that such interventions were not necessarily critical. By contrast, while the immediate debt relief efforts discussed above may have allowed large farmers to cope with falling coffee prices and cost increases, the low participation in such programs by small scale farmers and the lack of alternative coping mechanisms for them seems to explain to a large extent the large welfare impacts of the crisis on these small, immobile farm households. As such, understanding which populations shocks affect and how is key for designing appropriate interventions.

While households use a diverse set of informal risk management instruments, they are only partially effective

Coffee households used a multitude of risk management mechanisms to address the crisis. Some examples include informal support systems such as receiving remittances from family, income diversification to sales of assets (land or animals) or sending children to work. Nonetheless, the absence of formal insurance instruments available to these households implies that such self-insurance and risk management instruments are unlikely to be fully effective in protecting them from risk exposure. Indeed, the results indicate that coffee households, especially the poorer coffee-labor ones, were extremely vulnerable to insuring food consumption, with more than 43 percent of the income shock among coffee-labor households being passed through food consumption decreases (and 13 percent among coffee-farm households). Such findings reinforce the need for improving formal insurance mechanisms and enhancing informal risk management instruments. They also suggest that interventions should pay special attention on the poorer and more vulnerable populations.

Enhancing households' ex-ante set of risk management instrument base is crucial

The findings suggest that households that used ex-ante as opposed to ex-post mechanisms were better insulated from the coffee shock. For example, coffee household that diversified their incomes, invested in human capital or exited the coffee sector altogether before the crisis hit (and thus fully dissociated themselves from the coffee risk exposure) were better positioned to deal with the coffee crisis. By contrast, coffee households that did not have the ability or did not use such risk management instruments were not only affected worse, but they also used some coping mechanisms with potential long-term adverse implications (such as taking children out of school). Policies that enhance the ability and adoption of ex-ante risk management strategies should therefore be at the center of the policy agenda.

Shocks influence long run welfare dynamics

Coffee households were the most vulnerable to fall into poverty and the least mobile to exit poverty by taking advantage of the overall growth in rural Nicaragua over the period of the study. Still, while coffee farmers were affected the most in terms of levels, even after the crisis hit they were still among the wealthiest rural groups in Nicaragua. By sharp contrast, coffee laborers – by far the poorest rural group in the survey - were the most adversely affected with respect to their increased probability to fall and lower probability to exit poverty. These insights seem to indicate the distinction between the impact of shocks with respect to chronic and transient poverty. To some extent, while for coffee farmers the shock may have been more transitory in nature, it may have accentuated poverty traps among the chronically poor coffee laborers. This raises the need for distinct policy interventions for each of the two groups better addressing structural versus transient poverty. Some potential areas for further exploration on this comes out of the analysis by observing the various factors that are correlated with the ability to fall or exit poverty. Such factors include the role of human capital and its importance as an ex-ante instrument to minimizing vulnerability and enhance upward mobility, the ability to have a diverse income portfolio by including non-agriculture income sources or the role of the local context and infrastructure in providing alternative income opportunities to risk exposed households.

Long-run investments for short-run protection?

While not a direct outcome from the study, some of the insights seem to suggest that longer-term interventions such as cash transfers conditional on household investments in household members' (such as children) health and education can partially allow households affected by shocks to better cope with shocks by insulating them from their adverse impacts. Indeed, "Red de Proteccion Social" beneficiary households involved in the coffee sector seem to have faired better in a number of socio-economic outcomes compared to non-participating coffee households (such as the significant higher children's education attainment outcomes among beneficiary households)(Maluccio 2003).

Such programs are not designed to deal with shocks and are not "insurance" schemes per se. Still, the observed positive impact in the coffee crisis example suggests that by incorporating risk exposure in the design of such programs' eligibility rules, or by allowing additional flexibility in terms of scaling up or down such interventions to address large shocks on-demand is worth further examination to understand whether these programs can serve as alternative risk management instruments.

Agricultural interventions: structural shocks require structural changes

While this is beyond the scope of the paper, a number of insights with respect to the potential role of agricultural or coffee-industry specific interventions can be outlined. First, improving crop insurance schemes seems to be an important direction for further analysis. Introduction of such a market based ex-ante instrument can greatly improve households' ability to make decisions under uncertainty. This issue still remains highly understudied. Second, promoting product differentiation in coffee is another area for policy discussion. In fact, the fact that only ten percent of the current coffee production in Nicaragua is specialized (e.g. organic, fair trade) suggests that at least exploring its feasibility and pre-requisites of scaling up such practices is crucial (Varangis 2003). In addition, enhancing marketing practices and channels by promoting local and external demand also seem important areas for policy design and intervention. Finally, as the analysis shows, facilitating coffee households to exit the coffee sector altogether may be a desired policy. To the extent that such as policy can be targeted at small farmers that engage in lower quality coffees or farm in marginal lands, complemented by promoting alternative livelihoods for such households seems to be a direction by which policy can strengthen household adaptability and mobility. Such structural changes can only be part of large comprehensive vision for rural development, poverty reduction and risk management schemes and as such, adapting these to the specifics parameters of regional and household realities will be essential.

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Appendix 1: Tables and Figures

Table 1: Rural households coffee typology (sample sizes)

Type	**Number**
Non coffee - no household involvement in coffee activities in either year	1022
Exit coffee - involved in coffee activities in 1998 not in 2001	104
Enter coffee - not involved in coffee activities in 1998, yes in 2001	117
In coffee – both 1998 and 2001	112
Total	1355

Sources: Nicaragua LSMS 1998 and 2001; and National Agricultural Census 2001.

Table 2: Rural sample structure, extended coffee categories (sample sizes)

		2001			
		Non-coffee	Coffee-labor	Coffee farmer	**Total**
1998	Non-coffee	1022	62	55	**1139**
	Coffee-labor	66	31	11	**108**
	Coffee farmer	38	11	59	**108**
	Total	**1126**	**104**	**125**	**1355**

Sources: Nicaragua LSMS 1998 and 2001

Table 3 - Regional coffee definition using coffee intensity (sample sizes)

Type	**Number**
Low coffee intensity (< 1.3 % of total cultivated land)	765
Medium coffee intensity (between 1.4 and 10.7 % of total cultivated land)	302
High coffee intensity (> 10.8 % of total cultivated land)	288
Total	1355

Sources: Nicaragua LSMS 1998 and 2001; and National Agricultural Census 2001.
The cultivated land percentages correspond to the quintiles of municipalities' share of cultivated land in coffee. In particular, the first 3 quintiles define the low intensity region, the fourth the medium and the fifth (highest) the high intensity region.

Table 4: Selected household characteristics, 1998

	Non-Coffee	Exit	Enter	Coffee both years	
				Labor	*Farmer*
Consumption per capita (cordobas)	4180	3309	3074	2259	5099
Income per capita (cordobas)	3697	3695	2820	3073	6031
Main income sources (%)					
Wage agriculture	12	37	21	65	3
Self-employment agriculture	20	29	29	11	78
Wage non-agriculture	31	17	18	7	1
Self-employment non-agriculture	14	6	8	4	2
Non labor	22	11	25	14	15
Total	100	100	100	100	100
Mean farm size (hectares)	6.5	10.0	6.4	0.7	12.8
Median farm size (hectares)	4.2	4.0	4.2	2.1	5.6

Sources: Nicaragua LSMS 1998 and 2001

Table 5: Poverty evolution, by coffee definitions

	Extreme Poverty				**General Poverty**			
	Headcount		Δ Level	Δ %	Headcount		Δ Level	Δ %
	1998	*2001*			*1998*	*2001*		
All Households (full LSMS comparisons)								
All	17.3	15.1	-2.2	-12.7	47.9	45.8	-2.1	-4.4
Urban	7.6	6.1	-1.5	-19.7	30.5	28.7	-1.8	-5.9
Rural	28.9	24.7	-4.2	-14.5	68.5	64.3	-4.2	-6.1
Panel households								
All	21.4	12.7	-8.7	-40.7	46.8	40.1	-6.7	-14.3
Urban	10.1	5.6	-4.5	-44.6	30.2	26.3	-3.9	-12.9
Rural	35.1	21.4	-13.7	-39.0	67.2	58.5	-8.7	-12.9
Household Coffee Definition (rural panel)								
Non-Coffee (both yrs.)	31.3	16.5	-14.8	-47.3	64.7	54.6	-10.1	-15.6
Coffee – Enter	56.7	43.8	-12.9	-22.8	77.8	76.4	-1.4	-1.8
Coffee – Exit	41.8	32.8	-9.0	-21.5	76.1	62.5	-13.6	-17.9
Coffee (both yrs.)	35.3	37	1.7	4.8	73.6	75.4	1.8	2.4
Regional Coffee Definition (rural panel)								
Low Intensity	31	13.8	-17.2	-55.5	66.1	53.5	-12.6	-19.1
Medium Intensity	35.3	22	-13.3	-37.7	60.5	54.6	-5.9	-9.8
High Intensity	46.3	41.6	-4.7	-10.2	76.9	76	-0.9	-1.2

Sources: Nicaragua LSMS 1998 and 2001; and National Agricultural Census 2001.

Table 6: Poverty Evolution by Coffee Definitions

	General Poverty			
	Headcount rate		Level Change	% Change
	1998	2001		
Coffee labor, then exit	80.5	63.1	-17.4	-21.6
Coffee labor both years	95.5	91.9	-3.6	-3.8
Coffee farmer, then exit	69.3	61.7	-7.6	-10.9
Coffee farmer both years	60.9	67.2	6.3	10.3

Sources: Nicaragua LSMS 1998 and 2001.

Table 7 - Nicaragua: changes in per capita consumption, by coffee definitions

Type of Household	**1998**	**2001**	**% Change**
All Rural			
Total Consumption	4,010	4,480	11.7
Food Consumption	2,440	2,457	0.7
Non-Food Consumption	1,570	2,012	28.1
Household Coffee Definition[a]			
Non-Coffee (both years)			
Total Consumption	4,180	4,806	15.0
Food Consumption	2,515	2,609	3.7
Non-Food Consumption	1,664	2,185	31.3
Coffee - Exit			
Total Consumption	3,309	3,812	15.2
Food Consumption	2,242	2,334	4.1
Non-Food Consumption	1,066	1,478	38.6
Coffee - Enter			
Total Consumption	3,074	3,113	1.3
Food Consumption	2,019	1,763	-12.7
Non-Food Consumption	1,055	1,336	26.6
Coffee (both years)			
Total Consumption	3,881	3,248	-16.3
Food Consumption	2,285	1,771	-22.5
Non-Food Consumption	1,596	1,477	-7.5
Regional Coffee Definition[b]			
Low Coffee Intensity			
Total Consumption	4,074	4,723	15.9
Food Consumption	2,485	2,596	4.4
Non-Food Consumption	1,589	2,109	32.7
Medium Coffee Intensity			
Total Consumption	4,363	4,911	12.5
Food Consumption	2,576	2,605	1.1
Non-Food Consumption	1,787	2,304	28.9
High Coffee Intensity			
Total Consumption	3,491	3,395	-2.7
Food Consumption	2,183	1,933	-11.5
No-Food Consumption	1,308	1,463	11.8

Sources: Nicaragua LSMS 1998 and 2001; and National Agricultural Census 2001.

All values are in 1998 córdobas (C$) per capita. Average exchange rate 1998: C$10.58 / US$ 1.00.

[a] Household coffee definitions are based on the household's involvement in the coffee sector in either years. Specifically, a household is defined as: (i) coffee household if it was involved in the coffee sector in both years (112 observations); (ii) non-coffee household if it was not involved in any coffee activities in both years (1,022 observations); (iii) exiting coffee if the household was involved in coffee activities in 1998 but not in 2001 (104 observations); and (iv) entering coffee if a household was not involved in the coffee sector in 1998 but was in 2001 (117 observations).

[b] Regional coffee definitions are based on the municipal-level average of proportion of farm size dedicated to coffee production. Low = 0-1.3% (765 observations), medium = 1.4-10.7% (302 observations) and high = 10.8% or more of average farm size is dedicated to coffee (288 observations)

Table 8: Nicaragua: Changes in per capita income by coffee definitions and income sources

	Household Coffee Definition[a]											
Source of income	Non-coffee			Exit			Entry			Coffee		
	1998	2001	Δ %	1998	2001	Δ %	1998	2001	Δ %	1998	2001	Δ %
Wage agriculture	452	567	25.4	1367	901	-34.1	598	1104	84.6	864	829	-4.1
Self-employment agriculture	736	1359	84.6	1058	1155	9.2	806	1165	44.5	2688	1358	-49.5
Wage non-agriculture	1163	1446	24.3	622	1050	68.8	506	648	28.1	134	181	35.1
Self-employment non-agriculture	532	918	72.6	235	434	84.7	212	333	57.1	139	381	174.1
Non labor	814	894	9.8	413	600	45.3	698	493	-29.4	705	563	-20.1
Total	3697	5184	40.2	3695	4140	12.0	2820	3743	32.7	4530	3312	-26.9
	Regional coffee definition[b]											
	Non-coffee			Exit			Entry			Coffee		
	1998	2001	Δ %	1998	2001	Δ %	1998	2001	Δ %	1998	2001	Δ %
Wage agriculture	471	613	30.1	476	558	17.2	898	852	-5.1	563	652	15.8
Self-employment agriculture	846	1583	87.1	605	891	47.3	1454	1067	-26.6	925	1330	43.8
Wage non-agriculture	1018	1221	19.9	1322	1813	37.1	592	800	35.1	990	1254	26.7
Self-employment non-agriculture	504	839	66.5	542	958	76.8	234	516	120.5	455	795	74.7
Non labor	785	863	9.9	871	887	1.8	621	617	-0.6	768	816	6.3
Total	3624	5119	41.3	3816	5107	33.8	3799	3852	1.4	3703	4849	30.9

Sources: Nicaragua LSMS 1998 and 2001; and National Agricultural Census 2001
All values are in 1998 Còrdobas (C$) per capita. Average exchange rate 1998: C$ 10.58 / US$ 1.00

Table 9: Consumption and income among coffee households

	1998	2001	Level Change	% Change
Consumption				
Coffee labor, then exit	3,071	3,620	549	27.6
Coffee labor both years	2,259	2,219	-40	-1.8
Coffee farmer, then exit	3,679	4,113	434	11.8
Coffee farmer, both years	5,099	3,790	-1,309	-25.7
Income				
Coffee labor, then exit	4,019	3,990	-29	-0.7
Coffee labor both years	3,074	2,976	-98	-3.2
Coffee farmer, then exit	3,190	4,381	1,191	37.3
Coffee farmer, both years	6,031	3,696	2,335	-38.7

Sources: Nicaragua LSMS 1998 and 2001

Table 10: Consumption smoothing: income changes coefficients

	Total	Food	Non-Food
All rural	**0.14*** **	**0.14*** **	**0.13*** **
Coffee definitions			
Non-Coffee	0.14***	0.14***	0.13***
Exited Coffee	0.07	0.12	-0.01
Entered coffee	0.07	0.01	0.13
Coffee labor both years	0.22*	0.43*	0.08
Coffee farmer both years	0.20**	0.12	0.34**
Initial coffee classifications			
Non-Coffee in 1998	0.14***	0.13	0.13***
Coffee labor in 1998	0.12*	0.18**	0.14
Coffee farmer in 1998	0.19***	0.16**	0.24*
Regional coffee definitions			
Low coffee intensity	0.14***	0.14***	0.12***
Medium coffee intensity	0.14***	0.12**	0.13***
High coffee intensity	0.13***	0.11*	0.16***

Dependent Variable: Log of change in consumption per capita

Each coefficient comes from estimating a fixed effects model of consumption per capita changes regressed on income per capita changes and household size changes for the corresponding coffee classification. Both regressors are treated as exogenous. The municipal level fixed effects are jointly significant for all the specifications.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 11: Consumption growth and coping, by coffee household definition

	Non Coffee	Exited	Entered	Labor both years	Farm both years
Baseline period household characteristics (1998)					
Family size	0.04***	0.07	0.04	0.04	0.03
Maximum years of education in household	0.02**	0.02	-0.01	0.01	-0.01
Number of kids workers	-0.01	0.00	0.03	-0.03	-0.12
Number of adult workers	-0.02	-0.13	0.07	-0.23	0.03
Number of income sources	0.04*	0.13	-0.21**	0.04	-0.17
Land owned (hectares)	0.00	-0.00	0.00	0.04	0.01
Received remittances (yes=1)	0.06	0.08	0.14	-0.15	-0.30
Dist. to Managua (10 min. intervals)	-0.00	0.02	0.02	0.08	0.03
Elevation (100 meters)	0.00	0.01	0.05	-0.08	0.09
Affected by Mitch (yes=1)	0.00	0.00	0.00	0.00	0.00
Constant	-0.27**	-1.20	-0.59	-0.97	-1.35
Observations	1 022	104	117	31	59
R-squared	0.23	0.55	0.74	0.86	0.55

Dependent Variable: Change in (log) per capita consumption;
Additional controls: municipality fixed effects.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 12: Food consumption growth and coping, by coffee household definition

	Non Coffee	Exited	Entered	Labor both yrs	Farm both yrs
Baseline period household characteristics (1998)					
Family size	0.04***	0.05	0.06**	0.02	0.01
Maximum years of education in household	0.02**	0.04	0.03	0.02	0.00
Number of kids workers	-0.00	-0.02	-0.06	0.11	0.05
Number of adult workers	-0.01	-0.07	-0.13	-0.18	0.03
Number of income sources	0.04	0.10	-0.20	0.07	-0.12
Land owned (hectares)	0.00	-0.00	0.01	-0.01	-0.01
Received remittances (yes=1)	-0.02	-0.08	0.19	-1.05	-0.36
Dist. to Managua (10 min. intervals)	-0.00	0.04	0.01	0.10	0.03
Elevation (100 meters)	0.00	0.05	0.10	-0.14	0.09
Affected by Mitch (yes=1)	0.00	0.00	0.00	0.00	0.00
Constant	-0.41**	-1.79	-0.93	-1.27	-1.66
Observations	1022	104	117	31	59
R-squared	0.22	0.50	0.77	0.79	0.59

Dependent Variable: Change in (log) per capita food consumption.
Additional controls: municipality fixed effects.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 13: Non-food consumption growth and coping, by coffee household definition

	Non Coffee	Exited	Entered	Labor both yrs	Farm both yrs
Baseline period household characteristics (1998)					
Family size	0.04***	0.11**	0.00	0.10	0.07*
Maximum years of education in household	0.00	-0.01	-0.05	-0.05	-0.02
Number of kids workers	-0.01	-0.01	0.17	-0.29	-0.38***
Number of adult workers	-0.04	-0.23*	0.31**	-0.49	0.06
Number of income sources	0.04*	0.17	-0.24	0.15	-0.29
Land owned (hectares)	0.00	-0.00	-0.00	0.15	0.02**
Received remittances (yes=1)	0.15**	0.39	0.20	0.99	-0.23
Dist. to Managua (10 min. intervals)	-0.01	0.00	0.02	-0.00	0.04
Elevation (100 meters)	0.01	-0.06	-0.04	-0.04	0.10
Affected by Mitch (yes=1)	0.00	0.00	0.00	0.00	0.00
Constant	-0.02	-0.23	0.35	0.55	-1.25
Observations	1 022	104	117	31	59
R-squared	0.23	0.65	0.61	0.80	0.56

Dependent Variable: Change in (log) per capita non-food consumption.
Additional controls: municipality fixed effects.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 14: Consumption growth and coping, by 1998 coffee household definition

	Activity in 1998		
	Non-Coffee	Coffee labor	Coffee farmer
Baseline period household characteristics (1998)			
Family size	0.02	0.02	0.04***
Maximum years of education in household	-0.01	0.03	0.02**
Number of kids workers	-0.00	-0.06	-0.01
Number of adult workers	-0.14	0.05	-0.01
Number of income sources	0.03*	-0.11	0.03
Land owned (hectares)	0.04	-0.00**	0.00
Received remittances (yes=1)	-0.03	0.34	0.07
Distance to Managua (10 minute intervals)	0.02	0.01	-0.00
Elevation (100 meters)	-0.01	0.09*	-0.01
Affected by Mitch (yes=1)	0.00	0.00	0.00
Constant	-0.10	-0.97	-0.20
Observations	108	108	1 139
R-squared	0.61	0.44	0.22

Dependent Variable: Change in (log) per capita consumption.
Additional controls: municipality fixed effects.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 15: Food consumption growth and coping, by 1998 coffee household definition

	Activity in 1998		
	Non-Coffee	**Coffee labor**	**Coffee farmer**
Baseline period household characteristics (1998)			
Family size	0.00	0.02	0.04***
Maximum years of education in household	-0.00	0.01	0.02***
Number of kids workers	-0.01	-0.01	-0.00
Number of adult workers	-0.11	0.04	-0.01
Number of income sources	-0.03	-0.01	0.02
Land owned (hectares)	0.05	-0.00*	0.00
Received remittances (yes=1)	-0.19	0.11	-0.01
Distance to Managua (10 minute intervals)	0.01	0.03	-0.00
Elevation (100 meters)	0.02	0.15**	-0.02
Affected by Mitch (yes=1)	0.00	0.00	0.00
Constant	-0.17	-2.24***	-0.29*
Observations	108	108	1 139
R-squared	0.59	0.49	0.20

Dependent Variable: Change in (log) per capita food consumption.
Additional controls: municipality fixed effects.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 16: Non-food consumption growth and coping, by 1998 coffee household definition

	Activity in 1998		
	Non-Coffee	**Coffee labor**	**Coffee farmer**
Baseline period household characteristics (1998)			
Family size	0.07*	0.05	0.04***
Maximum years of education in household	-0.03	0.05	0.00
Number of kids workers	0.01	-0.17*	-0.00
Number of adult workers	-0.25**	0.06	-0.03
Number of income sources	0.15	-0.27*	0.03
Land owned (hectares)	0.03	-0.00*	0.00
Received remittances (yes=1)	0.15	0.76*	0.15**
Distance to Managua (10 minute intervals)	0.01	-0.02	-0.01
Elevation (100 meters)	-0.10	0.00	0.01
Affected by Mitch (yes=1)	0.00	0.00	0.00
Constant	0.38	0.77	0.00
Observations	108	108	1 139
R-squared	0.56	0.40	0.22

Dependent Variable: Change in (log) per capita non-food consumption.
Additional controls: municipality fixed effects.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 17: Consumption growth and coping, by regional coffee definition

	Coffee intensity in municipality		
	Low	**Medium**	**High**
Baseline period household characteristics (1998)			
Family size	0.04***	0.05***	0.02*
Maximum years of education in household	0.01	0.01	0.03**
Number of kids workers	-0.01	-0.03	-0.00
Number of adult workers	-0.01	-0.01	-0.04
Number of income sources	0.03	0.01	0.03
Land owned (hectares)	0.00	-0.00	-0.01***
Received remittances (yes=1)	0.06	0.10	-0.02
Distance to Managua (10 minute intervals)	-0.00	-0.03**	0.00
Elevation (100 meters)	0.02	-0.04	0.01
Affected by Mitch (yes=1)	0.00	0.00	0.00
Constant	-0.26*	0.20	-0.47
Observations	765	302	288
R-squared	0.21	0.21	0.25

Dependent Variable: Change in (log) per capita consumption.
Additional controls: municipality fixed effects.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 18: Food consumption growth and coping, by regional coffee definition

	Coffee intensity in municipality		
	Low	**Medium**	**High**
Baseline period household characteristics (1998)			
Family size	0.03**	0.05***	0.02
Maximum years of education in household	0.02*	0.00	0.02*
Number of kids workers	0.00	-0.03	0.00
Number of adult workers	0.02	-0.04	-0.03
Number of income sources	0.01	0.04	0.03
Land owned (hectares)	0.00	-0.00	-0.01***
Received remittances (yes=1)	-0.04	0.06	-0.15
Distance to Managua (10 minute intervals)	-0.00	-0.02	0.02
Elevation (100 meters)	0.03	-0.04	0.02
Affected by Mitch (yes=1)	0.00	0.00	0.00
Constant	-0.40**	0.12	-0.86**
Observations	765	302	288
R-squared	0.19	0.19	0.26

Dependent Variable: Change in (log) per capita food consumption.
Additional controls: municipality fixed effects.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 19: Non-food consumption growth and coping, by regional coffee definition

	Coffee intensity in municipality		
	Low	**Medium**	**High**
Baseline period household characteristics (1998)			
Family size	0.04***	0.06**	0.04**
Maximum years of education in household	-0.00	-0.00	0.01
Number of kids workers	-0.00	-0.03	-0.03
Number of adult workers	-0.04	-0.01	-0.03
Number of income sources	0.04	-0.02	-0.01
Land owned (hectares)	0.00	0.00	-0.01***
Received remittances (yes=1)	0.20**	0.18	0.12
Distance to Managua (10 minute intervals)	-0.00	-0.03**	-0.01
Elevation (100 meters)	0.01	-0.02	0.00
Affected by Mitch (yes=1)	0.00	0.00	0.00
Constant	-0.00	0.49	0.20
Observations	765	302	288
R-squared	0.22	0.19	0.19

Dependent Variable: Change in (log) per capita non- food consumption.
Additional controls: municipality fixed effects.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 20: Coping mechanisms, by initial coffee household definition

	Household experienced						
	Increases in child	Increases in adult labor	Migrating members	Decreases in school enrol-	Decreases in land owned	Decreases in cattle owned	Decreases in poultry owned
Coffee labor in 1998	0.03	-0.05	-0.01	0.02	-0.13***	-0.09**	0.11**
Coffee farmer in 1998	0.16***	-0.09*	-0.01	0.12***	0.10**	0.12***	0.22***
Affected by hurricane Mitch	-0.01	0.03	0.00	-0.00	-0.00	-0.04**	-0.03
Observations:	1355	1355	1355	1355	1355	1355	1355
Log likelihood:	-795	-863	-240	-788	-683	-521	-818
Adjusted percentage of correct prediction:	0.76	0.70	0.96	0.78	0.78	0.86	0.70

Table 21: Coping mechanisms, by initial coffee household definition

	Household experienced						
	Increases in child labor	Increases in adult labor	Migrating members	Decreases in school en-	Decreases in land owned	Decreases in cattle owned	Decreases in poultry
Coffee labor in 1998	-0.08	0.18	0.01	-0.07	-0.04	-0.04	-0.14
Coffee farmer in 1998	0.21**	0.02	-0.02	0.17**	0.25***	0.26***	0.21***
Poor in 1998	0.16***	0.10***	-0.01	0.05	0.06**	0.02	0.04
Coffee labor * Poor in 1998	0.10	-0.23**	-0.01	0.11	-0.13	-0.07	0.34**
Coffee farmer * Poor in 1998	-0.06	-0.16*	0.02	-0.06	-0.14**	-0.09**	0.01
Affected by Hurricane Mitch	-0.02	0.03	0.00	-0.01	-0.00	-0.04**	-0.03
Observations:	1355	1355	1355	1355	1355	1355	1355
Log likelihood	-795	-863	-240	-788	-683	-521	-818
Adjusted percentage of correct prediction:	0.76	0.70	0.96	0.78	0.78	0.86	0.70

Table 22: Coping mechanisms, by regional coffee intensity definition

	Household experienced						
	Increases in child labor	Increases in adult labor	Migrating members	Decreases in school enrollment	Decreases in land owned	Decreases in cattle owned	Decreases in poultry owned
Medium coffee intensity region	0.02	-0.09***	-0.01	-0.06*	-0.01	-0.02	0.02
High coffee intensity region	0.06*	-0.07**	-0.01	-0.02	-0.00	-0.02	0.11***
Affected by Hurricane Mitch	-0.01	0.03	0.00	-0.00	-0.01	-0.04**	-0.03
Observations:	1355	1355	1355	1355	1355	1355	1355
Log likelihood:	-795	-863	-240	-788	-683	-521	-818
Adjusted percentage of correct prediction:	0.76	0.70	0.96	0.78	0.78	0.86	0.70

Table 23: Coping mechanisms, by regional coffee intensity definition

	Household experienced						
	Increases in child labor	Increases in adult labor	Migrating members	Decreases in school enrollment	Decreases in land owned	Decreases in cattle owned	Decreases in poultry owned
Medium coffee intensity region	-0.01	0.01	-0.04	0.01	-0.10**	-0.11***	-0.07
High coffee intensity region	0.08	0.10	0.03	-0.00	0.04	-0.01	-0.03
Poor in 1998 (=1)	0.15***	0.15***	-0.00	0.07**	0.01	-0.03	-0.02
Medium coffee intensity region * Poor in 1998	0.07	-0.14**	0.07	-0.10*	0.16**	0.22***	0.16**
High coffee intensity region * Poor in 1998	-0.05	-0.21***	-0.03	-0.02	-0.05	-0.01	0.18**
Affected by Hurricane Mitch	-0.02	0.04	0.00	-0.00	-0.01	-0.04**	-0.04
Observations:	1355	1355	1355	1355	1355	1355	1355
Log likelihood:	-795	-863	-240	-788	-683	-521	-818
Adjusted percentage of correct prediction:	0.76	0.70	0.96	0.78	0.78	0.86	0.70

Table 24: Transition matrix between coffee and non-coffee work (in %)

		2001			
		Coffee-labor	Coffee-farmer	Non-coffee	Total
1998	Coffee-labor	35	9	56	100
	Coffee-farmer	10	54	37	100
	Non-coffee	5	4	91	100

Table 25: Mobility out of coffee: who can exit?

	Model 1	**Model 2**	**Model 3**	**Model 4**
Interacted with coffee farmer dummy	No	No	Yes	Yes
with fixed effects	No	Yes	No	Yes
	Marginal effect	Marginal effect	Marginal effect	Marginal effect
Baseline period household characteristics (1998)				
Coffee farmer	-0.22***	-0.20*	-0.71*	-0.68
Number of adults aged 19-64	0.04	0.03	0.09*	0.03
Interaction			*-0.05*	*0.06*
Age of head of household	-0.003	-0.004	-0.01	-0.003
Interaction			*0.003*	*-0.0002*
Average years of education in households	-0.02	-0.02	-0.03	-0.06
Interaction			*0.01*	*0.02*
Cultivated land owned (hectares)	0.0001	-0.002	-0.04**	-0.08*
Interaction			*0.04***	*0.09**
Received credit (yes=1)	0.10	0.12	0.43**	0.54**
Interaction			*-0.39**	*-0.49***
Income diversification index (0=not diversified)	0.27*	0.40*	-0.10	0.11
Interaction			*0.78***	*0.50*
Annual per capita consumption (cordobas x1000)	-0.01	0.01	0.01**	0.07*
Interaction			*-0.12****	*-0.1**
Affected by Hurricane Mitch (yes=1)	-0.14*	0.14	-0.33**	0.36
Interaction			*0.35**	*0.40*
Coffee farm intensity (% of total cultivable land)	-1.43***		-2.62***	
Interaction			1.76**	1.33
Dist. to Managua (10 mins. intervals)	-0.01**	-0.01	-0.01**	-0.04*
Interaction			*0.01*	*0.01*
Log likelihood:	-122	-85	-107	-75
Adj. percentage of correct prediction:	0.39	0.33	0.50	0.44
Observations:	216	151	216	151

Dependent variable: Coffee activity status in 2001 conditional on being in coffee in 1998.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 26: Use of risk management mechanisms and rural heterogeneity, by coffee definitions

		Type of strategy	Non-coffee	Coffee-labor	Coffee-farmer
Labor market adjustments	Income diversification	ex-ante	Yes		
	Child labor	ex-post		Yes	Yes
	Ex-post migration	ex-post			
	Exit coffee	ex-ante/ ex-post		Yes	Yes
Precautionary savings	Sale of physical assets	ex-post			Yes
	Consumption of owned animals	ex-post		Yes	Yes
Informal insurance	Remittances	ex-ante	Yes	Yes	Yes

Table 27: Rural poverty dynamics, by coffee definitions (% of households)

		Poverty in 2001		
		Poor	Non Poor	Total
Poverty in 1998	Non-Coffee			
	Poor	46	19	65
	Non Poor	9	26	35
	Total	55	45	100
	Exit			
	Poor	67	11	78
	Non Poor	9	13	22
	Total	76	24	100
	Enter			
	Poor	52	24	76
	Non Poor	11	14	24
	Total	63	37	100
	Both years-Labor			
	Poor	90	5	95
	Non Poor	2	3	5
	Total	92	8	100
	Both years- farmer			
	Poor	51	10	61
	Non Poor	17	23	39
	Total	67	33	100

Sources: Nicaragua LSMS 1998 and 2001.

Table 28: Consumption decreases, by coffee definitions (% of households)

	% of households experiencing a consumption decrease:	
	Level	Quintile
Coffee typology		
Non coffee both years	38	11
Exit coffee	46	27
Enter coffee	48	30
Coffee both years	61	39
Coffee farmers both years	56	47
Coffee labor both years	65	23
Regional coffee definition		
Low	36	15
Medium	43	8
High	52	25

Sources: Nicaragua LSMS 1998 and 2001.

Table 29: Poverty dynamics: examining vulnerability and mobility

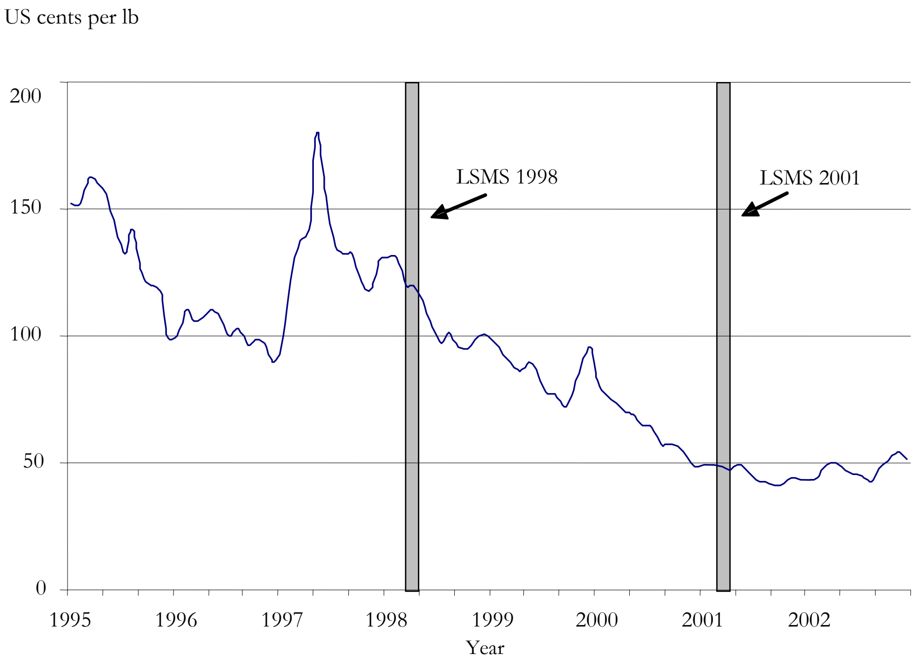
	Probability to:			
		Experienced a fall in consumption		
	Fall into poverty	Level	Quintile	Exit poverty
Baseline period household characteristics (1998)				
Coffee labor	0.07	0.07	0.05	0.09
Coffee farm	-0.09	0.01	-0.00	0.14
Family size	0.01	0.01	0.01	-0.04***
Maximum years of education in household	-0.03***	-0.03***	-0.03***	0.03***
Number of kids workers	0.03	0.00	-0.01	-0.00
Number of adult workers	0.01	-0.02	0.00	0.03*
Number of income sources	-0.02	-0.01	-0.02	0.05**
Land owned (hectares)	-0.00	-0.00	-0.00	0.00***
Received remittances (yes=1)	-0.03	-0.03	-0.01	0.06*
Dist. to Managua (10 mins.intervals)	0.00**	0.00	0.00	-0.00**
Coffee farm intensity in municipality	0.33	0.67***	0.43***	-0.78***
Affected by Mitch (yes=1)	0.03	0.07**	0.06**	-0.06**
Sample	Non-poor in 1998	All rural	All rural	Poor in 1998
Observations	505	1355	1355	850
Log likelihood:	-306	-936	-880	-481
Adj. percentage of correct prediction:	0.72	0.59	0.65	0.77

Dependent Variable for model 1: Poverty status in 2001 conditional on being non poor in 1998.
Dependent Variable for model 2: Dummy on whether a household experienced a decrease in consumption level between 1998 and 2001.
Dependent Variable for model 3: Dummy on whether a household experienced a decrease in consumption quintile ranking between 1998 and 2001.
Dependent Variable for model 4: Poverty status in 2001 conditional on being poor in 1998.
Additional controls: initial period consumption quintile ranking for 2nd and 3rd models.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 30: Poverty dynamics: predicted probabilities, by coffee Household (% of households)

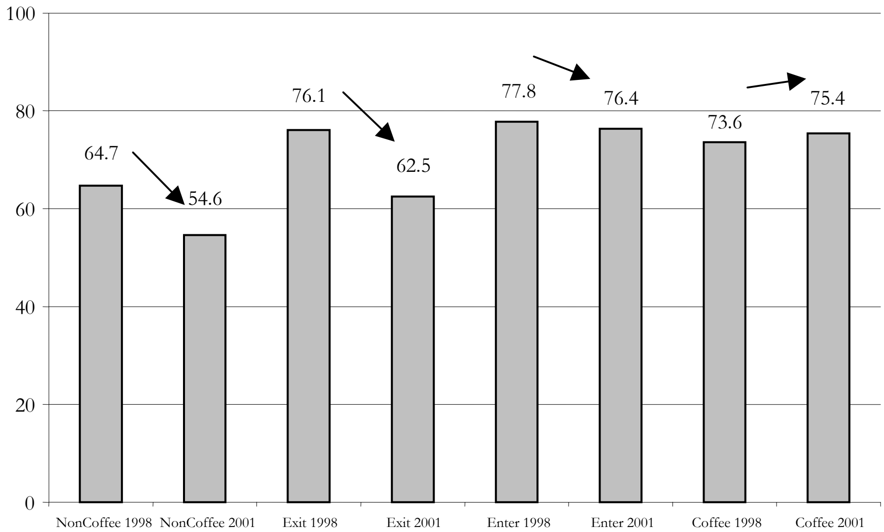
	Predicted probability to:			
	Fall into poverty	Experienced a fall in consumption:		Exit poverty
		Level	Quintile	
Household definition				
Non coffee both years	27	45	33	24
Exit coffee	32	52	39	27
Enter coffee	36	47	34	16
Coffee labor both years	44	55	40	17
Coffee farmer both years	30	61	47	17
Initial year classification				
Non coffee in 1998	27	45	34	23
Coffee-labor in 1998	39	52	38	19
Coffee-farm in 1998	29	59	45	23
Regional definition				
Low coffee intensity	27	43	32	27
Medium coffee intensity	26	46	35	23
High coffee intensity	33	56	41	14
Overall	28	47	35	22

Figure 1: Panel timing and coffee prices (composite index)



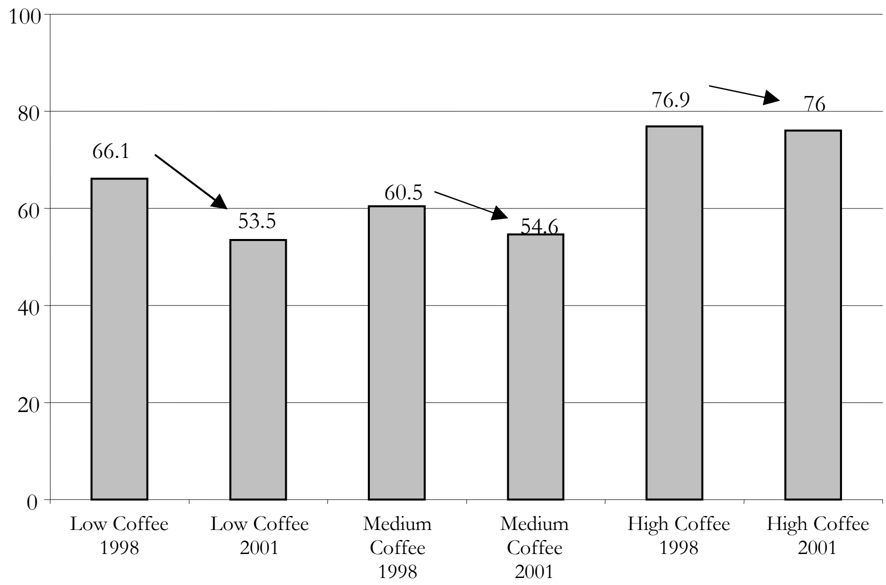
Source: International Coffee Organization

Figure 2: Poverty rate changes by coffee household definition



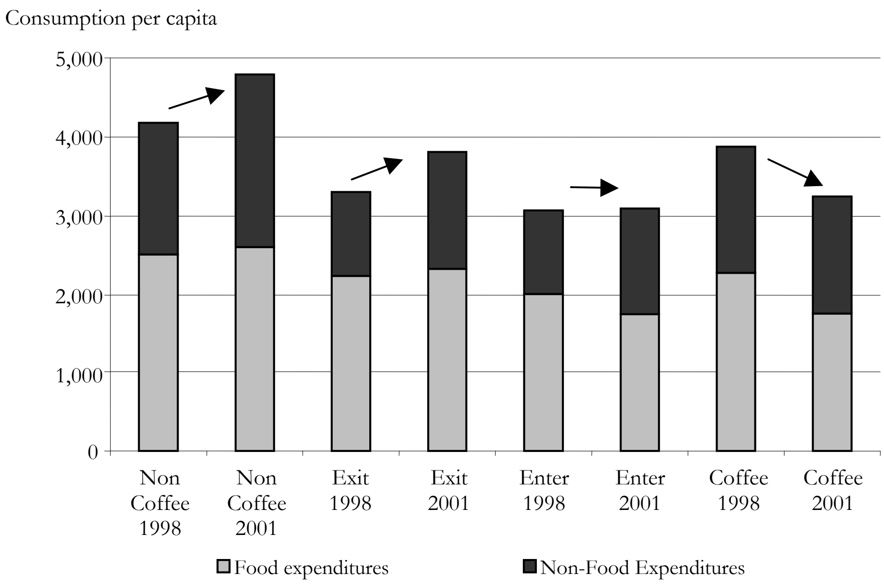
Sources: Nicaragua LSMS 1998 and 2001.

Figure 3: Poverty rate changes by regional coffee



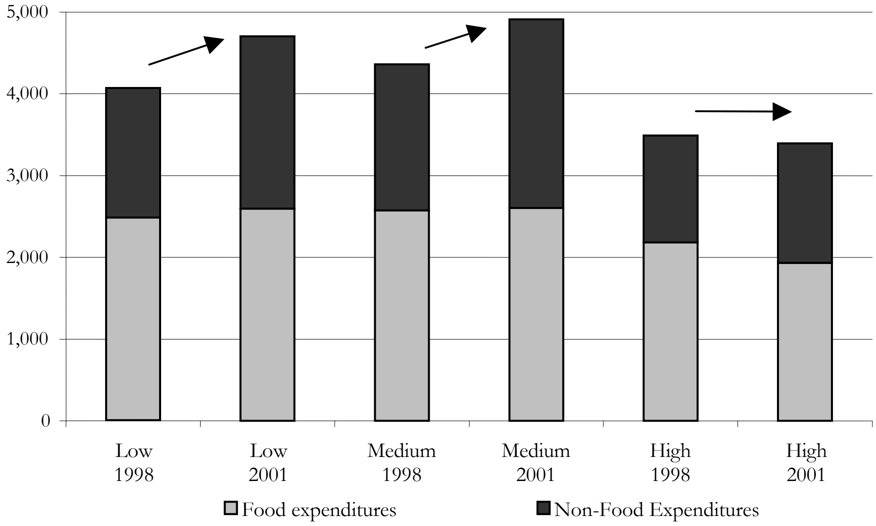
Sources: Nicaragua LSMS 1998 and 2001 and National Agricultural Census 2001.

Figure 4: Rural consumption per capita by household coffee definition



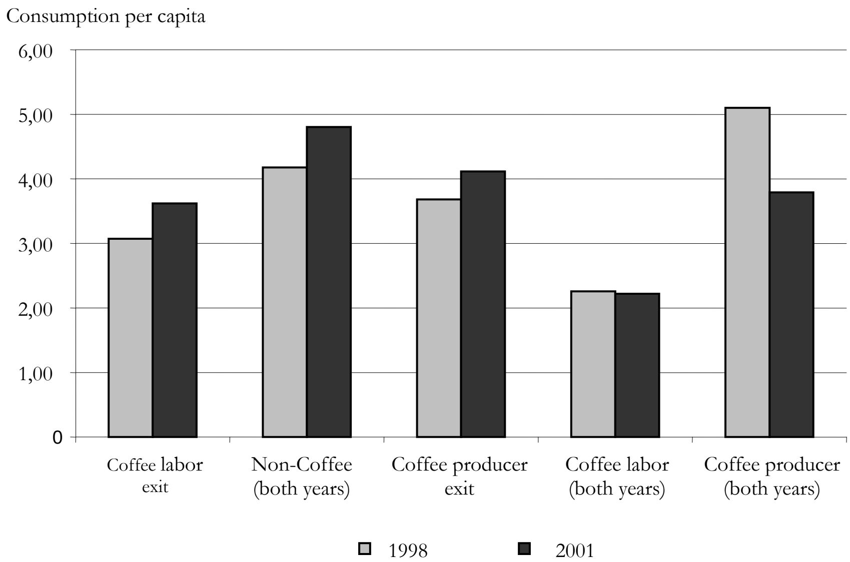
Sources: Nicaragua LSMS 1998 and 2001.

Figure 5: Rural consumption per capita by regional coffee definition



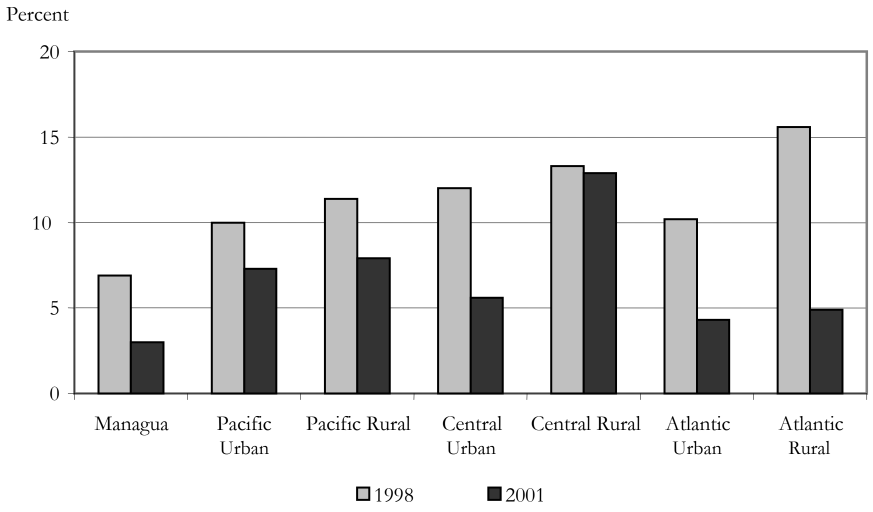
Sources: Nicaragua LSMS 1998 and 2001 and National Agricultural Census 2001.

Figure 6: Changes in per capita income



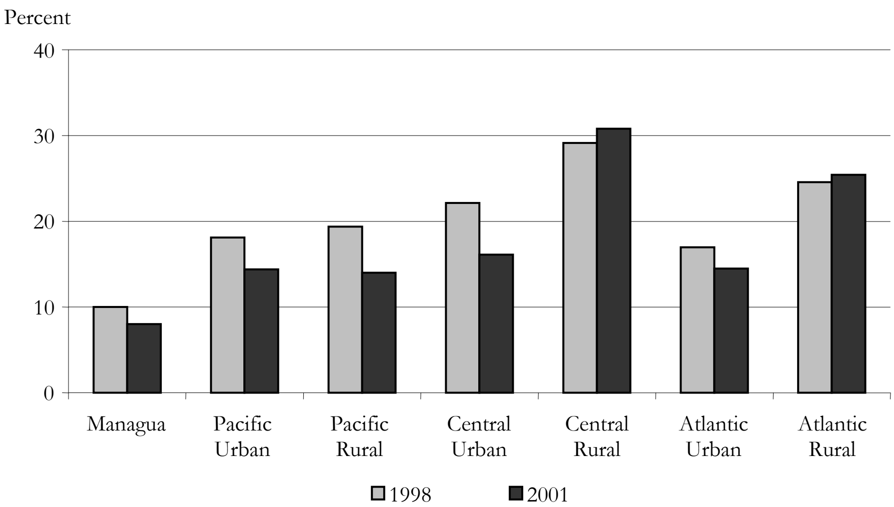
Sources: Nicaragua LSMS 1998 and 2001.

Figure 7: Incidence of Underweight Children, 1998 – 2001



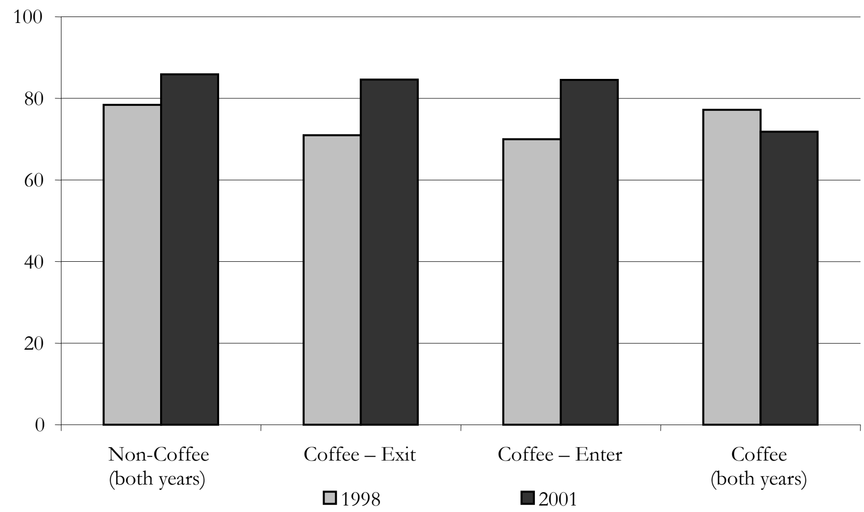
Sources: Nicaragua LSMS 1998 and 2001.

Figure 8: Nicaragua - incidence of Stunting, 1998 – 2001



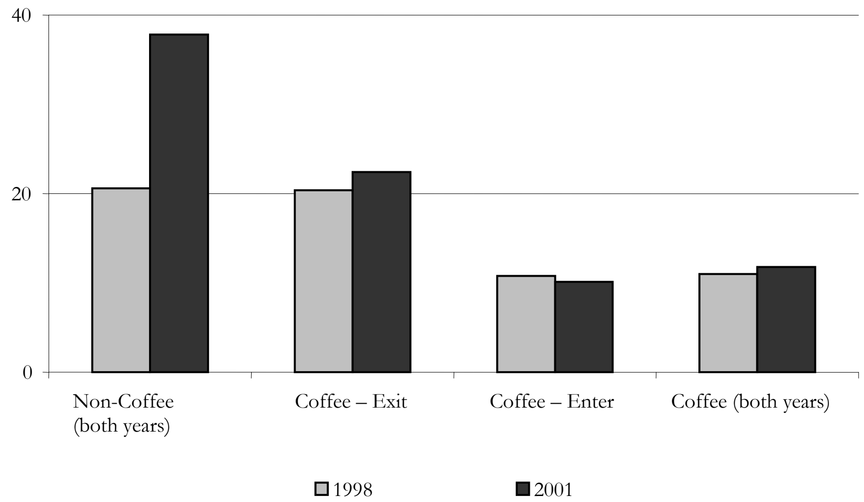
Sources: Nicaragua LSMS 1998 and 2001.

Figure 9: Rural net primary enrollment rates (7-12 year olds)



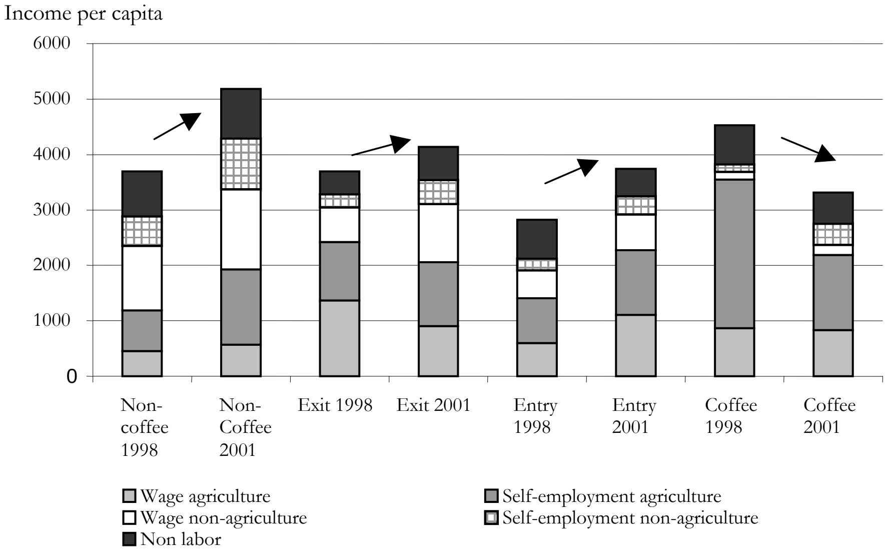
Sources: Nicaragua LSMS 1998 and 2001.

Figure 10: Rural net secondary enrollment rates,(13-17 year olds)



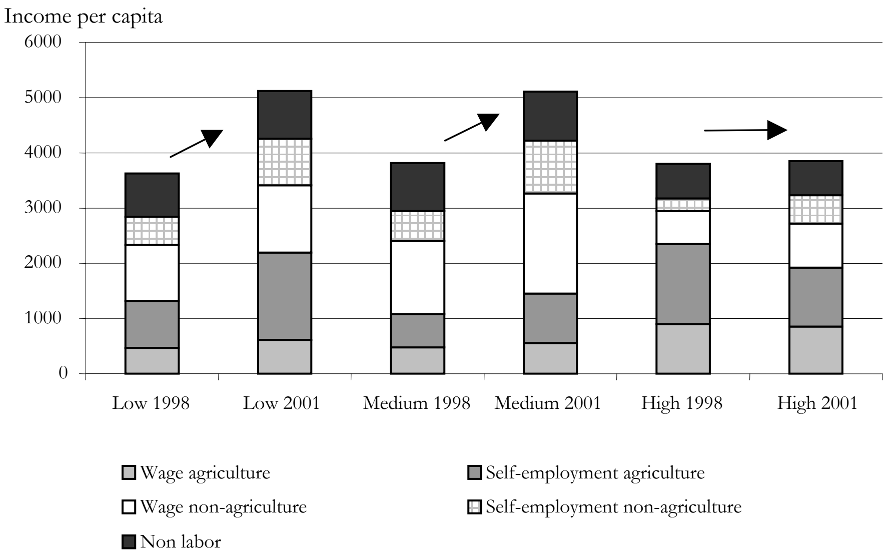
Sources: Nicaragua LSMS 1998 and 2001.

Figure 11: Sources of rural income per capita by household coffee definition



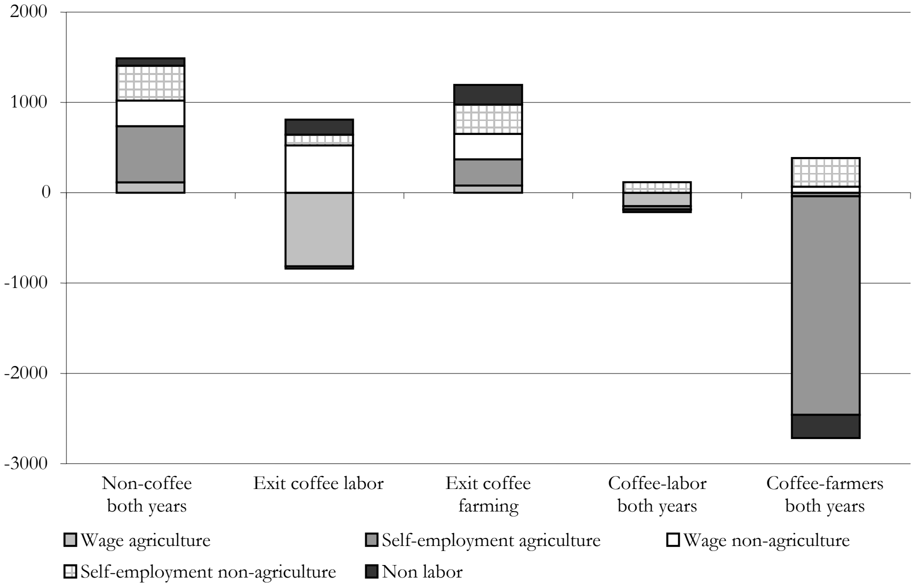
Sources: Nicaragua LSMS 1998 and 2001.

Figure 12: Sources of rural income per capita by regional coffee definition



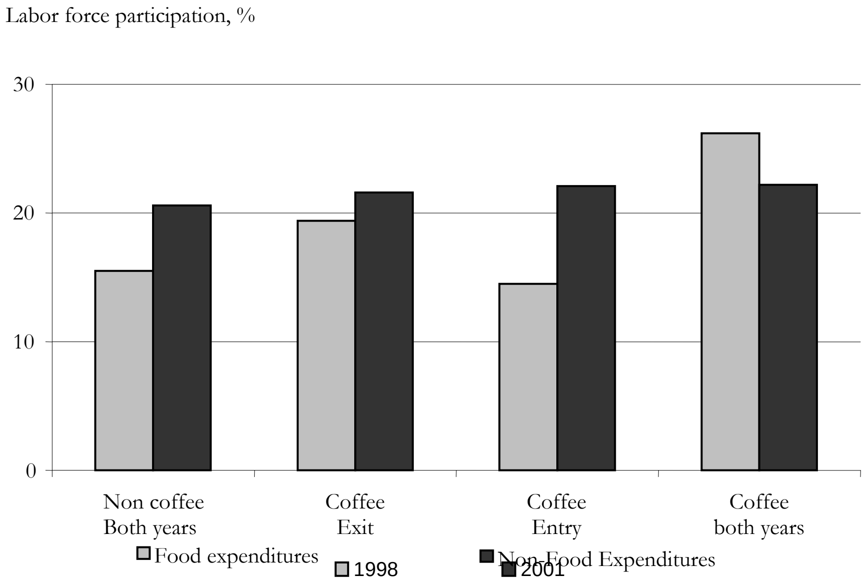
Sources: Nicaragua LSMS 1998 and 2001 and National Agricultural Census 2001.

Figure 13: Adjustments to income by income source



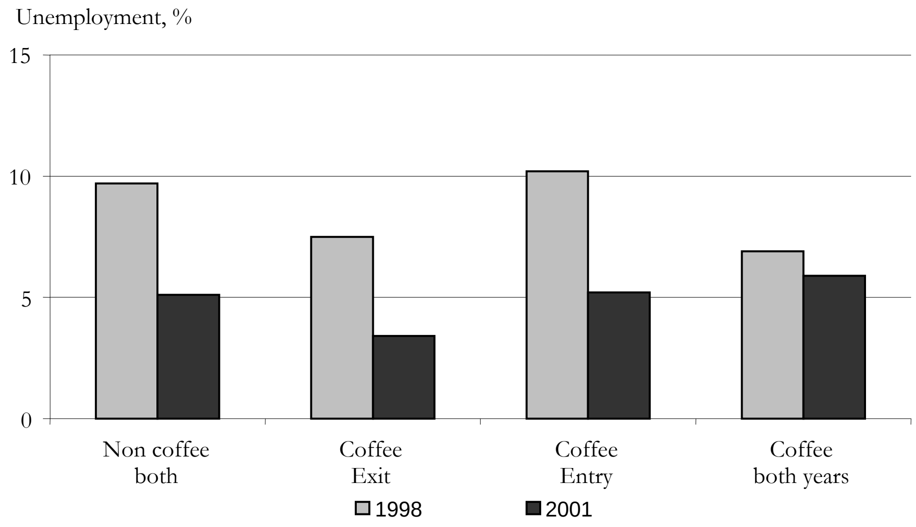
Sources: Nicaragua LSMS 1998 and 2001 and National Agricultural Census 2001.

Figure 14: The coffee crisis and child labor: labor force participation (ages 6-14)



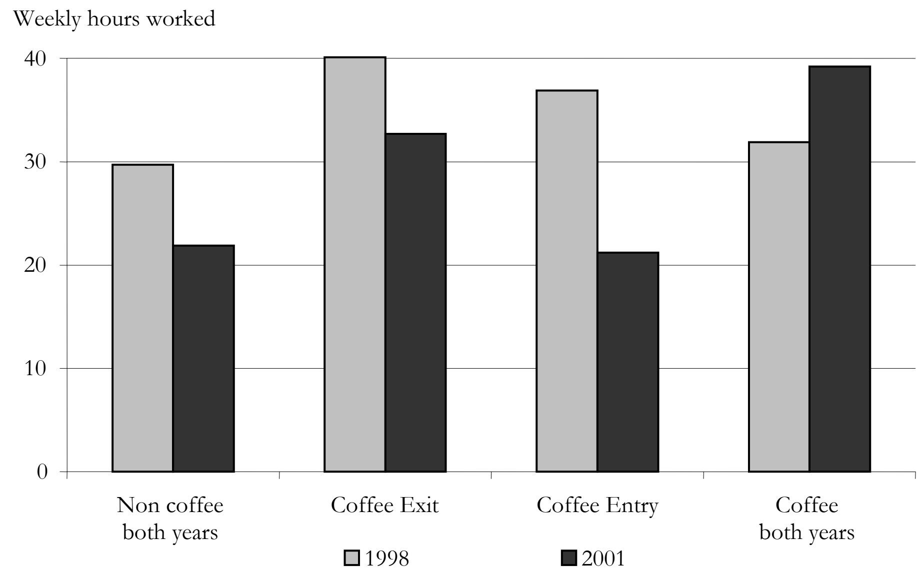
Sources: Nicaragua LSMS 1998 and 2001.

Figure 15: The coffee crisis and child labor: unemployment (ages 6-14)



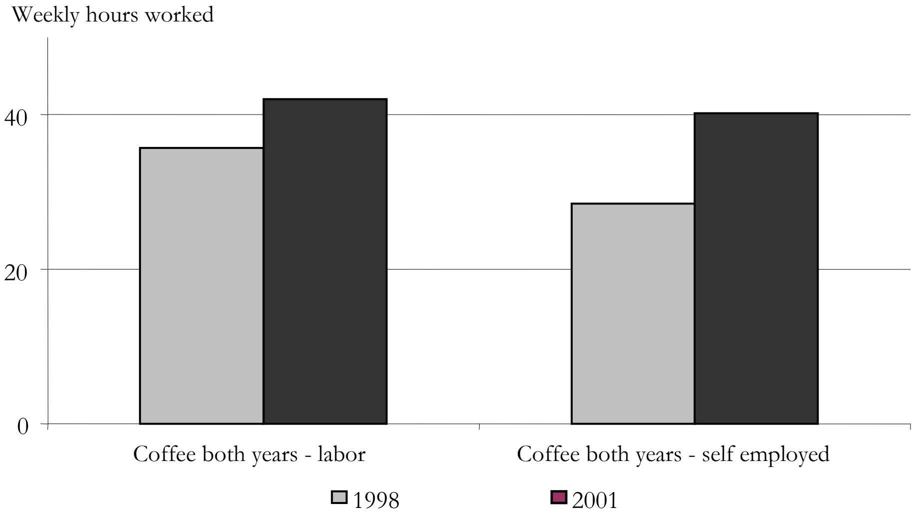
Sources: Nicaragua LSMS 1998 and 2001.

Figure 16: The coffee crisis and child labor: hours worked (ages 6-14)



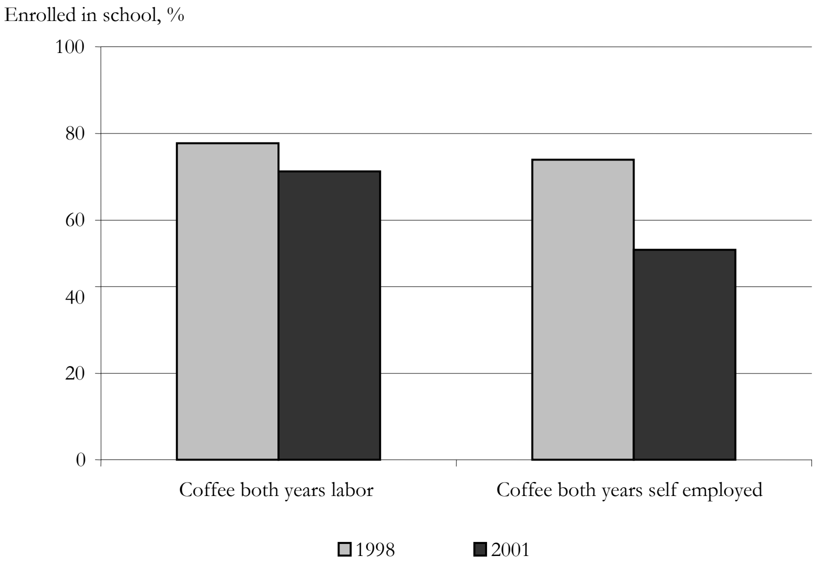
Sources: Nicaragua LSMS 1998 and 2001.

Figure 17: The coffee crisis and child labor: hours worked (ages 6-14)



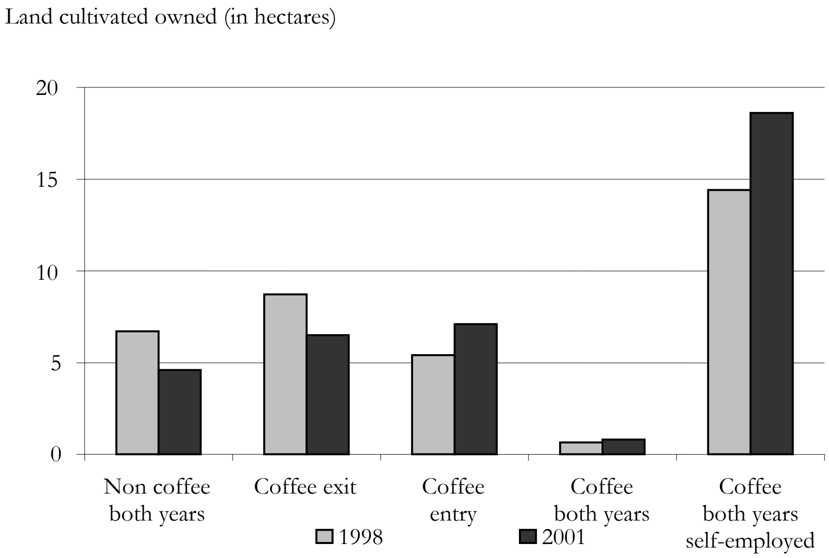
Sources: Nicaragua LSMS 1998 and 2001.

Figure 18: The coffee crisis and child labor: primary school enrollment (ages 6-14)



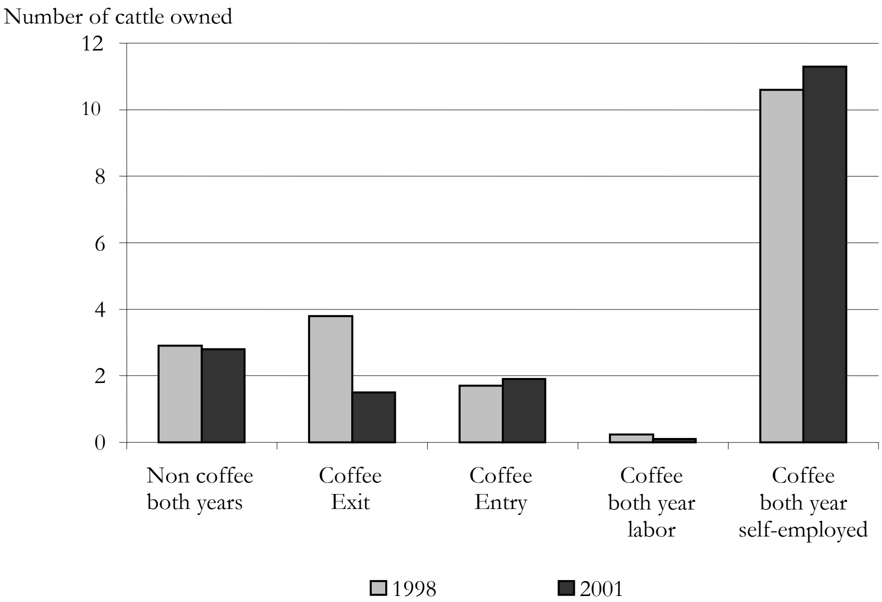
Sources: Nicaragua LSMS 1998 and 2001.

Figure 19: The coffee crisis and assets: land



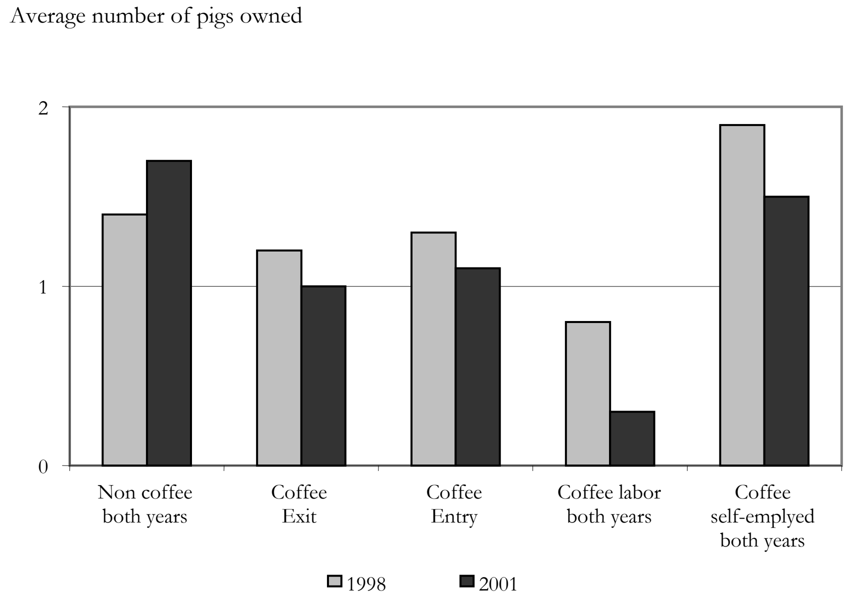
Sources: Nicaragua LSMS 1998 and 2001.

Figure 20: The coffee crisis and assets: cattle



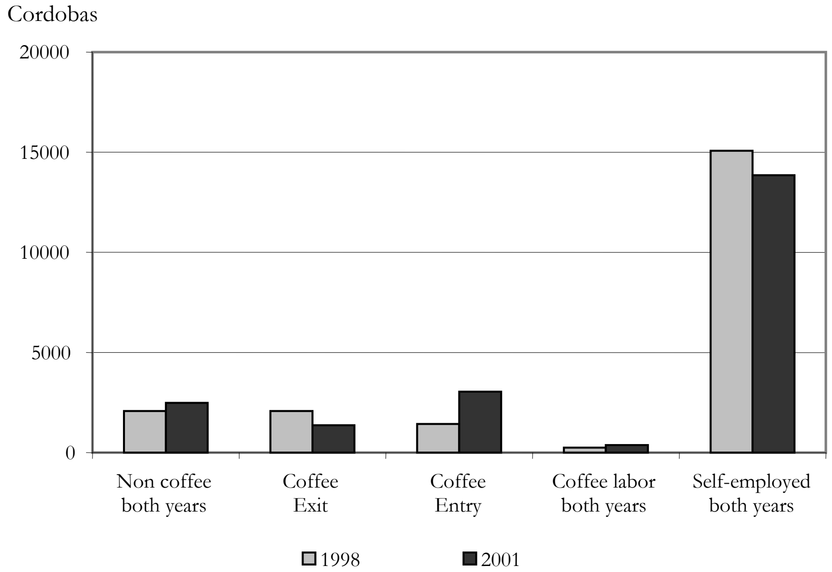
Sources: Nicaragua LSMS 1998 and 2001.

Figure 21: The coffee crisis and assets: pigs



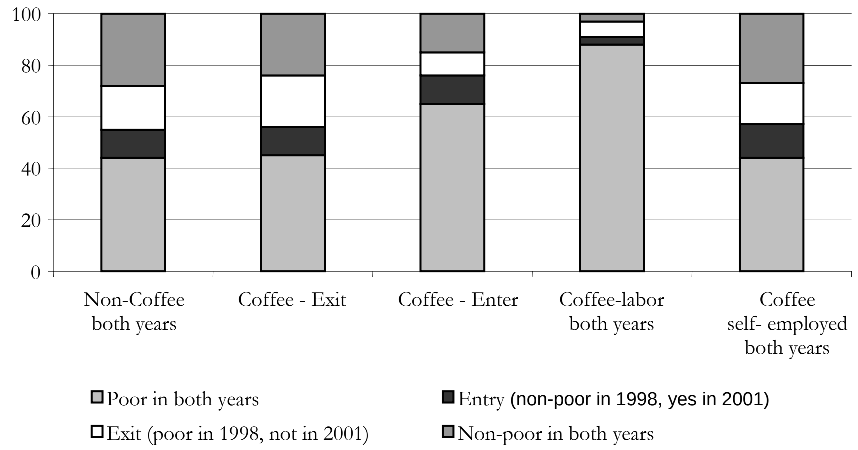
Sources: Nicaragua LSMS 1998 and 2001.

Figure 22: The coffee crisis and assets: value of equipment



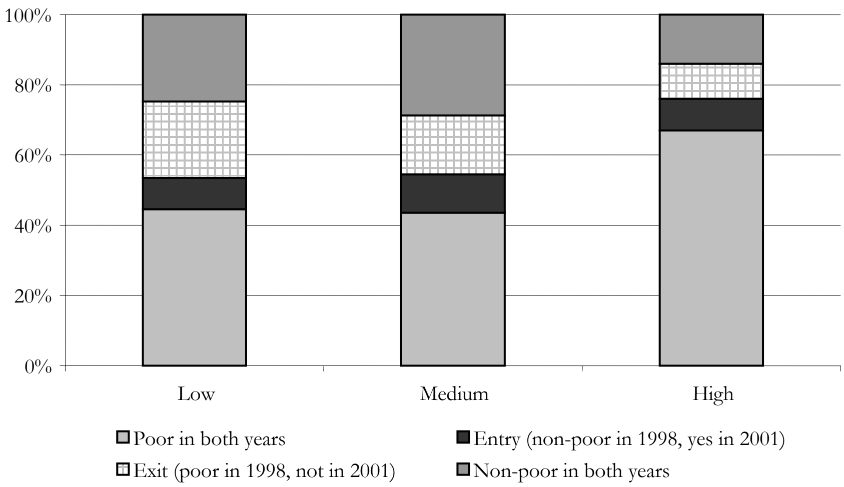
Sources: Nicaragua LSMS 1998 and 2001.

Figure 23: Poverty mobility by household coffee definition



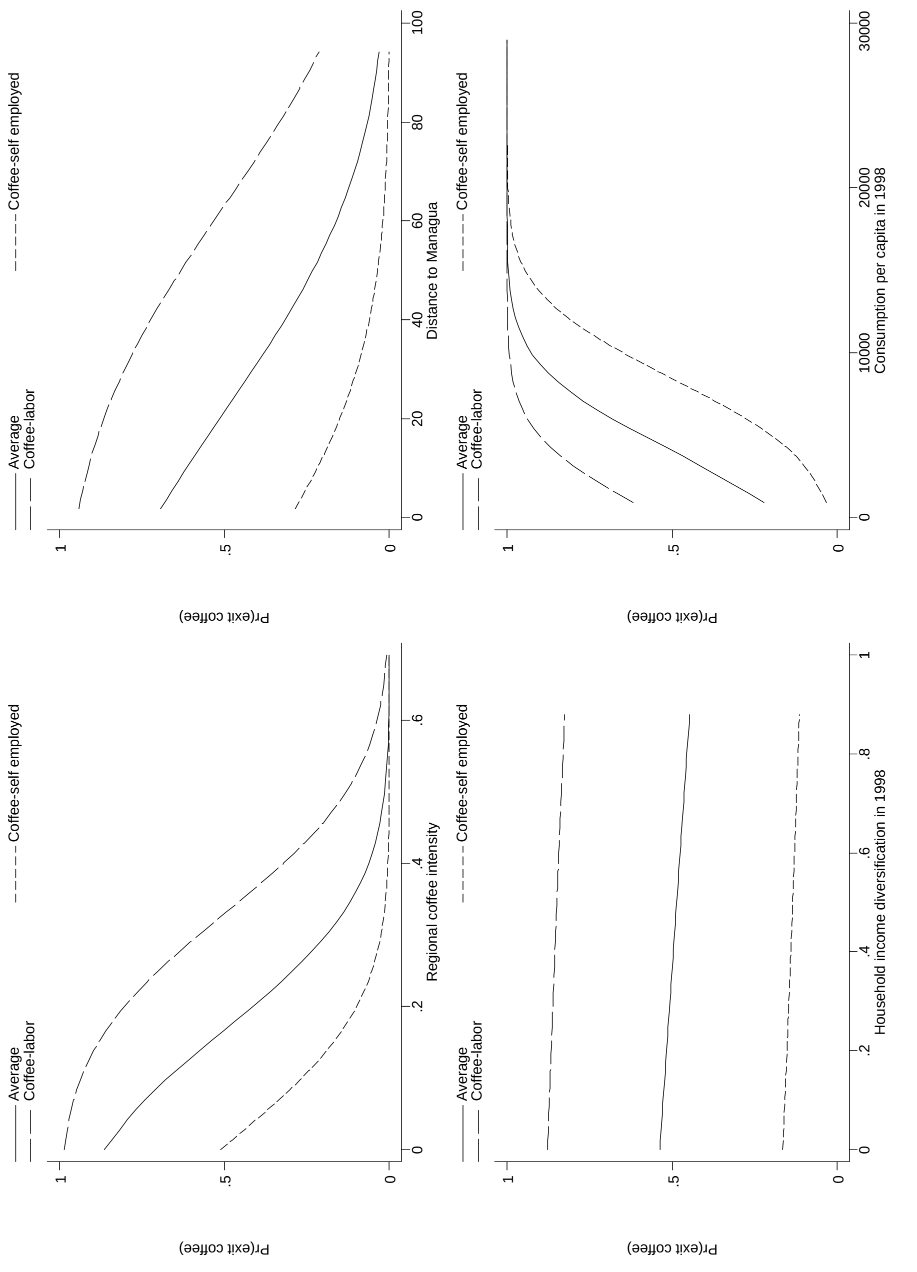
Sources: Nicaragua LSMS 1998 and 2001.

Figure 24: Poverty mobility by regional coffee definition



Sources: Nicaragua LSMS 1998 and 2001 and National Agricultural Census 2001.

Figure 25: Mobility out of coffee



Appendix 2: Attrition and panel construction

An extensive analysis of the attrition in the Nicaragua panel used in this paper can be found in Davis and Stampini (2002). They conclude that while almost a third of the original sample was not interviewed in 2001, attrition is not a major problem in the sample. In fact, the only exception in their analysis is among urban non-poor households, where they find some weak evidence of non-random attrition. In addition, there does not seem to be a systematic difference between coffee households (both labor and farm) with non-coffee households (Table 31). As such, and since this paper focuses exclusively on rural households, attrition is not considered to be a problem.

Table 31: Panel attrition

	Non coffee Households		**Coffee Households**						**All**	
			Labor		Farmer		All coffee			
	No.	%	No.	%	No.	%	No.	%	No.	%
Dropped in 2001	1109	**28.8**	61	**30.5**	46	**28.1**	107	**29.4**	1216	**28.9**
In Panel	2736	71.2	139	69.5	118	71.9	257	70.6	2993	71.1
Total	3845	100	200	100	164	100	364	100	4209	100

Risk Management and Crop Insurance Role and Importance for Horticultural Farms in Croatia*

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Abstract

Results of research collected in the first phase of the ongoing project "Risk Management and Crop Insurance in Croatian Agriculture" are presented. Main body of the paper contains results of horticultural farms survey. In the form of closed questions and using Likert type scale farmers' decision making process, risk perceptions and risk management strategies have been investigated. Survey put emphasis on crop insurance issues trying to find evidence about its use and role for farmers. The results show considerable gap between crop insurance importance perceived by farmers and application of crop insurance as the risk management strategy. About 75 % of farmers never use crop insurance. The main reasons are crop insurance premium price, small number of perils covered by the insurance policy and insufficient supply of crop insurance. After survey, based on the collected data, further research should evaluate risk management strategies and their effects on farm business results.

1. *Introduction*

Risk and uncertainty has been intensively treated subject in farm management research and practice during last decades. Nevertheless it seems it did not significantly influence or found much application in Croatia. Maybe obsolete or irrelevant in the centrally planned economy (which we seriously doubt) but how could we explain lack of interest for risk management today.

Especially if one is aware that globalisation trends brings (or already did) "…new, and thus yet uncertain, changing challenges for the billions of risk managers in agriculture" (Anderson, 1997). Also, risk management experiences can benefit farmers in meeting the challenges of transition process and EU accession (Szep, 2000).

Project "Risk Management and Crop Insurance in Croatian Agriculture" have been initiated two years ago and it is one of attempts and incentives to-

* The research project "Risk Management and Insurance in Croatian Agriculture" is funded by the Agricultural Research Council, Ministry of Agriculture, Forestry and Water Management of the Republic of Croatia.

Picture 1: Agricultural regions in Croatia

Legend: Pannonian region; P1= eastern, P2= Central, P3= Western, P4= Northwest
Mountainous region; G1= Sub mountainous, G2= Mountainous
Adriatic; J1= Northern, J2= Central, J3= Southern

Source: Croatian Agriculture, Food and Food Processing Industry, 2003,

ward wider use of decision analysis and correspondingly application of risk management strategies. The paper presents preliminary results of the project. They include data colleted by survey of farmers risk's perceptions and risk management. Survey put emphasis on crop insurance and tried to find reasons why is crop insurance, as risk management strategy so underrepresented and will crop insurance premium subsidization make some changes. Survey was done on the sample of fruit, grape and wine producers (family farms). It was the case because such farms generally show higher level of specialisation, higher income potential, asset value and knowledge involved. Also, investments in new orchards and vineyards recently have received special treatment and place by policy makers in Croatia. In the same tome, biological and economical characteristic of horticultural production makes it vulnerable on whole spectrum of risks.

After materials and methodology, the paper presents some basic fact about Croatian agriculture and overview of insurance market in Croatia. Decision making process, risk perceptions and risk management strategies applied by the surveyed farmers are elaborated in the chapter Survey results. At the end instead of conclusion, the Paper enlightens needs for further research.

2. *Materials and methods*

Primary data source have been collected using survey. Survey was developed based on similar research in USA and in Europe on the large sample of livestock farmers (Meuwissen, 2000). Survey questions are divided on five parts: 1) socio-economic characteristics of farm; 2) decision making process; 3) perception of risk sources; 4) risk management and 5) crop insurance. Likert-type scale was exclusively used for closed questions. Area of research was continental part of Croatia, agricultural region Pannonia (from P-1 to P-4, see picture 1) and on horticultural farms. Population was grape growers and winemakers in the evidence of Croatian Institute of Viticulture and Enology and fruit growers evidenced by different fruit growers associations. Sample included same proportion of both groups. After pilot interviews, face-to face interviews was conducted on the 98 farms. Survey results have been analysed by descriptive statistics. It was done by MS Excel and statistical software SPSS.

3. *Croatian Agriculture- some basic facts*

The Republic of Croatia is partly situated between the Alps and Adriatic Sea but the major part of its territory exist of the Pannonian area between rivers Una, Kupa, Sava and Danube. Three agro-ecologic regions could be distinct: Pannonian, Mountain and Mediterranean. (Figure 1) Each region provides different conditions for crop growing. Differences in farming systems, farm management as well as agricultural practices in plant and animal growing are evident through the regions.

The share of agriculture in the GDP is about 7% and its share in the trade balance is 10% (agricultural production together with the agro processing industry). At the same time, importance of agriculture lies in the provision of employment to a large part of the rural population.

Some basic indicators of Croatian agriculture based on Agricultural Census data are presented in the table 1. Total agricultural land area in Croatia is 3,155,690 hectares. Arable land and gardens prevail in the agricultural land structure with 46.4% out of total. They are followed by pastures (36.6%), meadows (12.9%), orchards (2.2%) and vineyards (1.9%). Family farms cultivate about two thirds of agricultural land. Furthermore, family farms possess largest area under orchards and olive-groves (96%), vineyards (92%), meadows (84%), arable land (80%) and pastures (40.5%). The rest of the land is generally owned by state and used by companies either in state or private ownership.

Agriculture is confronted with a large number of problems caused both by external factors such as war damage, high level agricultural import, an inefficient market system (including land market), restrictive taxes and internal factors like small and defragmented farms, an unfavourable educational and age structure of farmers and poor managerial skills.

Table 1: Basic indicators in Agricultural Census 2003

	Total	Agricultural households	Business entities
Number of units	449 896	448 532	1 364
Utilized agricultural land, (UAL)ha	1 077 403	860 195	217 208
Average farms size (UAL)	2.40	1.90	159.20
Average farm size (farms >1 ha)	4.40	3.50	167.90
Number of bovine animals, total	488 646	398 037	90 609
Cows and heifers	276 084	262 837	13 247
Number of pigs, total	1 924 672	1 726 895	197 777
Sows and gilts	248 649	224 292	24 357
Number of sheep, total	768 182	750 877	17 305
Breeding female sheep	493 159	480 440	12 719
Number of goats, total	203 979	203 340	639
Breeding female goats	106 516	106 172	344
Number of poultry, total	15 989 365	10 477 514	5 511 851

Source: Agricultural Census 2003

Based on the Farm Survey data[1] collected on two year period (1998- 1999) farm typology was determined. Results shown that highest number of family farms are of mixed types (19.27%) or different combinations of livestock and crop production (23% and 5%) (Njavro, 2001). According to the farm size (measured by European size unit) family farms are mostly very small or small (see table 2) (Njavro, 2001).

The major fruit crops in Croatia are apples, walnuts, plums peaches, cherries and sour cherries. Fruit occupies around four per cent of the arable land area. Contrary to the preferable agroecoloical conditions, the essential characteristics of the orchards are that they are old, poorly maintained and have made little use of modern technical and technological improvements. Crop yields are low by international standards with significant yield variation. Recent years have seen the growth of a number of larger family-owned fruit farms and it is clear that these farms are much more market-orientated and specialised than their small farm counterparts. A number of them have access to good storage facilities; some have invested in refrigerated storage to prolong the selling season. These larger family farms, some of which operate as companies seem for the most part to be or have the prospect of being economically viable.

[1] Farm Survey collected basic data on resources, production, revenues and expenses on family farms. Baseline Survey was carried out by the end of 1998 and continued with three monitoring surveys in following years that will register changes between two surveys. Three institutions included were Croatian Ministry of Agriculture and Forestry, Faculty of Agriculture - Institute of Agricultural Economics and Central Bureau of Statistics of Croatia.

Table 2: Economic indicators of family farms (1998/99)

Size classes	Size limits	Family farms		Farm inome	Net household income	Engaged means
	ESU	Number	(%)	(euro)	(euro)	(euro)
Very small	2	114	47.00%	2848.73	4522.07	29532.00
	4	192		1347.07	4750.12	40978.52
Small	6	132	31.64%	2035.33	6160.32	46201.83
	8	74		2995.56	5771.00	68287.97
Medium low	12	77	15.21%	4544.91	8296.40	75724.07
	16	22		1957.86	7206.61	82470.58
Medium high	40	30	4.61%	3147.94	9981.53	112613.99
Large	100	10	1.54%	385.90	7715.51	135623.33

Source: Njavro, 2001

Grape growing and wine making are distributed throughout the entire country. The wine culture is a part of the traditional Croatian way of life. Today, wine making has developed from a domestic craft into a sophisticated industry. About 60,000 ha of vineyards produce annually between 350 and 400 thousands tones, yielding the approximately 2,600,000 hl of wine. Of the total area under vineyards, 10% are operated by large scale publicly or privately owned enterprises. The remaining 50,000 ha belong to about 100,000 small family farms that grow about 90% of all grapes. All but about 300 of them who operate their own winery either sell their grapes to their neighbours or to commercial plants, or make wine artisanally for direct consumption or distribution as table wine without designation of geographical origin. Almost 60% of the wine, predominantly white, is produced in Continental Croatia, based largely on European varieties. The remainder, predominantly red, is produced in Mediterranean Croatia, based on native varieties. The overall breakdown by colour is 67% white, 32% red, and 1% rosé.

4. *Insurance market in Croatia*

With share of 5.5% in volume of assets, insurance companies hold the second place on the Croatian financial market in the year 2003. Banks were on the first place with 88.8% in volume of assets. Twenty five insurance companies run business in Croatia. Twelve of them are in majority of foreign ownership. According to the lines of business, 4 insurance companies are involved in life and 7 companies are in non-life insurance business. 13 companies are composite (life and non-life insurance) and one company is involved in re-insurance.

With 3.2% share of GDP (2003) insurance activities in Croatia are significantly below European Union. Gross written premium in the year 2003 showed 8.8% growth compared to the year before. Non-life insurance premium growth

Table 3: Information sources and their influence on decision making (1 weak influence to 5 strong influences on decision making)

Information source	average	standard deviation
Experiences	4.23	1.02
Family members	4.01	1.40
Own business data	3.75	1.21
Agricultural fairs, demonstrations and field trips	3.24	1.25
Extension workers	3.21	1.39
Buyers	3.19	1.42
Publications (newspapers, magazines, books etc.)	2.94	1.21
Scientists	2.86	1.44
Electronic media (TV and radio)	2.66	1.26
City markets, wholesale markets, etc.	2.44	1.33
Colleagues farmers	2.40	1.34
Input suppliers	2.24	1.29
Internet	2.13	1.34
Bankers	1.54	0.97
Accountant	1.54	1.03

Source: Risk survey

was 6.6% and life insurance premium growth was 17.1% (Insurance Companies Supervisory Authority). Increase of life insurance due to tax relief measures, as well as the new pension system and the development of the capital market are primary factors that influenced recent growth of insurance industry. The insurance market is still concentrated on a smaller number of companies. In the year 2003 share of ten largest insurance companies according to the volume of gross written premium in total insurance sector reached 90.4%. Besides the largest insurer Croatia osiguranje d.d. which hold 43.4% of market majority of other companies hold about 5% of market.

In the structure of the gross written premium by classes of insurance motor vehicle-TPL had 32.30%, life insurance 22.30%, land motor vehicles-Casco 11.80%, other damage to property 9.10%, accidents 7.40%, fire and natural forces 6.60% and others 10.50%.

Currently, agricultural insurance (crop insurance against unfavourable weather condition and livestock insurance) do not have much importance as risk sharing strategy in Croatian agriculture. Low relevance of crop insurance could be documented by small ratio between insured and insurable land area. Crop insurance in Croatia generally covers hail, fire and lighting as basic guarantees in insurance contracts. Other guarantees, like frost, storm, flood, salinity and quality insurance are optional. Official statistics or any other source of information does not collect and publish information about crop insurance. Gross written premium for group "other property insurance" (where, between other types of insurance, agricultural insurance belongs) was about 733 million Euro in the year 2003 or 9.1% out of total gross written premium for all insurance companies and groups of insurance. Based on rather scarce data, rough

Table 4: Perceptions of risk sources (descending from the most important, 1-not important to 5- very important -)

Risk source	**Average**	**Std. dev.**
Family health concerns	4.60	0.68
Climate factors (hail, storm, drought, etc.)	4.54	0.92
Enforcement of payment for sold products	4.24	1.11
Changes of agricultural policy	3.90	1.26
Marketing of products	3.88	1.17
Input prices variability	3.86	1.12
Diseases and pests	3.84	1.15
Higher quality standards and food control	3.78	2.34
Consumer preferences	3.73	1.06
Counterpart risk	3.63	1.40
Output prices variability	3.60	1.12
Lack of labor force	3.51	1.29
Accession to the EU and others European and world trade and political integrations	3.39	1.34
Environment policy	3.19	1.28
Changes in production technology	3.16	1.26
Property rights (enough own land and inheritance rights)	2.93	1.58
Changes of interests rates and ability to repay loans	2.84	1.56
Burglary	2.67	1.49

Source: Risk survey

estimation is that about 3% of agricultural land (or of the production on that land) is under insurance. Tobacco production is covered to the largest extent. About 80% of total area under tobacco is insured. Tobacco production is followed by sunflower, oilseed and soya (26%), and grain (14%). Percentage of orchards and vineyards covered by insurance are only about 2% of statistically recorded area.

5. *Decision making, risks and risk management- survey results*

A total of 98 horticultural producers in the continental part of Croatia were surveyed. Fifty nine wine growers and thirty nine fruit grower. In the grape growers group most of them process grape in wines while others sell grape to large wineries. Majority of grape and wine produced are predominantly white and based largely on European varieties. Apple is the main produce in the fruit grower group. It is followed by peaches, pears and plums and in very small extent with cherries and walnuts. Surveyed farms are much above Croatian average in the terms of land ownership. Even after elimination of extreme values average orchard is 15 hectares and average vineyard is 20 hectares! In addition, farms rented about 3 hectares of orchards and 8 hectares of vineyards. Average farm manager is 55 years old. Family farm consists of 5 people in average; two of them are active in agriculture full time. With tradition and production history of about 15 years horticultural farms could be classify as relatively young.

Table 5: Risk Attitudes (frequency distribution)

	don't agree		**↔**		**strongly agree**
I must be willing to take risk to be successful	2.1	3.1	8.3	34.4	52.1
I'm more concerned about loos then profit	10.5	10.5	30.5	22.1	26.3
I'm cautious about accepting new ideas	7.3	6.3	35.4	33.3	17.7
New technology must be first tested by others	9.5	15.8	13.7	33.7	27.4
I never plan too much	7.2	9.3	20.6	40.2	22.7
I more risk lover then othrs	5.2	16.7	27.1	26	24

Source: Risk survey

5.1. *Decision making*

The most useful asset a producer can have to help with the decisions making is information, on or off-farm in formations (Szep, 2000). Farmers should ranked different information sources according to their influence on decisions making process. Results are presented in the table 3. It seems that farmers (still) mostly rely on experience, family members and own business data in decision making process. Agricultural fairs, buyers and extension workers are two additional information sources evaluated with average mark above three. Bankers and accountant with average score of 1,5 are of less importance.

5.2. *Risk perceptions*

Eighteen risk sources were taken in consideration. Risk sources encompass important business and financial risks for horticulture. If we apply criteria that risk sources with average score below 3 are relatively unimportant (Meuwissen, 2001) then we could say that all risk sources are perceived as important (table 4). Health concerns earned the highest score. Climate risks are on the second place. Group of market risks are very high on the list. Price variability is less important but possibilities for marketing products and even most important ability to enforce payment of sold products. Small percentage of surveyed farmers reported credit burden. In line with that perception of credit risk (changes of interest rates and ability to repay) seems sound result.

In order to understand the behaviour of producers we asked them to scale their risk attitudes. The results are presented in the table 5. Although clearly aware the fact that risk taking is success factor farmers are cautious with new ideas and implementation of new technology and are more concerned with costs then profit.

5.3. *Risk Management*

Risk management strategies have been research in regard with its importance and application (table 6).

Table 6: Risk management strategy (importance and application)

Strategy	**Importance (1- to 5)**		**Application (frequency in %)**		
	average	st.deviation	never	sometimes	always
Own agricultural land	4.77	0.68	9.8	6.5	83.7
Adequate technology	4.71	0.63	4.3	4.3	91.3
Constant learning	4.68	0.63	7.5	22.6	69.9
Consultancy services	4.43	0.83	13	33.7	53.3
Labour force reserves (quality and quantity)	4.35	0.94	15.6	36.7	47.8
Spreading sales	4.24	1.14	17.8	18.9	63.3
Production for known buyers (under contract)	4.17	1.12	24.7	25.8	49.4
Anti-hail nets	4.06	1.44	93.5	1.1	5.4
Cash reserves	3.98	1.16	46.1	37.1	16.9
Off-farm sources of income	3.96	1.29	29.5	11.4	59.1
Crop insurance	3.82	1.44	77.5	10.1	12.4
Life insurance	3.70	1.59	51.7	6.7	41.6
Organized input supply (through cooperatives)	3.58	1.42	62.9	22.5	14.6
Irrigation	3.55	1.61	76.4	5.6	18
Anti-frost system	3.29	1.73	94.5	1.1	4.4
Geographical and time diversification	2.97	1.46	56.7	16.7	26.7
Stocks of machinery parts	2.64	1.46	65.9	21.6	12.5
On-farm enterprises diversification	2.58	1.43	65.9	8.8	25.3
Leasing/renting machinery	2.41	1.68	79.5	8	12.5

Source: Risk survey

On-farm strategies seemed to receive higher average scores. Ownership over land got the highest average mark. Application and importance of adequate production technology was expected due to type of production. Leasing as financial strategy is relatively unimportant which, together with low credit burden and relatively low perception of credit risk, could be sign of low farm's credit capacities or, on the other side, relatively undeveloped agricultural financial market. Importance of risk management strategies are more or less in line with application. Nevertheless gap between perceived importance and application of crop insurance exist. That fact support decision to investigate crop insurance issues more deeply. Survey revealed that about 75 % never use crop insurance (picture 3) although more than 50% of them experienced serious losses caused by weather risk in the last few years. Twenty five per cent of those who use crop insurance regularly or partially chose (table 8) credit risks, exposure to climate factors and inadequate supply of other risk management tools as the most important reasons for crop insurance application. Farmers buy crop insurance from only four insurance companies and Croatia osiguranje d.d. hold 80% of crop insurance supply. Relatively modest number of represented insurance companies is evidence of unsatisfied crop insurance supply. Farmers select

Table 7: The main factors that influence non-use of crop insurance (scale from 1-not important to 5- very important)

	average	st.deviation
Crop insurance premium	4,51	1,15
Number of perils covered by insurance	4,15	1,04
Scarce supply of crop insurance	3,62	1,31
Low exposition to climate risks	3,03	1,50
Too much paper work	2,89	1,38
Lack of information about insurance	2,71	1,27
Relay on hail suppression activities	2,62	1,61
Relay on other risk management instruments	2,29	1,52
Rely on the government disaster relief	2,21	1,43

Source: Risk survey

Table 7: The main factors that influence application of crop insurance (scale from 1-not important to 5- very important)

	average	st.deviation
Credit risks	4.31	1.12
Low exposition to climate risks	4.00	1.39
Insufficiently of others risk management instruments	3.50	1.25
Recommendation from experts	3.50	1.25
Crop insurance premium	3.48	1.33
Insurance premium subsidy	3.46	1.56

Source: Risk survey

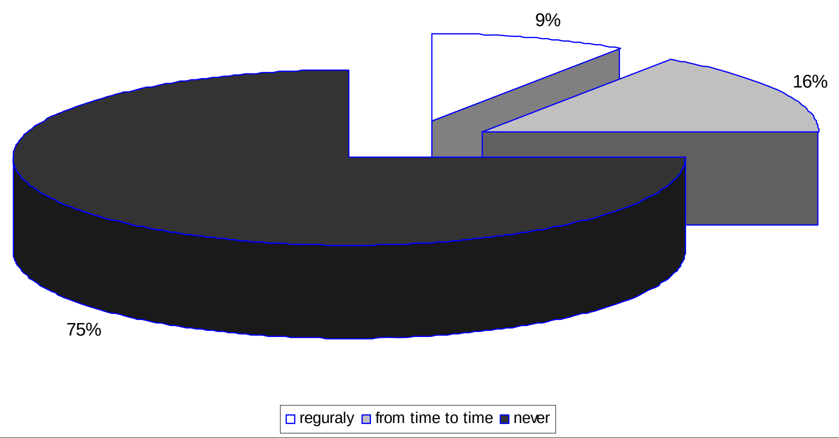
insurance companies primary based on positive experience from the past business relationships. Satisfaction with different elements connecting insurance is the lowest with crop insurance premium, claim adjustments and indemnity speed. Since farmers are very reluctant to give exact or sometimes even any financial data about insurance (premium and insured sum) such data did not take in consideration in order the to avoid any biased conclusion.

Group of farmers that do not use insurance is much bigger and their reasons for non use of crop insurance could be more important and representative due to their number in the sample.

They estimate crop insurance premium, number of perils covered by the insurance policy and insufficient supply of crop insurance. Relaying on other risk management strategies has weak influence (table7). It is because market for risk management strategies, especially risk transfer instruments is rather undeveloped. Croatian government have started to subsidize insurance premium from the year 2003. Premium subsidy on the national level is 25%. Some counties and towns also subsidize crop insurance premium and subsidy level is near national level. Most of farmers are satisfy with subsidy or do not have opinion about it.

Statistically significant relationship between crop insurance application regarding farm type, county, land area and leverage did not found.

Picture 2: Application of crop insurance as the risk management strategy between horticultural producers



Source: Risk survey

6. *Conclusions and further research*

Survey about decision making, risk perceptions and risk management strategies on the horticultural farms in Croatia was main goal of the paper. It seem that farmers still mostly rely on experience, family members and own business data in decision making process. Health concerns, climate risks and group of market risks are the most important risk sources. Risk management strategies have been research in regard with its importance and application. Special attention has been given to crop insurance. Considerable gap between crop insurance importance perceived by farmers and its application is evident. Survey revealed that about 75 % never use crop insurance. The main reasons are crop insurance premium, number of perils covered by the insurance policy and insufficient supply of crop insurance. The entry of foreign investors to the domestic insurance market has influenced the development of insurance activities in Croatia, the growth in competition and an improvement in the quality of insurance services. More competition may lead also in the future to new insurance programmes for agriculture. At the same time, the complexity and special nature of the agricultural insurance industry deserved government intervention

Further research will concentrate on microeconomics analysis of risk management strategies on the farm level. According to research results optimal strategy or their portfolio will be determined according to the farm type, farm size and region. Also emphasis will be given to new risk sharing instruments and their implementation by horticultural farmers in Croatia. Further research should rise awareness regarding strategic risk and risk management strategies that should enable competitiveness and farm's sustainability.

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Crop Insurance in Transition. A Comparative Analysis of Insurance Products: The Case of Kazakhstan*

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Abstract

The paper considers insurance as a possible instrument of farm income stabilization and compares several crop insurance products with respect to their applicability in a transition economy using the case of Kazakhstan. The analysis is based on a qualitative evaluation as well a quantitative assessment of selected insurance products. The qualitative analysis reviews the available literature on the topic. The quantitative assessment completes the comparison introducing the findings of a numerical analysis of farm and weather data.

1. *Introduction*

Governmental interventions were an important part of agricultural policies in socialist countries. Unfortunately, these government actions often neglected conditions for economically-sustainable farming. In the former Soviet Union, primarily output-oriented agricultural policies extended agricultural production even to marginal production areas, and thus created a significant misallocation of resources.

Under the Virgin Land policy, 41.8 Million hectares (ha) were opened up for grain farming in the Soviet Union. In Kazakhstan, crop farming was extended from 6.7 Million to 21.9 Million ha from 1954 to 1964. Thereby, in addition to the areas suitable for crop production, much virgin land was ploughed in areas with poor soil quality and weather conditions which were unfavorable for crop production. Prior to 1991, the crop farming in Kazakhstan was extended to 35.3 Million ha. In the Soviet times, production risks due to natural hazards and catastrophes did not affect farmers' incomes since their production losses were compensated by the government. Nowadays agricultural enterprises face high production risks and inevitably have to adapt to natural conditions. During the last 10 years, a drastic reduction of sown area has been observable. According to an official statistic, sown area was reduced from 35.2 to 17.8 ha in the same period. The steepest decline of sown area was evident from 1996 to 1998, when

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most parts of the country experienced drought, and as a result many farm businesses were forced into bankruptcy (Gray, 2000). However, even though much land where sustainable production is not achievable has been taken out of cultivation, Kazakhstan is still confronted with the problem of high vulnerability of farm incomes with regard to unfavorable weather and production conditions in vast areas of the country.

The option of reducing production risks by applying on-farm risk management tools can be used only to a limited extent in a transition economy. Hard budget constraints, the lack of working machinery, and scarce working capital result in even less favorable conditions for crop production when compared to previous years (Petrick, 2001). Like many of the former Soviet Republics, Kazakhstan preserved compulsory agricultural insurance in order to help farmers manage their risks. Up until 1997, insurance services for agriculture were provided by the state insurance company KazGosstrakh. In spite of the legal requirements for all legal farm entities to take risk insurance for all operations, the market for insurance remained under-developed and few farms were insured. Those, which did buy insurance usually did so only to meet formal requirements for other purposes such as access to credit (Gray, 2000). In 1998, the Government established KazAgroPolis in order to develop a public-sector supplier of crop insurance. However, its operations remained very limited and, according to the National Bank of Kazakhstan (The National Bank of Kazakhstan, 2002) after its last restructuring in 2001, KazAgroPolis lost its licence for providing any type of insurance services.

In 2003, Kazakhstan's government prepared a draft law on compulsory insurance in crop production. According to this document, private insurance companies were allowed to provide crop insurance, and the government was obliged to pay 50 percent of indemnity in case of crop failure. A survey of key actors[1] conducted in autumn 2003 showed that the insurance scheme proposed by the government contained many serious shortcomings and was attractive neither for insurance companies nor farmers. However, the Parliament passed the law in March 2004 to provide an insurance option to farmers. Nevertheless, no farm was insured in 2004, as many issues of the institutional framework with respect to the introduction of the new insurance scheme remain not solved.

There are many critical issues which explain the failure to develop a crop insurance in Kazakhstan. But, most of them could be separated into two major groups: neglecting of general insurance requirements and specific issues with regard to transition process. Therefore the motivation of this study is to assess several insurance products with respect to their potential to be adequate to both general insurance aspects and particular problems of transition. The study is

[1] The survey was conducted in the form of the structured interviews with members of Parliament, representatives of insurance companies, farmers' unions, regional administrations and insurance and agricultural experts. 21 persons were interviewed in September-October 2003.

Table 1 Main crop insurance products

Type of Insurance	*Based On*	*Examples of Existing Insurance Products*
All-risk insurance Multi-peril insurance Single risk insurance	Actual Production History (APH)	Whole-Farm Income Insurance (NISA) Whole-Farm Gross Revenue Insurance (FGRI) Commodity Gross Revenue Insurance (CGRI) Income Protection (IP) Crop Revenue Coverage (CRC) Revenue Assurance (RA)
Parametric Insurance	Area-yield Index; Weather Index	Group Risk Plan (GRP) Group Risk Income Protection (GRIP) Rainfall-Based Index Insurance (PBII)
Catastrophic Insurance	(APH)	Catastrophic Coverage Level (CAT)

Source: Bokusheva and Heidelbach, 2003

based on both the literature on the issue and the preliminary results of a numerical analysis of farm and weather data. The analysis uses extensively the results and data from a farm survey[2].

The paper is organized as follows: Section 2 gives a short overview and systematization of the most current and widespread insurance products. Section 3 presents a discussion of the comparative advantages of two well-established and two relatively new crop insurance schemes. This discussion is followed by a quantitative assessment of the potential for introducing parametric (index) insurance in Kazakhstan. Conclusions are drawn in the final section.

2. *Short overview of insurance products*

Crop insurance is used in many countries and a variety of crop insurance products are offered worldwide[3]. Several relatively new insurance schemes are being investigated to respond to special needs and issues on pilot-basis. The diversity of insurance products makes it difficult to draw a clear distinction between them. Therefore, before starting an analysis of different insurance schemes, the most important insurance products will be presented and systemized to provide an understandable overview (Table 1).

[2] This farm survey was implemented in October-November 2003 and May-June 2004. 73 farmers and managers of agricultural enterprises were interviewed in the different parts of the country during this time (Heidelbach et al., 2004).

[3] Most of them, however, were introduced in the USA, where crop insurance has a long history as an instrument of farmers' income stabilization.

Generally, one can distinguish between all-risk, multiple risk and particular risk insurance. Two additional important groups of insurance schemes should be considered separately: parametric and catastrophic insurance. At the same time, two mechanisms of crop insurance could be distinguished. The first mechanism is based on the actual production history (APH) of the farm. APH provides the base for different calculations using the insured's historical yield records. Another mechanism of insurance is the so-called parametric or index-based insurance, which uses weather or area-yield indexes for pricing insurance contracts. Thereby, insurance payoffs are subject to the occurrence of a special weather event, which can be described by a weather-based index (Skees, 1999). In case of area-yield insurance, average area yield "triggers" an indemnity payment which is equal to the difference, if positive, between the annual area yield and some predetermined critical yield (Miranda, 1991).

The next distinction can be made regarding crop insurance products is the particular objective they are designed for. Primarily, one can distinguish between yield-only (or crop), revenue and income insurance schemes. In contrast to crop insurance, revenue and income insurance schemes provide protection against both production and price risks.

Aside from this ordinary distinction, crop insurance products may be modified with regard to the following issues:

- Participation (compulsory versus voluntary participation),
- Contract duration (multi-year versus single year insurance contracts),
- Monitoring mechanism and technique,
- Re-insurance regulations,
- Deductibles, and
- Prices, which are used to calculate indemnity.

An important distinction to be drawn pertains to the organizational form of insurance provision. In this regard, several options exist: private and state-subsidized private insurance, insurance by the state and insurance on a mutual basis.

This short overview shows that, although there exists a variety of insurance products at the moment, most of them bear a resemblance to each other and are based on the same features or functioning principles. In the following, the paper discusses four insurance products with regard to their capacity and applicability under transition circumstances. Particularly, the discussion concerns two well-known products, multi-peril yield insurance and farm gross revenue insurance, as well as two relatively recently-developed insurance schemes, area yield crop insurance and weather-based index insurance. All four insurance schemes are analyzed with regard to their comparative advantages regarding general issues as well as aspects that are especially important under the conditions of a transition country.

3. *Qualitative comparison of insurance products*

In light of the complexity of challenges and many interdependencies between individual aspects of insurance market development, it is important to set up criteria which can help to compare individual insurance products. Though it is not easy to draw a clear division between individual aspects, the following assessment features were considered in this study:

- Insurability,
- Incentives for farmers to buy insurance,
- Incentives for private insurance to provide crop insurance,
- Possible effects on productivity and production patterns,
- Feasibility (applicability),
- Financial viability of insurance scheme.

In addition the assessment considers several issues which are especially important in the transition context. The most important follow:

- underdevelopment of financial markets,
- possible presence of marginal production areas, and hence a higher exposure to systemic risks, which can seriously affect the development of financially-viable crop insurance,
- large differences in farm productivity that can induce adverse selection,
- information deficiency in view of complex farm restructuring and changes in production patterns,
- underdeveloped market infrastructure, which lowers the profitability of farming,
- low liquidity of farms, which can hinder their participation in crop insurance schemes,
- many farmers had bad experiences with insurance during the Soviet era. This makes them cautious and less interested in insurance,
- low attractiveness of involvement in agriculture on the side of private insurance, first of all due to high risk and transaction costs. However, not least due to low profitability of farming in general.

The particular advantages and disadvantages of the considered crop insurance schemes with respect to the selected criteria are examined in the following.

3.1. *Insurability*

Past experience strongly suggests that not all risks are insurable. In agriculture in particular, many crop insurance programs fail to operate on an actuarially-sound basis. In theory, there are two attitudes towards the question of risk insurability. Among others, Berliner (1982) underlines the requirement that it must be possible to make reliable estimates of the relevant probabilities from statistical observations. The implication is that a risk is insurable only if it can apply the law of large numbers.

In the insurance sector, risk is classified as insurable as long as actuarially-sound premiums are charged. Actuarially-sound premiums have to accurately reflect the risks involved. However, actuarially-sound premiums can often be established only at a very high premium or cannot be achieved at all (Meuwissen *et al.*, 1999).

With respect to the realization of the law of large numbers, a serious difference may be constituted only regarding two general options: compulsory and voluntary insurance. In principle, every insurance product considered in this analysis can be provided in one of both ways. As mentioned before, many socialist countries tried to realize insurability by introducing compulsory insurance. Farms had to pay for insurance without any decision option (even if they did not need one). Moreover, the premiums established by the state insurance companies were not correlated with the actual risks involved, as premium rates were distinguished only according to relatively large territorial units (Zadkov, 1997; Pye, 2000). Such developments induced negative experiences with insurance in the cases of successful enterprises and the free-riding behavior of loss-makers.

The process of privatization in Kazakh agriculture has had a significant impact on the importance of risk for agricultural producers. Nowadays, farmers inevitably have to adapt their production to natural production conditions (Petrick, 2001). Thereby, they are looking for appropriate instruments of risk mitigation. As the results of the farm survey show, 64.4 percent of the respondents would like to be insured. However, only 43.8 percent of this number believes that crop insurance should be compulsory in Kazakhstan (Heidelbach, Bokusheva and Kussayinov, 2004). A compulsory insurance scheme usually undermines the farmer's decision-making autonomy and hence affects activity of individual farmers. In such circumstances, farms are forced to employ risk-management instruments which may not provide the best solution to the farm's problems, or must even pay for services which they do not need. This makes compulsory insurance rather different from transition goals, since it violates free decision-making and, respectively, production factors allocation. Additionally, a compulsory insurance scheme is usually heavily regulative, which prevents insurance companies from setting actuarially fair premiums.

In addition, to realization of the law of large numbers, the literature specifies two further aspects that have an effect on insurability: systemic risk and asymmetric information. In assessing the insurability of risks in agriculture, Miranda and Glauber (1997) identify both as basic conditions for risk insurability: first, the risks should be nearly stochastically independent across insured individuals; second, the insurer and the insured should have very nearly symmetric information regarding the probability distribution of the underlying risk.

Contrary to automobile or fire risks, which tend to be independent, the crop-yield risk exhibits a substantial degree of correlation across space (Miranda and Glauber, 1997). As stated before, crop losses in Kazakhstan are often driven by natural disasters, which simultaneously affect a large number of farms over a widespread area. Drought and extremely high temperatures are the main natural hazards that induce systemic yield losses of grain producers in most important production areas there. In light of the high specialization scale of Kazakh agriculture, where grain currently makes up 80 percent of gross agricultural output and covers 79 percent of the sown area in Kazakhstan (Statistical Yearbook Kazakhstan, 2003), the problem of systemic risk can be especially serious. The concentration of grain production in the northern regions in Kazakhstan with similar climatic conditions makes this issue even more severe. In this context, considering the capacity of an insurance scheme to treat systemic risk is of great importance in comparing alternative insurance products.

As multi-peril yield and revenue insurance could not provide a solution for systemic risk, innovative insurance schemes have been considered in several countries. Currently, area-yield insurance and weather-based insurance are regarded as the most appropriate alternatives to conventional insurance products. However, the high correlation among individual farm-level yields may force insurers to charge a high risk premium which makes insurance unattractive (Mahul, 2001). The problem in this context is that risk pooling is difficult to achieve between those who are exposed to the same type of systemic risk. Hence, to manage the problem of systemic risk in agriculture, risk pooling must be extended to other economic sectors, for example, by introducing financial market products such as weather derivatives. At the same time, considering the case of a transition country requires much attention to be paid to the economic viability of agricultural production in individual regions. If long-term farm profitability is not achievable due to unfavorable weather and production conditions in a region, risk pooling would not be an appropriate mechanism of farm income stabilization, since it would imply an income redistribution from profitable to unprofitable farms and, respectively, from more productive to less productive sectors of the economy.

Asymmetric information manifests itself primarily in terms of adverse selection and moral hazard. Adverse selection in insurance markets is caused by the inability of the insurer to accurately rate the risk of loss of individuals who purchase insurance.

Moral hazard is a result of hidden actions of the insured, which increase the risk of loss of the insurer. Theoretical and empirical studies (Akerlof, 1970; Rothschild and Stiglitz, 1976; Makki and Somwaru, 2001) have shown that adverse selection reduces the consumption of insurance by low-risk individuals or businesses, and results in the transfer of income from low-risk to high-risk insured. Miyazaki (1977) and Wilson (1977) demonstrate that, when it is impossible or highly-expensive to distinguish between low- and high-risk insurance applicants, the insurer prices insurance contracts at an average premium for all individuals. That results in undercharging high-risk customers and overcharging low-risk customers for similar contracts.

Past experience suggests that most popular crop insurance schemes, particularly multi-peril yield insurance and revenue insurance, are rather prone to adverse selection and moral hazard. Goodwin (1993) illustrates the effects of adverse selection on the actuarial performance of the US crop insurance program, demonstrating that only farmers whose risk is above average are likely to purchase insurance. The results of a study conducted by Just *et al.* (1999) suggest that participating farmers tend to be those with higher-than-expected indemnities, as farmers with lower-than-expected indemnities are priced out of the program. They conclude that the domination of high-risk farmers in the insurance market can lead to market failure.

Miranda (1991) argues that area-yield insurance offers numerous advantages over individual-yield crop insurance. Because information regarding the distribution of the area yield is generally available and more reliable than information regarding distribution of individual yields, insurers could more accurately assess the actuarial fairness of premiums under an area yield policy, thereby significantly reducing adverse selection problems. The use of an insurance product based on an index should eliminate the problem of asymmetric information between government and insurance companies, as well as between insurance companies and farmers, since all involved parties have symmetric information regarding the contract, and problems of moral hazard and adverse selection can be reduced significantly.

However, Skees and Reed (1986) show that the potential for adverse selection depends on a farmer's subjective assessment of the expected yield and the variability of the yield. They argue that premium rates based only on the mean crop yields of a region can lead to adverse selection, particularly when the variance of yield fluctuates considerably between farms. This aspect might be even more serious in a transition country, where farm productivity and production technologies could be rather heterogeneous in the initial stage. In this view, weather-based index insurance products provide some advantages because of the objective nature of the parameters that trigger indemnity payments. Varangis *et al.*, (2002) argue that the weather can be independently verified, and therefore is not subject to the possibility of manipulation. Pre-conditioned, reliable assessment of area-yield based insurance can have similar benefits to weather-based index insurance.

3.2. *Incentives for farmers and insurance companies to participate in crop insurance*

Realization of the law of large numbers is closely connected to incentives for farmers to buy insurance. If insurance is voluntary, then farmers' participation in crop insurance would depend on, among other factors, how well it is suited to their needs. According to the conducted farm survey in Kazakhstan, features of insurance contracts such as sensitivity to changes in weather conditions (60.8 percent of the respondents), timing of contract fulfillment (44.6 percent) as well as the possibility of selecting a reasonable coverage (28.4 percent) and regional differentiation in contract design (24.5 percent) were referred to as main preconditions for the farmers' participation in crop insurance. Additionally, the farmers mention the cost of insurance as an important factor of their willingness to buy insurance. In this view, most farmers would tend towards insurance against only a group of the most serious natural hazards they face, as opposed to multi-peril insurance, provided that it would lower insurance costs. According to survey results, drought represents the most important natural hazard to grain production in the region, therefore, weather-based index insurance is likely to be accepted by farmers there.

However, since other important risks cannot be insured under this insurance product, farmers with multiple risks may desire another insurance scheme to provide coverage against their further risks. On the other hand, insurance contracts that are designed to protect against losses from a multitude of hazards may present challenges in terms of accurately assigning a probability of loss and determining an appropriate insurance rate (Goodwin, 2001). This issue is even more critical if only limited historical yield data is available, as is the case in transition countries, where, due to restructuring, new entities have been emerging. Using regional data, however, may not accurately reflect the true likelihood of losses for individual farmers. As Miranda (1991) suggests, area-yield crop insurance provides incentives to farmers whose yields strongly correlate with the aggravate area yield. As the farm survey results demonstrate, this applies for most large farms in the investigated regions. Therefore, this insurance product can find acceptance by large farmers in Kazakhstan as well.

Furthermore, farmers, who in addition to high yield-variability face high price risk, could be interested in a revenue insurance scheme. In the context of an underdeveloped market infrastructure, price risk is of great importance to Kazakh farmers. According to the farm survey results, 64.4 percent of the interviewed farmers would like to have income insurance (Heidelbach *et al.*, 2004).

Another important aspect of insurance market development associated with insurability is readiness of the private insurance sector to extend their services to agriculture. As results of structured interviews with insurance experts in Kazakhstan show, insurance companies are strongly distrustful to business in agriculture. Most of them do not possess any expertise in providing agricultural insurance. Those small parts of insurance companies, which do have some experts in the field, do not believe that risks in Kazakh agriculture can be privately insured. Additional aspects that hold them from involvement in the crop insurance market are high administrative and transaction costs, problems with monitoring and controlling moral hazard, and heavy regulation of the crop insurance market. Considering that both, area-yield insurance and weather-based-index insurance possess some advantages compared to traditional insurance products with regard to the above-mentioned problems, they could serve as an "lead-in" for private insurance during the initial stage of development in the private insurance market in a transition economy. However, area-yield crop insurance, as well as weather-based-index insurance, does not solve the problem of risk pooling when systemic risk is present. In this case, an engagement on the side of either state or financial markets is inevitable for dealing with the problem.

3.3. *Effects on farmer's production patterns*

An important issue treated in the literature concerns effects of insurance on farm productivity and production practices (Chambers and Quiggin, 2002; Coble *et al.*, 1997; Smith and Goodwin, 1996). Reducing farmers' risk through insurance has been identified as affecting land use and inducing changes in production decisions. The effects of crop insurance on production pattern changes originate from the fact that under crop insurance, risk-averse farmers will behave as if they were risk-neutral (Chambers, 1989). In view of the problem of marginal production areas with less productive farms in Kazakhstan and some other transition countries, this effect of insurance can be even more serious and severely distort factor allocation. Crop insurance can motivate farmers to choose a riskier bundle of outputs, inputs, and production practices that make farming more risky. Regarding this general problem, the literature concerns the optimal design of insurance contracts. Chambers (1989) considers a contract-based approach, where insurance is designed with respect to an incentive compatibility constraint based on the agent's first-order conditions for choice of inputs. Miranda (1991), Mahul (1999) and Bourgeon and Chambers (2003) examined the design of area-yield crop insurance with regard to the farmers "beta"-coefficient relating a farmer's yield to the risk pool's yield.

On the other hand Chambers and Quiggin (2004) argue that by having access to fair insurance, the producer does not need to engage in costly self-insurance. In the framework of state-contingent approach the authors show that by looking for a cost-minimising bundle of risk management tools and the technology to reach the optimal level of state-contingent income, the producer will be required to equalise the rate at which the risk management tool and technology balance out the state-contingent incomes. In this context the challenge is to apply this approach to empirical investigations into crop insurance design and pricing.

3.4. *Feasibility and financial viability*

Feasibility of an insurance scheme plays an important role considering applicability and viability of an insurance product. From this point of view, index-based insurance schemes provide some important advantages over other insurance schemes. Primarily due to their capacity to reduce transaction costs on the insurance market. For instance, in the case of transition countries where many small farms have emerged, area-yield crop insurance could allow to manage to some extent the problems of limited data availability. On the other hand, as serious differences in farm productivity could be present during transition, using area-yield as a reference value for risk pooling should be considered with caution. Thus, weather-based insurance can be viewed as a more advanced insurance product under these circumstances. Like other crop insurance products, weather-based insurance cannot solve the problem of systemic risk pooling. However, due to similarities with weather derivatives, weather-based index insurance can prepare farmers for the potential adoption of such advanced financial instruments. An important precondition regarding the establishment of a weather-based index insurance product is the development of hydro-meteorological services and the provision of reliable and affordable weather information for insurance market participants. This issue underlines the importance of institutional frameworks. As most transition economies experience high budget restrictions, policy-makers have to pay attention to the insurance schemes which can be run privately, without any subsidization, or only on a small scale. Most attention must, however, be paid to the institutional accompaniment of the development of rural financial markets, in particular the crop insurance market.

At the initial stage of insurance market development, a great deal of attention must be paid to educating potential customers on insurance matters. In light of bad experiences with insurance during the Soviet era, farmers in most transition countries are skeptical about crop insurance. Hence, pilot projects must be started to convince farmers of the advantages of their participation in the initial stages of crop insurance market development. In this regard, a strong engagement of government and public agencies must be present.

To summarize, in the view of a less-developed financial market in a transition economy, crop insurance can be considered as a possible instrument of a farmer's income stabilization. The analysis shows that area-yield insurance and weather-based index insurance provide more advantages compared to multi-peril crop insurance and revenue insurance also in the transition context. These advantages include:

- AYCI and WBII are introduced to manage systemic risk;
- since only systemic risk is to be insured, insurers can more accurately assess the actuarial fairness of premiums, and thus reduce the adverse selection problems;
- both schemes have relatively low transaction costs;
- AYCI is better applicable given prevailing data limitations;
- WBII is less bureaucratic, and thus provides less scope for corruption;
- WBII is better positioned to avoid moral hazard because of objective nature of parameters that trigger indemnity payments.

Nevertheless, some important issues remain unresolved even by introducing these advanced insurance schemes:

- AYCI and WBII do not solve the problem of risk pooling;
- neither of them provide protection against price risk;

- there exists a danger that risk-averse farmers may change their production patterns in a way that increases systemic risk;
- AYCI can lead to adverse selection since it is based on average yields of a region;
- WBII is attractive for those farmers, who look for insurance against only one, most serious risk - other important risks cannot be insured;
- risk-averse farmers could prefer farm-level insurance to area products, thus WBII might be more attractive for them compared to AYCI.

With account of these critical issues both schemes have been considered in the quantitative analysis that is presented in the next section.

4. *Quantitative assessment of insurance products*

Weather-based index insurance is considered in the analysis by introducing rainfall-based index insurance (RII) and drought-index insurance (DII). In addition to area-yield insurance, they are evaluated with respect to their capacity to represent farmers' risks accurately and provide a proper basis for assessment of an actuarially fair premium.

4.1. *Procedure and Data*

To conduct the quantitative part of the analysis the study employs a procedure which contains the following steps:

- Index selection and design, estimation of the weights for the parameters included in an index;
- Numerical simulations to assess index distributions;
- Assessment of the expected indemnity and fair premium;
- Calculation of appropriate insurance price to assess the farmer's readiness to purchase insurance.

The most important steps of the procedure will be discussed in the next subsections.

To evaluate yield dependence on the annual weather conditions, yield data from 12 large grain farms, in the Atbasar-rayon in the Akmola-region were employed. Yield data covers the period from 1983 to 2002. Different functional forms were used to de-trend the farm's yields to account for technical change[4]. Since no time trend was found, the further analysis uses the farm yields without detrending[5].

[4] Linear, piecewise-linear, second and third degree polynomial and exponential functions were considered.

[5] Appendix A illustrates the yield development patterns in several (randomly selected) farms in the considered rayon.

Table 2: Descriptive statistics of the farm's and area yields and weather parameters (from 1983 to 2002, Atbasar-rayon in the Akmola-region)

	Expected value	**Std. Dev.**	**Min**	**Max**
Farm yield, 0.1 t	8.4	4.6	1.3	17.0
Area yield, 0.1 t	8.8	3.7	2.4	15.7
Annual precipitation, mm	323.0	61.1	231.0	453.0
Cumulative rainfall in June, mm	38.6	31.2	2.4	153.8
Cumulative rainfall in July, mm	49.7	37.0	9.0	151.8
Cumulative rainfall in August, mm	31.4	22.9	3.8	92.0
Average daily temperature in June, ^{0}C	18.9	2.1	14.7	22.6
Average daily temperature in July, ^{0}C	20.4	1.7	17.8	24.0
Average daily temperature in August, ^{0}C	18.0	1.5	15.7	22.0

Table 3 Minimum, maximum and average correlation coefficients between selected indices and farm-level yields (Atbasar-rayon in the Akmola-region)

Summer Wheat	**minimum**	**maximum**	**average**
From 1983 to 2002			
Drought Index by Selyaninov*	0.43	0.81	0.50
Drought Index by Ped*	0.52	0.85	0.58
Drought Index by Bova*	0.52	0.87	0.56
Cumulative Precipitation in the growing period (mm)	0.37	0.78	0.47
Annual Precipitation, in mm	0.33	0.75	0.49
Area Yield	0.74	0.98	0.79

* - drought indexes were calculated to correspond to the growing period (June1 - August 31).
Source: own calculation based on data, which was collected during the farm survey.

Additionally, data from a weather station in the same region has been used in the analysis. Weather data corresponds to the period from 1974 to 2003 and encloses (Table 2):

- daily precipitation (mm),
- average daily temperature (°C) and
- productive soil moisture in a one-meter soil horizon on May 18 in respective years.

4.2. *Index Selection and Design*

As results of the farm survey indicate, drought presents a major source of production risk over widespread areas in Kazakhstan (Heidelbach *et al.*, 2004). In view of the severity of the problem, much research has been done in Kazakhstan on the drought phenomenon, its consequences for agriculture, and instruments to manage its effects on farm. In the literature, drought is defined as a natural phenomenon induced by a continuous and substantial deficit of precipitation, accompanied by high air temperature, which, due to evaporation and transpiration, causes the drainage of productive soil moisture, and thus unfavorable vegetation conditions (Shamen, 1997). Three types of drought are distinguished: atmospheric and soil drought as well as dry wind. To be able to assess its extent, different measures of drought were introduced.

Selyaninov (1958) (quoted in Shamen, 1997) suggested to identify drought by using an index accounting for the effects of two factors: precipitation and temperature. He introduced the so-called hydro-meteorological coefficient (*HTC*):

$$HTC = 10\frac{\sum R}{\sum T}, \tag{1}$$

where $\Sigma\ R$ is cumulative precipitation in mm during the period with an average daily temperature $\geq 10\ ^0C$; ΣT is the sum of the average daily temperature in degrees Celsius in the same period. Selyaninov demarcated weak drought when $HTC \geq 2$, middle drought when $2.0 < HTC < 1.0$, and strong drought when $0.5 \leq HTC \leq 1$.

Later on, Ped (1975) (quoted in Shamen, 1997) suggested to measure drought by means of an index (S_i), which considers, additionally to precipitation and temperature, soil moisture:

$$S_i = \frac{\Delta R_i}{\sigma_R} + \frac{\Delta Q_i}{\sigma_Q} - \frac{\Delta T}{\sigma_T}, \tag{2}$$

where ΔR, ΔQ and ΔT stand for differences between long-term average and the *i*-considered period level of precipitation, soil moisture and temperature, respectively; σ_R, σ_Q and σ_T are their long-term coefficient of variation. Ped then defined the drought extent as weak if S_i = 1….2, medium if S_i = 2.…3 and strong if $S_i > 3$.

More recently, another drought index was introduced by Bova (Greengof *et al.*, 1987), who suggested to assess the extent of drought (*K*) by using the following formula:

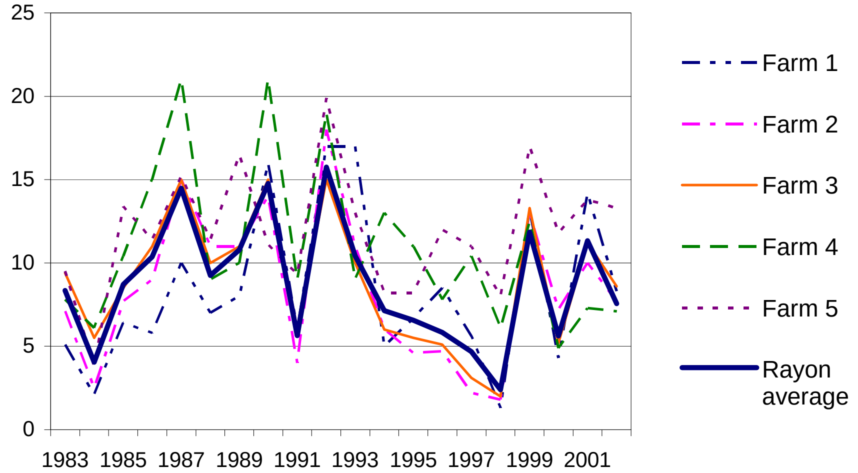
$$K = \frac{10(W + R)}{\sum T}, \tag{3}$$

where *W* is the productive soil moisture in a one-meter soil horizon in springtime, *R* is cumulative precipitation from springtime until the moment of index assessment, and *T* is the sum of the average daily temperature in the period, with an average daily temperature $\geq 0\ ^0C$.

In this study, all three presented drought indexes are examined and serve as a basis for the development of a drought-index insurance product.

To prove suitability of the selected indices to reproduce weather conditions in the individual years, their correlation coefficients with wheat yields for every of the 12 farms were calculated. Table 2 represents the minimum, maximum,

Figure 1: Wheat yields of 5 selected farms and the rayon average yield from 1983 to 2002, 0.1 t (Atbasar-rayon in the Akmola-region).



and average correlation coefficients between the farm yields and annual magnitudes of different weather indexes[6]. The average correlation coefficients are presented in the last column of the table. The results show that the performance of the indices is varying. The highest degree of dependence is observable in the case of area yield.

All drought indices also possess a strong correlation with the yields of several farms. The maximum correlation coefficients reach values 0.81, 0.85, 0.87 in the case of the drought indices by Selyaninov, Ped and Bova, respectively. It could be supposed that the highest correlation coefficients might be observable in case of the farms which are located in the weather station surrounding area. However, this was not always the case. By introducing data on the farms' yields power we could find out that the highest correlations are characteristic for the farms in the areas with low soil quality (yield power less than 35 points). In the farms with higher yield power the correlation between the yields and the selected indices is lower. This indicates that weather conditions influence production in the farms with less productive soils more seriously than in those with relatively good soils.

[6] First, correlation coefficients were calculated for every large farm in the rayon, then the highest and lowest coefficients were selected.

In our further analysis we used all drought indices and the rainfall-based index in addition to AYI and applied them to a farm with a high correlation between yields and weather indices[7].

To improve the performance of the selected indices we modified them by introducing monthly data and fitting them to the farm data. By means of least square regression the effects of the weather parameters (independent variables) on the farm's wheat-yields (dependent variable) were estimated and the following index structures (shapes/configurations) were identified[8].

- Rainfall-based index, R^2=0.80

$$\begin{aligned}&0.09(0.03)R_{May} + 0.09(0.02)R_{June} + 0.08(0.02)R_{July}\\&+ 0.1(0.03)R_{August} + 0.03(0.02)R_{Sept-April}\end{aligned} \tag{4}$$

where R is the cumulative rainfall (or precipitation) in a particular month;

- Drought index by Selyaninov, (*modification*), R^2=0.80

$$\begin{aligned}&0.09(0.03)R_{May} + 1.27(0.29)\frac{R_{June}}{T_{June}} + 1.48(0.33)\frac{R_{July}}{T_{July}}\\&+ 1.7(0.49)\frac{R_{August}}{T_{August}} + 0.03(0.02)R_{Sept-April}\end{aligned} \tag{5}$$

where R is the cumulative rainfall (or precipitation) and T - the average daily temperature in a particular month;

- Drought index by Ped (*modification 1*), R^2=0.81

$$\begin{aligned}&1.80(0.59)\frac{\Delta R_{June}}{\sigma R_{June}} + 2.19(0.64)\frac{\Delta R_{July}}{\sigma R_{July}} + 1.53(0.61)\frac{\Delta R_{August}}{\sigma R_{August}}\\&-1.26(0.59)\frac{\Delta T}{\sigma T} + 1.29(0.57)\frac{\Delta Q}{\sigma Q}\end{aligned} \tag{6}$$

where R is the cumulative rainfall in a particular month, T - the average daily temperature between June 1 and August 31 and Q is the soil moisture as on May 18;

- Drought index by Ped (*modification 2*), R^2=0.79

$$\begin{aligned}&2.22(0.68)\frac{\Delta R_{June}}{\sigma R_{June}} + 2.77(0.67)\frac{\Delta R_{July}}{\sigma R_{July}} + 1.83(0.67)\frac{\Delta R_{August}}{\sigma R_{August}}\\&-1.0(0.65)\frac{\Delta T}{\sigma T} + 1.12(0.66)\frac{\Delta R_{Sept-May}}{\sigma R_{Sept-May}}\end{aligned} \tag{7}$$

where R is the cumulative rainfall from June 1 to August 31;

[7] Descriptive statistics of the data employed is to find in the Appendix B
[8] Standard errors in parentheses.

- Drought index by Bova (*modification*), R^2=0.77

$$1.32(0.22)\frac{R_{June-Aug}}{T_{June-Aug}} + 0.93(0.33)\frac{Q}{T_{June-Aug}}, \tag{8}$$

where R is the cumulative rainfall, T - the average daily temperature from June 1 to August 31 and Q is the soil moisture as on May 18.

Since soil moisture is a parameter, which is related to soil cultivation intensity, using soil moisture as a parameter for an insurance product could induce moral hazard problems. Therefore, we modified the drought index by Ped by replacing data on soil moisture through data on cumulative precipitation in the period from September and May.

As it can be seen in (4) to (8) almost all parameters estimates are statistically significant; except the case of the parameter of cumulative precipitation between September and May in the Selyaninov-index and the same parameter in the rainfall-based index. Moreover, all selected weather-indices explain a substantial portion of annual yield volatility of the selected farm. The *R*-square measures range between 0.77 in the case of drought index by Bova and 0.81 for the first modification of the drought index by Ped. Correspondingly, the range of correlation between the modified weather indices and the farm's wheat yields is between 0.87 and 0.90. However, in view of the above-mentioned concern with respect to use of soil moisture as a parameter for insurance pricing, we decided to exclude those drought indices, which enclose soil moisture measures, from an extended analysis.

4.3. *Assessment of Fair Premium and Appropriate Price*

In this section, four insurance products are evaluated with respect to their capacity to present an appropriate base for accurate insurance pricing and a proper instrument of production risk reduction. These are:

- Rainfall-based index insurance;
- Drought index insurance 1 (modification of the Selyaninov-Index);
- Drought index insurance 2 (second modification of the Ped-Index);
- Area-yield crop insurance.

We compared these insurance schemes by considering their ability to provide an actuarially sound insurance pricing and evaluated them with respect to their accuracy in assessing fair premium and its correspondence with the actual yield loss. The actual loss was defined as an expected loss and thus is the expected negative difference between the farm yields in the individual years and the expected farm yield:

$$E(Loss) = E(y_i - E(y)), \tag{9}$$

where y_i is the yield in the year i ($i \in T$) and E(y) is expected yield.

Actual yield loss was calculated by employing the farm yield data corresponding to the period from 1983 to 2002. The insurance products were compared by considering the closeness of the assessed fair premiums to the actual loss.

Distribution estimations and generation of the index values were done by means of @risk and several add-in-programs for MS-Excel[9]. Two approaches were used to generate large numbers of weather-indices. The first approach employed the following procedure: using historical weather data as a particular index was calculated, then its historical probability distribution was assessed and after that an index distribution with 10000 sample points was simulated[10]. The second approach was based on the generation of a multivariate distribution of the parameters, which are included in the individual indices[11]; in doing so, the correlations between the individual weather parameters were taken into account. In the first stage mean values, standard deviations of the index parameters as well as covariance matrixes were calculated, after that index parameters were jointly simulated as uniform variables of a multivariate normal distribution, and finally the generated weather parameter sets were used to calculate the index values. With regard to area-yield insurance only the first procedure was employed.

4.3.1. *Fair premium*

We used the generated index values to assess fair premiums and appropriate price of insurance. To identify the fair premiums an indemnity function was employed (Turvey, 2001):

$$\text{indemnity} = \begin{bmatrix} 0 & \text{if } x > strike \\ strike - x & \text{if } x \leq strike \end{bmatrix} * \lambda \,, \tag{10}$$

where x is the index value in the individual years and λ stands for liability.

As it could be seen in equation (10), the indemnity function defines a weather-contingent contract as a put option, that would provide an indemnity if the index value falls below a strike level. In this study, the index strike level was defined as the average level of a particular index. To be able to compare the weather-index insurance products with the area-yield insurance, in contrast to the studies on weather derivatives (Turvey, 2001, Berg *et al.*, 2004), liability was set to correspond to the average farm's wheat yield in this study. Moreover, all

[9] NtRand (Version 2.01) and Matrix.xla.

[10] According to the Anderson-Darling (AD) and Kolmogorov tests area yields in the considered rayon are distributed as a Weibull-distribution. With respect to the weather indices best fit was provided by a Log-logistic distribution in the case of the rainfall index and drought index by Selyaninov (AD and Kolmogorov tests); drought index by Ped is distributed as an Inverse Gauss distribution with respect to Chi-square and AD tests.

[11] These parameters are presented with respect to the considered weather indices in the formulas (4) – (9).

estimations were completed assuming 100 percent insurance coverage[12] and in 0.1 tonnes per hectare.

The assessment of fair premium in case of area-yield insurance was conducted by the application of an indemnity function specified as

$$\text{indemnity} = \max\left[\frac{\alpha_i \mu - y}{\alpha \mu_i} \mu \phi_i, 0\right], \tag{11}$$

where y stands for the realized area yield, $\alpha_i \mu$ is the critical yield and ϕ_i responds the optimal level of coverage for the farm *i* (Mahul, 1999; Skees *et al.*, 1997).

Both indemnity functions were additionally employed to assess expected indemnity by means of the "burn rate" method. This method is often applied in actuarial practice and assumes that future losses will be distributed as in the past. In this analysis we assessed these values in addition to fair premium to prove the performance of the considered insurance products in the short-run using the yield and weather data from 1983 to 2002.

4.3.2. *Appropriate price*

To assess the readiness of farmers to purchase insurance, a formula derived by Chambers and Quiggin (2004) in the framework of state-contingent approach can be applied. The appropriate price indicates the maximal price that the farmer is ready to pay for one unit of insurance and is defined as follows:

$$v^* = \sum_s \frac{c_s(w, z)}{p_s} a_s, \tag{9}$$

where c_s are marginal costs in state *s*, p_s stands for output price in state *s*, a_s represents payout (indemnity) in state *s*, *w* is input price, and finally z_s is stochastic production in state *s*.

The formula allows comparing farmer's activities to manage risk through production decisions as well as an insurance. Thus, an insurance is plausible as far as it is not more then the cost of increasing revenue by one unit in every state of nature.

Applying this formula to our empirical investigation we had to define the farm's output prices and marginal production costs. This was a challenging task with respect to the data that was available in the framework of the study. Since no price and production data was available from the considered farm, the study employed regional price data over the period from January 2000 to June 2004 and used data on production costs, which were assessed for the current level of

[12] In the case of area yield insurance the optimal level of coverage was applied. To determine the optimal level of coverage the critical β as specified by Miranda (1991) was assessed by means of a regression equation.

technology employed on most large farms in the respective agri-climatic zone of the Akmola-region (Sigarev, 2003).

To account for the possible presence of natural hedge, different levels[13] of correlation between output price and index values were considered. We considered correlation coefficients between output price and index values instead of the correlation between output price and farm yield because only these variables are introduced into the appropriate price formula. Output prices are introduced directly into the formula and index values are considered indirectly through the parameter a_S – indemnity, which is subject to the index value in state *s*. In case of parametric insurance the farm's yields are not used for assessing indemnity, but natural hedge could be observed even better on a region-level, in our case the rayon-level. Thus, considering area-yield insurance it is legitimate to use the correlation between area yield and price. Further, since specific weather events determine farm yields, in case of presence of natural hedge they have to demonstrate a negative correlation with price as well. Therefore, in case of weather-index insurance we decided to concern this issue by accounting for a negative correlation between a weather-index and price. As the estimation results show, the appropriate price slightly decreases with increasing absolute values of the correlation coefficients between price and index values. This is in accordance with empirical evidence and shows that farmers are less willing to buy insurance when they can compensate their production losses by higher prices.

The empirical estimation of marginal production costs in different states is an object of our further in-depth investigations. For the moment, we decided to assess this value by using the average instead of marginal production costs. Additionally, we had to assume a constant technology so as to use the same level of costs over all states of nature. This illustrates that our estimates of appropriate price are rather rough and should be considered just as an approximation. Consequently, a more advanced investigation is required to introduce the concept of appropriate price into empirical research.

4.4. *Estimation Results*

In Table 4 the estimation results are presented with respect to the individual indices. The actual loss was calculated using the selected farms' yields and has an expected value of 1.89 tonnes over the period from 1983 to 2002. The fair premium was assessed on the basis of the generated index values. Estimations of the expected indemnity as well as the appropriate price were done using historical weather data in the above-mentioned period.

[13] In our analysis we considered the following values of the correlation coefficients: 0, - 0.1, - 0.3, - 0.5.

Table 4 Preliminary results of a numerical analysis (data from a farm and a weather station in the Akmola-region; 100 % coverage; 0.1 t per ha)

Insurance based on:	**Rainfall**	**Drought 1**	**Drought 2**	**Area Yield**	**Area-Yield optimal[1]**
Expected Loss	1.89	1.89	1.89	1.89	1.89
Fair premium, estimated by:					
- *index simulations*	1.64	1.62	1.64	1.60	1.65
- *index parameters simulations*	1.54	1.47	1.66	n.a.	n.a.
Expected Indemnity (est.d by burn rate method)	1.67	1.73	1.68	1.57	1.63
Appropriate price[3]					
Difference between:	1.56 - 1.64	1.55 - 1.63	1.54 - 1.62	1.43 - 1.50	1.48 – 1.56
- *fair premium and indemnity[2]*	0.92 - 0.98	0.85 - 0.93	0.98 - 0.99	1.02	1.01
- *indemnity and loss*	0.89	0.92	0.89	0.83	0.86
- *fair premium and appropriate price[2]*	0.95 - 1.01	0.96 - 1.11	0.93 - 0.99	0.89 - 0.94	0.90 - 0.95

[1] - according to the estimates 104%;
[2] - minimum and maximum percentage;
[3] - estimated by assuming presence of natural hedge.
Source: our estimations

As the estimation results show there are some differences in the estimated values of the fair premium with respect to the simulation procedures of the index value generation; particularly in the case of the rainfall-based index and drought index 1. That can be explained by different assumptions with respect to the probability distributions. Using the parameters simulation procedure, a multivariate normal distribution was assumed. In the procedure of direct index simulation, Log-logistic distributions were employed to generate the rainfall-based index and drought index 1 (by Selyaninov) and an Inverse Gauss distribution was applied in case of drought index 2 (by Ped).

Considering the estimations of the fair premium and the expected indemnity the lowest differences in their assessment could be found with regard to drought index insurance 2 and area-yield insurance. This indicates that these insurance products provide more precise estimates also in a short-run, and is an important aspect for actuarial practice.

Comparison of expected loss and indemnity estimates shows that there is no insurance scheme which provides a complete coverage of the farm's crop losses. This was to expect, since weather-based insurance provides protection against only one, usually the most important risk, in this case – drought, and area-yield insurance covers only systemic yield losses (e.g. idiosyncratic risk remains uninsured). However, all weather-based insurance products minimize the differences between expected indemnity and loss. This fact supports the argument that drought presents the most important natural hazard in the considered region.

Further on, for all insurance products the estimates of appropriate price approach the fair premium values. However, as appropriate price identifies the maximum price that the farmer is ready to pay for an insurance, it must be higher than the insurance premium. With respect to rainfall-based insurance and drought index (1) insurance no clear assessment is possible: the ratio of fair premium to appropriate price varies between 0.95 and 1.01 and 0.96 and 1.11, respectively. Conversely, in the case of three other insurance products the estimates of appropriate price is definitely lower than the fair premium. This indicates good prospects with respect to the farmers' participation in crop insurance.

By way of summarizing the discussion of the estimation results, the analysis and comparison of the selected insurance products show that two of them, drought index (2) insurance and area-yield insurance, provide a better basis for developing crop insurance in the considered region. However, further investigations are necessary before these insurance products can be recommended for introduction. This concerns both empirical and methodological issues. Our investigations into insurance contract design were based on the data from only one farm in the considered region. It remains to be proven empirically whether and which of the considered insurance products provide an adequate instrument of risk management to other farmers in this as well as other regions of Kazakhstan. Additionally, substantial effort is necessary to improve the empirical application of the appropriate price concept.

5. *Conclusions*

Due to the slow development of financial markets and the scarce provision of financial services to farmers in many transition economies, crop insurance can present an initial instrument of farmers' income stabilization. The analysis shows that most of the important aspects of insurance markets in developed countries can be applied in a transition economy as well. However, additional issues can arise in establishing crop insurance in this context. Depending on the extent of these problems, several insurance products could be assessed in terms of their potential and applicability in an individual transition country. The complexity of the problems to be treated in the transition process involves and requires the gradual development of crop insurance markets. This would allow the accumulation of extensive knowledge and experience for the development of a long-term strategy which aims to increase sustainability of farming. As first estimations show, in the case of Kazakhstan, introducing drought-index insurance or area-yield insurance for large farms in the grain-producing regions seems to have good prospects. Initial preconditions for that are analyzed in this study. However, in view of the problem's complexity, further investigations are necessary.

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SESSION THREE

FARM INCOME RISK AND PUBLIC POLICY

Production Incentives of Risk Reducing Policies and Strategies

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1. *Introduction*

Several recent policy developments have brought risk management back to the forefront of policy discussions[1]. The introduction of counter-cyclical payments and the increase in loan rates in the US 2002 Farm Act have accentuated the risk reduction orientation of US farm policy, which is particularly oriented to price risk. In addition to these programmes, the US Government provides subsidies to insurance. Policies in the European Union show the opposite trend. In the last decade there has been a reduction in intervention prices for crops and meats, their substitution with fixed payments based on area and animal numbers and — after the 2003 CAP reform — the single farm payment. Although lower intervention prices may contribute to increasing domestic price variability, some EU countries, particularly Spain, have insurance programmes complementing the CAP. Insurance subsidies and other policies oriented to the reduction of risk in agricultural production are or have been used in several other OECD countries, such as Canada with NISA and the Canadian Agriculture Income Stabilisation program (CAIS), or the new 2003 deficiency payments in Mexico. In addition, some OECD countries provide emergency assistance in circumstances of low yields or revenue.

These developments once again raise the question of the pros and cons of different policy interventions to deal with risk in farming. The starting point of this study is to compare existing policy measures from the point of view of their impact on production and their ability to reduce risk. In the context of "decoupling", as defined in OECD (2001a), two related questions are posed: What is the production response to each policy? What is the relative effectiveness of different policies in reducing farming risk? When dealing with the ob-

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[1] See the proceedings of the OECD Workshop on Income Risk Management (OECD, 2000) for some discussion of the best strategies to manage income risk in agriculture and the potential role of government.

jective of farm risk reduction, both questions are inter-related because risk reduction induces production response from risk adverse farmers (OECD, 2003a).

Most of the instruments examined in this paper have been analysed in previous literature. The main value added of this paper is to bring all of the instruments into the same analytical framework so as to attempt a more general analysis of support programmes that are oriented towards reducing farming risks. In particular, programs are compared from the double perspective of their effectiveness in reducing risk and the production incentives they create. This paper is organised in three parts.

Section 1 develops a simplified analytical framework to respond to the two questions posed. Different types of programmes/strategies are considered: price hedging, crop insurance, revenue insurance, deficiency payments, and direct counter-cyclical payments attached to land. The model considers an individual risk adverse farmer that is facing production decisions for only one commodity. He is choosing the number of hectares to cultivate and the quantity of other inputs to be used to maximise his welfare. He also has the possibility to hedge part of his expected production at a given future price and to insure, after a fair premium payment, part of the area planted against low yields. An expected utility / certainty equivalent of profit approach to production decisions is used: the farmer determine inputs use and degree of coverage (where appropriate) to maximise his expected utility, *i.e.* to maximise his certainty equivalent of profit. An initial joint distribution of prices and yields is constructed on the basis of empirical data. It is used to obtain a distribution of outcomes (profit and associated utility) that depends on production and coverage decisions made by the individual farmer and, when appropriate, on risk reducing policies in place. The farmer takes his decisions with a view to maximise the expected value of utility (from the distribution of outcomes) given risk reducing policy instruments. Each policy instrument changes the producer decisions and the risks he is willing to face.

Section 2 presents some results derived from the analytical framework that has been developed. Each policy or strategy is analysed at a time. First some basic results are discussed on the basis of the optimisation conditions for each strategy or program. Then these results are illustrated using Monte-Carlo simulations in order to quantify the different magnitude of effects. Demand for the risk strategy is analysed first, when relevant, and then the production and risk reducing impacts are studied. Some simulations are also used to illustrate how the interaction between strategies and programs is crucial for evaluating its impact. Finally some illustrative estimates of the relative production impacts of different programs are provided. These results are presented with some sensitivity analysis about the assumptions on risk aversion. Further sensitivity analysis is presented in Appendix II.

Section 3 gives some conclusions.

2. *Analytical model and numerical calibration*

The starting point is an individual farmer whose profits depend on his production decisions regarding the use of land and other inputs, and also with respect to government payments and other risk reduction strategies that he can use. Profit is uncertain due to both price and yield variability, and the farmer is risk averse. The covariance between prices and yields is crucial in this respect. The model is able to capture an individual farmer's decision in this context under risk aversion. The farmer is assumed to process the information about the distribution of the uncertain variables and its linkage with the government programmes and other risk management strategies considered.

2.1. *The model*

Drawing upon expected utility theory, the model assumes a utility function of the form (see, for instance, Gray *et al.*, 2004):

$$U(\tilde{\pi} + \omega) = \frac{(\tilde{\pi} + \omega)^{1-\rho}}{1-\rho}$$

with random profits:

$$\tilde{\pi} = \tilde{p} * \tilde{q} * f(L, I) - r * L - w * I + g(\tilde{p}, \tilde{q}, \lambda ...)$$

where:

- ω initial wealth
- ρ coefficient of relative risk aversion
- $\tilde{p}$ uncertain price;
- $\tilde{q}$ random yield shock, with $E[\tilde{q}] = 1$
- *f*(*L*,*I*) production function defining the output as a function of land, *L*, and other inputs, *I*;
- *r, w* rental price of land and price of the other inputs;
- $g(\tilde{p}, \tilde{q}, \lambda ...)$ net payment or benefit from the combination of the risk strategies (indemnity net of premium)

This form for the utility function, called the *power utility function*, was chosen because of its desirable properties of decreasing absolute risk aversion and constant relative risk aversion. The farmer maximises his expected utility, the mean of *U* from the simulation model. The certainty equivalence of profit is used to estimate the welfare impacts of changes in the distribution of profits with combinations of government payments. The certainty-equivalent profit is computed from the expected utility as:

$$CE = [(1-\rho) EU(\tilde{\pi} + \omega)]^{1/1-\rho} - \omega$$

Different programmes and strategies are defined in the function

$$g(\tilde{p}, \tilde{q}, \lambda ...) = \sum_i g_i$$

that is a mathematical expression representing the indemnities or payments to be received by farmers under a combination of strategies or programmes g_i, net of the premium that the farmer needs to pay to use the strategies (if any). The function g can depend on specific parameters denoted by λ. The list of strategies and programs analysed, together with the expressions of their indemnity functions are presented in Table 1. Since the producer is assumed to have only one possible commodity to produce, all historical and current parameters in Table 1 refer to the same commodity for which the producer will decide how much to produce.

Real programs in specific countries may not correspond exactly to the program description given in this paper, but some conclusions can be extracted from the stylised versions of the programs examined. For each program or strategy, two outcomes will be studied: how a program or strategy with a given budgetary cost impacts production and how it reduces farmers' risk. Two types of impacts on the objective function of the farmer are considered, related respectively to relative price and risk effects as defined in OECD (2001a):

> "A program or strategy may increase the expected total returns from farming. This could create relative price effects on farmers' decisions. The price effects on production will differ with the implementation criteria of the payments. Payments based on current production are generally found to create larger incentives to produce than do payments based on current area. In theory, payments based only on historical parameters may increase the expected income of farmers without a relative price impact on current production decisions.
>
> A program may reduce the variability of returns from farming. This would create risk-related effects on farmers' decisions. Depending on the implementation criteria they could also have other risk related effects. There is no clear set of criteria to rank these types of effects stemming from different implementation program rules. The size of the risk-related effects is very likely to be correlated with the reduction of variability, particularly since both sources of variability (prices and yields) appear in the profit function linked multiplicatively with the amount of output."

The size of risk effects is likely to be governed by the capacity of each program or strategy to reduce farming returns variability. This gives an idea of the trade-offs between a policy objective defined as "reducing variability of farming returns" and the efforts to reduce the production effects of the same policy measure (decoupling). However, where price effects also exist, the complete story includes the interaction between price and risk effects of risk reducing strategies and/or government programmes.

2.2. *A numerical calibration of the model*

The previous section lists programmes or strategies oriented to the reduction of farming risk and brings them into a common analytical framework. First

Table 1. Net indemnities for each risk reducing program or strategy

$\tilde{g}_i$	**Indemnity**	**- Premium**
Price hedging		
$\tilde{g}_1 =$	$[p_f * h]$	$-[\tilde{p} * h]$
Crop insurance		
$\tilde{g}_2 =$	$p_f * Max(0, \beta_q - \tilde{q}) * Y_H * L_I$	$-(1+\gamma) * p_f * E\left[Max(0, \beta_q - \tilde{q})\right] * Y_H * L_I$
Revenue Insurance		
$\tilde{g}_2 =$	$Max(0, \beta_{pq} - \tilde{p} * \tilde{q}) * Y_H * L_I$	$-(1+\gamma) * E\left[Max(0, \beta_{pq} - \tilde{p} * \tilde{q})\right] * Y_H * L_I$
Deficiency payments		
$\tilde{g}_3 =$	$Max(0, p_L - \tilde{p}) * \tilde{q} * f(L, I)$	
Area payments counter-cyclical with price		
$\tilde{g}_4 =$	$Max(0, p_T - \tilde{p}) * Y_H * L$	
Area payments counter-cyclical with yields		
$\tilde{g}_5 =$	$P_f * Max(0, \beta_q - \tilde{q}) * Y_H * L$	
Payments on "Historical area" counter-cyclical with prices		
$\tilde{g}_6 =$	$Max(0, p_T - \tilde{p}) * Y_H * L_H$	

where:

h	Quantity og output the farmer has decided to hedge
p_f	Price in the futures market
Y_H	Historical yield
β_q	Proportion of historical yield that is insured
g	Sum of the percentage administrative cost of the insurance policy and a percentage subsidy
L_I	Insured area
β_{pq}	Revenue per bushel insured
P_L	Target price (Deficiency Payment)
P_T	Target price (Area payment countercyclical with prices)
L_H	Historical area of the farm

order conditions that maximise the certainty equivalent of profits give analytical expressions that are difficult to quantify without an empirically calibrated model. A numerical calibration of the model can help to solve this problem and can illustrate the differentiated impacts of the different measures studied both on reducing farming risk and on total production.

Appendix I presents the calibration of the model using data from farms producing wheat in Kansas. Some assumptions have to be imported from other studies. Despite this calibration of the model for a "base farmer" the concrete numerical results are not representative of any real situation. The calibration procedure follows three steps:

- An average farm for Kansas is constructed using average values for the different production variables, particularly production and land use. A Constant Elasticity of Substitution (CES) production function is then calibrated to these data.
- Based on the means and variance-covariance matrix of wheat prices and yields observed in Kansas from 1973 to 2003, a multivariate normal distribution of price and yields is generated. However the variability of average yields is usually much lower than the variability of individual yields. Since individual farm yields information was not available for Kansas, another sample of individual yields and prices for wheat was used in order to "correct" this matrix with micro information that was available[2]. This means the model uses a standard deviation of individual yields that is 60% higher than for the aggregate yield, and a lower correlation between prices and individual yields (from -0.44 to -0.27).
- Random draws are taken from the multivariate normal distribution to make our empirical estimations of changes in variance and expected profits. With all this information a proper certainty-equivalent function can be constructed taking into account the risk reducing programmes available to the farmer. The parameters defining the policy instruments are calibrated in order to obtain interior solutions for insurance and hedging. That is, part of the cultivated land is insured against low yield and part of the expected production is hedged. This calibration is our initial point for our simulations and comparisons. Only one type of insurance is considered at a time. Crop insurance is used in most of the simulations as default. Revenue insurance is used only in the cases where explicitly stated.

Price hedging and insurance are the only instruments with a "self-selection" dimension that translates into a demand for the risk reducing instrument that will need to be analysed. For these two strategies/policies the demand for price hedging "h", defined as the amount of production whose price is hedged, and the demand for insurance "L_I", defined as the number of hectares insured, will be analysed. The general problem to be solved in each version of the model is to determine the optimal level of input use (and production) together with the optimal level of use of the risk reducing instrument (amount of output hedged and land insured), when appropriate. Non linear programming techniques for numerical optimisation are used to obtain the optimal response of the same "base" farmer under different program combinations and parameters.

Presented first is the reaction of our "base" farmer to specific types of risk reducing programmes when support is increased. The quantitative responses on both the level of self protection against risk and the level of production and profit variability are analysed. Then the results are compared across pro-

[2]. See methodological details in Appendix 1.

grammes. The change in response when different types of risk reducing support measures are present at the same time is also illustrated. Sensitivity analysis on farmers' risk aversion and risk reducing policies' parameters is presented in Appendix 2.

3. *Producer response to support for different policies or strategies*

3.1. *Price hedging*

The basic model of "hedging" in Holthausen (1979) is used. The farmer simultaneously takes his planting and hedging decisions, at which time he can commit himself to forward sell any quantity of output at the date of harvesting at a given certain forward price. Holthausen assumes a perfect futures market, so that any quantity can be sold or purchased forward at that given price. The hedging strategy is often available to the farmer at the time of planting, although there can be some transaction costs attached. In the model in this paper it is assumed that the forward price is net of these transaction costs. In some cases governments try to encourage the participation of farmers on these future markets by subsidising the costs of hedging. For instance, since 1994 the Mexican Ministry of Agriculture, through its agency ASERCA, has been financing a programme to subsidise the cost of hedging.

3.1.1. *Are production decisions affected by risk aversion and other risk related parameters?*

When price hedging is the only strategy used, Holthausen finds that if yields are certain then the forward price determines production decisions (classic price equal marginal cost). The equilibrium quantity is determined by the future price P_f without any reference to risk aversion: any subsidy to P_f may induce more hedging and less risk, but it will always create the same price effects as an output payment. However, this result has some analytical weakness in practice. If the future market is widely used by farmers, the price P_f depends on farmers' risk aversion and the demand for hedging. Higher risk aversion would imply higher demand for hedging and — potentially — higher costs of hedging; that is lower net future prices P_f. If, on the contrary, future markets are not commonly used by farmers it is difficult to argue that P_f would be the main determinant of production decisions.

The model in this paper recognises that individual yields are uncertain. In this case, even if price and individual yield were independent, production decisions depend on risk related variables. This is due to the fact that price hedging does not protect against yield uncertainty. If price and yields are not independent but the farmer is risk neutral, the incentive price depends on the covariance between price and yields. Finally, in the most general case, price and yields are not independent and farmers are risk averse. Production is then determined not only by the (subsidised or non-subsidised) forward price rate P_f,, but also by risk attitudes and price/yield covariance. In general, the existence of a futures market can modify (and often reduce) the risk reducing effects of policy but it does not eliminate them.

3.1.2. *What is the incentive created for production when future prices are subsidised?*

A subsidy for the net forward price P_f that is accessible to farmers has the same impact on production as producer price support[3]. However, the budgetary cost of supporting P_f can be significantly different since the subsidy goes only to the quantities hedged. This means that subsidising future prices may have larger impacts per dollar of subsidy than those of price support if the quantity hedged by the farmer is below total production.

These results can only be applied in the case of an interior solution for hedging, defined in this case as a situation with an optimal hedged proportion of expected production that is positive. This admits farmers speculating in the future markets (hedging more than the entire crop when P_f is large relative to the expected price) which may in practice not be possible or realistic. In addition any government intervention oriented to reducing the variability of prices will automatically crowd out some of the incentives to hedge and reduce the role of future markets in farming decisions (see sections 2.3 and 2.5). Some sensitivity analysis on the differences of results when assuming different values of the main parameter in the hedging contract (the future price P_f) is presented in Appendix II.

3.1.3. *Demand for price hedging*

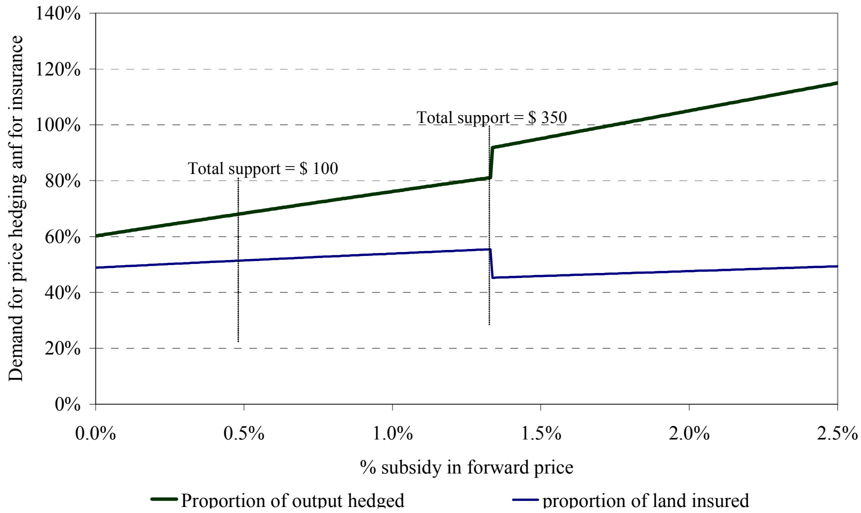
As expected, the demand for hedging increases when the forward price is increased (for instance by government subsidies) (Figure 1). In the example, producers would hedge 60% of production if the initial hedging price is USD 115.7/t., but they would hedge all production if the forward price was 2% higher (USD 118.5/t.). Further supporting hedging prices would create incentives to over-hedge; to hedge more than the expected production with a view to speculate on the market. That could also occur for some farmers — or other agents — even if the market forward price was not supported.

The subsidy to forward prices induces moderate increases in crop insurance to exploit the complementarities of covering both price and yield risk (Figure 1)[4]. The interaction between these risk management instruments becomes evident when the subsidy to forward prices reaches 1.3%. At this level the gains in expected revenue from an effective forward price that is above the expected

[3]. We assume that the government subsidy increases the net forward price. However, government subsidy may just reduce the transaction costs of hedging.

[4] On the contrary, when the alternative market instrument is not crop insurance but revenue insurance, support for hedging tends to reduce revenue insurance coverage. This is due to the lack of complementarity between the two instruments: revenue insurance covers already against price risk.

Figure 1 Demand for Hedging:
Evolution of the level of production hedged when subsidising the forward price

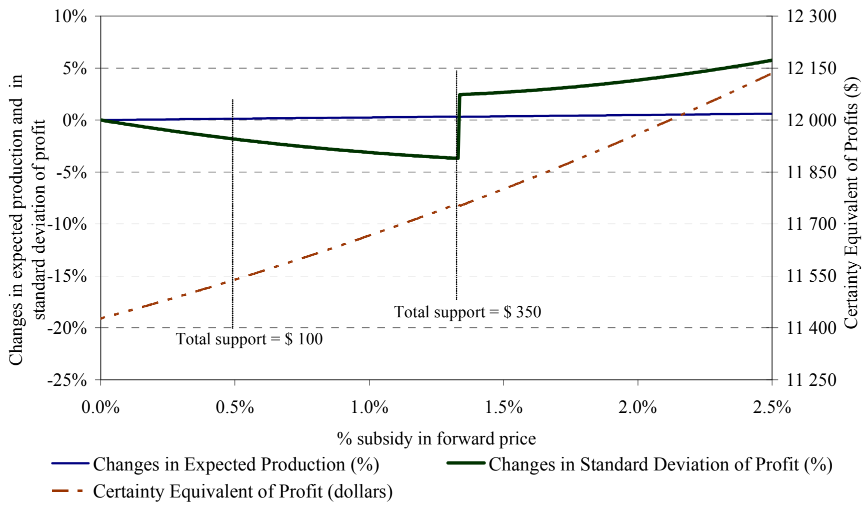


price are big enough for a discrete movement out of crop insurance into price hedging to be welfare improving for the farmer. This movement is represented by a "jump" in Figure 1, a common result in highly non linear models. Figure 2 shows the impacts of the subsidised forward price on production, risk (profit variability) and farmer's certainty equivalent of profit (measure of welfare). The change in farmer's risk management strategy when subsidy is big enough (the "jump" in the figure) leads to an increase in the variability of profits. This would reduce welfare. However welfare continues to increase because the risk related losses are more than offset by the expected gains from additional production hedged at subsidised forward prices. This explains the switch of risk management strategies represented by the jump in figure 1.

3.1.4. *Impacts on production, risk and farmer's well-being*

Figure 2 shows how higher forward prices sustained by Government increase the level of production. The level of support (percentage of initial forward price) is used in the horizontal axis and two vertical lines have been added to show two examples of corresponding total amount of support. The main driving force of this production response is the price effect associated with higher expected returns from farming (the farmer is "fishing" for hedging subsidies). However, up to the "jump" subsidies to price hedging contribute to a reduction in the standard deviation of profits and there can be some risk related production incentives. When the proportion of subsidy in the forward price is

Figure 2: Impact of subsidising price hedging on production and risk



higher than 1.3%, the standard deviation of profit increases with additional support and risk effects stop inducing increases in production. Only price effects are left and all gains in certainty equivalent are associated with higher expected profits that more than compensate increases in risk. Different calibrations of the initial forward price (or transaction costs) may lead to different quantitative results in the example.

3.2. *Crop and revenue insurance*

This paper uses two stylised forms of crop and revenue insurance that are inspired by the design of US insurance programmes as described as in Barnett (2000). In both cases the farmer decides the surface he will be insuring given the conditions provided by the insurance scheme. The crop insurance contract fixes a minimum yield guaranteed by the contract for the insured hectares. Meanwhile, the revenue insurance contract fixes minimum revenue (price times yield) per hectare guaranteed by the contract for the insured hectares. The mathematical model assumes perfect information to avoid moral hazard and adverse selection effects, the analysis of which has been the focus of a vast literature on optimal contracts (see, for instance, Cobble *et al.*, 1997). The magnitude of the indemnities is calculated from the random deviation of yields and revenues away from the historical yields. This approach eliminates the possibility of moral hazard behaviour: farmers cannot deliberately increase their historical yields in order to profit from future indemnities, nor can they reduce yields in order to "harvest" indemnities in the short run. The focus is on the production and risk reduction effects of insurance subsidies rather than on the optimal insurance policy designed to avoid moral hazard or adverse selection problems. However, as the model stands, the insured farmer has incentives to produce more and therefore follow riskier production strategies. In fact, these are the production effects the model will measure.

The model assumes the existence of a competitive insurance market where risk neutral insurance companies are able to offer contracts at a price that equals their expected value. The model also introduces a parameter γ of percentage administrative costs and/or government subsidy that allows a reduced form of market imperfections. The structure of the insurance market described is not very different from Duncan and Myers (2000).

3.2.1. *Can insurance subsidies help to develop a market for insurance?*

The private cost of the insurance (net of subsidy) for the farmer is represented by γ. High marginal (administrative) costs of insurance will prevent some marginal gains from reducing risk from being exhausted. These costs could even prevent the market from existing. In this sense, a subsidy could cover some of these costs and bring some farmers to participate in the insurance market. In order to evaluate the appropriateness of these subsidies they must be compared to the opportunity cost of the budgetary expense. It is likely that insurance costs also exist for other activities and the right level of support to maximise societal welfare cannot be presumed. OECD (2003b) presents some data on the loss ratios of insurance programmes in Spain, Canada and the United States. Indemnities plus administrative costs are on average 8% above premia. Loss ratios reported in Skees (2000) for the United States and other countries are much higher, showing net expected gains from buying insurance (Net indemnities are higher than the premium paid). As for price hedging, any parallel policy measure reducing the variability of yields (for crop insurance) and price times yield (for revenue insurance) implies lower insurance coverage by farmers[5]. The interaction among risk-reducing measures can be very strong and have consequences on both risk reduction and production effects.

3.2.2. *How do insurance subsidies affect production?*

An insurance subsidy would normally only affect production through the insurance effects. That is, the subsidy[6] creates incentives to insure more land. This additional "insurance" then creates incentives to produce by reducing risk. The incentive prices of land, other inputs and the output are not modified by the insurance. Under this situation there is a limit to the potential production

[5]. Innes (2003) explores the relationship between crop insurance and *ex post* relief by the Government. However his results are very much determined by the assumption of farmer's risk neutrality.

[6]. Subsidy is defined by a negative γ in the equations.

impact of insurance subsidies determined by the size of production under risk neutrality.

Insurance cannot be undertaken for a negative number of hectares or for a surface that is larger than the planted hectares. In other words, it is not possible to speculate with insurance and the optimal level of insurance has to be between zero and one hundred per cent of the planted hectares. High risk aversion, compulsory insurance and other circumstances may lead to insuring the total cultivated land (maximum insurance with Li=L). In this case, the indemnity (net of premium) depends directly on total planted land and insurance affects production through incentive price of land instead of through risk effects. This change of "regime" may need further empirical investigation and can have important implications for the aggregate impact of insurance subsidies on production (OECD, 2003b). Some sensitivity analysis on the differences of results assuming different values for the main policy parameter (the level of yield insured) is presented in Appendix II.

3.2.3. *What is the relationship between insurance and other inputs in production?*

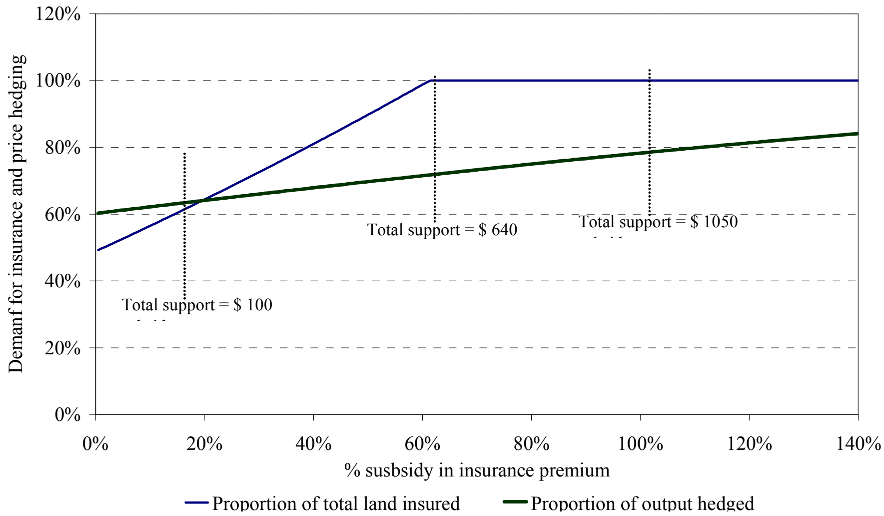
Lower input prices induce an increase in the use of inputs and higher production levels with higher profit variability. For a given level of risk aversion this would induce further use of insurance to reduce undesired increases in risk. In this sense there is a complementarity relationship between insurance and other inputs, although it is generally assumed that there is some degree of substitubility among most of the other inputs. This is, for instance, the assumption in simulation models that have explicit production functions such as GTAP or the Policy Evaluation Model (PEM). This complementarity can indirectly be inferred from some results in the empirical literature on the relationship between risk aversion and input use[7]. However, the results from the study on insurance in Spain (OECD, 2003) were not conclusive in this respect. Dewbre *et al.* (2001) show that the production impacts of input subsidies as compared to price support depend crucially on the elasticity of supply of the corresponding input; inelastically supplied inputs, such as land, have less impact on production than elastic inputs. This result may not be true for insurance (normally assumed to be elastically supplied) if it is not easily substitutable with other inputs.

3.2.4. *Do results differ for crop and revenues insurance?*

These two types of insurance may have significant differences in their actual impact on risk reduction and production decisions. The potential for reducing farming risk is larger in the case of revenue insurance due to better targeting of the source of risk. The optimal insured area may also be larger with the likely result that revenue insurance is more efficient in reducing farming risk but may

[7]. Roosen and Hennessy (2003) find empirical evidence of a negative relationship between risk aversion and input use.

Figure 3: Demand for Crop Insurance:
Percentage of planted land that is insured for different insurance subsidy rates

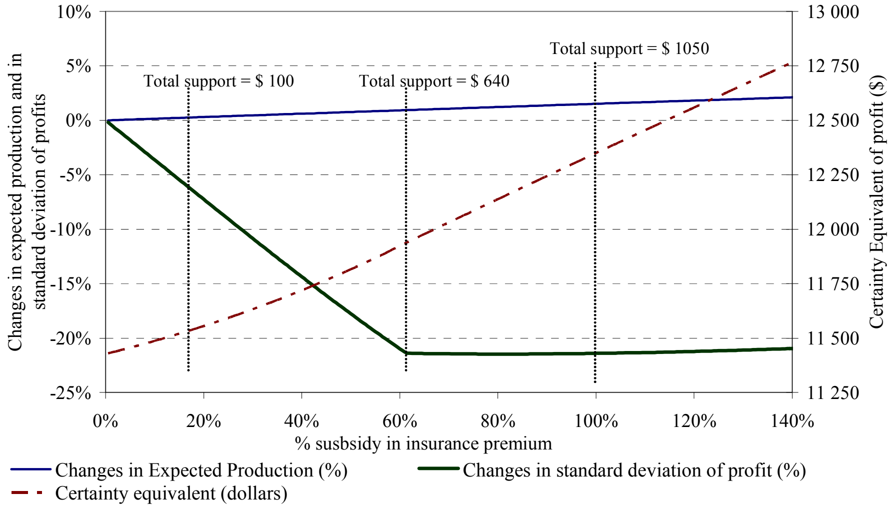


have a larger impact on production. For instance, Hennessy *et al.* (1997) find empirical evidence of this higher efficiency in reducing risk when the instrument concentrates on revenue rather than on only one of its components (be it prices or yields). They compare the costs of the US 1990 deficiency payments scheme with a hypothetical equivalent revenue insurance scheme and find that the same benefits (in terms of certainty equivalent of profit) for the producer could have been achieved with only one fourth of the cost. The shape of insurance demand and of the curves representing impacts on production and risk are the same for both crop and revenue insurance. That is why only the curves for crop insurance are presented. However the quantitative magnitude of the effects can differ.

3.2.5. *Demand for crop insurance*

The proportion of insured land increases with the insurance subsidies (Figure 3). In this example, when the insurance subsidy is 60% of the premium or above, the farmer insures all land. It is assumed that the farmer cannot insure more than the land he decides to plant, which explains the change in regime when the subsidies are above that level as shown in the horizontal part of the demand curve (Figure 3). The farmer responds to further insurance subsidies by also increasing his use of hedging, showing again the complementarity be-

Figure 4: Impact of subsidies to crop insurance



tween these two strategies. This complementarity does not exist for revenue insurance already covering low prices; revenue insurance subsidies tend to reduce the hedging coverage (the corresponding graph is not shown in this paper)[8].

3.2.6. *Crop insurance subsidies: Impacts on production, risk and farmer's well-being*

The level of subsidy increases production and reduces the variability (standard deviation) of profits until all the land is insured (in the example this occurs when total subsidy equals USD 640 or 60% of the premium) (Figure 4). Up to this level of support, insurance subsidies present a trade-off between the reduction in variability of farming returns and the avoidance of production incentives. The subsidies induce more insurance coverage, reducing farming risk. However, this reduction in risk has an immediate impact on production for risk-averse farmers.

When the subsidy is greater than 60%, a change of regime occurs and the producer is situated in the horizontal part of the demand curve (Figure 3). That is, he has already insured all the land that he plants. If so, only price effects occur and insurance subsidies have no risk-reducing effect[9]. The additional insurance subsidies provide higher expected returns from farming the land and, thereby induce some production effects. This additional production increases

[8]. This same result is found by Coble *et al.* (2000).

[9]. In fact there is a very small positive slope in the standard deviation curve for subsidies higher than 60% in Figure 4.

the variability of profits, implying that insurance subsidies that are too high may have negative effects in reducing risk of farmers already covered by the insurance.

3.3. *Deficiency payments*

Deficiency payments are payments per unit of output that cover the difference between a guaranteed producer price level P_L and the market price[10]. The payment becomes zero if this difference is negative. The payment is received with no cost or premium to be paid by the farmer (Table 1). Those payments have been studied extensively in the literature, particularly the programmes that have been applied in the United States for many years.

3.3.1. *How do deficiency payments affect production?*

A deficiency payment program truncates the distribution of prices received by the farmer and impacts production decisions in two ways. Both effects increase with the level of P_L.

It increases the expected producer price and therefore the output incentive price by the expected amount of the payment. That is, deficiency payments have a direct impact on output incentive price.

It reduces the variance of prices and therefore the risk premium. This creates risk-related effects on incentive prices.

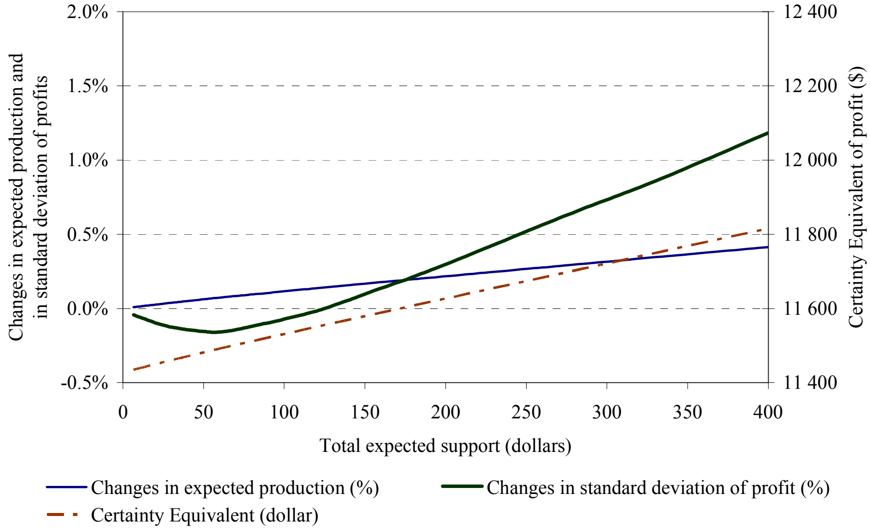
Both the price and the risk effects of deficiency payments depend on the covariance between prices and yields. Strong negative covariance between prices and yields reduces both the expected value of these payments and their contribution to reduced variance of profits. Unlike insurance and price hedging, deficiency payments are provided to all producers. There is no self-selection among farmers and no revealed preference on risk.

3.3.2. *Impacts on production, risk and farmer's well-being*

Deficiency payments increase the expected price and have a price effect on production that may induce a net increase in the variability of profits. This price effect can dominate when compared to the direct effect of deficiency payments on reducing price variability. This is probably not true for all levels of minimum prices. For instance, for low subsidy levels (below USD 50 in our example), profit variability is reduced with deficiency payments. Nevertheless, it is possible that deficiency payments increase production sufficiently, with positive correlation with yields, such that they induce increases in the final variability of

[10] These deficiency payments and all the payments considered in this paper are stylised and have neither limits nor compliance requirements attached.

Figure 5: Impacts of deficiency payments



profits (Figure 5)[11]. Both production and the well-being of the farmer increase with the amount of payments.

3.4. *Area-based counter-cyclical payments*

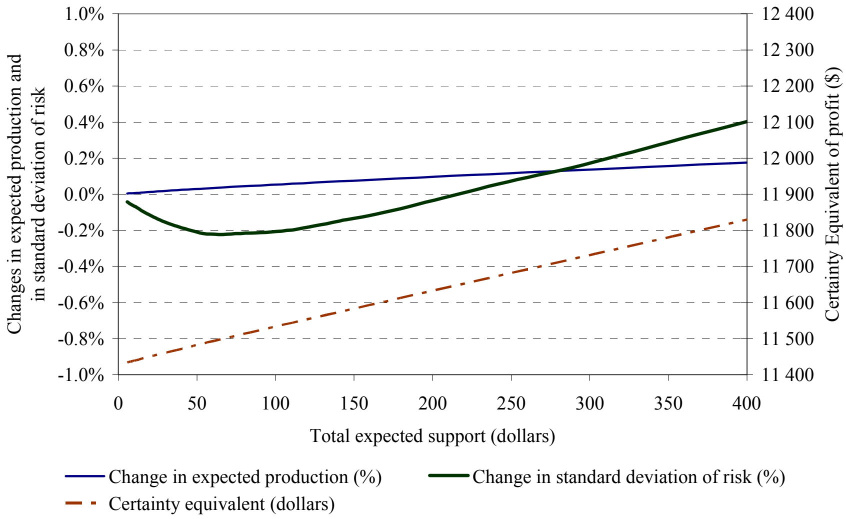
There are only relatively recent examples of area-based countercyclical payments in OECD countries. The most obvious one is the *ad hoc* Market Loss Assistance payments paid in the United States from 1998 to 2000 and the explicit counter-cyclical payments created by the 2002 US Farm Bill. Both of these are and were based on historical area. Several OECD countries have paid *ad hoc* "emergency payments" on the basis of planted area in special circumstances of low yields.

3.4.1. *How do area-based payments affect production decisions?*

Depending on the production requirements to receive the payment, area-based payment can have different price effects on production. If the payment is based on current planted area, the expected value of the payment reduces the demand price of land and, therefore, creates incentives to bring additional land into production. If the payment is based on historical area with no linkage to current production decisions or uses of land, it is safe to assume that price ef-

[11] This type of effect from the negative correlation between prices and yields is also analysed in FAPRI (2003).

Figure 6: Impacts of area payments countercyclical with prices



fects will be nil. If payments are countercyclical with commodity specific prices or revenues, they will create commodity specific risk effects that will prevail (see Anton and LeMouel, 2004).

The risk effects associated with these payments also differ depending on the targeted variable to reduce risk. Three alternatives are worth considering: prices, yields and revenues. Area-based payments that are counter-cyclical with prices are less targeted to the true source of variability faced by the farmer. Therefore, they are likely to be less efficient in reducing farming risk and have a smaller impact on risk premia and on production (Figure 10). However, if the targeted variable is yield or revenue per hectare, the reduction of variability is better targeted to farmers' income risk, and therefore the risk-related effects are potentially larger.

3.4.2. *Impacts on production and risk*

Area payments that are counter-cyclical with prices increase production and farmers' well-being (Figure 6). However the reduction in the variability of profits occurs only up to a certain level of payments, beyond which the variability of profits increases; the variability curve has a U shape. The same shape of curve is found for area payments countercyclical with yields and historical area payments countercyclical with prices. This is due in part to countercyclical payments reducing the incentives to use market strategies such as price hedging. The payments are trying to reduce variability which was already–to a certain extent- covered by the farmer in the market. The U-form for the standard deviation of profit curve seems to be robust for payments that intend to reduce risks[12].

3.5. *The interaction between existing measures or strategies*

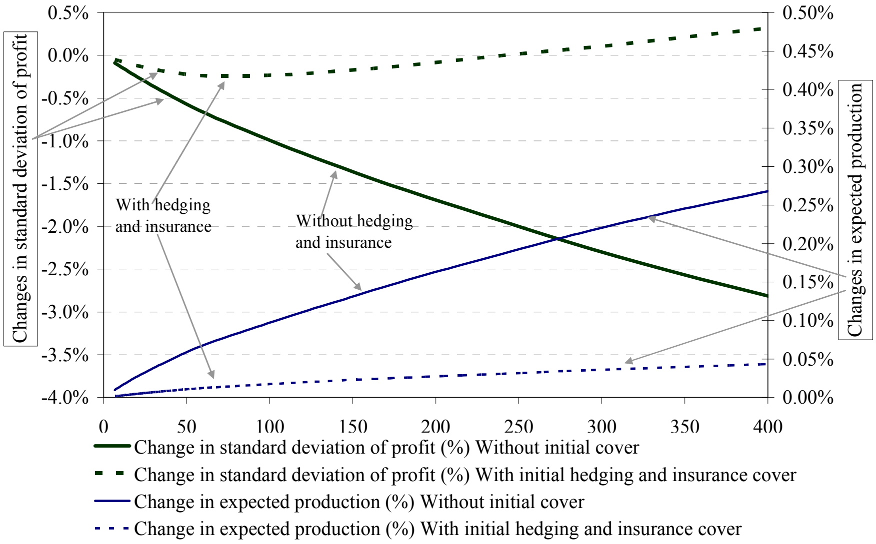
When several strategies and programs are available to the farmer, there will be interactions between different policy measures that can generate some crowding out of market strategies and make some support measures ineffective in reducing risk. This occurs with all countercyclical payments described in sections II.3 and II.4; payments that are countercyclical with prices have a particularly large negative effect on price hedging coverage. The payments are just giving for free some of the reductions in variability that the farmer had been buying in the market.

If the risk covered by the different measures or strategies are targeted to different sources of risk, as in the case of crop insurance and price hedging, there can be some complementarity in the reduction of both types of risk. Subsidising the insurance premium leads not only to more insurance, but also to more price hedging contracted by the farmer. It can also occur that additional subsidies to one instrument can make interesting a sudden change in the risk management strategy in order to "fish" more subsidies (Figures 1 and 3). The farmer is suddenly ready to accept increases in profit variability by reducing its insurance demand in order to get the net expected value of the subsidies provided to the price hedging programme (the "jump" in Figure 1).

Figure 7 illustrates also the different types of impacts when a support measure is or is not interacting with other risk management strategies. The continuous lines represent the impacts on production and profit variability of countercyclical historical area payments when there is no insurance or hedging coverage. The discontinuous lines represent the same impact when the farmer's decision includes market strategies and he decides to buy some insurance and hedge some of his production. The risk reduction effect in the first case is much more significant than in the second case, in which the farmer was already covering some of his price risk through price hedging and therefore the new payments are crowding out the market strategies. Ultimately, subsidies that crowd out price hedging can even increase variability. When crowding out is not possible, the risk-reduction effects exist for even larger levels of support. As a consequence, production impacts are significantly higher due to the reduction in risk.

[12] In general, for all examples of policy interventions in this paper, we find that low levels of subsidy contribute to reduce risk variability. However there is usually a threshold beyond which further subsidy contribute to increase variability. We call this type of response a U-curve.

Figure 7: Comparison of impacts of historical area payments countercyclical with prices with or without access to market risk reducing strategies

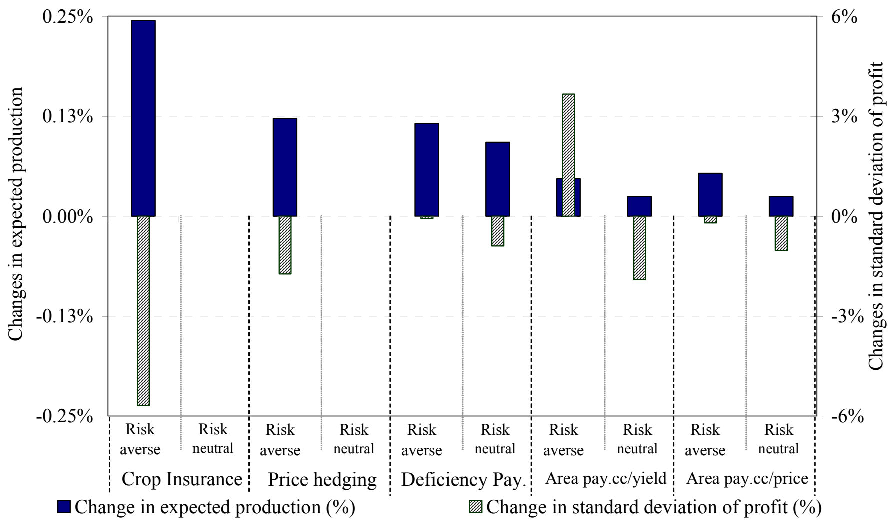


3.6. *Production and variability effects of different support measures*

In order to compare impacts on output and on profit variability of the different support measures considered in this paper, the same amount of support (USD 100) was provided in all cases. Results may depend on initial rates for the key parameters, such that the numbers are merely illustrative (Figure 8). The results include additional simulations under the assumption of risk neutrality in order to illustrate the sensitivity of the results to this key parameter.

Consider a risk-averse farmer. In general all support measures oriented to reduce risk have some impact in reducing his profit variability. However, supporting measures designed to reduce farming risk can have the effect of increasing the variability of farming returns due to both their production incentive effects and their effect of crowding out market mechanisms. For example, area payments counter-cyclical with yields have the effect of increasing the profit variability of the risk averse farmer (Figure 8). This is because the farmer was already covered for this type of risk through an insurance policy that is crowded out by the payment. The largest reductions in risk are achieved with crop insurance followed by price hedging. Crop insurance is targeted to yields, the main source of variability for the farmer, and both crop insurance and price hedging are voluntary schemes with less potential for crowding out market strategies.

Figure 8: Comparison of impacts of a USD 100 payment to risk reducing policies



In all cases, the effectiveness in reducing variability of profits is larger when the farmer is risk neutral, as there is no crowding out of market strategies. However, this risk neutral farmer is indifferent about this reduction in variability. On the contrary, for support to market strategies, the effectiveness in reducing risk is larger if the farmer is risk averse, because there is no crowding out of market strategies and there can be some "crowding-in" of complementary strategies. There is no impact from these USD 100 subsidies for risk neutral farmers simply because such farmers are not willing to take this money for buying insurance or hedging (Figure 8). Only if the subsidy was much larger (positive net returns from insurance) would he make use of it.

For a risk-averse farmer, there seems to be some trade off between reducing risk and avoiding production effects of policy measures. This is true for most of the measures considered. The measures that have a larger impact on reducing risk (crop insurance and price hedging) are also the measures with larger impacts on production. Deficiency payments have also large impacts on production, but they result mainly from price effects rather than risk-related effects. This is not true for the risk neutral farmer for which there is no relationship between variability and production. These quantitative differences have to be interpreted with caution as the model is designed to give more weight to risk-related effects.

4. *Conclusions*

As illustrated in the appendix on sensitivity analysis, concrete quantitative results for production, risk reduction and welfare are very sensitive to specific assumptions regarding technological parameters, risk aversion and policy parameters. No particular number in this study can be considered as representative of quantitative effects of any specific policy in any specific country. However the illustrative model developed in this paper provides some insights on how farmers respond to different risk reduction measures and strategies.

No policy expenditure that is oriented to reduce the risk of farming can be production neutral. For commodity specific programmes, the better the policy is targeted to risk on revenue (price times yield), the larger the potential production effect. Other studies show that policies targeted to total farming revenue across commodities, or total farm household income, do better in reducing the relevant farm household risk and have potentially smaller production impacts.

Different risk reducing policies and strategies interact. When giving support through a risk reducing payment, some use of risk reducing market strategies such as insurance and hedging is crowded out. This gives sometimes perverse impacts of risk reducing programs on farming risk.

Greater expenditure on risk reducing policies or strategies generally results in a reduction in farming risk and an increase in production. However if the subsidy is high enough, additional support may have the perverse effect of increasing farming risk while also increasing production. This is for two reasons: the crowding out of market instruments and the higher variability induced by higher production levels.

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Appendix I.

I. 1. *Calibrating the Optimal Conditions: Example of Wheat Production in Kansas* (*USA*)

I.1.1. *Detailed description of the data*

Price – Yield distribution

Historical data from the Economic Research Service of the US Department of Agriculture concerning aggregate production of wheat in Kansas (Area planted / harvested (hectares), Yield (tons/hectare), Production (tons), Price (dollars per ton) and Value of Production) have been used. Historical moments of the Price (P) - Random Yield (Q) distributions were computed from this information: price and random yield expectations and variance-covariance matrix. Over the period 1973-2003 the average historical price for wheat in Kansas was equal to USD 115.7 / ton and the average yield was 2.4 tons / hectare.

No micro data on historical price / yield variability was directly available for Kansas wheat farmers. Historical information on aggregated prices and yields is however public. It seems to be important to understand how prices and yields at the micro and macro levels differ as this can potentially affect results of the farmers' problem of maximising the certainty equivalent of profits. One could expect yield variability to be significantly higher at the individual farm level than at aggregate State level. Price and yield information of a sample of individual Spanish wheat farmers has been used to infer some conclusions on the price / yield relations at the individual and aggregate level. Information on historical aggregate prices and individual yields and uses of land was available.

The average of aggregate yields (tons / hectare) is equal to the average of the production weighted historical individual averages of yields on the sample of farmers. Mathematically we have the following expression for the average historical yield $\overline{Y}$ using wheat land at the individual and aggregate level.

$$\overline{Y} = \frac{1}{N_{YEARS}} \sum_{y=1}^{N_{YEARS}} \left(\frac{1}{L_y} \left(\sum_{f=1}^{N_{FARMERS}} Y_{yf} L_{yf} \right) \right) = \frac{1}{N_{YEARS}} \sum_{y=1}^{N_{YEARS}} Y_y$$

Where Y_y : Aggregate wheat yield (in tons / hectare) in year y

Y_{yf} : Wheat yield (in tons / hectare) of farmer f in year y

L_{yf} : Wheat land (in hectares)of farmer f in year y

L_y : Aggregate wheat land (in hectares) in year y

The covariance between prices and aggregate yields can also be defined as the average over all the farmers in the sample of individual price-yield covariance:

$$COV(P,Y) = \frac{1}{N_{FARMERS}} \sum_{f=1}^{N_{FARMERS}} COV_f(P\ ,Y\ )$$

However there is a difference between the average of individual yield variances (or micro level yield variance) and the variance of historical aggregated yield (or macro level yield variance, $VAR_{macro}(Y)$). As expected, the variance of aggregated yield is lower as aggregate yield do not contain any information on individual farmer yield variability.

Over the period 1990 – 1998, $\overline{P}$ = 142.3 EUR / ton and $\overline{Y}$ =2.3 tons / hectare for the sample of Spanish wheat farmers. Over the period 1990-1998, $COV(P,Y)$=-2.7. Over the period 1990-1998, we have found empirically that the standard deviation of yields at the micro is equal to 160% of the standard deviation of yield at the macro level.

It seems important to incorporate the information on individual yield variability into our empirical modelling of US wheat farmers. So, the historical wheat yield variance in the variance-covariance matrix of wheat prices and yields observed in Kansas from 1973 to 2003 has been adjusted to include a standard deviation of yields that are assumed to be 60% higher. Then an estimated multivariate normal distribution of micro level prices and yields is generated.

Individual Farm characteristics

Data on characteristics and production costs of US wheat farms has been obtained from the US Department of Agriculture July 2002 statistical bulletin:

L_H: The average harvested size of a wheat farm in Kansas is 119 hectares

Y_H: The average historical yield is 2.4 tons / hectare

r: The average rental price of land is 79 dollars per harvested hectare

Based on the 1999 USD agricultural income and finance outlook data, the farmer is assumed to have an initial worth of USD 336 per hectare.

The "base" farmer is assumed to be risk averse with a relative risk aversion coefficient ϱ=2.

I.1.2. *Calibration of the production function*

The farmer production can be represented by a production function f which determines the quantity of output with respect to the quantity of input I and land L used. The elasticity of substitution between land and purchased factors has a base value of 0.5 in the United States (see OECD, 2001). To allow for that degree of substitutability between factors of production, we have used a Constant elasticity of Substitution (CES) production function. It can be specified as:

$$f(I,L) = U_F\left((1-\alpha)\times U_I \times I^{-\lambda} + \alpha \times U_L \times L^{-\lambda}\right)^{-\mu/\lambda} \qquad \text{(I. 22)}$$

Where:

λ is the substitution parameter, elasticity of substitution $\sigma = 1/(1+\lambda) = 0.5$;

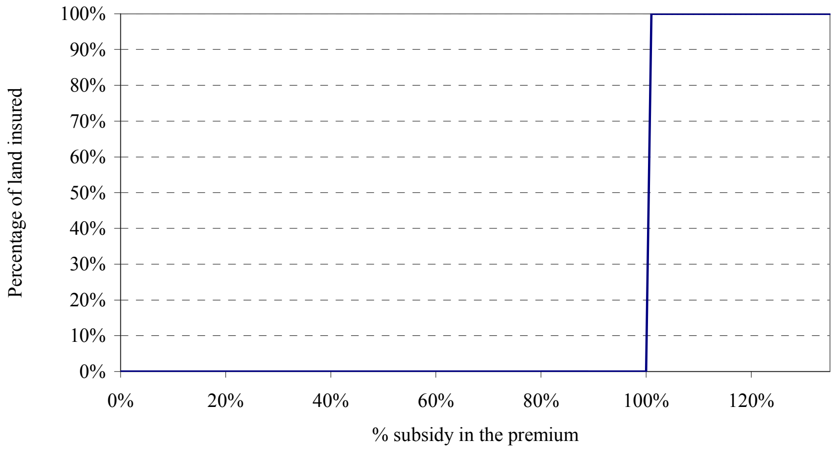
α is the distribution parameter, it is the share of land for the production of wheat in the United States. According to OCED (2001), it is equal to 0.21;

μ is the return to scale parameter, we consider that the returns to scale are decreasing so μ has to be less than 1, we used $\mu = 0.5$;

U_F, U_I and U_L are the production function's parameters.

Using the farm characteristics information provided by USDA, we were able to determine U_F, U_I and U_L so that the average historical wheat farmer in Kansas maximises his expected utility and produces a quantity of wheat similar to the average wheat production per farm.

Figure 9: Impact of subsidising crop insurance on demand for insurance when the farmer is risk neutral



I.1.3. *Calibration of the different risk strategies*

Future Prices p^f

Historically wheat future prices are above cash wheat prices. For the risk strategies using futures, we have been using future prices equal to 100.6% of the average historical wheat price per ton.

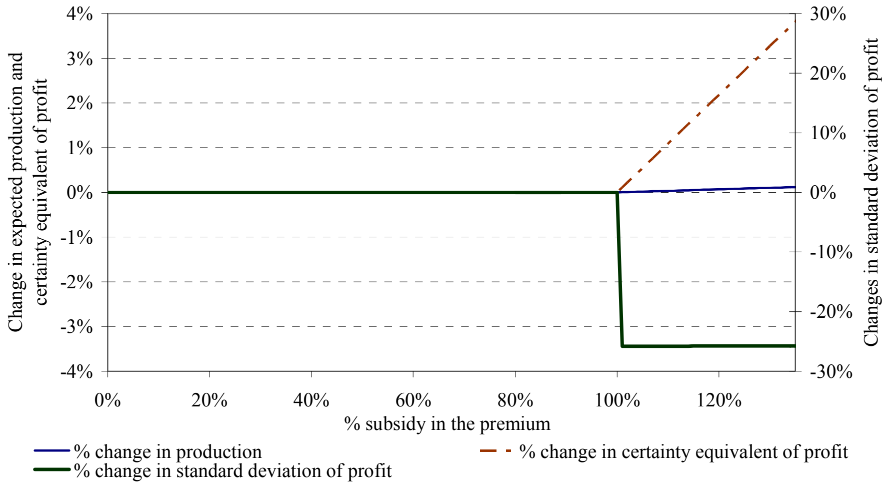
Insurance Strategies

We have been calibrating the model to determine the initial percentage administrative cost of the insurance policies γ_i. Without subsidy, the farmer will have an incentive to insure a part L_I of the land L he devotes to wheat. The optimal level of land insured L_I is a function of the proportion β_q of the historical yield that is going to be insured (in the case of the crop insurance) or function of the revenue β_{pq} insured (Revenue Insurance). We assume that the farmer does not over-insure himself: L_I is smaller or equal to L. Any insurance subsidy given by the government will be deducted from γ_i.

I.1.4. *Profit Maximisation*

The farmer chooses his optimal allocation of L and I to maximise his expected utility according to the risk strategies in place. When he chooses price hedging or insurance as risk reducing strategies, he also has an optimal demand for the risk reducing instrument: demand of price hedging h or insurance demand L_I. In this empirical estimation we focused on price and risk effects of

Figure 10: Impact of subsidising crop insurance when the farmer is risk neutral



each measure per dollars given by the government and on the reduction in profit variability.

Appendix II.

II.1. *Sensitivity analysis*

The results from the analytical framework that has been developed are very dependent on the assumptions made on policy parameters and individual farmers' characteristics. To better understand the results, sensitivity analysis has been carried out. Two main issues have been studied through sensitivity analysis: How do results vary when farmers are assumed to be risk neutral? What are the implications of changes in the values of the main parameters defining the market strategies?

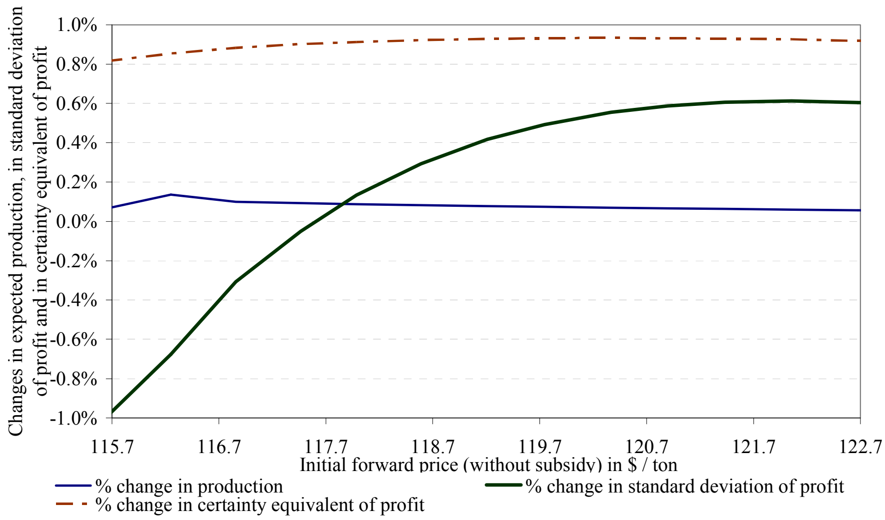
II.1.1. *Risk aversion*

The summary of results presented in Figure 8 in the main text includes both assumptions or risk aversion considered in the sensitivity analysis. That is zero risk aversion (risk neutrality) and relative risk aversion equal to 2. In this appendix some implications for the demand of the market instruments are discussed.

Risk aversion versus risk neutrality

A risk neutral farmer and a risk averse farmer do not make the same choices concerning the use of inputs and consequently levels of production. The risk neutral farmer's problem of utility maximisation is equivalent to a maximisation

Figure 11: Sensitivity analysis: Impact of a USD 100 subsidy to price hedging when the initial forward price is varying



of profit. Consequently, the total expected production will be higher for the risk neutral farmer. This will imply higher variability (higher standard deviation of profit) and also higher certainty equivalent of profit (as it is equal to expected profit with no risk premium).

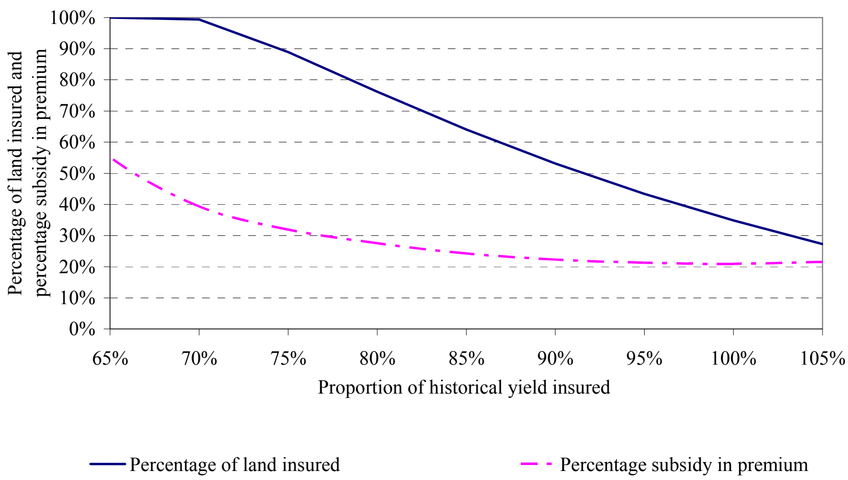
Impacts of risk neutrality on demand for hedging

When the farmer is risk neutral, the demand for hedging remains null as long as the future price is smaller than the expected price. However, when the future price becomes greater than the expected price, the farmer is taking as much coverage as possible: he will cover all his production and, if there is no limit on the quantity of output that can be hedged, he speculates on the market. This has no impact at all on production (the demand for input is staying constant).

Impacts of risk neutrality on demand for crop insurance

When the farmer is risk neutral, the demand for crop insurance is null as long as the net indemnities from subsidising crop insurance are lower than the premium paid. When they become higher (due to government support), the farmer is taking insurance for all the planted land and even increasing the area planted and insured, and, therefore, production, as illustrated in Figures 9 and 10. Figure 10 describes the effects of subsidising crop insurance for a risk neutral farmer on expected production and profit variability. This variability is reduced when the insurance is taken but with no impact on the wellbeing of the

Figure 12 Sensitivity analysis: Impact on the demand for insurance of a USD 100 subsidy to crop insurance when the proportion of historical yield insured is varying



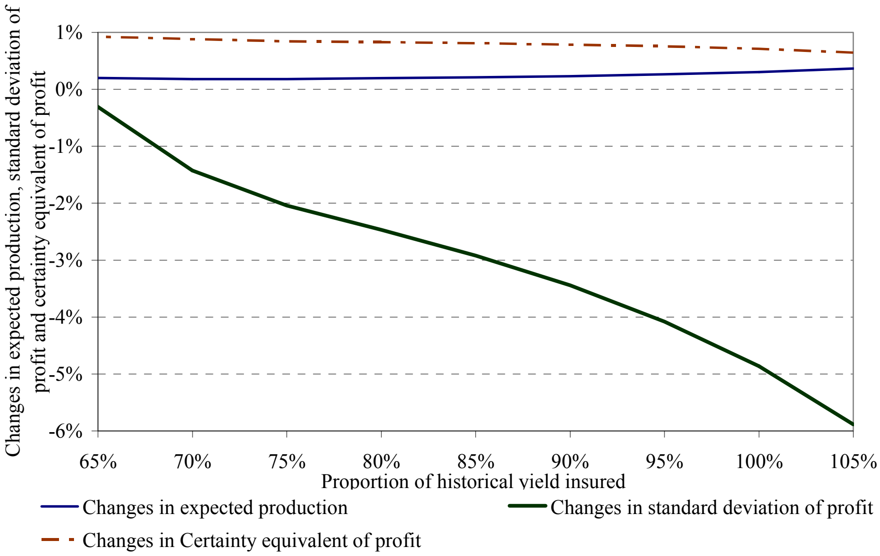
farmer: the increase in the certainty equivalent is only due to the net expected value of the indemnities.

II.1.2. *Policy parameters*

Price hedging

When price hedging is a market strategy available, the farmer commits himself, before planting, to forward sell a quantity of output at the date of harvesting at a given certain forward price P_f. The net value of P_f depends on market forward prices, costs of hedging and eventual subsidies. Different initial level of P_f may imply different impacts of government subsidies to price hedging. The higher the initial P_f before subsidy, the smaller the marginal impacts of the same amount of subsidy to price hedging. Marginal effects are decreasing with P_f and a subsidy may be ineffective in reducing risk when the initial P_f is too high. In Figure 11, impacts of a USD 100 subsidy to price hedging on production and profit variability are represented for different initial levels of the forward price. The USD 100 subsidy to price hedging fails to reduce risks when the initial forward price P_f is greater than USD 117.6 per ton.

Figure 13:. Sensitivity analysis: Impact of a USD 100 subsidy to crop insurance when the proportion of historical yield insured is varying



Crop insurance

Producer's demand for crop insurance varies with the proportion of historical yield insured (that is normally a parameter in the insurance policy) and with the administrative costs of insurance.

The former is represented in Figure 12. For the same USD 100 of subsidy, a higher coverage of historical yield reduces the percentage subsidy in the premium and the demand for crop insurance: higher coverage of historical yield implies an increase in the premium paid by the farmer that is larger than the certainty equivalent of the corresponding reduction on profit variability.

As illustrated in Figure 13, the effect of a same amount subsidy to crop insurance in terms of risk reduction and production incentives will be higher, the higher the percentage of historical yield insured. However the impact on farmers well-being is decreasing. This figure illustrates the high sensitivity of the specific quantitative result with respect to the parameter values in the policy specification. In this example the same USD 100 can have very different effects on production (up to double) and on risk reduction (up to ten times).

Will Farm Income Risk Change under the New Cap Reform?

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Abstract

Investments in public goods, price stabilisation schemes, compensatory payments, farm insurance and calamity assistance programs are some examples of public intervention to reduce risk in agriculture. Using discrete stochastic programming associated with a Minimisation of Total Absolute Deviations framework, the impact of the 2003 Common Agricultural Policy Reform on income risk of a typical Mediterranean farm was analysed. The introduction of the single payment scheme leads to increase in total farm income and to a decrease in the total income risk. However, the relative production risk increases.

1. *Introduction*

Farming is an economic activity subject to several sources of risk such as production risk, market risk, institutional risk, financial risk, technological risk, etc. Both risk sources and farmers' attitudes to risk have been deemed by governments as very important issues. Farm income reduction to avoid risk has a negative multiplier effect on income and on employment in rural areas. Moreover, farmers' strategies to avoid risk tend to reduce efficiency of farm resource use, which diminish income and decrease the supply of risky products. Governments have had public intervention in various vectors: investments on public goods, price stabilisation measures, compensatory payments, farm insurance and disaster assistance programs are some of the traditional measures implemented (European Commission, 2001). Direct governmental intervention, particularly the semi-decoupled compensatory payments, has been very important to Mediterranean farmers in reducing their income variability. Farmers in Mediterranean areas face a climate characterised by a considerable variability of both rainfall and temperature levels that can lead to not only crop yield decline but also to total crop destruction by fires or late frosts.

According to the 2003 Common Agricultural Policy (CAP) reform, a system of a progressive reduction of direct payments shall be introduced on a compulsory basis for the years 2005 to 2012. This means that farm subsidies are expected to be completely decoupled from production by 2013. To avoid the abandonment of agricultural land and ensure that good agricultural and environmental conditions will be maintained, each Member State establishes a set of standards. Hence, the single farm payment will be conditional upon cross-compliance with environment, food safety, animal health and welfare as well as the maintenance of the farm in good agricultural and environmental conditions. Therefore, the new reform of the CAP involves some discretion for member states including in respect of how fully to decouple subsidy payments from production (EC Nº1782/2003). Portugal decided to implement the single payment scheme starting from 2005. For instance, arable crops subsidies will be totally decoupled, while the subsidies for extensive livestock production will be partially decoupled. This change is expected to have a major impact on both farm income and income variability. This will be particularly evident in the dry land areas of the Mediterranean region in which cereals and extensive cattle are the principal activities. For farms located in this region, the single payment scheme might increase the total farm income but its variability might decrease since cereals and fodder production are very dependent from climatic conditions, in special rainfall. Thus, the objective of this paper is to study the impact of the new CAP reform on income variability of a Mediterranean farm located in the south of Portugal. The two conflicting farm objectives, farm income maximisation and income variability minimisation, are investigated.

2. *Analytical Framework*

In order to achieve the objectives of this paper, the base model developed by Carvalho (1994, 2002) was modified, improved and applied to a typical farm in the Alentejo region, located in Évora County.

According to Hazell and Norton (1986), if resources are freely tradable, any stochastic discrepancies between the resource requirements of a farm plan and the resource supplies can be captured in the objective function through buying and selling activities. All the risks in the constrained set can be transferred into the objective function of the model and a single risk decision rule can be applied. Hence, the model is based on *Discrete Stochastic Programming* (DSP) associated with a *Minimisation of Total Absolute Deviations* (MOTAD) framework (Hazell, 1971; Hazell and Norton,1986). These techniques take into account the variation of the growing season reflected on crop yields. Several states of nature corresponding to different types of years, associated to a certain probability of occurrence, are modelled. Hence, the model represents rainfall variability and its effects on yields, farmer's decision-making flexibility, and indirect farmer's aversion to risk. While the DSP framework allows for sequential decision making, which characterizes the flexibility of farmers in modifying strategic decisions as the growing season unfolds; the MOTAD framework captures the effects of income risk. This risk results from cash crop yield variability, intermediate products selling variability from adjustments in livestock feed-mix, and animal selling variability from adjustments in marketing strategies for selling meat.

The model assumes that farmer maximise expected returns to management and land, subject to a set of constraints related to farm's limited resources of land, machinery, and labour, livestock feeding requirements and risk, as well as to the non-negativity conditions. A simplified formulation of the model is:

$$\max E(Z) = E(Z_n X_n) - W_g N_g + R_p P_i V_{pi} + W_r P_i N_{r,i} \quad (1)$$

subject to

$$A_{mn} X_n \leq T_m \quad (2)$$

$$Y_i + M_{si} X_s + M_{ir} - M_r + M_{pi} - M_p \geq 0 \quad (3)$$

$$p_i Y_i \leq \lambda \quad (4)$$

Equation (1) states that producer maximise the expected return to land, management, and other fixed factors, and $E(Z_n X_n)$ stays for expected gross margin of X_n crop and livestock activities, N_g represents purchasing activities and W_g their prices; V_{pi} represents the livestock selling activities for the different marketing strategies by state of nature, R_p their gross margin, and P_i the probability of occurrence of each state of nature; N_{ri} represents the selling activities of intermediate products and W_r their prices.

Equations (2) stay for resources availability and livestock feed requirements in which A_{mn} represents a mxn matrix of technical coefficients for crop and livestock activities; T_m is the vector of the available resources.

Equation (3) computes the sum of absolute deviations from expected returns *per* state of nature. In this equation, Y_i stays for total negative deviation from expected income for each state of nature; M_{si} is the matrix of absolute deviations from expected income of crop activities (X_s); (M_{ir} -M_r) is the deviation from the mean of the intermediate products selling activities, and ($M_{pi} - M_p$) represents the deviation from the mean for marketing strategies of livestock activities.

Equation (4) sums weighted negative deviations across states of nature according to their probabilities of occurrence. Thus, λ is the sum of the expected total negative deviations and will be parameterised from 0 to λ^{max} in order to analyse the trade-off between expected income and risk.

The model is applied using data available from a farm survey, for the years 2000, 2001 and 2002, which correspond to the "reference period", and are used to calculate the reference subsidy amount under the CAP Reform. These data are referred to resources availabilities, technical coefficients and farmer objectives. Other data like product and factor prices, soils and alternative activities were available from official statistics and experts.

Dry land crop activities of this farm, with 366 ha of total area, are based on cereals (wheat, durum wheat, and triticale), on forages (oats*vicia, oats*lupines, oats), and on pastures (fallow, subterranean clover and fertilized fallow). The

Table 1: Impact of 2003 CAP Reform on Expected Income and Risk

	MODEL					
	BASE		PARTIAL		FULL	
λ/λ^{max}	0%	100%	0%	100%	0%	100%
Expected Total Income (€)	213 702	229 804	215 830	230 967	261 499	278 505
Expected Total Income (w/o subsidies) (€)	-18 438	-14 893	6 694	12 491	43 287	48 490
Expected Prod. Income (€)	213 702	229 804	104 175	114 987	43 287	48 490
Expected Subsidies (€)	232 140	244 697	209 136	218 476	218 212	230 015
Sum of neg. deviations (λ□)	0	12 533	0	9 293	0	5708

Source: Compiled from model solutions

irrigated crop activities, followed in 65 ha, include corn for grain or for silage, wheat, sunflower, sorghum for hay or silage, tomato and sugar beet.

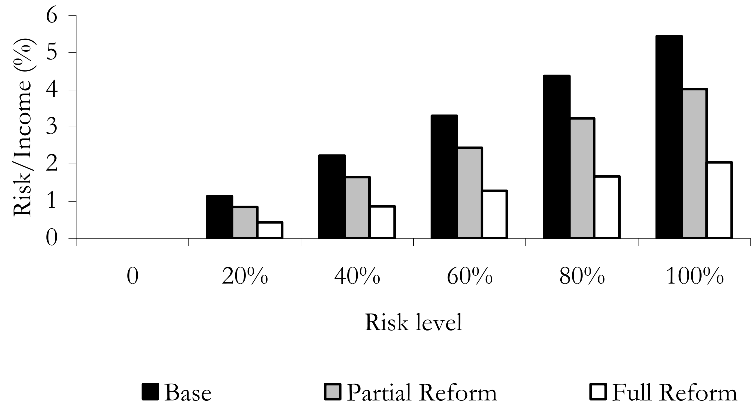
Livestock activities, which include cattle and sheep, are based on different production technologies, and distinguished by different breeding periods, and crossing strategies. The composition of livestock unit (the unit of account for livestock) is defined according to the male/female ratio and to the replacement rate of males and females, and includes breeding and replacement animals. The several marketing strategies for selling meat represent independent activities related to the respective production activity through a production rate. Livestock feed requirements are entirely fulfilled from foodstuffs supplied from crop activities. Fodder production variability determines the selection of livestock technology and marketing strategies.

3. *Model results*

The model was applied to three CAP political scenarios. In the first one, named *Base Model* (BASE), the CAP scenario refers to the 1992 CAP reform with the changes introduced by the Agenda2000. Under this scenario, the main measures are concerned to arable crops, beef and sheep activities. The compensatory payments are awarded *per* arable hectare, according to the farm productivity class, and *per* livestock head. The producer also receives a monetary compensation due to the set-aside requirements. Related to bovine activities, CAP measures introduced in the model refer to calves and heifer premiums, special male bovine premium and slaughter premium, and to the extensification payment. Regarding to sheep activities, the subsidies included are the ewe premium and the supplementary premium.

The second scenario, indicated as Partial Reform Model (PARTIAL) reflects the partial implementation of the new agricultural political agenda, and actually applied to Portugal. Under this scenario, crop compensatory payments awarded in the base scenario are transformed in a single payment and totally decoupled from production. However, livestock subsidies are only semi-decoupled from production. This means that part of the livestock subsidies is still linked to the

Figure 1: Risk and total income

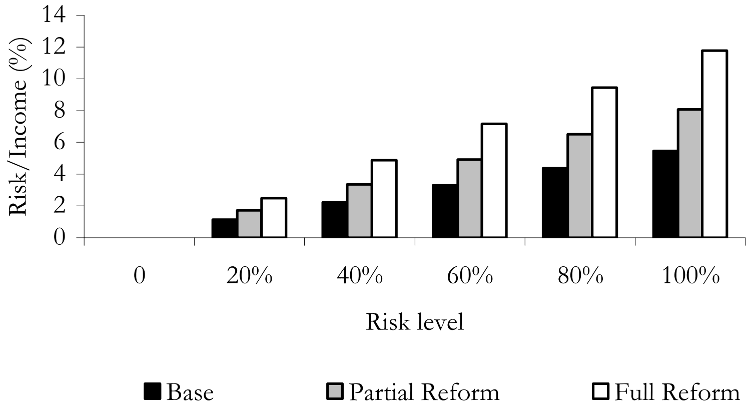


number of livestock heads and part is included in the single payment. Finally, the third model (Full Reform Model) reflects the full implementation of the 2003 CAP reform in which the total amount of subsidies related to the reference period are transformed into a single payment subsidy and totally decoupled from both crop and livestock production.

The comparison between the three political scenarios for the two extreme situations of income variability –λ equal to 0% of λ maximum and λ equal to 100% of λ maximum - is shown in Table 1. This λ is the total weighted sum of negative deviations, and represents what, in average, the farmer can loose in income. It is related to dry land crop activities and to livestock activities.

The implementation of the 2003 CAP reform leads to an increase in the total expected returns to land and management under full implementation scenario. The income increase for this scenario, in relation to the base model, is about 22 % and 21 % for 0 % and 100% of risk, respectively. However, production expected income, that is, the value of the objective function of the model, and hence related to the level of production activities, diminishes with the CAP reform. This decrease is very significant for both scenarios, about 50% under the partial implementation scenario, and about 80% under the full implementation. Under base scenario, many activities have negative gross margins without subsidies, as the total expected farm income without subsidies shows in Table 1. However, the farmer continues following those activities since they still have high subsidies coupled (livestock activities) and semi-decoupled to their production level, as it is the case of cereals.

Figure 2: Risk and production income



Figures 1 and 2 show the trade-off between expected income and risk for the different levels of risk aversion. In this analysis, the different levels of risk aversion, that is, the expected total sum of negative deviations (λ), was parameterised at the levels of 0%, 20%, 40%, 60%, 80%, and 100% of its maximum value. As expected, the 2003 CAP reform, introducing the single payment scheme, totally decoupled from production, reduces the relative income variability (λ divided by expected total income) (Figure 1). This reduction is more effective for higher levels of risk or income variability (100% of λ^{max}).

Figure 2 shows that the new CAP reform increases the relative risk (in this case, λ is divided by expected production income) for all the levels of risk and under both scenarios. Thus, new CAP situation is more risky than the old one when only the expected production income is taken in account. As the new CAP measures are decoupled or semi-decoupled from production, farmers have no longer the stabilisation effect on production income variability from political intervention. Hence, farmers are expected to respond more to market signals. In summary, the analysis of both Figures allows one to conclude that, under the new CAP reform, the existence of the single payment decreases the variability of total farm income but relative risk increases when only the expected production income is taken in account.

The previous Figures are based on data contained in Table A1 of Appendix. In this table the expected total income and expected production income associated with the total weighted sum of negative deviations (λ) is presented for the three models.

Table 2: Impact of 2003 CAP Reform on Crops and Livestock Activities

	MODEL					
	BASE		PARTIAL		FULL	
λ/λ^{max}	0%	100%	0%	100%	0%	100%
Crops						
Dry land						
Cereals (*ha*)	56.1	56.1	45.0	56.1	17.1	45.0
Hay (*ha*)	86.7	86.7	80.5	86.7	65.0	80.5
Pasture (*ha*)	152.0	152.0	170.5	152.0	217.0	170.5
Irrigated land						
Sunflower (*ha*)	7.3	7.3	1.9	3.9	0.9	2.2
Cereals (*ha*)	21.9	21.9	5.6	11.8	2.8	6.6
Hay (*ha*)	7.3	7.3	1.9	3.9	0.9	2.2
Silage (*ha*)	14.6	14.6	3.7	7.9	1.8	4.4
Sugar beet (*ha*)	0.0	0.0	56.0	46.9	58.0	53.0
Tomato (*ha*)	32.5	32.5	0.7	0.6	2.9	2.7
Livestock						
Bovines (*livestock unit*)	288	322	213	207	94	146
Stocking rate (*Standard Unit/ha*)	1.24	1.38	0.87	0.89	0.34	0.60

Source: Compiled from model solutions

The results of the 2003 CAP reform on cropping areas and on livestock activities for the two levels of risk (0% and 100%) are shown in Table 2. Under the assumption of high risk aversion (λ/λ^{max} equal to 0%), dry land crop activities change for the three models, with cereals being substituted by pastures from Base Model to Partial Model and Full Model. Thus, CAP reform leads to cereals extensification since cereals are risky activities as referred previously. For higher level of risk (λ/λ^{max} equal to 100%) the impact of the CAP reform on dry land cereal production is less relevant. Triticale substitutes for durum wheat under both scenarios.

Regarding to irrigated land, the major differences are observed in tomato, cereals and sugar beet activities. Sugar beet production, not produced under the Base scenario, replaces cereals and tomato under both the partial and full models. This can be the result of the strong effects of decouple of the tomato price subsidies and of sugar beet and cereals compensatory payments under the two new scenarios. The costs used to estimate the gross margin of the activities might also explain this result since only the variable costs are taken in account and these costs are heavier for tomato than for sugar beet. Taking in account the total costs (including the fixed costs) this substitution could not occur, as sugar beet has higher fixed costs than tomato. The production of intermediate products for animal feeding in irrigated land decreases under both scenarios but it is more pronounced under the full reform model. Even though the increase in dry land pasture areas, the decrease of fodder production in irrigated land leads to decline in livestock activities (bovines) which is more pronounced under lower level of risk (λ/λ^{max} equal to 0%) and with the full implementation the CAP reform. One should notice that the partial implementation of the reform leads to the production of heavier animals (small number of bovine heads but larger stocking rate) for the maximum level of risk (λ/λ^{max} equal to 100%) compared with the minimum risk. In summary, the full implementation of CAP reform leads to an increase of extensification of production activities. This is more pronounced for dry land areas in which pastures substitutes for cereals, and in livestock activities which stocking rates decreases to less than half.

4. *Conclusions*

Agriculture in dry land Mediterranean areas faces a considerable level of production risk as result of the unpredictable weather. Governmental intervention, such as income stabilisation instruments, has had a major impact on Mediterranean farmers in reducing their income variability and changing income levels. This study also shows that the implementation of the 2003 CAP reform has a strong effect on farmers' income, measured in terms of total expected returns to land and management, and on farmers' production risk. The introduction of the single payment scheme, totally decoupled from production, increases the total farm income but reduces the relative total income variability. The reduction of income risk is more effective for higher levels of risk or income variability (100% of λ^{max}).

When only the expected production income is taken in account, this means that the decoupled subsidies are not accounted for the farmers' income, the new CAP situation is more risky than the old one and the production income decreases. Hence, the relative risk increases when only the expected production income is taken in account.

In terms of farming activities, the full implementation of CAP reform leads to an increase of extensification of production activities. This is more pronounced for dry land areas in which pastures substitutes for cereals, and in livestock activities which stocking rates decreases to less than half.

As only a single farming system is analysed, further research should be conducted on other farming systems. In addition, the agri-environmental measures, not modelled in this study, should be included in future research.

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Appendix

Table A1 – Trade-off between expected income and risk

	λ/λ^{max}					
	0%	20%	40%	60%	80%	100%
Base Model						
Expected Total Farm Income(€) (*TI*)	213702	220387	224923	227871	229325	229804
Expected Production Income(€) (*PI*)	213702	220387	224923	227871	229325	229804
Sum of negative deviations (€) (λ)	0	2507	5013	7520	10027	12533
λ/PI (%)	0	1.14	2.23	3.30	4.37	5.45
λ/TI (%)	0	1.14	2.23	3.30	4.37	5.45
Partial Model						
Expected Total Farm Income(€) (*TI*)	215830	221164	224676	228891	230346	230967
Expected Production Income(€) (*PI*)	104175	107941	110779	113034	114366	114987
Sum of negative deviations (€) (λ)	0	1859	3717	5576	7435	9293
λ/PI (%)	0	1.72	3.36	4.93	6.5	8.08
λ/TI (%)	0	0.84	1.65	2.44	3.23	4.02
Full Model						
Expected Total Farm Income(€) (*TI*)	261499	264211	266290	268028	273427	278505
Expected Production Income(€) (*PI*)	43287	45690	46835	47823	48325	48490
Sum of negative deviations (€) (λ)	0	1142	2283	3425	4566	5708
λ/PI (%)	0	2.50	4.87	7.16	9.45	11.77
λ/TI (%)	0	0.43	0.86	1.28	1.67	2.05

Price and Income Stability in Turkish Agriculture: An Evaluation of the IMF Led Agricultural Policy Changes

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Abstract

In the last twentyfive years, Turkey has been involved in debts from International Monetary Found (IMF), and especially since 2000 this urged the country to apply certain policies relating to the agricultural sector. In this study, effects of the agricultural policy adopted along the relationships with IMF on the price and income stability in Turkey have been examined using time series data for last ten years. Coefficients of variation and the random coefficients of variation have been estimated for series of agricultural prices and incomes per sub-periods, during which various limitations and changes in agricultural policy have been experienced. The results revealed that, even if the prices seem to be rather stabilized after 2000, this trend is changed after the crisis of 2001. Besides, increased instability in agricultural income reveals the impact of real decreases in agricultural prices and of the reduced agricultural subsidies on the production. It is concluded that the view that the market mechanism would remedy all the problems should be re-examined, especially for agriculture. Tasks of the social state have become more vital in fighting the negative influence of the problems in agriculture on the whole society. Such problems emerging in the developing countries will not only be limited to those countries but also will be reflected in developed countries in form of clandestine immigration, global terror etc. The developed countries should pay attention to the agricultural policies they applied, which creates adverse results on developing countries.

1. *Introduction*

Turkey is a country trying to fulfill the transition process from being an agricultural population to an industrial and a knowledge one simultaneously. Yet, the fact that the agricultural sector still has an important role in the nations' economy, as it is clearly reflected by the share of the sector in total employment and in the GDP, makes the sector critical for the country and imposes a reasonable process of transition. However, together with the problems present at the national level, exogenous factors like intensive and unfair competition brought about by the so called "globalization" process all negatively influence the Turkish agricultural sector and the income of the farmers.

As in most of the countries, the GATT agreements imply constraints on income stabilization policies applied so far in Turkish agriculture. In addition, in the case of Turkey, there emerged additional obligations in order to comply with the relations with the European Union (EU), e.i. Customs Union. Furthermore, in last twenty five years, Turkey has been involved in debts from International Monetary Found (IMF), and especially since the year 2000 this urged the country to apply certain policies relating to the agricultural sector.

Among all these institutions having impact on Turkish agricultural policy, the most influential one is the IMF. Turkey's agricultural support policy existed at the beginning of 1990s didn't require substantial changes regarding the terms of the GATT agreements. Because, the country's financial resources to support agriculture were already limited, and the aid to the farmers have never gone beyond the permitted level by the WTO's limitations. Especially, starting from the 1980's the preferred economic development strategy was determined to be export oriented growth and accordingly agricultural support have been reduced to a great extend.

On the other hand, Turkey's affairs with IMF had imposed drastic changes on the countries agricultural policy. Most strikingly, in last several years, direct payment to the farmers per hectare of the land they owned has been imposed by IMF as a unique substitute for all before existent support policy practices. However, after three years of practice, there is still considerable doubt on both the suitability and the applicability of the system in the country. The authors believe that the direct payments are welcome as a social support policy tool, and especially helpful in eliminating the lack of record keeping in the sector, but, more is needed to manage the necessary re-orientation in Turkish agriculture. Overall, the IMF led changes in Turkish agricultural policy have been toward a less supported agriculture, and thus, one may suppose that, toward a more variable income for farmers.

The main objective of the present study has been to put forward the effects of the recent policy changes in Turkish agriculture on price and income stability. To fulfill this objective, the paper is structured under five main sections. After this brief introduction, in the second section, an overview of Turkish agriculture is provided comprising the importance of the sector in the countries economy as a whole, and its structural characteristics. In this section, a brief comparison between the Turkish and the European agricultural sectors has been made based on the main indicators. In the third section, changes in the Turkish agricultural policy along the relationship with IMF have been described. This section contains a brief picture of the characteristics of IMF's economic policy suggestions in general, and a history of the Turkey's relations with this institution. Then, IMF's economic policy applied in Turkey since 1980 have been summarized, with special reference to their influence on the agricultural sector. Terms of the Program of 24th January 1980 (1980-88), those of the Program of 5th April 1994 and the Programs Applied since 2000, the Letter of

Table 1: Role of Agriculture in the Turkish Economy

Year	Share in GDP (%)	Share in Fixed Invest. (%)	Share in Foreign Trade: Imports Value (mil. $)	Imports Share (%)	Exports Value (mil.$)	Exports %	Share in Total Empl.nt (%)
1963	39,3	12,3	37	0,5	292	83,8	74,0
1970	37,3	9,5	--	--	442	75,3	64,0
1980	26,1	7,6	51	0,7	1,671	57,5	54,0
1990	17,4	5,4	1,318	5,9	2,347	18,1	48,0
1999	15,1	4,3	1,814	4,5	2,592	9,8	45,0
2000	13,4	4,9	2,127	3,9	1,973	7,1	34,9
2001	13,6	4,8	1,412	3,4	2,234	7,1	36,1
2002	13,4	4,6	1,706	3,3	2,038	5,7	33,9
2003	12,4	3,9	2,563	3,7	2,465	5,2	34,7

Source: DİE (State Institute of Statistics), DPT (State Planning Organization).

Intent of the 9th December 1999, and the Economic Crisis of February 2001 and the following new Stand-by Treaty have all been elaborated in terms of their influence on the countries agricultural sector. In the forth section, effects of the agricultural policy adopted along the relationships with IMF on the price and income stability in Turkey have been examined using time series data for last ten years. Coefficients of variation and the random coefficients of variation have been estimated for series of agricultural prices and incomes per sub-periods, during which various limitations and changes in agricultural policy have been experienced. In the fifth and the last section, a general evaluation of the agricultural policy changes in relation with IMF have been put forward according to the results obtained. Then, some suggestions are presented that could help recover the negative influences on the price and income stability.

2. *An Overview of Turkish Agriculture*

In this section, first, importance of the agricultural sector in Turkish economy has been put forward by means of main indicators. Then, the agricultural structure has been described and a comparison with the EU agriculture has been made regarding the main figures.

2.1. *Role of Agriculture in the Turkish Economy*

The role of the agricultural sector in the Turkish economy by main indicators and its evolution over time is given in Table 1. As it may be observed, drastic changes have occurred regarding the role of agriculture in overall economy in last 40 years. During the period from 1963 to 2003, share of the agriculture has been declined from 39.3% to 12.4% in GSYİH, from 65.5% to 39.4% in

Table 2: Agricultural Structure in Turkey (2001)

Farm Size	Farms			Cultivated Area		
	Number	Share (%)	Share irrigated (%)	Area (da)	Share (%)	Share irrigated (%)
Small (5<Ha)	1.958.281	64,8	43,9	39.331.138	21,3	21,5
Medium (5-20 Ha)	887.328	29,4	40,9	82.004.847	44,5	18,0
Large (20 Ha +)	175.598	5,8	41,8	62.993.516	34,2	18,8
Total	**3.021.207**	**100,0**	**42,9**	**184.329.501**	**100,0**	**19,0**

Source: DİE

Table 3: Number of Animals and Production of Animal Products in Turkey

Indicators	1990	2003
Cows (heads)	11.77.000	9.89.000
Sheeps (heads)	40.553.000	25.31.000
Goats (heads)	10.977.000	6.772.000
Chickens (units)	96.676.000	277.533.000
Milk production (tons)	9.617.415	10.611.011
Meat Production (tons)	506.995	366.962

Source: DİE

population, and from 74% to 34.7% in total employment. The authors of the current study think that, together with the rather rapid development in the other sectors, the underlined trend has been a result of the decreased share of agriculture in fixed capital investments. The latter figure has shrunk from 12.3% in 1963 to 3.9% in 2003.

Another field, where important changes have occurred concerning the role of agriculture in economy along the evaluation period has been foreign trade. Imports of agricultural products have risen from 51 million dollars in 1980 to 2.5 billion dollars in 2003, increasing approximately 50 times. Exports of agricultural products, on the other hand, have risen only 47.5%, from 1.6 billion dollars in 1980 to 2.4 billion dollars in 2003.

2.2. *Agricultural Structure in Turkey*

Due to differing climate and soil conditions over a large area, a wide range of agricultural products are grown in Turkey. However, the great potential owned can not be exploited adequately. Bellow, in the Table 2, data from the Agricultural Census of 2001 are given. As it may be noted, 18.43 million hectares are cultivated by approximately three millions of farm households. Of these farms, in about 42.9% irrigated agriculture is practiced, a figure accounting for 19% of the total cultivated area. When the farm sizes are examined, it is observed that, of the total number of the farms 64.8% are those smaller than 5 hectares, while 29.4% are between 5 and 20 hectares and only 5.8% are bigger than 30 hectares.

Table 4: Comparison of Some Economic and Agricultural Indicators in Turkey and in the EU (2001)

INDICATORS	EU-15	TURKEY
GDP (Billion $)	8 700	150
Population (millions)	377	70
Rural population (millions)	15.6	20.3
Employment in Agriculture (millions)	7.4	9.4
Employment in Agriculture/Total Employment (%)	4.1	34.4
Arable Land (1000 Ha)	134 261	27 000
Number of Farms (1000 units)	7 310	4 106
Mean Farm Size (Ha)	17.4	5.9
Exports of Agricultural Products (billion $)	169	3.6
Imports of Agricultural Products (billion $)	172	2.1
Agriculture / GDP	1.9	14.0
Agricultural Support (billion $)	45	1.2

Source: DİE, TKB (Ministry of Agriculture)

When the distribution of area cultivated is examined by groups of farm sizes, the unfavorable structure becomes evident. The small scale farms accounting for about 64.8% of the total number of farms use only 21.3% of the total area cultivated, while the big scale farms accounting for 5.8% of the total number of farms use 34.2% of the total area cultivated. These data reflect that small and medium size farms dominate Turkish agriculture.

In Table 3, some other data on Turkish agriculture are presented. Figures show that, the number of animals, other than laying hens, has decreased in last 14 years. Accordingly, meat production has reduced, while milk production has increased only to a small extend.

When evolution of input use is considered, during the study period, a serious growth has taken place in the number of tractors, while use of certificated seeds has increased unsatisfactorily.

In brief, structure of the agricultural sector in Turkey represents quite an unfavorable prospect and the situation has been worsening over time.

2.3. *Comparison of the agriculture in Turkey and in the EU*

On the way to full membership in the EU, Turkey has been in "forever candidate" status since 1963. After 42 years of volatile relationship between the parties, now negotiations on accession have started. Thus, comparison of agricultural sectors in Turkey and in the EU (EU-15) would be of assistance.

As can be inferred from Table 4, rural population in Turkey is larger than that in the EU-15. Similarly, the rate of employment in agriculture is about 8 times more than that of EU-15. Besides, average farm size in Turkey is one third of that in the EU-15.

These data reveal the proportional importance of agriculture in Turkey compared to EU countries. Yet, the agricultural support in Turkey is forty times less than that in the EU-15. It is obvious that, as the Commission member responsible of agriculture Franz Fishler highlighted, agriculture will represent one of the most serious problems during the accession negotiations.

3. *IMF and Turkey*

3.1. *Characteristics of the Economic Policy imposed by IMF*

IMF is a very important institution in barrowing from foreign capital markets, not only with the credits provided by her own resources, but also with the signals she sent to the international institutions involved in finance. Thus, countries living economic crisis go to IMF, and IMF lends credit to them with the condition that they follow certain economic policies. Standby agreements covering the economic policy promised to be applied by the barrower country generally consists of radical and rigid precautions called "orthodox" ones. The underlined policy, shaped upon the existent problems in the country, mostly involves practices like, priority to liberalization in economy, openness, tight money and fiscal policies, real devaluations, reduction in agricultural support and real wages. Meeting the resource requirement, lowering the inflation rate, and export promotion generally becomes main concerns.

3.2. *History of the relations Between Turkey and IMF* (*Two unsuccessful old friends!*)

Turkey has signed stand-by agreements with IMF for 19 times. The stand-by agreements, from the first one signed in 1958 to that of 1994 were generally targeting elimination of the foreign trade balance deficits. However, those applied after 1994 focused on the roll-over of both the internal and external debts. Naturally, the underlined change in the aims of the agreements created a severe shift in the priorities of the economic policy. Debt payment oriented redesign of economic policy had also resulted in changes in public expenditure and tax policies. In these debt payment oriented programs, agriculture had been considered as a factor increasing the public expenditure. As a consequence, resources allocated to agriculture were cut down and subsidies provided to the farmers were reduced to a considerable extend. In addition, improved liberalization of foreign trade and priority given to operation of the market mechanism within the country had press the agricultural sector, which is naturally the less compatible with this mechanism. In this direction, not only the prices were exposed to market mechanism, but also the State Owned Enterprises operating in the agricultural sector were privatized.

3.3. *IMF Economic Policies Applied in Turkey Since 1980*

3.3.1. *Terms of the Program of 24th January 1980*

As a result of the economic instability started during the second half of the 1970's and continued with an increasing pace, Program of 24th January 1980 was put in force. Main target of this program was to overcome the problem of unsustainable foreign trade balance deficit. The main strategy adopted by the program was rapid increase in exports, implementation of flexible exchange rate together with a high devaluation, control of inflation, application of monetarist money and credit policies, real interest rate policy, promotion of foreign capital investment, and priority to enhanced use of existing capacity instead of new investments. Besides, elimination of public deficits, formation according to the market mechanism of the prices of the goods produced by State Owned Enterprises were other practices adopted (DPT, 1980). To sum up, the existing growth strategy has been changed form import substituting industrialization to export oriented industrialization.

Terms of the program relating to agriculture were: reduction in the number of the products covered by the price support scheme; decline in real support prices; and reduction of input subsidies (Uysal; 1990). The aims of these policy suggestions were adoption of the agricultural sector to market mechanism, reduction of the burden of the sector on the Budget and export promotion via low product prices. In other words, together with the export oriented growth strategy, agriculture was assigned to the role of main supporter of the growth. Operation of the underlined task attributed to agriculture is shown in Figure 1.

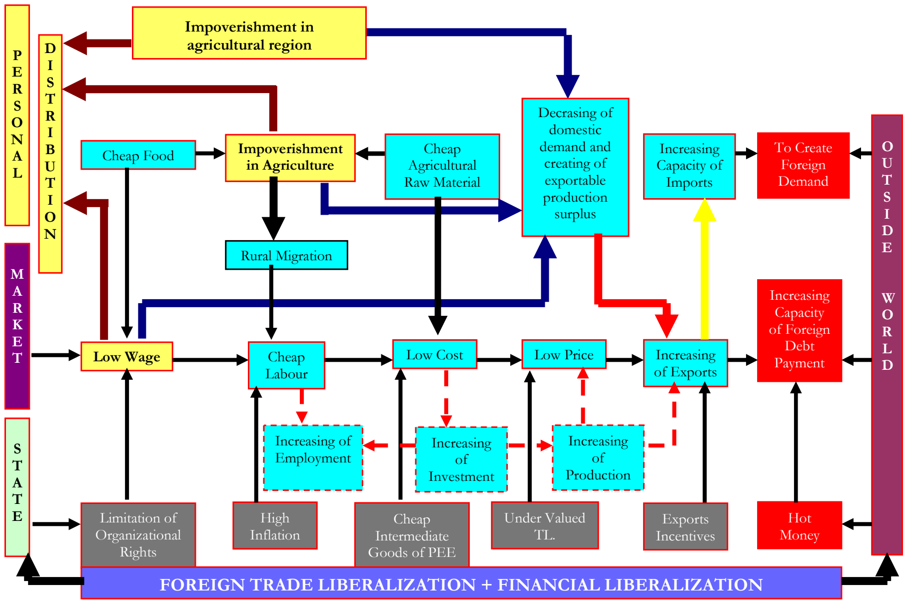
During this period, reduced prices for agricultural products were also aimed at provision of cheap food for the sustainability of diminishing real wages. Because, along the export oriented industrialization strategy, and based on the factor endowment in the country, main means of comparative advantage in international markets was determined to be cheap labor. This in turn obliged the food prices to be low for those living on wages. After a while, the underlined process has become a facet circle. Low wages caused to decreased demand for agricultural products, which in turn bounded the increase of prices (Uysal, 1998).

In Figure 1, three main functions attributed to agricultural sector after 1980 may be listed as: (1) Providing cheap raw material for the Industry, (2) Providing cheap food for low wages to be sustainable, and (3) Raising the poverty in the rural area, in order to accelerate the immigration which creates a pressure on wages.

Besides, and as a result of the limited capacity in the other sectors to absorb the unemployed in agriculture, hidden unemployment has increased in agriculture. This means a forth function performed by agriculture, insurance against a social crises.

Another point to be emphasized regarding this period is that there occurred no improvement in terms of integration to the EU relating to agriculture. Even if, at the beginning of 1996, Customs Union has been established with the EU for industrial products; agricultural products have been exempted from it. Since then no strategy has been put forward with reference to the adoption to CAP

Figure 1: Macro economic policies and the role attributed to the agricultural sector after 1980 in turkey



SOURCE: Yaşar UYSAL, 1998. "Functions Attached to Agriculture in the Income Distribution Process Endured in Turkey after 1980 and Mechanisms Used in Transfer of the Resources". Proceeding of the METU International Congress of Economics, September 1998, Ankara.

which constitute a key subject regarding the accession full membership in the EU.

3.3.2. *Terms of the Program of 5th April 1994 and Agricultural Policy* (*1994-95*)

Between 1990-1993, in Turkish economy, public deficit and debt burden has increased rapidly, high inflation rates have persisted, foreign trade deficit has risen up to huge levels and the growth rate have had an instable path. Besides, during this period, the international capital flows liberated by the Directive Number 32 have caused the national economy to become fragile against foreign capital flows as well.

Under these circumstances, at the beginning of 1994, setting of an economic crisis has started to materialize and after the elections of 27 March 1994, "The Economic Precautions Action Plan" has entered in force by 5th of April 1994. In the program, which was essentially a synthesis of Orthodox and Heterodox elements, the economic policy implemented and the related policy targets and tolls were mostly similar to those of the Program of 1980: A huge devaluation, severe increases in the prices of the goods and services provided by the State

Owned Enterprises, real decline of wages and further privatization. The new program was supported by a stand-by agreement with IMF that was signed on 8th July 1994 and included a 509 million dollars credit for 14 months (Alpago, 2002).

While all these were occurring in the economy, especially the huge devaluation and other macro economic policy implementations toward lessening the domestic demand both carried out within the framework of the Program have negatively affected agriculture. Further, these indirect effects were accompanied by direct regulations concerning agricultural sector which can be listed as follows (Uysal *et al.*, 1995):

- Agricultural support prices would be fixed considering the evolution both in the world prices and in the domestic factor prices.
- Among agricultural support policy tolls, those other than price support such as direct payments to the target groups and provision of credit under favorable conditions would have further priority.
- According to the restriction imposed on the Public Expenditure, subventions relating to agricultural input would be limited to budget allowances. Prices of the inputs distributed by the State hand would be determined considering market conditions.
- Scope of the agricultural product purchases by the State performed as an agricultural support would be restricted. Grains, sugar beat and tobacco would remain under the scheme and other products would be excluded.
- For the products with excess of supply, the area cultivated would be restricted and precautions would be taken to bind the production.
- Direct or indirect funding of State Owned Enterprises operating in the agricultural sector and the Alliances of the Agricultural Sales Cooperatives by the Central Bank would not be permitted.
- Provision of re-discount credit to the Alliances for the products under the scheme of premium payments would be ended.
- The on going privatization process of the State Meat and Fish Institution and Feed Industry would be completed as early as possible.
- Turkish Agricultural Input Providing Institution would be called off if not sold until the end of the year.

Evidently, the Program included critical terms regarding agricultural policy. However, because of the general elections of 1995, a great deal of the terms listed above has not been applied. Hence, the reform in agricultural policy has not turn out to be as large as expected.

3.3.3. *Terms of the Programs Applied After 2000 and Agricultural Policy*

From the above explanations it may be concluded that with the Program of 24th January 1980 a serious structural transformation has been launched in Turkish economy. As a result of the indirect effects of economic policy applied and the direct effects of the agricultural policy followed since than, the agricultural sector was influenced to a great extend. Even if, during the late 1980s, the early 1990s and the second half of 1990s, some backward steps to populism had been experienced regarding agricultural policy; terms applied in 2000s relating to agriculture involved far more radical changes and their application has influenced agriculture to a greater extend. In the following, these policy changes and their influence on agriculture are examined.

3.3.4. *Letter of Intent on the 9th December 1999 and Agriculture*

The most recent pace of IMF – Turkey relations was initiated in 1998 with the "Close Follow-up Agreement". With the stated agreement, Turkish economy was exposed to IMF's inspection, without asking for any financial support in turn. The follow up inspections would be carried out per each three months and would take a total of 18 months. In this way IMF would follow up Turkish economy under the light of the goals and the realizations of the Program (Esen, 2002). The letter of intent December 1999 submitted to IMF after 18 months from the Close Follow up Agreement in the form of an application for stand-by agreement for 3 years was the one having the most conclusive and detailed terms regarding structural changes.

When the text of the Stand-by is examined, it might be concluded that more than a stability program, it was a program targeting disinflation. Indeed, the basic and central program target was to reduce the inflation rate to a one digit number by end of the three years program. In order to fulfill this target, together with tight money and fiscal policies, serious structural reforms were imposed, mainly in financial and agricultural sectors.

Main adjustments of the program relating to agriculture could be summarized as follows:

- In the Program, it is emphasized that the existing agricultural support policy has negatively influenced the resource allocation; it has benefited the rich farmers more than the poor ones; and the related public expenditures, accounting for 3% of the GDP, were placing a great burden on the tax payers. Therefore, the program suggested gradual phasing out of the existing support policies (regulatory purchases and input subsidies) and replacing them with a decoupled direct income support system targeting the poor farmers. In other words, with the program, the agricultural support policy aiming at production increase has been changed and increasing the farmers' income is declared to be the new strategy.

  This means replacement of the support policy targeting economic objectives with the one targeting social objectives which would not remedy the problems in Turkish agriculture, and inversely make them more severe. The fact that in last 20 years the agricultural production has increased less than the population growth, and that the agricultural imports which were 50 million dollars in 1980 has risen more than 50 times and reached at 2.5 billion dollars indicate that it would be insufficient to consider the sector only from the social dimension. Instead, the goals of increased income for farmers and increased production should have been integrated. Otherwise, it was straightforward to foresee a decline in the rate of production growth.

- The Program suggested that the support prices for grain in 2000 would be fixed such that the difference between the support prices and the predicted world prices would not exceed 35% of the predicted world prices (CIF). In 2001 the difference was suggested to be even less. The predicted world price was described as the USA2HRW price quoted at the Chicago Board of Trade. Besides, it was suggested that the necessary institutional changes would be carried out in order that the TMO (State Grain Products Purchasing Institution) could operate not as a State owned institution but as a private sector firm.

  It could be advocated that, by the application of this regulation, it was aimed to equalize the domestic grain prices to those of the world. However, it should be remembered that, the low world prices are due to the high level of export subsidies provided by USA and the EU, and neither many countries nor Turkey does have sufficient financial power to subsidize the sector as much. Therefore it could be concluded that the domestic wheat production would be adversely affected by this regulation.
- In the program, increases in the support prices for sugar beat were suggested to be limited to the targeted inflation rate. This promise was aimed at control of the increase in support prices and reduction of the losses of the supporting institutions.
- In the Program, the Government has also prepared legislation to give complete autonomy to the Agricultural Sales Cooperatives Unions (ASCUs) which were operating under the Ministry of Industry. The law intended to be enacted before the end of May 2000 has entered in to force by first of June 2000.

  It could be reflected that the law would eliminate all preferences and government role in the operation of the ASCUs, and establish a framework for carrying out their restructuring into true private cooperatives. Nevertheless, the fact that the ASCUs may disappear over time seem to be a danger waiting for the farmers.
- The Program suggested gradually phasing out agricultural credit subsidies over the course of 2000.
- The fertilizer and other input subsidies would remain constant in nominal terms in 2000-2001.

  The last two regulations means that the credit subsidies provided to the farmers would decrease and the input subsidies would diminish in real terms parallel to the rate of inflation. When the recent trends in agricultural input and output prices and the fact that the difference between the growth rates of the two has changed unfavorably for farmers are considered, the underlined reduction in input subsidies should be viewed as a practice that may result in declines in agricultural production.

During the application period, realization of the Program dues have been followed up each three weeks, and the results of the applications have been evaluated in the additional letters of intent. In these letters, even more robust intensions have been declared regarding the delays in practice. The process has been continued until the economic crisis came out in February 2001.

3.3.5. *Economic Crisis of February 2001 and Agriculture in the new Stand-by Treaty*

In 2000, there emerged a crisis of interest in Turkish economy and it is tried to be eliminated with the assistance of IMF. Nevertheless, as a result of the Program being applied the exchange rates were undervalued, the economy has been growing faster than expected, the problems in the financial sector have became apparent, foreign trade and current account deficits have reached at record high levels, and finally the cyclical political instability added to the listed have all caused to a great economic crisis in February 2001.

To combat the crises a new program called "Transition to Powerful Economy" has been designed under the guidance of IMF and put into effect. To a great extend, the program was a continuation of that of the 2000, but, it contained much more radical measures regarding both macro economy and agriculture.

In macroeconomic framework, the basic differences from the program of 2000 were the shift from flexible to floating exchange rate regime and the highlighted focus on minimizing the macroeconomic influence of the economic crisis.

Main adjustments of the program and of the following additional letters of intent relating to agriculture were as follows:

- In the Program, it is focused on completion of the preparations for privatization of agricultural state-owned enterprises, including TEKEL (tobacco and spirits monopoly) and ŞEKER (sugar factories) till the end of 2001. As suggested in the program, the Sugar Law reforming the sugar market has been enacted in April. The Tobacco Law liberalizing the tobacco sector, phasing out the support purchases of tobacco, and allowing for the sale of TEKEL assets is approved by the Parliament on the 3rd January 2002.
- In the program, it was declared that the credit subsidies would be totally eliminated by January 2002.
- Reduction of the sugarbeet quotas from 12.5 million tons to 11,5 million tons, and strict adjustment of support price increases for this product to not more than the targeted inflation rate were agreed upon.
- Reduction of the quantity of support purchases for grain products, and elimination of the excessive grain stocks were suggested.

As it may be appreciated, the regulations brought about with the Transition to Powerful Economy Program were, to a great extend, continuation of those of the program of 2000. Yet, in the second Program, realization of the proposals and reduction of the agricultural subsidies have been carried out much faster.

4. *Effects of the Agricultural Policy Adopted under the Relationships with IMF on the Price and Income Stability in Turkey*

4.1. *Data and Methodology*

In this section, in accordance with the main objective of the paper, influence of the stand-by agreements signed with IMF and of the related macroeconomic and agricultural policy changes on price and income stability in Turkish agriculture have been analyzed.

The analysis has been carried out using monthly time series data for agricultural prices and seasonal and annual data for agricultural incomes obtained from the State Institute of Statistics (DIE).

Coefficients of variation and the random coefficients of variation have been estimated for series of agricultural prices and incomes. As the first step of analysis, and in order to eliminate the influence of the inflation, all the series have been deflated using corresponding whole sale price indexes. Coefficients of variation have been calculated directly as the ratio of standard deviation of the related series to its own mean. On the other hand, random coefficients of variation have been estimated using standard errors of regression from the regressions of the related series on a simple trend and corresponding monthly/seasonal dummy variables, if any.

The analysis has been restricted to the period after 1994, during which besides indirect effects of macroeconomic policy commitments, serious transformations in agricultural policies took place. As explained above, because stand-by agreements signed after 2000 have included more direct interventions on agricultural policy - mainly in form of reduced allocation of resources to the sector, two main sub-periods have been distinguished: between January 1994 and December 1999, and between January 2000 and August 2004.

In addition, under these conditions, the agricultural sector has been exposed to a severe economic crisis in April 2001, and in May, a new strand-by bringing about more radical reforms in agriculture have been signed. Therefore, it is aimed at analyzing the influence of this turning point as well. Thus, in the case of prices, the period after 2000 is also analyzed by sub-periods as being between January 2000 and April 2001, and between May 2001 and August 2004. As these last two periods were too short for analysis using seasonal and yearly data, the influence of the crisis in 2001 on income stability haven't been analyzed. Results of the underlined analysis are presented below for the cases of price stability and income stability respectively.

Table 5: Random Coefficients of Variation Based on the Index of Prices* Received by the Farmers

	S.E. of Regression	Mean Dependent Var.	Random Coef. of Var.
All products			
'94-'99	5.94	120.79	4.92
'00-'04	8.21	120.59	6.81
Field crops			
'94-'99	6.80	115.50	5.89
'00-'04	4.70	104.84	4.48
Vegetables			
'94-'99	23.80	115.23	20.65
'00-'04	17.48	118.09	14.80
Fruits			
'94-'99	17.58	131.04	13.42
'00-'04	14.99	140.77	10.65
Livestock			
'94-'99	12.51	116.18	10.76
'00-'04	8.12	108.63	7.48
Animal products			
'94-'99	8.68	111.08	7.81
'00-'04	6.90	114.02	6.05

* Real price index (current price index deflated by the whole sale price index).
Source: DİE

4.2. *Stability of Agricultural Prices*

In Table 5, random coefficients of variation estimated based on the real price index for the prices received by farmers are given. When the levels of price fluctuations in the periods of 1994:1-1999:12 and 2000:1-2004:8 are compared, it is observed that the price variability has been increased for the group of all agricultural products. This result is totally reversed when sub-groups of agricultural products are considered. It is understood that, this finding has been a result of increased price stability in sub-groups toward different directions. For instance, while for the prices of vegetables, fruits and animal products increased stability has been toward increased prices, in the case of field crops, which is the sub-sector most directly intervened by the IMF's conditions and for the livestock the prices have seriously decreased.

In Table 6, simple coefficients of variation have been estimated for the three sub-periods, differentiating in this case for before and after the crisis of April 2001 as well. As the period have not been long enough to estimate the random coefficients of variation using twelve dummies, this method of estimation is preferred for this case.

Table 6: Coefficients of Variation Based on the Index of Prices* Received by the Farmers

	All products	Field crops	Veget.	Fruits	Livestock	Animal Products
1994:1-1999:12						
Mean	120.79	115.50	115.23	131.04	116.18	111.08
Std. Deviation	13.44	7.55	29.25	34.25	15.60	9.97
Coef. Of variation	11.12	6.54	25.39	26.14	13.43	8.97
2000:1-2001:4						
Mean	127.12	106.18	117.42	153.02	126.10	121.84
Std. Deviation	8.90	4.74	23.68	20.78	5.10	8.12
Coef. Of variation	7.00	4.46	20.16	13.58	4.04	6.66
2001:5-2004:8						
Mean	117.98	104.30	118.36	135.87	101.63	110.90
Std. Deviation	10.24	5.20	24.64	24.16	10.71	6.22
Coef. Of variation	8.68	4.98	20.82	17.78	10.53	5.61

* Real price index (current price index deflated by the whole sale price index).
Source: DİE

Table 7: Evolution of the Per Capita Income in Agriculture

Year	Per Capita Farm Income (real index, 1980=100)	Ratio of the Per Capita Incomes in Different Sectors	
		Industry / Agriculture	Services / Agriculture
1994	109.39	4.85	4.37
1995	105.07	5.84	4.83
1996	108.79	4.10	5.56
1997	123.31	5.35	4.45
1998	128.62	5.22	4.24
1999	119.08	5.45	4.31
2000	157.70	4.06	3.22
2001	142.93	4.18	3.37
2002	163.42	3.85	3.08
2003	149.14	4.58	3.45
1994-99	*115.71*	*5.14*	*4.63*
2000-03	*153.30*	*4.17*	*3.28*

Source: DİE

When considered by the three sub periods, it is seen that after 2000 the price stability has been increased, in other words, coefficients of variation have shrunk for all groups. On the other hand, figures reveal that both for the group of all products and for sub-groups of products, the real prices were decreased severely after the crises of 2001. The only exception of this trend seems to be the group of vegetables. Although the coefficients of variation for the period after 2001 are estimated to be less then that of the period between 1994:1 and 1999:12, it is observed that the crisis has badly affected the stability of the prices. Again the field crops are noticeably the most disadvantaged, with more reduced prices per each period.

Table 8: Stability of the Agricultural Incomes along the Analysis Period

	S.E. of Regression	Mean Dependent Variable	Random Coeff. of Variation
For the Gross Agricultural Income (Billion Turkish Lira) (seasonal data and dummies)			
1994-99	452	15126	2.99
2000-03	596	15596	3.82
For the Per Capita Agricultural Income (Billion Turkish Lira) (annual data)			
1994-99	0.095	1.632	0.058
2000-03	0.156	2.162	0.072
For the Growth Rate of the Agricultural Sector (%) (annual data)			
1994-99	4.83	1.1	433.92
2000-03	6.05	0.4	1412.71

Source: DİE

4.3. *Stability of Agricultural Income*

When the influence of IMF led economic and agricultural policy changes on per capita agricultural income are examined for the analysis period, it is reflected that the programs applied after 2000 have given positive results (Table 7). According to the figures, the per capita income has increased about 49% from 1980 to 2003. On the other hand, when investigated truly, it may be explored that the highlighted increase from 1999 to 2000 has been a result of the correction made in the agricultural employment statistics in that year. For the very same reason, the ratios of per capita incomes by Agriculture/Industry and Agriculture/Services which were moving against agriculture until 1999 seem to have turned in favor of agriculture after then.

In Table 8, random coefficients of variation are given for Gross Agricultural Income, for per capita income and for growth rate of the gross agricultural income. While the Gross Income of Agriculture has been increased in real terms, detrended series reveal that fluctuation has increased from 2.99 to 3.82 % over time. The same finding is also true for per capita agricultural income. Because of the above mentioned correction in the employment statistics, increase in the mean per capita income in agriculture after 2000 seems to be even more pronounced than the increase in Gross Agricultural Income. Regarding the variation in the growth rate of the gross agricultural income, the figures reveal that, after 2000, the growth has slowed down and became more volatile.

5. *Conclusions and recommendations*

5.1. *Conclusions*

As may be recognized from the above given information, it is possible to call the period after 1980 as "the years with IMF" for Turkey. Because, other than the years between 1990-93 and 1996-97, in other words, other than six years out of last 25, the economic policy suggested by IMF have been continuously applied in Turkey. Nevertheless, the economic policy imposed by IMF has caused a severe debt problem at macro economic level, and an absolute decline in agriculture. The collapse in agriculture became even worse after 2000.

The basic implications of the changes made in the agricultural sector within the framework of the Stand-by agreements with IMF have been, reduction of the financial burden of agriculture over the budget; and exposure of the sector to liberal economical conditions and to international competition as never ever done in any country sufficiently.

The key adjustments made in order to fulfill these targets have been:

- Reduction or elimination of the support prices,
- Reduction or elimination of the input subsidies (credit, fertilizer, pesticide, oil vb.),
- Privatization of the market regulating State Owned Enterprises serving in agricultural sector,
- Shift to the direct income support system which is no way a substitute for all the listed above and which would not be decoupled but negatively effect production.

As a result of these radical changes in the agricultural policy, it is observed that no any problem present in the sector has been resolved; on the contrary, they became severer.

At the point where we stand, income variability generated both from production and prices are huge; which poses serious questions on the viability of the sector. Even if the prices seem to be rather stabilized after 2000, this trend is changed after the crisis of 2001. Besides, further rapidly increasing instability in agricultural income compared to that in prices reveal the impact of real decreases in agricultural prices and of the reduced agricultural subsidies on the production in the sector.

In Turkey, neither the agricultural policy applied during the period before the IMF was successful enough. However, the problem was not the agricultural policy tools used during this period, but, the misuse of them with populist approaches. Without sufficient inquiry on whether the unsuccessful were the policy tools employed, or the way they were applied, orientation of the IMF in agricultural policy was accepted, and accordingly, the government intervention to the sector was aimed to be reduced and not to be converted in to an efficient one.

As a result:

- The increase in agricultural production became less than the increase of the population,
- Foreign trade balance of agricultural products changed in favor of imports,
- Farmers received more volatile prices, at a reduced level, especially after the 2001

- Their earnings become more volatile and unfavorable compared to other industries,
- They became poorer,
- Many of them sold their fields and immigrated to big cities with their problems

5.2. *Recommendations*

Moving on from the Turkish case:

- The view that the market mechanism would remedy all the problems should be re-examined, especially for agricultural and regional policies.
- All the countries should re-evaluate the place of the state in the economy as a whole and in agriculture.
- Role of the State in agriculture has become more important than ever. Stabilization of the prices and the incomes for the farmers is one of the reasons for that.
- Moreover, tasks of the social state - such as rebalancing the social disequilibrium, reducing the crime (theft, usurpation etc.) brought about by the poverty and immigration - have also become more vital in fighting the negative reflections of the problems in agriculture on the whole society.
- Additionally, we believe that,
- The farmers and the rural youth should be provided with additional educational facilities.
- Bettering of the existing farmers' organizations and establishing new ones should be supported.
- Futures and options markets should be established and farmers should be informed.
- Establishment of the agricultural insurance system should be subsidized.

In addition to these suggestions for the Turkey side, we would like to point out to the importance of reducing negative effects of the unfair competition atmosphere created in the agricultural commodity markets by the USA and the EU, on the agricultural production, prices and incomes in the developing countries. As in the case of Turkey where the increased poverty in agriculture have caused social, cultural and political problems in the cities and on overall society as well as economical ones, the problems emerging in the developing countries in which the poverty in agriculture played essential role will not only limited to those countries but also will be reflected in developed countries in form of clandestine immigration, global terror etc. Therefore, it would be appropriate to consider the agricultural and peasant problems as a global trouble. At this point, we would like to capture the developed countries attention to the agricultural policies they applied, which creates adverse results on developing countries.

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Farm Income Support and Agricultural Policy Reform in Korea

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Abstract

In order to prepare for the opening of the agricultural market in the post-UR era, a large scale 'Agricultural Investment and Loan Program' aiming at improving agricultural production structure has been implemented in Korea. However, Korean agriculture is still facing several structural issues causing farm income problems, which in turn are hampering the policy reform directed by the WTO regime. In this paper, some long term policies such as a direct income payment completely decoupled from rice production that does not make farmers stick to rice farming and comprehensive agricultural land policies that guarantee low agricultural land price are suggested.

1. *Introduction*

Korean agriculture has experienced considerable structural adjustment during last four decades. Along with the adjustment, it has been heavily subsidized. Although the percentage producer support estimate (%PSE) has fallen from 70% in 1986-1988 to 64% in 2001-2003, it is still twice as high as the average of the OECD (Table 1). The producer support estimate (PSE) in Korea consists mainly of market price support (MPS) through domestic and trade policy measures. Even though the share of MPS is on the decreasing trend, it is still about 93 percent of total PSE in 2001-2003 (Table 1). MPS was the most important policy tool for the Korean government in pursuing its agricultural policy objectives such as farm income support. The Korean government, without clearly specifying the policy target, has used MPS as a panacea which could cure all the problems in agriculture.

Currently, internal and external forces necessitate policy reform in Korean agricultural sector. While the global standards of domestic farm policy demanded by the WTO are the external forces, increasing competition over limited government budget between agricultural and non-agricultural sectors represents the internal forces. Farm income policy has always been at the center of the policy reform issues, and now it is undergoing considerable academic and political debates. This study is motivated mainly by those debates.

Table 1: PSE of OECD and Korea (Unit: million US$)

	OECD		Korea	
	1986-88	2001-03	1986-88	2001-03
Total value of production(at farm gate)	596484	673377	16985	25824
Producer Support Estimate(PSE)	241077	238310	12120	17264
Market Price Support(MPS)	186331	148597	11997	16038
Payments based on output	12547	11649	0	0
Payments based on area planted/animal nr.	15833	34639	0	345
Payments based on historical entitlements	515	11257	0	0
Payments based on input use	20324	21243	88	454
Payments based on input constraints	2993	7242	0	39
Payments based on overall farming income	2253	3486	35	388
Miscellaneous payments	281	197	0	0
Percentage PSE	37	31	70	64
MPS/PSE(%)	77	62	99	93

Source: OECD data base

Some interesting questions to be answered in this study are: i) What problems does Korean agriculture have and what is in the background of the problems? ii) How have the current farm income problems been formed in the process of economic development and trade liberalization? iii) What are the alternative policy options for farm income problems in Korea under the new global standards required by WTO regime?

The case study of Korean agricultural policy reform will provide us with valuable information since Korea is in a unique position in the sense that it is not only a major importer of agricultural products but also a country still trying to complete its industrialization process through structural adjustment.

2. *Structural Adjustment and Agricultural Problem*

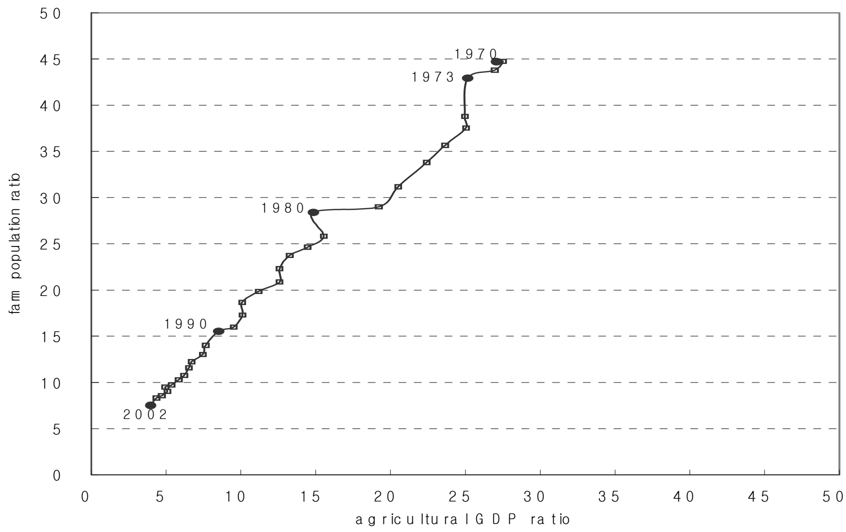
Korean agriculture has experienced considerable structural changes along with economic development and the process of trade liberalization. In the early 1960s, the agriculture's share of GDP and total employment accounted for almost 50 and 60 percents, respectively. It took only four decades for the shares of GDP and total employment to fall to the current levels of 4.5 and 8 percents, respectively. As shown in table 2, the high speed at which Korean agriculture has been changing seems to be unprecedented in the world. Korean agricultural sector is now seriously fatigued with the rapid structural changes.

Figure 1 shows that, due to the fatigue, the speed of adjustment is getting slower (the gaps between the dots in figure 1 are getting smaller) as time goes by. Furthermore, despite the rapid structural changes, Korea still maintains a very large number of very old farmers close to retirement compared to other OECD countries.

Table 2 Populations, Employments, Arable Land per Farmer, and International Comparison of Time Required for Structural Changes

Countries	**Total population**	**Agricultural employment**	**Arable land per farmer**	**Agricultural share of GDP**			**Agricultural share of employment**		
	(2002)	(2001)	(2001)	When 40%	When 7%	Time span	When 40%	When 16	Time span
	(x000)	(x000)	(ha)	(year)	(year)	(years)	(year)	(year)	(years)
Korea	47,430	2,271	0.75	1965	1991	26	1977	1991	14
Japan	127,478	2,608	1.70	1896	1969	73	1940	1971	31
UK	59,287	515	10.97	1788	1901	113	1800	1868	68
Netherlands	16,067	241	3.76	1800	1965	165	1855	1957	102
USA	291,038	2,964	47,430	1854	1950	96	1897	1950	53
Germany	82,414	967	12.22	1866	1958	92	1900	1942	42
Denmark	5,531	106	21.62	1850	1969	119	1920	1962	42
France	59,850	858	21.50	1878	1972	94	1921	1965	44

Figure 1: Structural Adjustment of Korean Agriculture



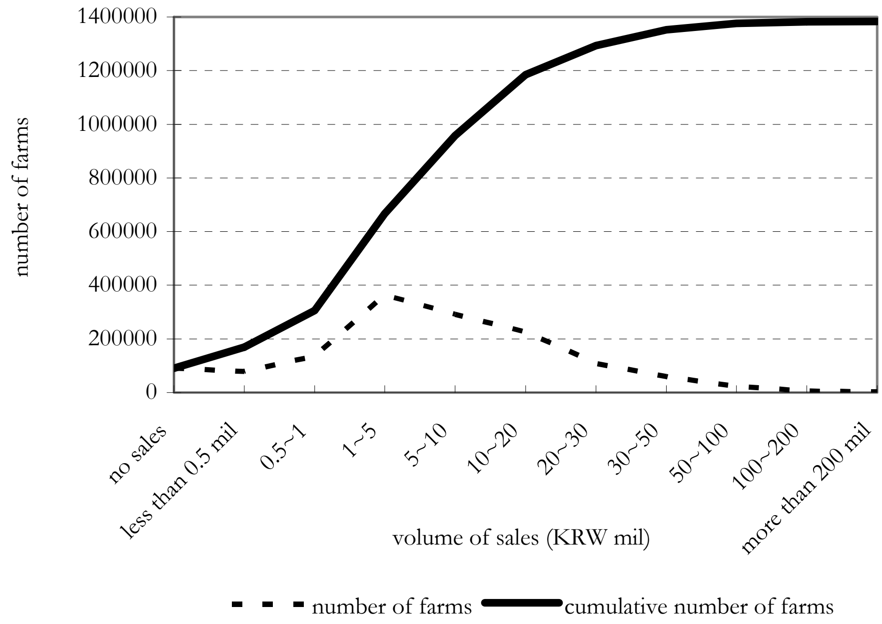
Source: Korean MinistrY of Agriculture and Forestry

2.1. *Large Farm Employments with Many Small Farms*

The share of agriculture in total employment is still near 10% in Korea which is much higher than the average of the OECD. It means that structural adjustment is still underway in Korean agricultural sector. The number of agricultural employment in Korea is almost the same as the total number of German, French, and UK agricultural employment combined together (table 2).

Figure 2 shows that, among 1,400 thousand farms, over 600 thousand farms' sales amount of agricultural products is less than 5 million won (US$4,200). This large number of small farms has important implications for production efficiency and policy effectiveness in Korea. Since 1970s, Korean government has pursued a farm scale enlargement policy to improve production efficiency. Despite of these efforts, the average farm size is still less than 1.5 ha. The ultimate limitation to the expansion of farm size seems to be the large number of farms. It is very difficult to convert market price support (MPS) to direct payments for an agriculture where there exists a large number of small farms. In this context, reducing the number of farms and farm employments is, in general, regarded as the most urgent prerequisite for successful agricultural policy reform in Korea.

Figure 2. Number and Size of Farms('00)



Source: Korea National Statistical Office, Agriculture Census, 2000.

2.2. *Excess of Old Farmers: An Aftermath to the Rapid Structural Change*

Korean agriculture has inherited an excess number of old farmers as an aftermath to the rapid structural change. Currently, over 50% of total farm managers are 60 years old or over (table 3). The excess of old farmers and the large number of farms gives rise to several problems hindering effective policy reform.

First, it is difficult to reduce the number of farmers under the excess of old farmers. Currently the 'natural exits' by death or retirement has replaced the out-migration as the decisive cause for a decrease in farm labors in Korea (Lee 1997). The rates of 'natural exits' are independent of the changes in agricultural share of total economy, and in general very stable. These stable exit rates may cause the number of farmers to decrease at a steady pace which is disproportionate with the rapid shrink of agricultural share in Korea as shown in table 2. This in turn raises a barrier to new entrance of young farmers. In this context, the aging process in Korean agriculture is expected to continue.

Second, land mobility is highly restricted by the large proportion of old farmers. Old farmers with very limited labor mobility have no other choices except farming, which results in very low land mobility. The rigid land mobility is

Table 3: Farm Manager's Age Distribution(Unit: %)

year	Total	Share										
	(1000)	<25	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	≥70
1990	1767	0.3	1.7	5.3	7.3	9.3	11.8	16.6	16.5	13.0	9.8	8.5
1995	1501	0.1	0.7	2.7	6.3	8.2	10.0	12.5	17.3	17.5	12.1	12.7
2000	1383	0.1	0.5	1.7	4.4	8.0	9.2	11.3	13.9	18.4	16.3	16.4
2003	1264	0.0	0.2	0.7	2.6	6.0	9.6	10.2	12.9	16.7	19.7	21.3

Source: Korea National Statistical Office, Agriculture Census, 2000

Table 4: Labor Hours Required for the Cultivation of Major Products (hours / 10 acres)

	Rice	Chinese Cabbage	Red Pepper	Onion	Lettuce (greenhouses)	Apple
1981	93 (100%)	176 (100%)	249 (100%)	220 (100%)	837 (100%)	415 (100%)
1995	35 (37%)	140 (80%)	243 (98%)	193 (87%)	724 (87%)	334 (81%)
2001	28 (30%)	101 (57%)	205 (82%)	136 (62%)	688 (82%)	196 (47%)

Source: Korea Rural Development Administration

partly responsible for the current high price of farm land. Almost a half of the rice production cost is attributable to rent in Korea. The high price of farm land is regarded as the most restrictive factor in achieving the price competitiveness of rice industry. Due to rigid land mobility, it is very difficult to improve the scale of farms.

2.3. *Vulnerable Farm Household Income Structure*

The excess of old farmers might have an adverse effect on the income structure of farm household by intensifying the tendency of rice-monoculture. The old farmers tend to stick to rice farming which in general requires less labor compared to other major crops. The government policies have induced the labor saving technology in favor of rice farming as in table 4 for a long time. With this technological condition at hand, the old farmers cannot help but choose rice farming with their infirm labor forces.

As a result, rice became a major farm income source which, as a single commodity, accounts for 33 percent of total agricultural production values, and 52 percent of average farm income per farm household (table 5). Combined with the low level of off-farm income, the high dependency of farm income on a single commodity, rice, constitutes very vulnerable farm household income structure. As shown in table 6, Korea has relatively low level of off- farm income compared with other Asian countries of similar agricultural background. Low dependency of farm household income on off-farm sources restricts policy options and makes the burden of government heavier in the process of agricultural policy reform.

Korean government has put much efforts in increasing off-farm income since early 1980s. However, these efforts have not been rewarded satisfactorily. Currently the circumstances to enhance off-farm income are increasingly get-

Table 5: Rice Farming as a Major Income Source

Year	Farm household income (A) (thousand KRW)	Income from farming (B) (thousand KRW)	Income rom rice farming (C) (thousand KRW)	Ratio (%)	
				C/A	C/B
1970	256	194	88	34.4	45.4
1980	2,693	1,755	741	27.5	42.2
1990	11,026	6,264	3,097	28.1	49.4
1995	21,803	10,469	3,984	18.3	38.1
2000	23,072	10,897	5,671	24.6	52.0
2001	23,907	11,267	6,051	25.3	53.7

Sources: Korean Ministry of Agriculture and Forestry, "Major Statistics on Agriculture," 2002.

Table 6: Share of Off-Farm Income in Farm Household Income

Year	Korea(thous. KRW)			Japan (thous. JPY)			Taiwan (thous. NT$)		
	A	B	B/A(%)	A	B	B/A(%)	A	B	B/A(%)
1985	5,736	2,037	35.5	6,916	5,850	84.6	310.6	233.7	78.2
1990	11,026	4,762	43.2	8,399	7,235	86.2	503.8	402.9	79.9
1995	21,803	11,334	52.0	8,917	7,474	83.8	871.1	699.0	80.2
2000	23,072	12,175	52.8	8,280	7,176	86.9	917.6	756.5	82.4
2002	24,475	13,200	53.9	7,163	6,234	87.0	860.8	684.4	79.5

A=farm household income, B=off-farm income(transfer income included)

Sources: Korean Ministry of Agriculture and Forestry, "Major Statistics on Agriculture," 2004

ting worse. The Korean rural areas do not have comparative advantages in terms of wages or land prices in attracting outside firms that can provide off-farm income opportunities. Currently, many small or medium sized firms are relocating their plants in foreign countries such as China and the ASEAN rather than in domestic rural area.

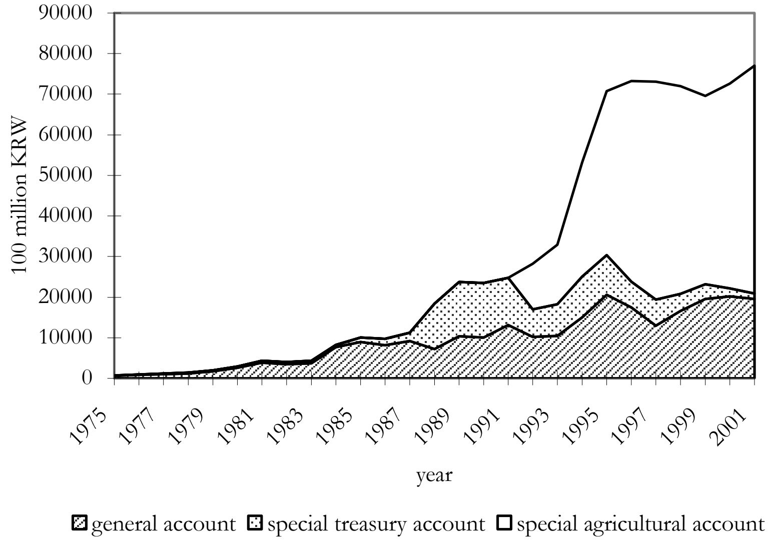
3. *Policy for the Post-Uruguay Round Problems*

3.1. *Agricultural Investment and Loan Program*

In 1992 when the UR agreement on agriculture was about to be finalized, the Korean government decided to implement a large scale 'Agricultural Investment and Loan Program' aiming at improving agricultural production structure in preparation for the upcoming agricultural market opening. As shown in Figure 3, the government budget has been sharply increased since 1992, which reflects the budget increase for the Agricultural Investment and Loan Program that is financed by the special agricultural account.

Total fund of 42 trillion won (US$ 35billion) were appropriated for the program during the period of 1992 to 1998. This program has been extended to 2004 with new fund of 45 trillion won (US$ 37.5billion). The major sources of

Figure 3: The Government Budget for Agriculture



Sources: Korean Ministry of Agriculture and Forestry

the fund consist of agricultural import tariff revenue, value-added tax revenue from some agricultural inputs like assorted animal feeds, and agricultural land conversion duty. Additional special tax revenue, almost 15 trillion won (US$ 12.5billion) has been also allocated to agricultural investment and loan purposes from 1993 to 2003.

However, the effectiveness of the agricultural budget outlay has not increased commensurately with the increase of the budget. For example, in 2002, 8.37 trillion won (US$ 6.9billion) was allocated to agriculture from the funds mentioned above. But, as shown in Table 7, only 38.7 % of total budget was used for the investment and loan activities aiming at enhancing agricultural competitiveness. Significant amount of the budget (59.5%) is not used for the actual investment or loan purposes, but used for the compensation for past policy failures including farmers' burden relieve and income compensation, budget deficit compensation, grain market intervention, and debt repayments.

3.2. *Remaining Problems after the Agricultural Investment and Loan Program*

3.2.1. *Deterioration of Agricultural Terms of Trade*

From early 1990s, right before the implementation of WTO agreements and afterward, the slight increase in the index of average price received by farmers is attributable to the rice which has been under continuous government price support programs. The rice price support was substantial even after the Uruguay Round. Without the increase of rice price the price index for the agricul-

Table 7: Composition of Agricultural Budget Outlay ('02)

Activities	**Outlay** (KRW x 100 mil.)	**Share** (%)
I. Investment and Loan Activities	**32,429**	**38.7**
◦ production structure improvement and farm mechanization	18,358	21.9
◦ production and marketing improvement	7,861	9.4
◦ technology and information system development	641	0.8
◦ human development; income source development	5,536	6.6
◦ other investment and loan activity	33	0.0
II. Non-Investment and Loan Activities	**49,766**	**59.5**
◦ farmers burden relief and income compensation	16,166	19.3
◦ budget deficit compensation	2,728	3.3
◦ grain market intervention	9,969	11.9
◦ debt repayments related expenditures	20,903	25.0
III. Operational Costs	**1,510**	**1.8**
Total	**83,706**	**100.0**

* Included only the budget of the Ministry of Agriculture & Forestry (Excluded the budgets of affiliated organizations like Rural Development Administration, Korea Forest Service).
Source: The Korean Ministry of Planning and Budget

tural products would have declined. However, the prices of vegetable, fruits, livestock animal, which are less important income sources for Korean farmers, have shown sharp declines or fluctuations. Input prices used for agricultural production have increased relatively fast. Especially, the prices for fertilizer, pesticide, farming machinery, and wage have increased approximately as much as 50 percent after 1995.

As a result, the terms of trade, defined as the ratio of the prices received by farmers to the prices paid by farmers, have been deteriorated since 1995, falling down to 83.5% in 2001. It is expected that prices of agricultural products would fall as import liberalization proceeds. And the input prices are expected to increase continuously due to the chronic imperfect competition in the input market. The falling trend of the terms of trade does not seem to be reversed in the near future.

3.2.2. *Widening Income Disparity*

There was a big change in farm household income growth pattern around 1995. Before 1995 both income from farming and total farm household income were increasing at two digit annual growth rates. However, the growth rates have begun to seriously decline since 1995. In fact, the growth rates of income from farming and total farm household income even fell down to negative levels in 1997 and 1998. Considering that the number of farm household has been decreasing at 3 percent annually on average, the stagnation of income from farming and total farm household income has been even more serious. Several factors might be responsible for such serious income stagnation. Market

Table 8: Price Indexes Received and Paid by Farmers, and Terms of Trade

	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2**
Price Index Received	84.5	84.7	91.7	100.0	105.2	102.2	101.9	108.5	109.6	1
Rice	84.9	89.1	91.5	100.0	114.9	116.7	124.5	131.4	137.8	1
Barley	90.7	95.2	100.0	100.0	100.0	100.0	105.5	110.7	115.2	1
Soybean	69.3	78.4	86.3	100.0	103.9	102.7	111.3	142.8	136.0	1
Vegetable	80.7	79.9	88.9	100.0	104.6	103.1	105.2	95.7	94.8	1
Fruits	65.8	66.4	93.5	100.0	92.5	93.9	93.4	102.0	80.3	(
Livestock	96.2	88.4	91.0	100.0	100.2	88.3	76.7	96.6	101.1	1
Flower	66.0	78.4	83.2	100.0	90.1	93.8	102.6	113.0	95.7	[illegible]
Price index Paid	90.2	90.9	94.4	100.0	104.3	106.7	118.0	121.2	127.5	1
Fertilizer	95.7	96.9	96.9	100.0	100.3	105.8	149.7	149.6	149.6	1
Pesticide	95.5	97.9	99.0	100.0	103.7	108.0	140.0	130.7	129.4	1
Machinery	130.7	100.6	99.0	100.0	101.6	104.2	153.4	153.8	154.0	1
Feed	94.8	95.4	95.6	100.0	104.8	110.5	136.4	109.3	104.8	1
Wage rates	85.4	90.5	93.6	100.0	109.7	116.5	110.5	124.2	140.8	1
Terms of trade	93.7	93.2	97.1	100.0	100.9	95.8	86.4	89.5	86.0	[illegible]

Source: Korean Ministry of Agriculture and Forestry, "Major Statistics on Agriculture", 2002.

opening due to the UR, and financial crisis in 1997 might be the most influential factors. The most sudden drop to negative growth rates in 1998 might be due to the financial crisis.

The stagnation of farm household income is clearly identified by comparing it with the urban income. Since the late 1980s, the farm household income has lagged behind the urban labor's household income. However, the gap continued to be widening further after 1995 (Figure 5). In 2002, the farm household income fell down to 73 percent of urban laborers' household income.

4. *Farm Income support Policy*

4.1. *A Brief History of Farm Income Support Policies*

Until the 1980s farm income policies mainly consisted of market price support programs that included a broad range of policy measures such as the two-tier price for grain and the import restrictions for agricultural products. After the mid 1980s, rural industrialization became a new alternative for price support policy. It was believed that the development of small and medium firms in rural communities could increase rural household income by creating job opportunity. However, the rural industrialization policy was not so successful for the following reasons:

In contrast to the relatively decentralized pattern of industrialization in Taiwan and Japan, industrialization in Korea was concentrated in the Seoul and Busan areas. And so was the infra-structure for the industrialization.

Figure 4: Farm Income Trend

Source: Korean Ministry of Agriculture and Forestry

A depletion of young and productive human capital in rural areas occurred as a result of migration from rural to urban areas (Song, 1991).

In the early 2000s, Korean government began to realize that "The Rural Structural Improvement Project" was not so successful. Though Korean government wanted to see a soft landing of agriculture, the economic indicators of agriculture were set in a crash landing course. As shown above, the scale of farms were not enlarged enough to get the benefit of economies of scale and the structure of agriculture was not adjusted satisfactorily.

To rectify the problems, the government divides its agricultural policy into three parts—agricultural industry policies, farmer policies, rural community policies. For the agricultural industry policies, the government is trying to get rid of less market oriented programs and promoting "innovative policies that facilitate responsiveness to market conditions by agricultural producers."[1] For the farmer policies and the rural community policies, the government is taking a role of 'the visible hands' and trying to correct the results of market failures in the agricultural sector. The problems such as low farm income, weak agricultural labor power and insufficient farmers' welfare are the major concerns of

[1] OECD, Ministerial Communiques Related to Agricultural Policies, 1998, http://www.oecd.org/agr/ministerial/commune.htm

Figure 5: Income disparity between farm households and urban laborers' households

Source: Korean Ministry of Agriculture and Forestry

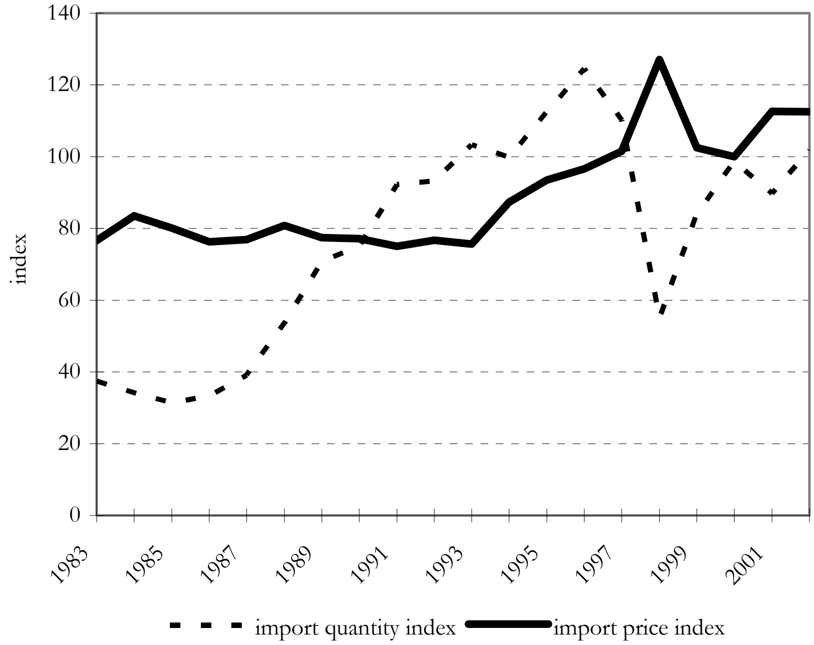
the government. The farm income support policy is beginning to be used as a comprehensive countermeasure against those major problems.

4.2. *Suggestions for Farm Income Support Policy*

Since the UR, Korean government tried very hard to rectify the aftereffects of the rapid and compact economic growth on agriculture such as 'large number of farm employments with small size farms,' 'excess number of old farmers,' and 'vulnerable income structure.' The government spent billions of dollars in "The Agricultural Investment and Loan Program" for restructuring of the agriculture. However, farm income growth rate began to slow down in 1994 when the first market opening shock hit the domestic market (figure 4). Figure 6 shows that, in the early stage of agricultural trade liberalization, the market opening power was so strong that both the import quantity and the price went up simultaneously. As we have seen in Table 8 and Figure 5, the deterioration of agricultural terms of trade and the income disparity became eminent after the opening of agricultural product market in 1994.

It is clear that the government policies could not make the agriculture recover from the trade liberalization shock. "The Agricultural Investment and Loan Program" failed in creating appropriate structural changes that are needed for farmers to make sufficient agricultural income. Hence, Korean government

Figure 6: The Import Quantity and Price Index of Agricultural Products



Source: Korean Ministry of Agriculture and Forestry

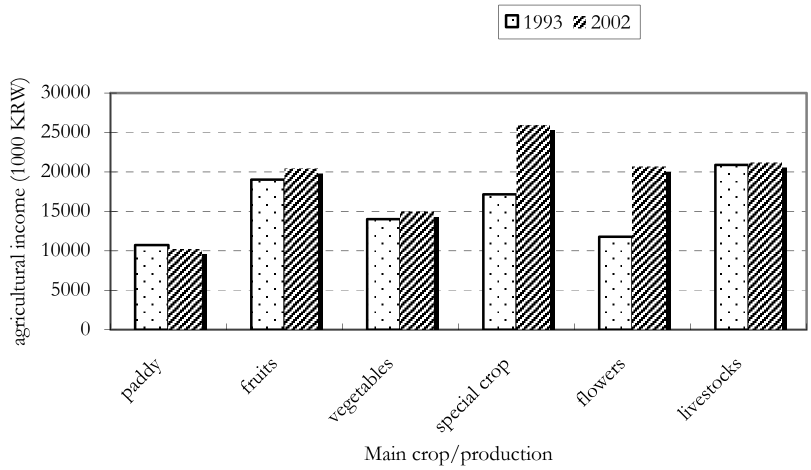
has to bear a heavy burden of running farm income programs and agricultural restructuring programs at the same time.

4.2.1. *Farm Income Program: Direct Payment for Rice Farmers*

Rice is the most special and sensitive agricultural product in Korea. About a half of farm income is generated from rice farming. However, Korean Rice industry suffers from chronic excess supply problems. Although per capita consumption of rice is decreasing very rapidly (137kg in 1979, about 80kg in 2004), old rice farmers do not want to give up rice farming. Furthermore, the mandatory rice import quota (MMA or TRQ) imposed by the UR agreement will be increased substantially after the WTO/DDA negotiation. It is obvious that the domestic price of rice will go down due to the excess supply and so will be the income of farmers.

According to Figure 7, the income from paddy rice farming was decreased during the period of 1993-2002 while the incomes from other farm products were increased. About one half of rice farms had harvested area less than 1.5ha (Figure 8). Table 9 shows that rice took up 33.9% total PSE in 2003. To sum up, rice farmers in Korea are old, poor and with small farms.

Figure 7: Type of Farms and Agricultural Income



Source: Korea National Statistical Office, Agriculture Census, 2000.

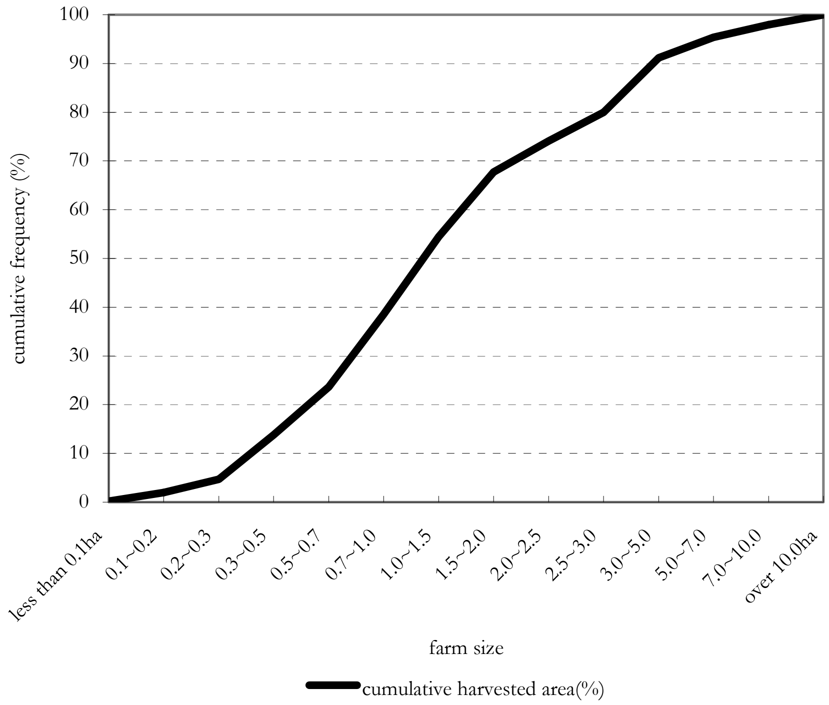
To overcome these problems, various blue box subsidy programs and farm scale improvement programs are tried and implemented. But many of the rice farmers still think that market price support (MPS) is the best policy measure for them. Old farmers are not interested in expanding the size of their farms. Farmers with small farms are not attracted to blue box subsidy that is paid for the area of farms. The farm scale improvement programs are working much slower than expected due to the high price and the low mobility of agricultural land. However, because of the excess supply problem and WTO's criteria for domestic support, MPS is no longer a good policy option for the government.

At this point, a direct payment completely decoupled from rice production that does not make farmers stick to rice farming can be an effective policy measure. Of course, it is necessary to allow an adjustment period for farmers who want to switch over to other crops or other industries. During the adjustment period, the MPS should be cut down gradually and substituted slowly by appropriate income safety nets or welfare programs.

4.2.2. *Agricultural Restructuring Program: Agricultural Land Policy*

In Korea, the price of agricultural land is so high that a good portion of production cost is paid for rent. For example, in the case of rice, 45.4% of production cost is paid for the paddy field rent (Table 10). Also the high price of agricultural land is the worst obstacle for the farm scale improvement policy. The high cost of production and small farm size are the principal causes of farm income problems. The acute rise of agricultural land price in late 1990s considerably worsened farm income situation (Figure 9).

Figure 8: Cumulative Distribution of Rice Farm Size ('00)



Source: Korea National Statistical Office, Agriculture Census, 2000.

Due to the high price of agricultural land, most of the farmers have to expand their farm land by renting rather than purchasing. Hence, the area of agricultural land cultivated by tenant farmers is expanding rapidly. Already 45% of agricultural land is cultivated by tenant farmers. The government is helping many commercial tenant farmers to acquire land through midterm lease/loan programs provided by the farm scale enlargement policy.

However, this tenant farm oriented policy has two shortcomings. The first one is that it is not good for environment-friendly farming. For environment-friendly farming, especially for organic farming, the top soil of the farmland should be cultivated carefully. It might not be attractive for tenant farmers to preserve good quality top soil for organic farming since it needs long-term investment.

The second one is that it is not good for direct income payment programs. Direct income payment programs are designed for farmers' benefit not for land owners.' However most of the direct income payment programs are based on the area of farms, the benefit of the payment eventually go into land owners' pocket. If the government wants to support environment-friendly farming and

Table 9: The PSE of Agricultural Products in Korea(Unit: million US$)

	1986	1989	1992	1995	1998	2001	2003
Rice (**A**)	4567	8192	8013	8258	4930	6976	5767
Barley	214	412	328	322	100	211	143
Soybeans	136	334	234	323	160	189	214
Milk	335	686	656	762	524	747	811
Beef and veal	485	844	1036	1727	646	1073	1204
Pig meat	390	525	859	1242	443	252	581
Poultry meat	86	295	396	601	159	237	201
Eggs	1	174	198	106	88	104	121
Garlic	295	608	730	1140	633	54	250
Red pepper	467	241	896	1112	354	671	517
Chinese cabbage	67	146	115	158	108	125	131
% PSE	66	76	73	72	57	63	60
MPS	9437	18207	18792	23860	11769	15432	15510
PSE (B)	9491	18487	19700	25204	12475	16399	17016
A/B(%)	48.1	44.3	40.7	32.8	39.5	42.5	33.9

Source: OECD data base

to stabilize tenant farmers' income through direct income payment programs, it is necessary to give up tenant farm-oriented policy. And if the government wants to expand the size of farms without using tenant farm-oriented policy, it is necessary to keep the level of agricultural land price sufficiently low so that the farmers can purchase land more easily.

In order to keep the agricultural land price low, the government may take a three step approach as follows. First, set up a comprehensive national land use plan. Second, according to the plan, implement appropriate legal restrictions on the use of agricultural land. Third, establish an institution that deals with long term lease/loan program for agricultural land (e.g. a land bank).

5. *Conclusion*

After the UR, Korean government and farmers tried hard to restructure the agriculture in preparation for the opening of agricultural market. However, the fast structural adjustment did not solve farm income problems but brought about many controversial issues such as rapidly aging farmers, too many tenant farmers, rice-monoculture, and so on. Those issues are not likely fixed by mid-term policy programs that are only useful for patching up temporary income fluctuations. For a more thorough settlement, it is necessary to implement long term policies such as completely decoupled direct income payment policies and comprehensive agricultural land policies that guarantee low agricultural land price.

Table 10: Rice Production Cost

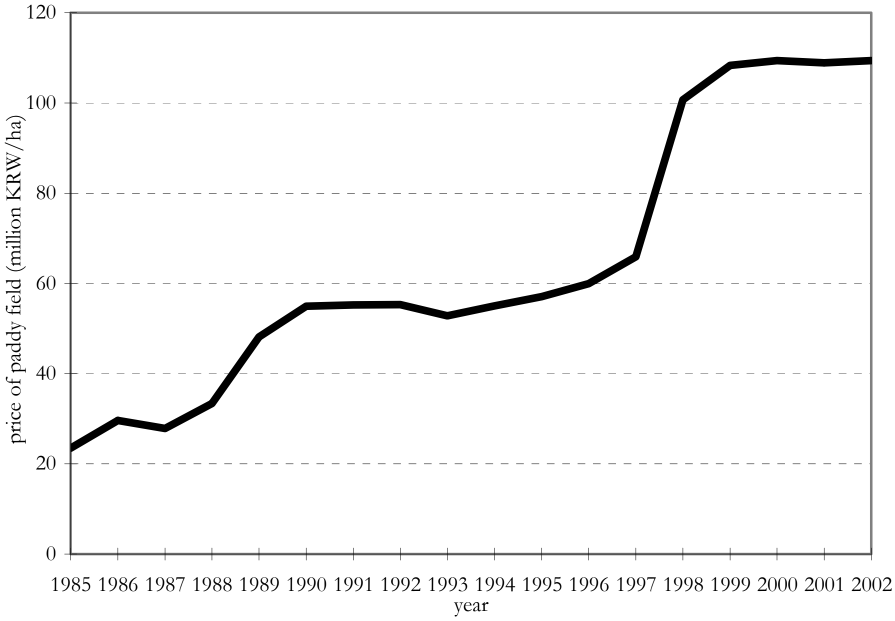
	2001		2002	
	KRW	ratio(%)	KRW	ratio(%)
production cost per 0.1ha	**535,712**	**100**	**529,609**	**100**
- seed	10,065	1.9	9,763	1.8
- fertilizer	23,567	4.4	24,842	4.7
- insecticide	26,024	4.9	22,549	4.3
- tools & machine	80,128	15	80,368	15.2
- wage	115,774	21.6	112,738	21.3
- rent for land	241,006	45	240,639	45.4
- interest	25,989	4.9	24,716	4.7
- others	13,159	2.4	13,994	2.6
production cost per 80 kg	**81,371**		**87,995**	

Source: Korean Ministry of Agriculture and Forestry

For Korean agriculture, 2004 is a year of negotiation. So called "The Rice Negotiation"[2] and the WTO/DDA negotiation is under way. Whatever the results of the negotiations turn out to be, the Korean agricultural market will be opened wider than ever. And Korean farmers will suffer from the reduction of the PSE. If the attempt to the structural adjustment was successful, Korea could open its agricultural market more willingly. However, the negotiations could be enlightening experiences for Korean agriculture. If the government and farmers could learn that all agricultural problems cannot be solved through a few months of negotiation, the government and farmers would concentrate on long term agricultural policies that could transform the agriculture into more efficient industry.

[2] According to the UR agreement on agriculture annex 5 section B, a negotiation on the question of whether there can be a continuation of the minimum market access (MMA) quota for rice shall be initiated and completed within 2004.

Figure 3: The Trend of Average Agricultural Land Price



Source: Korean Ministry of Agriculture and Forestry

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The Futures Market as a Tool for Farm Commodity Price-Hedging under the Conditions of State Interventionism in Poland

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Abstract

This article tackles the problems of the economic conditions and opportunities in the Polish agriculture for the application of the futures market instruments as tools for managing the risk of adverse price changes and stabilizing the prices of agricultural commodities. It also recounts the results of an experiment conducted between 1998-2000 on the application in the Polish agricultural market of the futures market instruments as tools for hedging grain prices in a situation when the government's interventionist policy directly confronted and influenced the functioning of this market in Poland.

1. *Introduction*

The period between 1990 and 2002 in Poland was marked by intensive laying of the groundwork for the functioning of the market economy. It was at that time that many market institutions were taking shape and assuming their present characteristics, including the institutions providing market instruments for managing price risk – the commodity exchanges, as well as the institutions participating in the process, such as commodity brokerage houses or licensed warehouses. The agriculture of that period was under strong influence of state interventionism, which considerably affected the prices of agricultural commodities and also the shape and functioning of the new agricultural institutions, as well as the attitudes of the people involved in commodity trading. The Polish agricultural market in the last decade has been marked by considerable instability and fluctuations in the economic factors influencing production, including the prices of basic commodities, and above all, grains and pork. Governmental interventions in these markets did not always bring the desired effect. On the other hand, a considerable proportion of the agricultural market players did not have the chance to use their own discretion to apply market instruments to manage price risk and stabilize the income from farming, which made production less and less profitable and, simultaneously, gave rise to a growing dissatisfaction in the farming community.

This article tackles the problems of the economic conditions and opportunities in the Polish agriculture for the application of the futures market instruments as tools for managing the risk of adverse price changes and stabilizing the prices of agricultural commodities. It also recounts the results of an experiment conducted between 1998-2000 on the application in the Polish agricultural market of the futures market instruments as tools for hedging grain prices in a situation when the government's interventionist policy directly confronted and influenced the functioning of this market in Poland.

2. *The futures market in agriculture*

In agriculture, more than in any other area of the economy, the fluctuations in the economic setting for production are poorly tolerated. The investment made by the producer in land, the means of production and the equipment is usually beyond their current financial means, thus forcing them to resort to obtaining the help of a bank. The producers are, therefore, constantly burdened with loans, the repaying of which depends on the price they obtain for the commodities they produced. This is, however, the most uncertain aspect of the business – the price that the producer will be able to obtain at the moment of selling his commodities. If it is lower than the cost of production, the farmers will not be able to repay their debts and may consequently lose everything.

In the case of production risk, which cannot be avoided or predicted with certainty – floods, hailstorms, droughts, etc. – farmers can undertake measures in order to mitigate the results of such occurrences, by taking out insurance against losses from those risk. However, the one type of risk that leaves agricultural producers as well as manufacturers powerless is the market risk, especially the risk of adverse price change. The countries where the market economy has been developing uninterruptedly for many years naturally developed strategies and mechanisms making it possible to avoid the risk of future unfavorable sales prices of commodities. The basic tools used for this purpose are commodity derivatives. They emerged because of the needs of the economy, and their considerable role in risk management in agriculture was defined many years ago.

In the literature on this subject, the futures contracts are sometimes called derivative instruments/securities or simply derivatives, and are considered securities whose value depends on the value of some other, basis variables (Hull 1997). They are also regarded as financial instruments whose value depends on the future prices of the so-called "basis assets". Derivative instruments as such have been known for ages to both producers as well as traders. They were contracts which guaranteed the future purchase or sales prices of goods (assets), signed in advance in order to insure the parties against adverse market price changes. The term "derivative instruments" indicates that their value is derived from the value of another asset or commodity, which makes them effective as tools securing against unexpected price changes (Bernstein 1997). These securities fulfill a number of useful functions in the economy, one of which seems particularly essential. Namely, it makes it possible to redistribute the risk to-

Table 1: The volume of trading in derivative instruments on the commodity exchanges around the world.

	Number of contracts in mln per year			
Country	1997	1998	1999	2000
USA	635	707	655	648
Great Britain	277	264	201	217
Japan	125	124	127	156
Germany	109	187	314	365
Other	383	388	428	640

Source: Santana Boado, 2002

wards those agents that are willing to accept and manage it. It has been determined that the instruments of the futures markets are valuable only in those environments which are open to change. Alone, they do not bring about fluctuations in the prices of basic commodities, as is commonly feared. The futures markets truly flourished in the second half of the 20th century, thanks to the development of methods of fine valuation and the increasing safety in trading achieved through the establishment of regulated futures markets.

Purchasing a futures instrument in order to secure the assets one possesses is actually no different from taking out standard insurance. The cost of security incurred in both cases may be returned manifold (if damage occurs) and similarly, in both cases "the installment" is lost if nothing adverse takes place. Insurance companies, therefore, offer a financial lever very much like derivative instruments. It simply does not appear so sinister, because we assume that the instruments purchased from the insurance companies have a specific purpose. Nonetheless, there is no difference between the intentions of the two types of contracts. Derivative instruments, purchased in quantities necessary to secure one's position in underlying assets, amount to the insurance against adverse price changes, in the same way as insurance policies covering those assets insure them against fires or other disasters. In the world economy, the impact of this market is growing steadily. Apart from the commodity exchanges which have been around for decades, new ones are appearing and successfully offering these instruments to traders around the world. Table 1 shows that between 1997- 2000 in the countries which are considered leaders in commodity trading (e.g. the USA, the UK) the number of signed contracts maintained a high, but reasonably stable level. The largest, threefold increase in the number of the contracts signed in the commodities derivative market, was noted in Germany. It is optimistic that the number of contracts in the so-called "other" commodity exchanges around the world rose twofold. This increase is mostly thanks to the new exchanges established on all of the continents which successfully trade in the commodity futures market.

The above data represent the overall commodity market, however, agricultural commodities hold a well-grounded position there. 90.2mln contracts in agricultural commodities were signed in the USA in 2000, which accounts for over 13% of the overall trading volume. In 2001, 87mln contracts were signed. Likewise, in Japan 28mln contracts in agricultural commodities were signed in 2000, which amounts to 19% of the total trading volume, and in 2001 the number of contracts was 27.5mln. In Germany, the year 2000 brought 0.35mln contracts in agricultural commodities, which accounts for only 0.1% of the total number of commodity contracts signed there. In 2001 this number was up to 0.54mln contracts and this tendency is being maintained (UNCTAD 2002). In Poland, the agricultural commodities market encountered derivative instruments for the first time in 1995 at the Poznań Commodity Exchange. They were European-style commodity calls options for frozen half carcasses from the ARR (Agricultural Market Agency) reserves. Two years later, in the commodity exchanges in Poznań and Warsaw, American-style call options and put options were offered on milling wheat also from the ARR reserves. In Poland's economic history, the first and, so far, the only futures contracts in the commodity market were signed in Poznań in 1998,where the basis commodity was milling wheat.

An analysis was carried out in the grains market, which is one of the largest and the most liquid commodity markets in domestic agriculture. The volume of grain production ranges between 24-28mln tons per year, while the domestic grains consumption is quite stable and normally reaches between 28-29mln tons. When it comes to the trading volumes, the market is dominated by trading in wheat, reaching 8.5mln tons per year. Simultaneously, it involves the largest number of potential traders.

The analysis of the wheat prices showed that between 1990 and 2002 they were quite varied, with standard deviation ranging from 2.15 PLN in 1991 to 43.47 PLN in 1996 and 49.30 PLN in 2000. A similar variability was noted in the rye market, where standard deviation ranged from 3.65 PLN in 1991 to 66.8 PLN in 1998, and 28.2 PLN in 2000. The above level of price changes classifies Polish agriculture market as one of this where production is exposed to considerable instability with regard to the price and, thereby, charged with high price risk.

In addition, the risk of adverse price changes that producers face is further aggravated by the fact that a considerable proportion of grains, i.e. 75% of crops, remain on the farms and are stored there. There are also no developed private techniques working towards the reduction of the risk of adverse price changes, such as vertical integration of the market participants. This situation indicates that it would be reasonable to undertake actions aimed at establishing the commodity futures market in order to hedge commodity prices in future transactions. Still, although there are theoretical premises suggesting that functioning of the futures market should be feasible, among others in the grains market, and despite two-years practical experience of the Poznań Exchange, the existing political and economic conditions have not been conducive to the development thereof.

3. *Commodity futures market and state interventionism*

When attempting to find reasons for the above situation, one must bear in mind that agriculture as part of the national economy is typically considered naturally weak and unattractive as a potential partner for other branches of the economy, which is related to its characteristic features, such as:

- seasonal character of production and dependence on the soil and the climate conditions;
- high risk related to the long production cycle;
- long return period on the capital tied into technological investments;
- inability to quickly change the field of production;
- combining of producer and consumer functions;

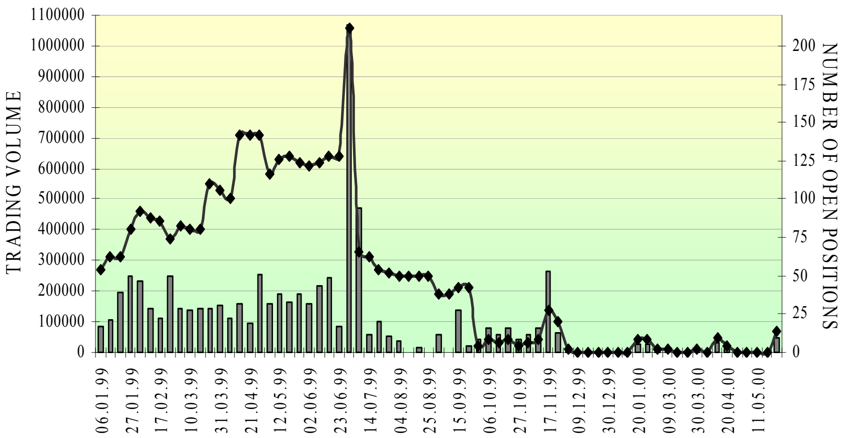
Agriculture deals primarily with the production of foodstuffs and as such, it receives special treatment. The grain and meat markets enjoy state protection in most countries. The governments of those countries consider the provision of food security to their people to be one of their main objectives. In Poland, too, such an approach was taken in the period under scrutiny, although the government's policy on agriculture was ambiguous, and above all, it did not clearly specify the rules concerning the functioning of the agricultural commodities market. This situation put the commodity futures market, whose natural habitat is the so-called "free market", in a peculiar predicament with regard to its opportunities for growth.

On the one hand, the government policy included interventionist activities meant to support agricultural producers and to ensure profitability of their production by arbitrary price fixing or using direct payments to purchasing prices. On the other hand, there was talk of a market economy where free-market rules were to regulate the supply and demand in agriculture. This ostensibly self-contradictory system caused severe criticism, yet it was sanctioned by successive governments and it was endorsed in the most strategic documents on agriculture.

The dominant opinion among the critical voices was that government's interventions in the market hindered and slowed down the development of the market economy, including that of the market instruments offered by the exchanges – e.g. the agricultural commodity derivatives. In other words, the government's direct interference into commodity trading processes and prices, which took place in Poland, brought about "market incapacitation" of the agricultural market players. This is because in their decision-making processes, they stopped following the market stimuli and instead they concentrated on the information originating in governmental agencies.

It is due to interventionism that the agricultural commodity exchange market in the European Union, although gaining in significance, is still very limited. It involves those commodities which are either excluded from the intervention scheme, or that have quotas allocated to the global market. Criticism of interventionism is further supported by the domestic experience from the only fu-

Figure 1. The influence of state interventionism on the functioning of the derivatives market in agriculture in Poland



Source: M.A Jerzak „Znaczenie rynku terminowego." Poznań 2000

tures trading episode so far, i.e. on milling wheat in the Poznań Exchange in 1999, which is presented in Chart 1.

The case illustrated in the chart shows that in the initial stage of operation (up to June 1999) the market development seemed very promising. However, the governmental intervention in the grain market which took place directly before the harvest and included a state increase of the minimum purchasing price to a level exceeding the futures price on the exchange, led to the breakdown in the development of the derivative instruments market.

On the other hand, it is known that all the governments of both the developed and the developing countries in the world employ interventionist policies in agriculture, as confirmed by data presented in Table 2.

The above data show that in the USA, the cradle of commodity exchanges and price hedging exchange instruments, in 1999 farmers received support equivalent to 20% of the average value of sold output per farmer. In Poland support amounted to 23%, this being quite a comparable quantity. Consequently, one may want to ask why it is that the US interventionism in agriculture does not collide with the functioning of the market, nor does it interfere with the market price, and on top of that, the commodity exchanges have experienced such flourishing development of the derivatives markets in agricultural commodities. In Poland, on the other hand, despite the similar size of support, interventionism has arrested the development of price hedging exchange instruments (derivatives). Even a cursory analysis of the situation leads

Table 2: The average level of support for farmers in OECD member states between 1997 and 1999

Country	PSE (mln. USD)	Weight of support* (%)
Australia	1,344	7
Canada	3,529	17
Czech Republic	722	18
EU	116,552	44
Hungary	661	13
Japan	53,127	61
Korea	17,398	65
Mexico	4,996	19
New Zealand	98	2
Norway	2,675	66
Poland	3,521	23
Switzerland	4,951	70
Turkey	12,133	34
USA	44,303	20

*weight of support expressed as a percentage of the output value per farmer
Source: OECD, 2000

to the location of its causes in the appropriate selection of the form of state intervention and the proper laying down of the procedures.

In the past decade, the grains market as well as other basic agricultural commodity markets in Poland were subject to direct governmental interference in the trading process and price pegging. Interference was arbitrary in nature, through direct payments and departamental fixing of intervention prices. Such a situation made it impossible for a nationwide market-balance price for a commodity to be arrived at. It also gave rise to a peculiar price duality, whereby the official purchasing price subject to government support existed side by side with the so-called market price. This led to the situation in which government takes over the job of price setting from the market, and the role of derivative instruments became very limited and even superfluous.

There exists another, more market-friendly form of interventionism – through indirect activities. It has been used in Poland, too, in the form of preferential loans, or subsidizing fuel prices. This form of state interventionism allows the government to meet its agricultural objectives in an indirect way, without interfering into commodity trading or price setting. In such a situation, the government's actions are no longer antagonistic towards the opportunities the commodity futures market offer. The commodity exchange can then successfully develop the futures market and offer its clients an opportunity to hedge the price for future transactions independently.

4. *Conclusions*

To sum up, it should be stated that Poland does offer the conditions necessary for the agricultural futures markets to exist. Their effectiveness, however, depends on the political line towards agriculture. This market requires that the laws of supply and demand and the rules of competition be adhered to. It was the clash between the operation of the futures market and the forms of direct state interventionism observed in the Polish grain market that has led to the breakdown of the derivative instruments market on the commodity exchange. It needs to be highlighted, though, that it is possible to continue interventionist policies in agriculture and yet avoid conflict and the undermining of the role of price-hedging market instruments. It would require that direct interventions be abandoned and replaced with indirect methods making it possible to activate market players.

The continuing liberalization of the agricultural market in the EU, of which Poland has recently become member, is forcing us to search for market ways to hedge the prices of commodities sold by producers as well as to stabilize their income. If Poland accepts the EU's clear agricultural policy, it will create conditions conducive to the development of the agricultural futures markets as important tools for price-hedging and, therefore, stabilizing incomes in farming and the entire domestic agricultural market.

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PART FOUR

PRIVATE TOOLS FOR RISK MANAGEMENT IN AGRICULTURE

Price Volatility and Flexible Trading Strategies

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Abstract

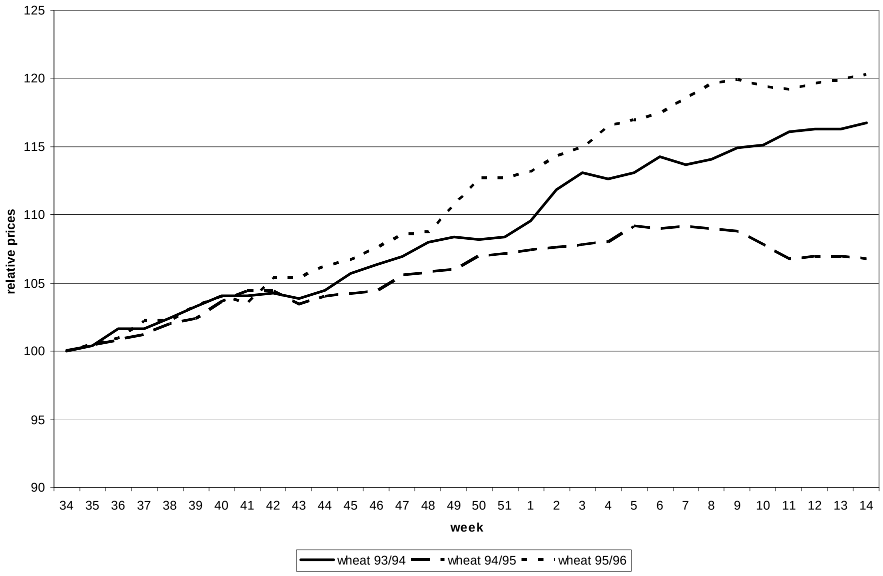
Volatile prices are a threat to many farm managers because the volatility prevents a precise and reliable ex ante calculation, whereas others regard price fluctuations as a chance to enhance their personal income situation. Farmers applying a flexible storage policy can improve their farm income without noticeably augmenting their risk exposure. Therefore price stabilization policies are of questionable utility to farmers. At first, the paper pictures alternative storing strategies and discusses flexible storing strategies which can be utilised to advantageously exploit a randomly varying price. If a respective reservation price is determined, the realized expected sales price is always higher than the expected price of the underlying price distribution presupposed that such a price is attained at all. The computations based on reasonable market conditions demonstrate that the risk to fail can be adequately reduced, hence the strategy can also be employed from risk averse farmers.

1. *Background*

Many European cash crop farmers have at their disposal considerable storage space for grain on their farms. This space was used to store the harvested crop, which was then later sold under more favorable price conditions. In the 70ies, 80ies and also in the first half of the 90ies, farmers could be sure that the market price of grains increased more or less constantly until the beginning of the following calendar year (see figure 1). The highest price usually occurred in the months between March to May with a subsequent strong fall in prices until the new crop was harvested.

Farmers could count on the expected increase as the increase of grain prices was due to the pricing policy of the EC with its strong intervention price system. The intervention price was raised monthly by a margin reflecting average storing costs of professional European grain dealers. The storage costs on many farms (at least in Germany) were considerably smaller than the national or EU average storing costs. This occurred in many cases, because farmers had unused storage capacity available and therefore did not need to attribute full costs to the storage of grain. Hence, as long as European pricing policy more or

Figure 1: relative wheat prices 1993-1996 in Germany

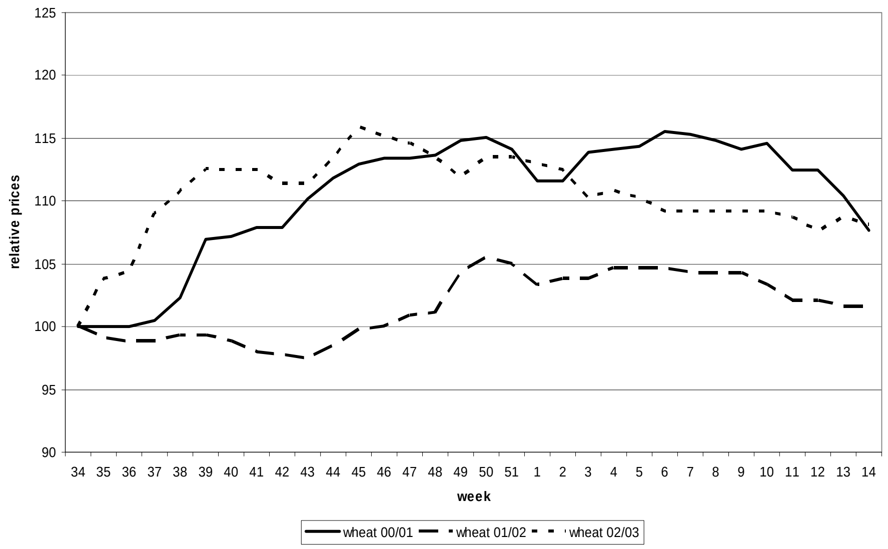


less guaranteed such an increasing price progression many farmers could realize profits by storing their grain harvest. The additional profit that could be earned by storing was only moderately high but very secure.

In recent years and also in the future, crop farmers will encounter a rather different market situation. The political intervention price system lost and will continue to lose its impact on EU market price level. World market demand and supply gained and will gain more and more influence on EU grain prices. Consequently, the seasonal pattern of grain prices changed dramatically. Rather irregular seasonal patterns displaced the familiar regular slope with one price peak in spring. Additionally, price volatility strengthened substantially (see figure 2). Consequently, the almost secure income gain, related to grain storing, vanished.

Given the remarkable changes in the market, many farmers decided to completely desist from grain storage leaving valuable storage facilities unused. The decision to give up storing grain is often done without recognizing that the changed pricing policy offers other opportunities to realize considerable profits through the storing of grain. Admittedly, the utilization of these profit opportunities demand not only switching from one strategy to another, but also a different market perception. Changing storage strategies makes it possible to substitute considerably larger but riskier ones.

Figure 2: relative wheat prices 2000-2003 in Germany



2. *Different grain storing strategies*

Farmers can utilize two rather different strategies of grain storing that vary in several aspects. Grain storing with *fixed, optimal date of sale* is a static strategy and may be successfully applied in a relatively stable market environment. This strategy demands no special efforts as to the procurement of market information. This strategy is from an economic point of view rather technical and simple, one may say too simplistic under normal market conditions.

The second strategy with *flexible date of sale* is a dynamic, highly sophisticated strategy that especially pays when markets are very volatile. This strategy requests a permanent market observation and in its most consequent variant a continuous updating and revision of the utilized price forecasts. In the following sections both strategies are described where the dynamic approach is further subdivided in models with and without updating forecasts.

2.1. *Fixed date selling strategy*

This strategy takes advantage of the fact that market prices of grains usually exhibit an increasing tendency from main harvest time (July/August) to early spring (February/March). The increase of market prices reflects the increase of storing costs of the marginal warehouse keeper, at least, in long-term average. As the storing costs of many farmers are considerably smaller than the storing costs generated by marginal commercial suppliers, farmers can expect a market price increase larger than the rise of their storing costs. Thereof follows an increasing net profit during winter and early spring months.

By the end of the storing period, in late spring and early summer months, the grain prices used to decrease to the harvest level, although the storing costs continue to accumulate. There are mainly two reasons for this definite decrease of market prices before the new harvest supply is launched:

1. the harvest supply of the southern hemisphere,
2. the expectation about the new harvest in the northern hemisphere.

Because harvested quantities in the south and the expected harvest in the north are subject to considerable fluctuations, the price decreasing phase is much more irregular than the price increasing phase. The irregularity relates not only to the timing of the turning point but also to the speed and extent of the price reduction. (Herrmann and Thompson, 2000)

The criterion for determination of the selling day is the maximum difference between expected sale price and expected storing costs. Usually a fixed selling date is determined in winter or early spring depending on location, type of grain and individual storing costs. In specific years, the difference between price and storing costs still increases in late spring and early summer but there is always a considerable risk of an unexpected and drastic fall in prices. However, in any case, the expected difference diminishes in these months.

The outlined development tendency of prices is also valid when "free market prices" exist, but is naturally much more pronounced in an intervention price system. In times when a strong intervening and stabilizing policy was carried out – e.g. in the 70's and 80's, farmers could count on this annual increase. They realized that although the gains were relatively small there was almost no risk attached to this strategy. With increasing liberalization of agricultural policy the price development became unstable and the fluctuation of prices around expected values became more distinct (Witzke, 2002). Therefore many farmers gave up storing grain because of the increased risk of this strategy.

2.2. *Flexible date selling strategy without updating*

The initial point of the alternative grain selling and storing strategy is rather different in nature. This strategy is targeted at the exploitation of the erratic and random price fluctuations around the expected value. The strategy simply requests that the stored grain is sold if the actual market price, less storing costs, is higher or equal to a preset price level, the so called "reservation price or reserve price".

In the following, we assume for the sake of simplicity, that the trend of prices from harvest to early spring outweighs the increasing storing costs, i.e. the net prices of grain (net of storing costs) have an identical expected value over the whole period from the time after harvest until March. The average realized net price by this strategy is higher than the expected price if three conditions are fulfilled:

1. The probability of occurrence of a market price higher than or equal to the reservation price must be sufficiently large.
2. The fluctuations of market price must be random and not too strongly auto correlated.
3. In the period between price observation and actual selling, the market price has to remain unchanged or at least the prices, at both the points in time, have to be serially correlated.

The expected net return resulting from applying the flexible strategy $E(RNP)$ is then given as:

$$E(RNP) = p\,[E(rNP \mid rNP \geq RP)] + (1-p)M \qquad (1)$$

with:

$E(RNP)$ = expected net return resulting from flexible strategy
rNP = market prices net of storing costs
RP = reservation price
M = value of marginal utilization if $rNP_t < RP$, for all t
p = probability of $(rNP_t \geq RP)$

The expected return realized from reservation price strategy result as the probability weighed average of two possible cases.

Either: the net market price is at none of the possible selling points equal to or higher than the reservation price. In this case, the grain will not be sold within the whole period and must be supplied at the end at marginal utilization.

Or: the market price is higher than or equal to the reservation price at least at one selling point. In that case, the grain will be sold at this point in time. A selling price equal to or higher than the reservation price can be expected according to the assumed selling behaviour.

Among the variables and parameters of function (1) the following relationships are given:

1. If the reservation price RP increases, the probability to be successful p decreases.
2. If the reservation price RP increases, the expected value of the selling price, $E(rNP \mid rNP \geq RP)$ increases.
3. If the reservation price RP increases, the expected result of the flexible strategy $E(RNP)$ shows at first an increasing and then a decreasing curve progression with a maximum at $rNP_{lower} \leq RP_{opt} \leq rNP_{upper}$ where rNP_{lower} and rNP_{upper} are the smallest and largest possible market price. The reservation price corresponding to $max\ E(RNP)$ is RP_{opt}.

A simple numeric example shall illustrate relationship 3. Assume there is only one selling possibility per week and there are 25 possible weeks for selling. The market price would be normally distributed with an expected value of 100 and a standard deviation of 50. The value of marginal utilization M be 0. If the market prices between two weeks are uncorrelated, the probability p that the reservation price is matched or overdone by the market price at least in one week can be derived from the probability p_w of occurrence of market prices equal to or higher than the reservation price in any week:

$$p = 1 - (1 - p_w)^{25} \quad (2)$$

If the reservation price is increased, the probabilities p_w and p decrease whereas the expected price, in case of matching or exceeding the reservation price, increases. Consequently, also the respective price expectation $E(rNP \mid rNP \geq RP)$ increases. As the two components of the return of the strategy $E(RNP)$ goes in different directions, the expected value has a maximum. Furthermore, it should be considered that too strong a raise of the reservation price leads to an expected return what maybe clearly under the value of any fixed date strategy.

The expected value of the strategy result depends on the one hand on the characteristics of the market price distribution and on the other hand on the chosen reservation price. The reservation price that causes the maximum expected result would be optimal. However, the maximum result is dependent on the number of potential selling possibilities that still exist. The more selling possibilities exist, the higher the probability to find, at least once, a market price matching or exceeding the reservation price. That means that the optimal reservation price is also higher the more selling possibilities exist. As those selling possibilities diminish with the elapsing time the optimal reservation price decreases with time.

3. *Flexible date selling strategy with updating*

Models determining the reservation prices can also make use of a permanent updating when new information arrives. In consequence of updated estimates the reservation price model must be revised and re-run. Two situations may particularly request updating and re-running.

World market prices of grains are affected by many factors. The harvested quantity of grains, the available stocks and the world economic situation are prominent impact factors. If the comprehension of these or other factors improves the quality of price estimation, the calculation of strategies should be based on such enhanced procedures. However, grain prices have frequently shown in the past a shift in the level of prices that could not easily be explained by these factors, but this shift remained persistent over the main part of the year. Annual dummy variables are often and successfully used to grip this shift phenomena but without any explanation. However, including the year dummy makes the price estimates much more precise, hence to consider the yearly shift in the determination of reservation prices would certainly improve the results. Yet, these dummies are usually ex post estimated and therefore cannot be used for the prognosis of market prices within the current year. A possibility to make use of the incoming information at an earlier time is to estimate the annual shifter by applying Bayesian statistics (Hamburg, 1977). Noell and Hanf (1990) have shown that in many cases such price shifters can already be determined sufficiently precisely when only a minimum of price information is available.

This possibility, to successively improve the estimated prices, can also be implemented in the modeling to determine the reservation prices. The consideration of learning about annual shift parameters request that the model has to be re-run after each new price is entered with the respective adjusted values. As the initial Bayes estimates can indicate the wrong direction, one should wait, if using Bayes updating, until three or four weeks price information is available.

Another reason for applying reservation price models with updating routines is the serial correlation of prices. Particularly, when we have to consider the possibility of selling grains every day. In this case, the assumption of a random price deviation, independent of the price realization of the day before, seems to be rather unrealistic. The relationship between consecutive prices can, for instance, be modeled by introducing autocorrelation coefficients or by applying random walk procedures. Theoretically, the price estimates of all prices are affected by any singular deviation, however, practically only the first two or three prices may be noticeably influenced. Hence, only a very small part of the reservation price model has to be revised daily.

4. *Computation of storing strategy and determination of the reservation price*

In general, two computational approaches are used to determine a best reservation price strategy. First, a stochastic dynamic programming approach has been used by Berg and Weindlmaier (1984), Berg (1987), Hanf and Kuehl (1986) and Thomsen (1999). Much easier to establish and easier to adjust to changing market conditions are the heuristic approaches of budgeting (Hanf, 2004). Both approaches should be briefly outlined.

4.1. *Dynamic programming approach*

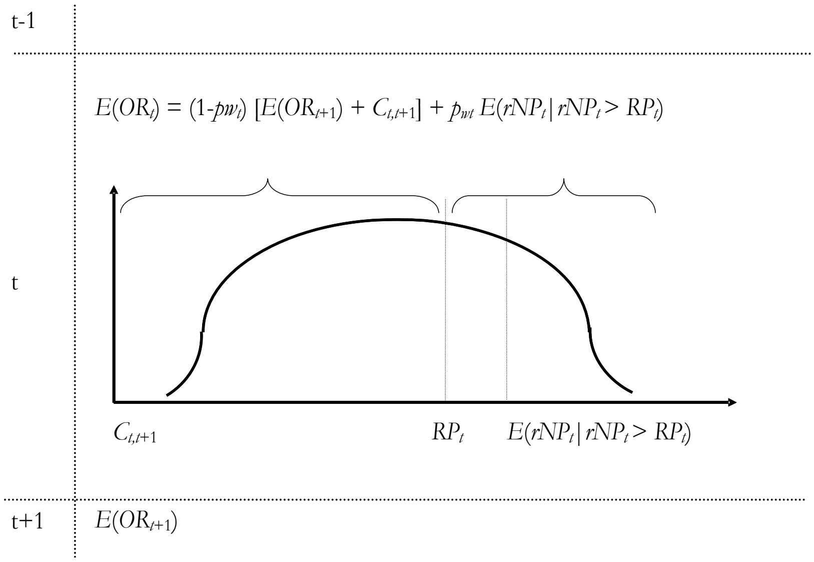
If we use the recursive approach to dynamic programming we have to sequentially appoint a reservation price to any potential selling period (Kennedy, 1986). The optimal reservation price of any period t is given if the expected value of the net market price lying above the reservation price in t multiplied by the probability p_{wt} to reach such a net price in t is equal to the expected result of storing one period longer. The expected result of storing in t is equal to the expected result in $t+1$ less the accruing storing costs multiplied with the probability $(1\text{-}p_{wt})$ of reaching the reservation price. This condition is given in (3):

$$p_{wt}\ [\ E(\ rNP_t \mid rNP_t \geq RP_t)\ ] = (1\text{-}p_{wt})\ [\ E\ (\ OR_{t+1}) - C_{\ t,\ t+1}\ ] \qquad (3)$$

with:

$$E(OR_{t+1}) = p_{w,\ t+1}\ [E(\ rNP_{t+1} \mid rNP_{t+1} \geq RP_{t+1})] + (1\text{-}p_{wt})\ [E(OR_{t+2}) - C_{\ t,\ t+1}] \qquad (4)$$

Figure 3: Recursive relationships between two periods



where $E(OR_{t+1})$ is the expected result after determining optimal reservation price in t+1 and $C_{t,\,t+1}$ is the storing costs from t to t+1

In the last potential selling period T the expected result $E(OR_{T+1})$ is replaced by M, the monetary value of marginal utilization.

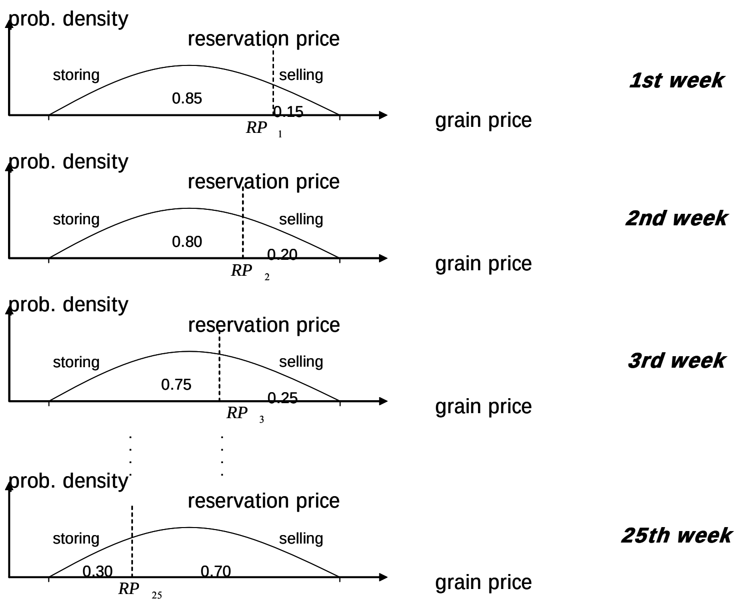
Figure 3 exemplifies the recursive relationship for two periods t and t+1. In period t a reservation price RP_t has to be assigned. If a net market price occurs that is higher than or equal to RP_t, the grain is sold with an expected price of $[E(\,rNP_t \mid rNP_t \geq RP_t)]$. The probability of such a price is p_{wt}. In case that the market price is below the reservation price level, the grain is stored to the next period and is supplied there to the optimal use that has an expected value of $E(OR_{t+1})$. In addition, the storing costs have to be taken into consideration.

4.2. *Heuristic and parametric approach*

A rather simple approach is to heuristically predetermine a functional form of the development of the reservation price in time. If the progression of the reservation prices is known, it is easy to calculate the expected result of this given strategy or the reservation price formulation respectively, considering the assumed weekly price distribution from the beginning to the end. A best solution is to be found by the systematic changing of the parameters of the progression curve.

In figure 4, this approach is outlined. It might also be that the weekly price distributions shift with time; the only pre-condition for calculating the profit-

Figure 4: Heuristic predetrmination of a reservation price and probabilities to exceed it or fall short



ability of the strategy is that the weekly distributions are ex ante known and the reservation price is pre-determined (Hanf and Schiefer, 1980).

5. *Volatility of market prices and farm profits from grain storing*

5.1. *An exemplary model situation*

In order to analyze the relationship between price volatility and farmers' possible profits from grain storing, a rather simplistic model situation is defined. It is assumed that prices randomly vary around a linear trend line with positive gradient in order of magnitude of the increase of accrued storing costs.

For the sake of simplicity, it is further assumed, that the harvested grain is placed in store in any case. Hence, the costs of rolling in can be neglected. Therefore, the only decision to be investigated remains to determine the date or the conditions under which the stored grain is sold. We consider as the possible selling period the 25 weeks from end of September to the middle of March. Due to this assumption, sufficient time elapsed between harvest and the beginning of the investigation period in order to estimate the annual shift of prices sufficiently accurately. Furthermore, only one selling day per week it is assumed.

Table 1: Expected return of a flexible strategy under changing reservation prices

reservation price RP	probability p_w that $rNP \geq RP$	probability p that at least once $rNP_t \geq RP$	expected price if at least once $rNP_t \geq RP$	expected net return of flexible strategy $E\,(RNP)$
100	0.500	1.	133.72	133.72
110	0.421	1.	140.26	140.26
120	0.345	1.	147.26	147.25
130	0.274	0.999	154.67	154.61
140	0.212	0.997	162.42	162.00
150	0.159	0.987	170.48	168.21
160	0.115	0.953	178.79	170.58
170	0.081	0.878	187.32	164.49
180	0.055	0.756	196.02	148.12
190	0.036	0.599	204.89	122.81
200	0.023	0.437	213.88	93.57
210	0.014	0.295	222.99	65.85
220	0.008	0.186	232.19	43.19
230	0.005	0.110	241.49	26.62
240	0.003	0.061	250.84	15.54
250	0.001	0.033	260.26	8.64

Distribution of market prices: Normal(μ = 100; σ = 50).

As we do not want to refer to a particular type of grain, a particular region or a particular year, we simply assume that there is a grain which prices are randomly varying, serially independent and normally distributed about an expected net market price (net of storing costs) of $\mu = 100$ with a standard deviation σ. The assumption of serial independence maybe justified in case that only one selling day per week is admitted.

The heuristic and parametric approach described in section 2.4.2 is used. The parameterization of reservation prices is simply based on a constant value at every selling point in time, although a correct determination of optimal reservation prices would result in decreasing prices when approaching the last selling possibility. Hence, the presented results marginally underestimate the possible results of the storing strategy.

6. *Some computational results*

6.1. *Interpretation of the basic run*

In Table 1, the results of one of the parameterization are presented. The different lines show results of computations with different reservation prices *RP* (see col. 1).

Figure 5: Expected value and probability of price > RP

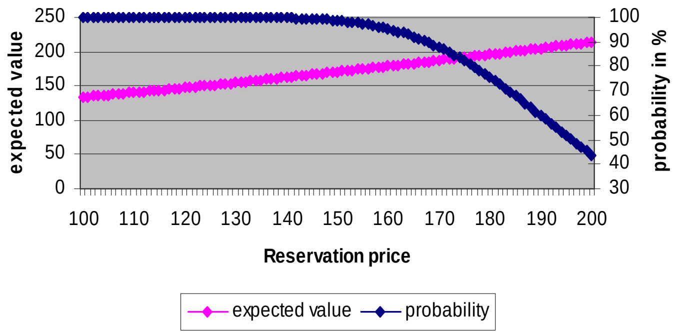
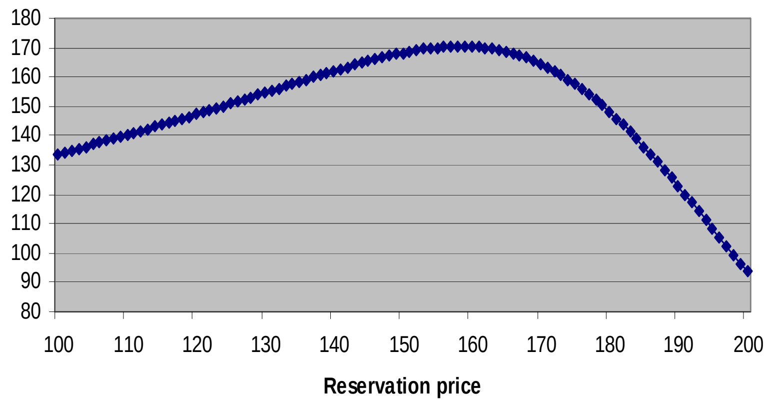


Figure 6: Expected return of flexible strategy



If the reservation price *RP* is set to 100, the probability of receiving a market price higher than *RP* is $p_w = 0.5$ in every of the periods 1 to 25 (see col. 2). The probability to find at least one market price in the 25 weeks that equals or exceeds *RP* = 100 is almost 1 (see col. 3). The expected value of the net price found $E(rNP_{t+1} \mid rNP_{t+1} \geq RP_{t+1}) = 133.72$ (see col. 4). The expected return of the flexible strategy *E*(*RNP*) also equals 133.72 as the multiplier *p* is only marginally smaller than 1.

Line 11 of this table shows the respective results when a reservation price *RP* = 200 is taken into account. The probability of exceeding the reservation price of 200 is rather small in every single period with $p_w = 0.\ 023$, however, the probability to exceed this reservation price at least once in the 25 periods is with $p = 0.437$ still relatively high, almost a 50 percent chance. If the reservation price strategy is successful, the expected price is 213.88 (see col. 4), but

Table 2: Expected net result of flexible storing strategy under varying standard deviation of market prices

Standard deviation of market prices σ	Optimal reservation price *RP*	Expected net return *E (RNP)*	Standardized reservation price $(RP-\mu) / \sigma$	Probalitity (price > RP) *p*
10	109	112.58	0.90	0.99
20	121	126.58	1.05	0.98
30	133	140.98	1.10	0.97
40	146	155.64	1.15	0.96
50	158	170.46	1.16	0.96
60	171	185.40	1.18	0.96
70	185	200.41	1.21	0.95
80	198	215.49	1.23	0.95
90	211	230.61	1.23	0.94
100	224	245.75	1.24	0.94

Average market price: μ = 100

since the chance of selling is only less than 50% the expected return to the strategy is only 93.57 (see col. 5).

The best result is achieved under these conditions when the reservation price is set to 160. The expected return is then 170.58 (see col. 4). The probability of not selling is $(1 - p_w) = 0.047$. This maybe too high for risk averse decision makers (Odening and Musshoff, 2002). This risk can be considerably reduced without a strong loss, with respect to the expected return of the strategy. If the reservation price is set to 150 instead of 160 the expected return diminishes only by a little more than 1% (from 170.58 to 168.21) whereas the risk declines remarkably from 4.7% to 1.3%.

Column 3 and 4 of table 1 reflect the development of the probability p and the expected net marked price when the reservation price increased. The curves of both the components of the expected result of storing go steadily in opposite directions with increasing RP (see figure 5). As a consequence, the function of the expected results is concave with a single maximum (see figure 6).

6.2. *The impact of price volatility on flexible storing strategy*

To investigate the impact of price volatility on flexible storing strategy the above-described model was employed. The optimal reservation price and the thereof resulting probabilities and expectations have been determined in a series of computations where the standard deviation of the net market price was systematically varied. Optimal reservation prices are calculated for standard deviations from $\sigma = 10$ to $\sigma = 100$. Taking into account an expected market price of 100, this means the coefficients of variation vary between $v = 0.1$ and $v = 1.0$. The lower value corresponds to market situations with a political price intervention. In the time of strong intervention in the EU the coefficient of variation was usually even below 0.05, whereas in free market situations, coefficients of variations larger than 0.3 are not uncommon. (Drescher and Hanf, 1995)

In Table 2, the main computational results are summarized. It can be seen that with increasing volatility of market prices – here expressed by increasing standard deviations – the optimal reservation price also increases. By the way, the optimal reservation prices increase slightly more than proportionally with standard deviation (see table 2, col. 4). The expected outcome of the flexible strategy also increases with increasing standard deviation and reservation price.

If price variation is characterized by a coefficient of variation about 0.3 or $\sigma = 30$ respectively, a net profit of storing of about 40 percent over the average market price can be expected (table 2, line 3, col. 3). The risk of not finding a market price above the optimal reservation price and of keeping the stock until only marginal utilization is available, is with 3 percent rather moderate (see line 3, col. 5). If this risk appears too high one could choose a reservation price of 126.5 instead of 133. With this reservation price, the flexible storing strategy results in an expected outcome that is almost exactly 1 percent less and risk is reduced from about 3 percent to less than 0.6 percent.

The calculations are only based on stylized data and only very simplistic market and storing conditions are considered. Nevertheless, the attained results indicate the order of magnitude of the possible gains that farmers can receive by consequently applying flexible storing strategies, provided the random fluctuations that are inevitable in free market systems are not levelled off by expansive policy interventions.

The advantage of a flexible strategy becomes especially visible if one compares its profit potential with that from a fixed date strategy. The additional profit to be expected by consequent exertion of fixed date strategy is usually relatively small. The expected profit results mainly from the difference between the storing costs of a marginal supplier and the storing costs of the farmer under investigation. Even if the marginal supplier calculates full costs and the farmer only variable costs, the cost difference may not exceed 50 percent of storing costs which account for notably less than 10 percent of the price (Thomsen, 1999, p.123). Approximately calculated, the profit margin by applying a fixed date storing strategy maybe at a maximum 5 percent of the average market price but probably even less.

6.3. *The impact of the number of selling opportunities*

The investigations, as to the number of selling points, resort again to the base model with expected net market prices of 100 and a standard deviation of 50. These investigations should indicate to which extent the number of selling possibilities affect the results of flexible storing strategies. For this purpose, the number of independent selling opportunities are reduced and for each opportunity an optimal reservation price has been calculated.

Table 3: Expected net result of flexible storing strategy under varying number of independent selling points

Number of selling points	Optimal reservation price *RP*	Expected net return *E* (*RNP*)	Probability of (price > *RP*)
30	163	174.56	0.96
25	158	170.46	0.96
20	153	165.33	0.96
15	145	158.55	0.96
10	133	148.65	0.95
5	110	131.11	0.93

Average market price: $\mu = 100$; standard deviation of price: $\sigma = 50$

In table 3 the optimal reservation prices for a varying number of selling points in time are presented. The less selling dates available, the smaller the reservation price. Consequently, the expected outcome from flexible storing E(*RNP*) decreases. Only if less than 10 selling points are still available, the risk of failure of the strategy increases and may not easily be equalized by reducing the reservation price and thereby the expected outcome.

The presented results of the calculations in table 3 are also useful with respect to the specification of the functional form of the change of reservation prices in time. As discussed above, dynamic optimization models will result in optimal reservation prices diminishing to the end of the selling period. Therefore, it is sometimes recommended, if simulation models are used, not to assume constant reservation prices but rather a decreasing function. Such results can be used to elaborate to which extent the reservation price function will curve on the graph.

7. *Summary and conclusion*

The most important statements of this contribution may be summarized as follows:

1. Storing of the harvested produced grain on farm can provide farmers with a chance for additional profit but admittedly there is always a certain risk attached to this.
2. Storing and selling the grain may be done by implementing two rather different business strategies, a fixed date and a flexible strategy.
3. The fixed selling date storing strategy is employed in order to utilize the usually recognizable seasonal rise of grain prices between harvest of grain and spring. This strategy presupposes that the respective farmer have at their disposal cost-efficient storing facilities.
4. The flexible strategy systematically utilizes the (random) weekly or daily deviations from the expected market prices. A reservation price is pre-

defined and if the market price equals or exceeds this reservation price the grain is sold.

5. The intervention price system of the EU in the 70ies and 80ies considerably reduced the price volatility and strengthened a continuously increasing price drift from harvest to spring. The fixed strategy has been outstandingly attractive for farmers under these market conditions.
6. Considering present and particularly future market conditions, farmers are facing a market situation with pronounced price deviations and ambiguous seasonal price development. The flexible storing strategy employing reservation prices notably gains attractiveness under these market conditions.
7. Employing a flexible storing strategy under free market conditions promises even higher profits than a fixed date strategy could gain under the strong intervention regime of the EU. However, this strategy brings a non-negligible risk if the strategy is consequently applied.
8. In view of the risk of failure, the determination of reservation prices should only be done by experts.
9. An improved operational security is possible by slightly deviating from the optimal value of the reservation price without losing too much of expected return but reducing the risk significantly.

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Weather Derivatives as a Risk Management Tool in Agriculture

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1. *Introduction*

The settings towards entrepreneurial risk have changed as a consequence of past and presumable future reforms of the CAP. Globalisation and liberalisation of agricultural trade combined with declining commodity price support results in an increase of market risks. In agriculture more stringent regulations with regard to the application of agro chemicals evoke a rise of yield variability. In livestock production the high degree of specialisation simplifies the spreading of diseases leading to extreme economic impacts for the farmer. On the other hand the direct payments of the CAP are risk reducing as they are independent of price and yield. There is still a controversial discussion whether all this results in an increased variability of net farm income. An increase of risk can be expected in any case if compensation payments are reduced or linked to additional constraints.

It therefore appears worthwhile analysing new or additional risk management instruments. Besides the securitization of price risk on the futures market, crop insurance concepts are discussed. Approaches already exist in the USA and in some European countries. However these concepts are afflicted with problems of moral hazard, adverse selection and others (Berg, 2002). Weather derivatives which have gained a considerable amount of interest could be an alternative. Contrary to traditional financial derivatives, their payoff is determined by future weather events such as temperature or precipitation. Thus, they allow the securitization of risks which are not caused by changes of market values of traded financial titles, but result from the uncertainty of climatic processes.

In 1996 the first weather contract was traded between two energy suppliers in the USA, where meanwhile a flourishing market has been established. In Germany, the number of weather contracts traded over the counter is increasing steadily. Since agricultural production is heavily dependent on weather processes it makes sense to analyse the applicability of weather derivatives to reduce agribusiness risk. In this paper we will discuss this question.

The paper starts with a brief characterisation of weather derivatives. Following, we discuss fields of application as risk management tools in agribusiness.

An example illustrates the effects. The paper ends with some conclusions showing the possibilities of weather derivatives in agriculture.

2. *Characteristics of weather derivatives*

Generally speaking, weather derivatives are forward contracts. They normally occur either as futures or as options. In principle both types can be traded at financial exchanges or "Over The Counter (OTC)". In the first case the contracts are standardised. The buyer or seller cannot influence the contract parameters. Contrary to financial exchange tradings the OTC market is less formalised and is characterised by individual agreements between the contract parties.

Most weather derivative transactions take place at the OTC market. Only so called "Degree-Day-Derivatives" are traded at the Chicago Mercantile Exchange (CME). Their market volume is steadily increasing. In Europe, the London International Financial Futures Exchange (LIFFE) quotes indices based on the cumulative average temperature (CAT) of the cities of London, Paris and Berlin, but trading of weather derivatives has not yet started.

Although each kind of future transaction is possible, options dominate the market as they are particularly appropriate to reduce downside risk. For this reason, we will focus on options in the reminder of this paper.

3. *Function and characteristics of weather derivatives*

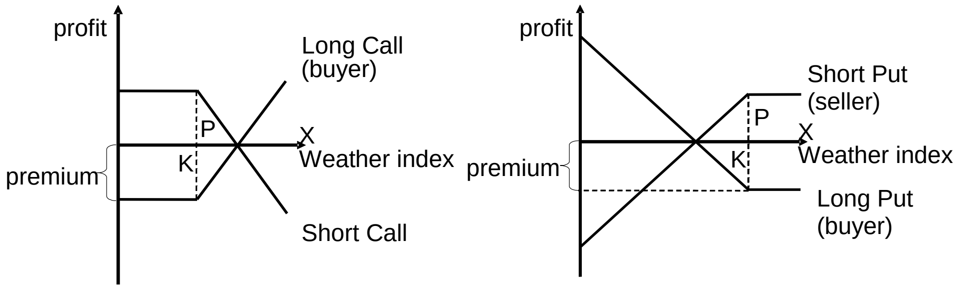
Generally, the buyer and seller of an option are in the following situation: the buyer (long position) purchases a right and pays a premium for it. The seller (short position) accepts an obligation and receives the premium. Depending on the content of the right, options are distinguished in two basic types: in the case of a call option the buyer purchases the right to buy an underlying at a certain price (strike price) and at a certain time. Contrary, in case of a put option the buyer purchases the right to sell the underlying at a certain price and time[1].

The buyer of a call option hedges against increasing market prices of the underlying he wants to buy in the future. If the market price exceeds the strike price, the option will be exercised. On the other hand, a put option serves as hedge against decreasing market prices of the underlying that shall be sold at a certain time in the future. Thus, the option will be exercised if the market price falls below the strike price. In both cases the difference between market price and strike price determines the payoff of the option.

Contrary to most of the other traded derivatives, a weather derivative's underlying is not connected with financial or commodity markets. Underlyings are

[1] European options can be only exercised at maturity. American options can be also exercised prior to maturity.

Figure 1. Payoffs from different positions and options



weather indexes like temperature, precipitation, solar radiation or wind velocity. Since these variables represent no assets they are neither storable nor tradable and therefore represent so called exotic underlyings (Schirm, 2000, p. 722). But their magnitude is measurable so the payoff can be uniquely linked to the observed value of an index.

The basic positions long/short call and long/short put result from the combination of the option types "call" and "put" with the possible positions "long" and "short". The payoff structure of the respective option at maturity is depicted in figure 1. The positions "long" and "short" represent the buyer and the seller. K marks the strike level that corresponds to the strike price of a traditional underlying (for example stock prices). P is the premium to be paid or the price of the option.

The payoff is determined by the positive difference between the observed index value at maturity and the strike level K. This difference is multiplied by the tick size V that corresponds to the payment per index point. Deducting the premium *P* from the payoff leads to the profit or loss of the option. The buyer's profit (long position) for a call option is:

$$G_C^L(V,x,K) = V \cdot Max[0,(x-K)] - P \tag{1}$$

The buyer's profit for a put option is:

$$G_P^L(V,x,K) = V \cdot Max[0,(K-x)] - P \tag{2}$$

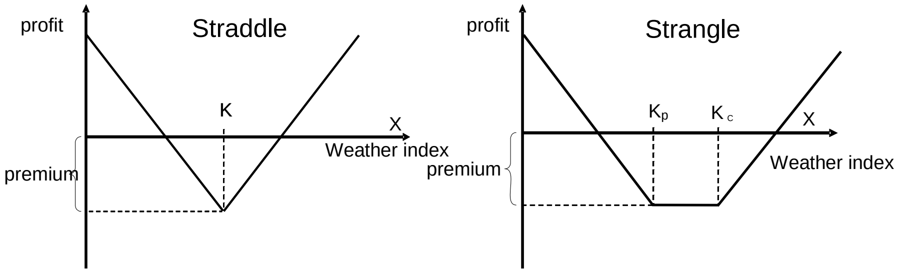
Symmetrical to the long position the profit of the seller is:

$$G_C^S(V,x,K) = -V \cdot Max[0,(x-K)] + P \tag{3}$$

$$G_P^S(V,x,K) = -V \cdot Max[0,(K-x)] + P \tag{4}$$

Generally, weather derivatives are characterized by the following parameters (see Cao and Wei, 2002, S. 2; Schirm, 2001, S. 6):

Figure 2. Payoffs from straddle and strangle



1. The *underlying*: an index based on temperature, precipitation, wind velocity or other weather parameters that can be measured at a weather station;
2. The weather station where the index variable is measured;
3. The *maturity*: described by the period for that the basic variable is aggregated or averaged (for example cumulated rainfall or average precipitation);
4. The *strike* level: if the index value is below or above the strike level, the underwriter has to exercise a payment to the holder;
5. The *tick* size: amount to be paid per index point;
6. Type of the derivative: This determines the payoff structure of the contract. Besides the options described above combinations of put and call options are possible. These will be explained briefly in the following section.

In agriculture, extreme weather conditions (e.g. both too little and too much rainfall) cause yield losses. Thus, the combination of a put and a call option based on the same underlying can be appropriate. Figure 2 shows the payoff structure for the holder of such financial constructs[2]. The combination of a put and a call option with the same strike level is called "straddle". A payoff is exercised, if there is a deviation from the strike level *K*. It is calculated by multiplying the index deviation $|K\text{-}x|$ with the tick size V. Subtracting the premium P the profit becomes:

$$G_{SD}^{L}(V, x, K) = V \cdot |K - x| - P \tag{5}$$

Let us consider an index value (e.g. cumulative rainfall in the growing period) with a strike level K where the highest yield is expected. Deviations to either side cause lower yields. In this case, the holder of a straddle receives pay-

[2] Hull (2003, pp. 185) gives an overview over different derivatives and trading strategies.

ment from the put option (if the index is below the strike level) or from the call option (if the index is above the strike level). The price for the achieved variance reduction of the turnover is the option premium that has to be paid.

If only very extreme weather events (e.g. drought and heavy rainfall) lead to lower yields, a combination of a put and a call option with the same maturity but different strike levels could be appropriate. Such a combination is called “strangle”. Its payoff function is:

$$G_{SG}^{L}(V, x, K_p, K_c) = V \cdot \Big(Max\big[0, (K_p - x)\big] + Max\big[0, (x - K_c)\big] \Big) - P \quad (6)$$

If the realized index value lies between the strike level K_p for the put option and the strike level K_c for the call option at maturity, no payoff will occur. In case of a realized index value below K_p or above K_c the payoff is calculated by multiplication of the deviation from the corresponding strike level with the tick size V. A strangle appears particularly appropriate when the relationship between yield and weather index is non linear.

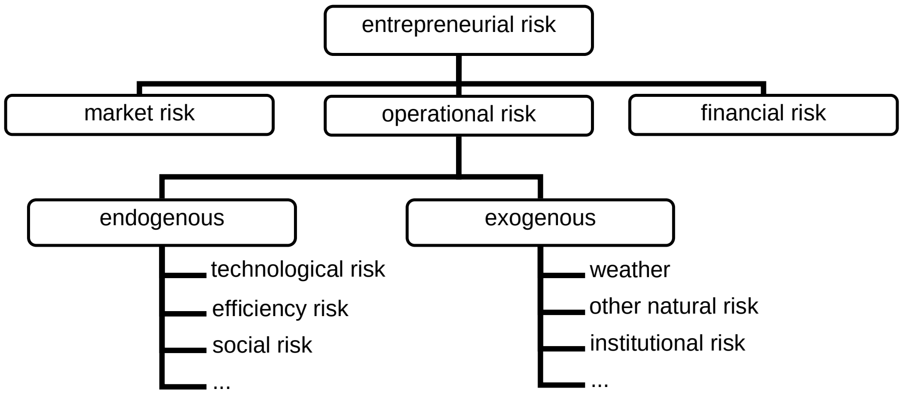
4. *Markets for weather derivatives*

Weather derivatives are relatively new instruments. Since at the beginning only individual contracts were settled “Over The Counter (OTC)”, it is difficult to determine the date of the first contract. Some sources mention that the first known transaction took place in September 1997 while others date it back to 1996 (Ellithorpe and Putnam, 1999, p. 166; Kim, 2000; Schirm, 2001, p.9; Tigler and Butte, 2001, p. 2; Becker and Hörter, 1998, p. 701). The power and gas company Aquila claims to be the first actor on the market: “Aquila has been a pioneer in developing weather derivative products, having issued the industry’s first weather derivative hedge in August 1996” (Aquila, 2000). According to Clemmons (1999) Enron also issued a weather derivative at the same time: “The first weather derivative, a temperature-related power swap between Enron and Florida Power and Light, was transacted in 1996.” In contrast, the exact starting date of trading at financial exchanges is known. The Chicago Mercantile Exchange (CME) started trading temperature derivatives on September, 22nd of the year 1999. The London International Financial Futures Exchange (LIFFE) started quoting weather indices in Europe at December, 10th, 2001.

In Germany the first weather derivative comprised a hedge of the Munich October festival against bad weather. The first energy supplier hedging against a warm winter was Bewag in Berlin in 2000/2001.

Many parts of the economy are weather sensitive. Jain and Foster (2000) estimate that 70 % of all businesses face weather risk of some form. The Deutsche Börse AG assumes that in Western Europe 5 % of the gross national product is influenced by weather (Meyer, 2002, p. 1). At the beginning primarily energy suppliers traded on the market for weather derivatives. However other sectors can be identified as potential participants. Besides the energy sector,

Figure 3. Categories of entrepreneurial risk



case studies treat branches like agriculture, vineyard, beverage and food industry, textile industry, construction industry and gastronomy as notably weather exposed (Auer, 2003; Deutsche Börse, 2000, p. 3).

While agriculture is directly dependent on weather conditions, there is hardly any hint that a farmer ever used weather based derivatives. Only the "lack of moisture of option" as a part of the silage/greenfeed insurance program offered by the Canadian Agricultural Financial Services Corporation (AFSC, 2003) is in fact an insurance based on a rainfall index. For this reason we will quantify the weather impact on field crops in the next chapter. Based on this quantification we will try to assess the possible benefits of weather derivatives in agribusiness.

5. *Fields of application for weather derivatives*

Generally, weather derivatives can reduce risk if the revenues of a firm strongly depend on weather conditions. In the following we first describe how weather derivatives can be incorporated in the risk management of agricultural operations. Thereafter we will quantify their economic effects using an example.

5.1. *Weather derivatives as risk management tools in agriculture*

There are many sources of entrepreneurial risk, and there are as many possibilities to categorise them. In the context of this paper it is appropriate to distinguish financial risk, market risk and production or operational risk (see figure 3). Financial risk results from the debt ratio of a firm. Market risk characterises the economic consequences of unpredictable input and output price changes. The third category is production risk including all risks left (Cooper, 1999). In agriculture, these refer to the volatility of input and output quantities. They can be further divided into endogenous production risks that can be controlled by the farmer and exogenous production risks that cannot be influenced (Schirm, 2001, p. 13). According to this definition, weather risk belongs to the exogenous operational risks.

Since the occurrence of exogenous risks cannot be influenced, they fulfill an important requirement for the application of insurances as risk management tools[3]. Therefore insurance policies are available for a number of weather risks (e.g. hail, storm). However, insurances primarily cover the financial impacts of catastrophic events that occur at low probabilities but have extremely negative financial outcomes (Breustedt, 2003). Weather derivatives, in turn, are useful to hedge against events having less extreme financial outcomes but occur at a higher probability. In these cases insurance solutions are less appropriate because of high transaction costs involved (see Schlieper, 1997).

5.2. *Conditions for the efficiency of weather derivatives in risk management*

The application of weather derivatives in agriculture is appropriate if there is a high correlation between yield and a weather index (Stoppa and Hess, 2003). Let us assume that the yield of wheat is normally distributed with an expected value of 80 dt/ha and a standard deviation of 10 dt/ha. Furthermore a wheat price of 10 €/dt be hedged by a future or forward contract. Thus, the revenue distribution corresponds to the black line in figure 4 with an expected value of 800 €/ha and a standard deviation of 100 €/dt.

Now we buy a put option on a weather index which represents the cumulative rainfall over a defined period of time. The weather index shall also be normally distributed with the mean $E(x) = 100$ mm and the standard deviation $\sigma = 12.5$ mm. We set the strike level at the mean. The tick size V shall be 8 € per index point. According to formula (2) the payoff is given by:

$$A = V \cdot Max[0,(K - x)] \tag{7}$$

The fair premium of the option corresponds to the discounted expected value of the payoff $E(A)$ and is calculated by multiplying the tick size V by the negative deviation of the precipitation index x from the strike level K. Finally the factor e^{-rh} discounts the payment over the duration h using the interest rate r.

$$P_f = e^{-r \cdot h} E(A) = e^{-r \cdot h}\ V\ E(Max[0,(K - x)]) \tag{8}$$

The expected value of the *Max* function, $E(Max[.])$, represents the weighted average of the payments that occur if the index is above or below the strike level, respectively:

$$E(Max[0,(K - x)]) = (1 - H(K))\,0 + H(K) \cdot (K - E(x \mid x \le K)) \tag{9}$$

[3] For further requirements see Berg, 2002, p. 95

In formula (9) H marks the probability that x falls below K. Inversely (1-$H(K)$) characterises the probability that x exceeds K. If x is a continuous random variable, the probability H is the area under the density function $h(x)$ up to the boundary K, i.e.:

$$H(K) = \int_{-\infty}^{K} h(x)\, dx \tag{10}$$

While K is given, we still have to determine the expected value of x given that x falls below K. This is symbolised by the expression $E(x \mid x \leq K)$. The value corresponds to the expected value of the distribution of x truncated above K.

As mentioned above, we assume that x is normally distributed. Thus we can write

$$H(K) = \Phi(z) \qquad \text{where } z = \frac{K - E(x)}{\sigma} \tag{11}$$

The expected value of the truncated normal distribution is (Hartung, 1998, p. 149)

$$E(x \mid x < K) = E(x) + \sigma \frac{-\phi(z)}{\Phi(z)} \tag{12}$$

where $\Phi(.)$ is the standard normal distribution and $\phi(.)$ the respective density function.

Using the above assumptions for mean and standard deviation of the weather index the result for $H(100)$ is 0.5 and for $E(x \mid x < K)$ it is 90 mm. Thus, the average negative deviation of the index from K in formula (9) is 5 mm. Multiplying by the tick size of 8 €/mm this yields a fair premium of 40 €/ha.[4]

With the subsequent model calculations we shall examine the effect of different correlations between the yield and the weather index on the total revenue per ha W_P which comprises the market revenue plus the option payoff and minus the fair premium P_f. It is given by

$$W_P = y\, p_y + V \cdot Max\left[0, (E(x) - x)\right] - P_f \tag{13}$$

[4] For reasons of simplification the discount factor was ignored.

Figure 4. Cumulative distribution function for wheat revenue per hectare for various correlations between weather index and yield

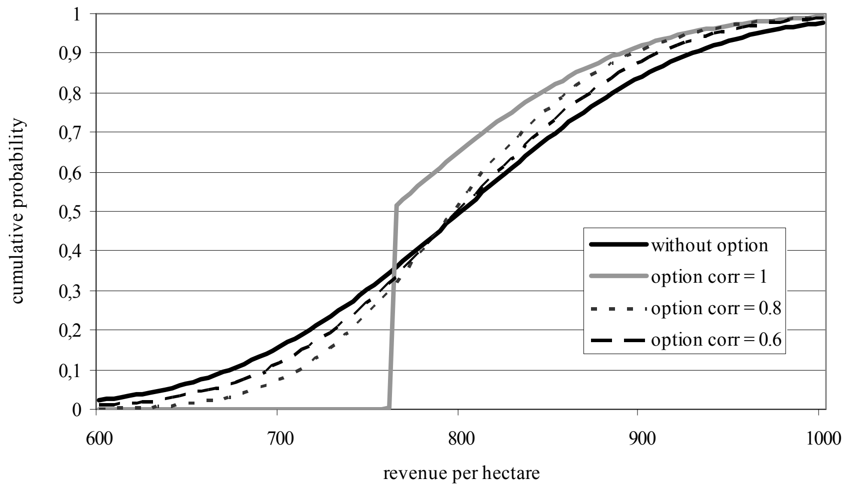
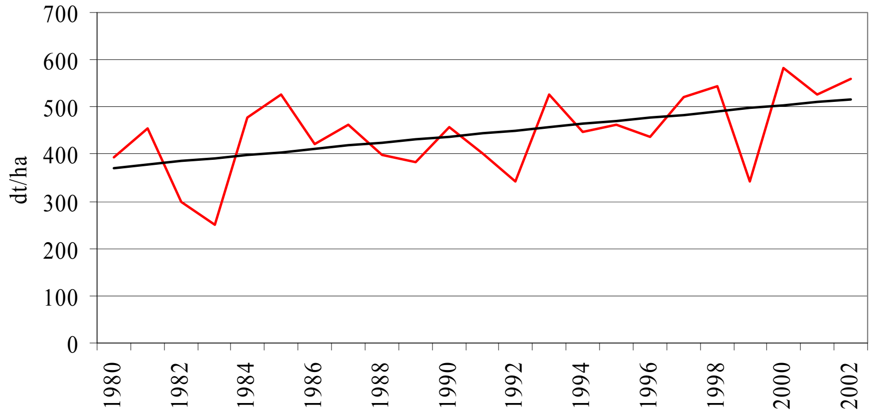


Figure 5. Development of potato yield in Bremervoerde



where y is the yield and p_y represents the product price. According to our assumptions y and x are normally distributed and positively correlated random variables. Thus, we can create a stochastic simulation model[5]. The simulation results are depicted in figure 4.

[5] We used the MS Excel AddIn @Risk for simulation.

If we assume a correlation of +1 between yield and index, we can eliminate the downside risk completely by buying a put option. The lower part of the distribution is truncated. On one hand a revenue smaller than the expected value minus the fair premium cannot occur. On the other hand we lose the chance to attain the highest revenues. The distribution is left shifted by the value of the premium. In all cases the expected value remains the same.

With the assumption of a correlation of 0.8 we cannot exclude very low revenues any more. Compared to the first situation (no hedge) the probability is lower but it is still possible that the yield is low and no payoff will occur. If we take the 10 % percentile as measure for the downside risk, it amounts to 672 €/ha without the option and 712 €/ha with the option, given a correlation of 0.8. Assuming a correlation of 0.6 the 10 % percentile amounts to 696 €/ha. If the correlation is even less than 0.6, the option hardly reduces the weather risk at all.

Besides the correlation the magnitude of yield variability also influences the risk reducing effect of weather derivatives. Furthermore the price causes a leverage effect on the returns per hectare. High variability of the yield and prices can be found in potato and vegetable production. Thus, we will illustrate the farm level effects of weather derivatives using potatoes as an example[6].

5.3. *Weather derivatives in potato production*

The Chamber of Agriculture of Hanover in the state of Lower Saxony regularly runs experiments with starch potatoes on its experimental fields at Bremervoerde. The weather data are recorded by a weather station on the field. Using these data we obtain a yield pattern that exhibits a linear trend of 6.6 dt per hectare and year as given in figure 5. In 2004 the trend value of the yield amounts to 530 dt/ha. We observe negative deviations from the trend of more than 20 % in 1982, 1983, 1992, and 1999.

In order to construct a risk reducing weather derivative we first have to analyse the relationship between yield and weather variables. Obviously, temperature and precipitation during the growing season should have a high impact on yield. We therefore calculated the correlation between the de-trended potato yield, the monthly accumulated precipitation, and the monthly average temperature (see table 1).

The high correlations between yield and monthly precipitation from June to September are striking. There seems to be a high water demand in this period. Rainfall in April above average is negatively correlated and apparently causes a delay of planting, thus shortening the growing season. High monthly temperatures from June to August seem to have a negative impact on yield. In addition

[6] Meuwissen et al. (2000) examined the feasibility of a derivative based on a weather index in the potato processing industry in the Netherlands.

Table 1. Correlation between potato yield and monthly cumulative precipitation and monthly average temperature

	precipitation	**temperature**
April	-0.30	-0.01
May	-0.17	0.11
June	0.57	-0.20
July	0.47	-0.57
August	0.35	-0.24
September	0.27	0.07
May-September	0.67	0.02

source: own calculation; data: chamber of agriculture, Hannover

to the correlations between yield and the monthly figures we also calculated the correlations between yield, average temperature and cumulative precipitation over several months. In this way, we obtained the highest correlation between yield and the cumulative rainfall from May to September.

In figure 6 the triangles indicate the relation between cumulative rainfall and yield from 1980 to 2002. According to the data, low yields can be expected in years where the cumulative rainfall falls below 340 mm. While rainfall below 340 mm lowers the yield, rainfall exceeding the average leaves the yield constant. This relationship is estimated by least squares using a linear limited function:

$$\hat{y} = Min\left[(a + b\,x), \hat{y}_{\max}\right] \tag{14}$$

The above function is composed of two parts. The former one is a linearly increasing function depending on rainfall. The constant a is 55.3 dt/ha, the slope is 1.52 dt/(ha*mm). Maximum yield is achieved at a cumulative rainfall of 342 mm or more. The second part of the function is given by the constant $\hat{y}_{\max}$ = 573 dt/ha and represents the upper limit.

As we see from figure 6, a put option whose parameters have to be determined (as described in equation (2)) can reduce the rainfall related yield risk. The maximum yield can be expected at a cumulative rainfall of at least 342 mm. This amount therefore marks the strike level *K*:

$$K = \frac{\hat{y}_{\max} - a}{b} \tag{15}$$

The optimal tick size *V* can be expressed by the slope *b* and the product price p_y:

$$V = b\,p_y \tag{16}$$

Because of effective market regulations and the fairly low quality requirements for starch potatoes, we consider the price p_y to be constant. The producer price is determined by the starch content which we assume to be 19 %.

Figure 6. Correlation between potato yield and cumulative precipitation from May till September from 1980 till 2002

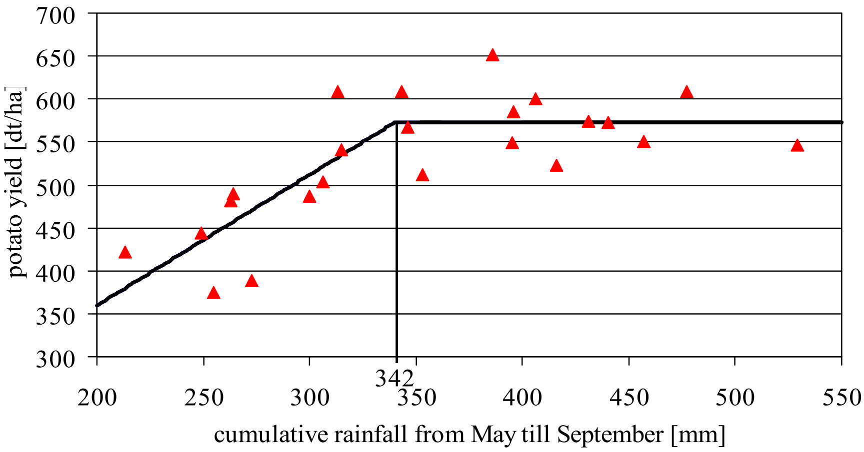
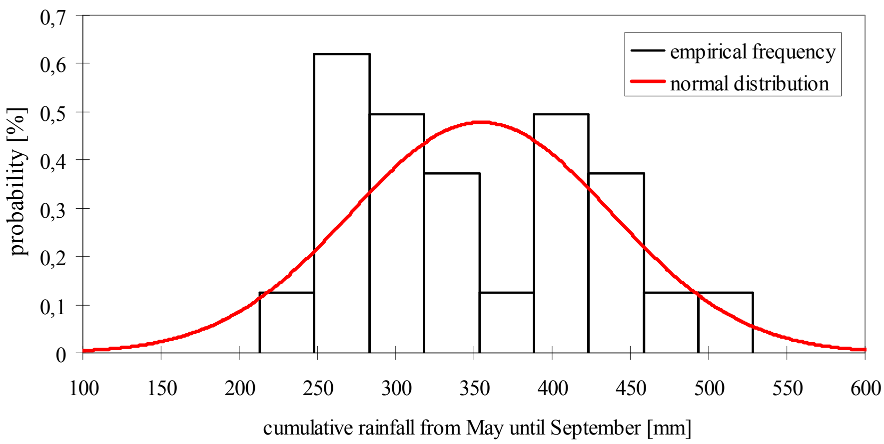


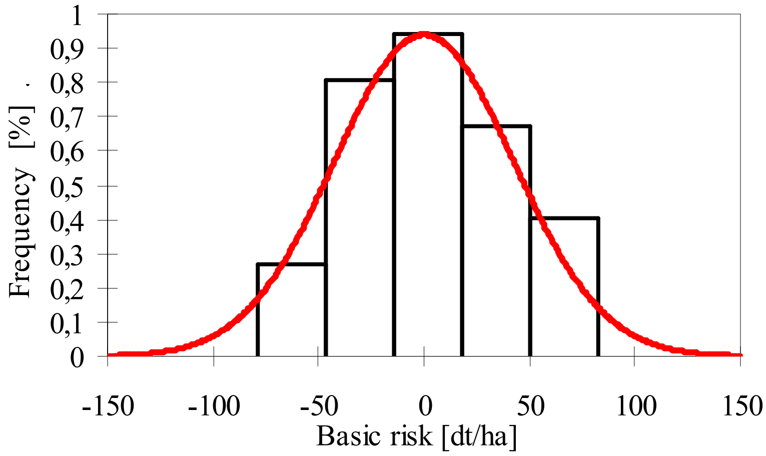
Figure 7. Cumulative distribution function for cumulative rainfall from May till September



From this the producer price is p_y = 6.55 €/dt (Marktfruchtbericht Bayern 2002, p. 32).

In the next step we examined the empirical frequency distribution of the cumulative rainfall from 1980 until 2002. The histogram is drawn in figure 7.

Figure 8. Frequency distribution of the basic risk



The χ^2 test with 8 degrees of freedom yields a test measure of 7.9 for a normal distribution. Thus, the normality hypothesis cannot be rejected at an error level of $\alpha = 0.05$.

Under the assumption of a normal distribution the expected value E(x) is 353 mm and the standard deviation σ is 82 mm.

The total yield risk can be estimated analogous to the approach of the preceding section using the historical data. Another way of estimating the total yield risk is by summing up the rain related variance and the (unexplained) basic risk. Using the latter method the basic risk is represented by the deviation of the observed yields from the estimation function. The respective histogram is given in figure 8.

Assuming a normal distribution the χ^2 test with 4 degrees of freedom yields a test value of 1.28. Thus, the normality hypothesis cannot be rejected at an error level of $\alpha = 0.05$. We obtain an expected value of 0 and a standard deviation of 43 dt/ha.

With these assumptions, the revenue distribution without derivative (W_0) can be simulated according to equation (17):

$$W_0 = p_y\, y = p_y\left((Min\,[a + b\,(E(x) + e_x),\, \hat{y}_{\max}\,])+ e_B\right) \tag{17}$$

The yield variability is determined by the variability of rainfall (Min function in (17)) and the unexplained remaining variability e_B.

The total revenue with option W_P is composed of the market revenue (see 17) and the payment from the put option G_P^L (see (2)). Substituting K and V by (15) and (16) and rearranging the terms finally yields equation (18):

$$\begin{aligned} W_P &= W_0 + G_P^L = p_y\left((Min[a + b\,x, \hat{y}_{\max}]\,) + e_B\right) + V \cdot Max\left[0, (K - x)\right] - P_f \\ &= p_y\left(\hat{y}_{\max} + Min[a + b\,x - \hat{y}_{\max}, 0]\,) + e_B\right) + p_y b \cdot Max\left[0, (K - x)\right] - P_f \\ &= p_y\left(\hat{y}_{\max} + Min[a + b\,x - (a + b\,K), 0] + e_B + Max\left[0, b(K - x)\right]\right) - P_f \\ &= p_y\left(\hat{y}_{\max} + Min[b(\,x - K), 0] + e_B - Min\left[0, b(x - K)\right]\right) - P_f \\ &= p_y\left(\hat{y}_{\max} + e_B\right) - P_f \end{aligned} \qquad (18)$$

W_p is not dependent anymore on cumulative rainfall but only on the basic risk. In turn, the fair premium P_f has to be paid. Equation (8) contains the general approach to determine the premium. The interest rate is 5 % p.a., the duration amounts to five months. For analytical determination of the fair premium we have to derive the probability that the cumulative rainfall is less than the strike and the respective expected value (see (9)). Using the approach of equation (11) and (12) a fair premium of 277 €/ha was derived.

Figure 9 shows the simulation results for the distribution of the total revenue with and without the option.[7] The standard deviation can be reduced noticeably. The put option also changes the downside percentiles. With option, the 5 %-percentile is shifted by 500 € in comparison to the situation without option. Since the cumulative rainfall influences yield only in the lower parts, the distribution without option is left skewed. Due to the symmetric basic risk the skewness is completely compensated in the case with option. Due to the interest on the premium the mean revenue with option is marginally lower than the one without the option.

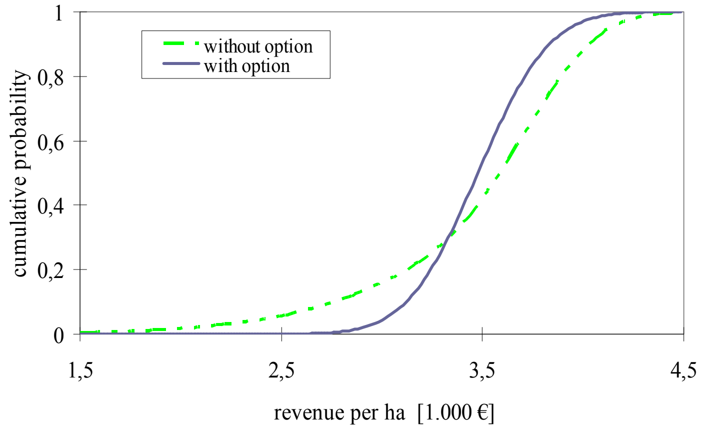
The effect of the option would be less evident if the price or the standard deviation of the yield, or the correlation would be lower. The relatively high correlation is certainly influenced by the fact that the weather station is close to the experimental field. For precipitation a higher geographical basic risk can be expected than for temperature. The positive option effect would also be reduced by a higher premium than assumed here.

6. *Conclusions*

In this paper we have shown that weather derivatives can be useful tools to reduce risk in agriculture. Their primary goal is not to protect against cata-

[7] We run the simulation 10000 times.

Figure 9. Cumulative distribution function for potato yields with and without option



	without option	with option
mean	3.483 €	3.480 €
Std. dev.	519 €	278 €
5% Per.le	2.457 €	3.023 €
10% Per.le	2.766 €	3.124 €
90% Per.le	4.026 €	3.838 €
95% Per.le	4.139 €	3.935 €
skewness	-1,14	0,00

strophic single risks that threaten the existence because there will never be a perfect correlation between the yield and the weather index. The benefit is rather the variance reduction of economic figures. In this respect, hedging with weather derivatives is one of several useful risk management instruments. Others are insurances (for existence imperilling risks), price hedging with futures and options and last but not least the choice of production programme.

A high correlation between the yield of the crop and the weather index is an important precondition for the efficiency of weather derivatives. Primarily crops with high yield variability are suitable hedging with weather derivatives. Furthermore the price acts as a lever. A further condition for the establishment of weather derivatives is the availability of partners taking the risk. In the first instance these could be actors with an adverse risk structure. Besides taking the short position on the option market can be interesting for actors whose remaining risks are largely uncorrelated with the weather index. So the derivative diversifies the portfolio. As examples in the USA show, insurers and re-insurers are potential derivative underwriters.

So far, there is only little knowledge of the effectiveness of weather derivatives in risk management. Further research is therefore needed particularly in the following fields: For which crops are weather derivatives a useful tool to reduce risk? In this instance it is important to find appropriate weather indexes with high correlation to the respective yield. In this context the contract design is also important. Simple put or call options are not always the best choice. Secondly, the fair premium or fair price of the option must be quantified to establish whatever market (OTC or exchange) for weather derivatives. In this respect option pricing methods have to be analysed and developed. Relating to the operational level, weather derivatives have to be analysed and evaluated in comparison to other instruments of risk management. Finally it has to be investigated which partners are willing to take the risk that farmers want to transfer via weather derivatives and under what conditions the deal is acceptable.

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An Income Risk Management Framework for Mediterranean Agricultural Products

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Abstract

Liberalisation of agricultural markets and reduction of agricultural markets protective schemes have increased the risks faced by farmers. Furthermore, the introduced new quality and strict food safety requirements will increase the risks that the agricultural production will encounter, especially in smallholdings like those common in Greece. The new uncertain environment affects income variability and requires complementary measures to stabilize and safeguard the farm income. Until now, the EU's policies in the framework of CAP have had as a major role that of lessening the risks and securing a minimum level of income. The ongoing Common Agricultural Policy reforms should be accompanied by risk reducing schemes. A deep understanding of risk and risk management tools will assist policymakers in assessing the effectiveness of different types of risk protection tools. The main objective of this research is to provide an introduction to income insurance either as yield or gross revenue for two main Mediterranean agricultural products, tobacco and cotton. A Monte Carlo simulation model will be used to illustrate the effect of such revenue insurance schemes on the stability of the individual farmer's income. Finally, we discuss the effectiveness of an income insurance scheme and the need for further research on income risk management tools.

1. *Introduction*

Agriculture has faced significant changes in recent years. It is characterised by a strong exposure to risk, which is expected to increase in the near future. Increased global competition, more regulation, less intervention, rapid changes in the structure of agriculture production, changes in the marketing of agricultural products in the farm supply sector, new technologies and more volatile weather patterns are factors that make farmers come to risky decisions (OECD, 2000). More specifically, *production risk* is expected to increase due to stricter farming practices in the use of inputs that create potential environmental damages. New friendly environmental regulations with respect to the application of agro chemicals can cause an increase of yield variability. According to FAO, there is a possibility the production risk will rise due to the easy spread of diseases across national borders because of the growing mobility of people, animals and agricultural products (animals and crop products) (FAO, 2000). *Climate change* (summer heat waves, floods, summer drought, etc) will also have an impact on production risk (European Commission, 2001).

Price risk is likely to rise because of agricultural trade liberalisation. Trade liberalisation aims at increasing price transmission from world markets to domestic markets and therefore brings domestic prices more under the influence of fluctuating world market prices. In Europe due to CAP price support, the variability of the main Mediterranean agricultural product prices is very limited. Under the recent reforms of the CAP, price volatility will increase. The continuous liberalisation of markets combined with decreasing price support results in an increase of market risks (Berg, 2002).

European Mediterranean agriculture is characterised by specialisation and it is expected to continue, thus increasing both producer's production and price risk (European Commission, 2001). Consequently, i*ncome variability* is expected to increase in the future either as a result of price risk or production risk or as a combination of both. As a result there is a need for complementary measures that will stabilise and safeguard agricultural incomes. Until now, the EU's policies in the framework of the CAP have had a major impact on farmers' risk, even if their main goal may have been income stabilisation and not risk reduction (market intervention, direct payments, rural development measures providing incentives for on- and off-farm diversification). It is obvious that the government intervention modifies the risk faced by farmers, either by increasing income levels or by reducing income variability. The available risk management tools for farmers are divided into strategies concerning on-farm measures (diversification, specific crops with either a short production cycle or guarantee prices) and to strategies referring to risk shared with others (insurance, contract marketing, hedging on the future markets) (Meuwissen, Huirne and Hardaker 1999).

Agricultural insurance is a risk sharing strategy to manage agricultural risk. It is an effective, modern financial instrument that can help farmers reduce income variability and stabilize it. Agricultural insurance has become an important issue in the discussion about a European common agricultural policy. The main reason for this is that the existing conditions of farming have changed considerably since the CAP reform of 1992. The currently granted area payments are risk reducing but area payments will be lowered or linked to environmental constraints so new or additional risk management instruments are necessary (Berg, 2002). In European agriculture the available tools to manage agricultural risk through insurance are limited and not common for all Member States. In Europe, there are many different systems of agricultural insurance. Greece has a public system; Spain and Portugal have public-private partnership system while Italy, France, Austria and Germany have private system of agricultural insurance (European Commission, 2001). Consequently, at the end of '90s, European Commission has been started to investigate the adoption of a common framework for agriculture insurance in Europe.

Various forms of agricultural insurance have been applied in the USA and in Canada and there exist a vast literature. The purpose of this paper is firstly to investigate the adoption of a yield insurance and gross revenue insurance scheme for the tobacco and cotton sectors in the EU, and secondly to assess if risk management tools such as yield or gross revenue insurance schemes improve the farm income level in these two sectors. Tobacco and cotton sectors are expected to have a lot of changes due to the new applied policy, the price liberalisation and the application of environmental friendly production practices. Under this uncertain environment, income variability is expected to increase and complementary measures are required to stabilize and safeguard farm income. The work consists of the following parts: at first, some aspects of agricultural insurance and EU situation of the cotton and tobacco sectors are presented. Then, the Monte Carlo simulation model and application results of a yield and gross revenue insurance scheme are presented. Ultimately, the paper highlights the effectiveness of an income insurance scheme in the cotton and tobacco sectors and the need for further research on it.

2. *Agricultural insurance*

Agricultural insurance is an effective modern instrument that can help farmers achieve important objectives such as avoiding catastrophic losses, maintaining its their living standards and promoting the economic development not only of their farm but also of the countryside (Burgaz, F., 2000). It is important for farmers to understand the benefits of this efficient risk-sharing mechanism. It is a financial instrument that pays out compensation to stabilize farm income. Farmers are risk averse so they have incentive to buy an insurance scheme (Hardaker *et al.*, 1997; Skees and Reed, 1986). They are willing to pay a relatively small payment (the premium) for protection against uncertainty in order to avoid potentially large, catastrophic losses that would affect the survival of their farm businesses (Harwood *et al.*, 1999). As Burgaz mentioned in the OECD Conference about income risk management, compensation for any losses comes in the form of an income allowing the farmer to remain in the production cycle without incurring debt. It improves the financial solvency by offering a more stable annual income and enables farmers to specialize more when expanding their business without increasing the risks inherent to the activity. It gives agriculture a fair and equitable system of compensation for losses after they occur and provides additional back-up for agricultural guidance and rural development programmes (Burgaz, F., 2000). Governments also benefit from the introduction of insurance systems because the income stability of farmers helps to maintain the rural population in agricultural areas providing in this way the social cohesion of the countryside. In practice, however, agricultural insurance has been a costly mean of transferring the risk from the farmers to the governments and/or other insurers (Nelson and Loehman, 1987).

In the development of agricultural insurance the most common problem is the asymmetric information between the insured and the insurer as research has shown. Asymmetric information occurs if the insured (or the insurer) has more or better information than the insurer (or insured). It refers either to moral hazard or adverse selection problems. In insurance models, there is adverse selection when the level of risk in the insured population is higher than the average. It occurs if the insurer cannot distinguish the inherent riskiness of different farmers (Nelson and Loehman, 1987; Ahsan *et al.*, 1982). Adverse selection is avoided if insurance contracts are based on perfect information on each individual's risk. More specifically, research has shown that adverse selection will be avoided if there is an application for different coverage levels among regions and crops, specification of farmers types based on yield distribution, risk attitudes and production possibilities (Nelson and Loehman, 1987; Skees and Reed, 1986). Moral hazard occurs when the insured has the ability to increase his or her expected indemnity by actions taken after buying the insurance. The effects of moral hazard depend on the form of the insurance contract and the distribution of yield. Insurance companies collect as much information as possible about farmers and use some tools such deductibles, co-payments, multi-year insurance contracts to help to control moral hazard problems (Chambers, 1989).

3. *EU situation of Tobacco and Cotton sectors*

Tobacco is a representative sector of the Mediterranean agriculture in EE. Greece and Italy cover more than 75% of EU raw tobacco production (Tzouramani *et al.*, 2003). Tobacco represents 0.4% of the EU agricultural output and only 0.1% of the utilized agricultural area. The Greek tobacco production is 40.46% of the EU tobacco production and 4% of the total Greek agricultural production (Tzouramani, *et al.*, 2003). The sector has a declining trend. The total number of farms with tobacco in the EU was 79,510 in 2000, following a ten-year decline of 3.6% per year (Eurostat, 2002). In Greece, the role of this sector is vital because it constitutes an important source of employment for a significant number of people mainly in less favoured areas, as it employs 209,147 persons. Over the last decade, there has been a reorientation towards the production of high-quality varieties, an increasing specialisation per variety both at farm and regional level, and the prices of EU-produced raw tobacco at an international and domestic level have increased. On the other side, the market price of raw tobacco is too low to cover the production costs and positive margins at a grower level are currently allowed only by CAP direct payments.

Cotton is a very significant product for Greece. Greece produces 80% of the total EU production while in Spain and Portugal the production is limited.

Table 1. Tobacco sector in Greece and in EE

	Area 1000 (ha)		% Share in UAA		Share in value of crop output in Greece	Share in value of total agricultural production in Greece
Year	E.E.	Greece	E.E.	Greece		
1990	127	78	0.1	1.6	8.10	5.48
1995	147	64	0.1	1.6	5.48	4.00
2000	126	57	0.4	1.5	6.27	4.49

Source: European Commission, Eurostat

Table 2. Cotton sector in Greece and in EE.

	Area 1000 (ha)		%Share in UAA		Share in value of Crop output in Greece	Share in value of total agricultural production in Greece
Year	E.E.	Greece	E.E.	Greece		
1990	346	262	0.3	4.4	11.67	7.89
1995	475	444	0.3	11.2	15.19	11.08
2000	496	405	0.4	10.3	12.84	9.31

Source: European Commission, Eurostat

The cotton sector has limited significance in the EU as a whole, contributing only 0.5% to the final agricultural output. However, for Greece, cotton represents 9.31% of its final agricultural output while in Spain only 1.5%. Cotton production in Greece is located in three regions: Thessaly, Macedonia-Thrace and Sterea Ellada (Tzouramani, 2002). In Spain, production is concentrated in Andalusia, mainly in the provinces of Seville and Cordoba. Cotton holdings in these regions are characterised by their large number (71,600 in Greece and 7,600 in Spain) and small size (Greece, 4.9 ha and Spain 12.0 ha) (Eurostat, 2002).

4. *Monte Carlo Simulation*

Monte Carlo simulation model used to illustrate the main principles of insurance schemes on the stability of a farmer's income. More specific, yield insurance and gross revenue insurance scheme were examined to determine their effects on tobacco and cotton farmers' income variability. The model runs on commodity basis and is developed in @RISK (Palisade, 2000).

In yield insurance, yield fluctuations are insured. The development of this insurance is to cover quantity risks. In the simulation model, variation of the net return to labour and management is caused by variation in yields and prices. We use income definition as the net return to labour and management (Meuwissen *et al.*, 1999; Meuwissen, 2000). Net returns to labour and management are a function of commodity prices, yields, cost of production estimates, crop insurance premiums and indemnity payment (equation 1) (Meuwissen *et al.*, 1999; Meuwissen, 2000).

Yield-only insurance

$$NR_{insurance\,f,c,t} = Y_{actual_{f,c,t}} * P_{actual_{c,t}} - Y_{actual_{f,c,t}} * VC_{f,c,t} - FC_{f,c,t} - PR_{f,c,t} + I_{f,c,t} \quad (1)$$

$$NR_{f,c,t} = Y_{actual_{f,c,t}} * P_{actual_{c,t}} - Y_{actual_{f,c,t}} * VC_{f,c,t} - FC_{f,c,t} \quad (2)$$

$$PR_{f,c,t} = LC(d\%)_c * \overline{Y}_{f,c} * el_p(\%)_f * \overline{P}_c \quad (3)$$

$$Tr_{f,c} = Y_{actual_{f,c}} < Y_{guarantee_{f,c}} \quad (4)$$

$$Y_{guarantee_{f,c}} = (100\% - d\%) * \overline{Y}_{f,c} \quad (4bis)$$

$$I_{f,c,t} = (Y_{guarantee_{f,c}} - Y_{actual_{f,c}}) * el_p(\%)_f * P_{actual} \quad (5)$$

With:

$PR_{f,c,t}$ = premium for farmer *f*, commodity *c* and year *t*;
LC_c = loss cost for commodity *c*, given a deductible of *d*%
d% = yield deductible;
$\overline{Y}_{f,c,}$ = average yield of farmer *f* for commodity *c*;
$el_p(\%)_f$ = election percentage for price chosen by farmer *f*;
$\overline{P}_c$ = average price for commodity *c*;
$Tr_{f,c}$ = trigger level for commodity *c*, chosen by farmer *f*;
$Y_{actual_{f,c}}$ = actual yield for farmer *f* of commodity *c*;
$Y_{guarantee_{f,c}}$ = guarantee level of farmer *f* for commodity *c*;
$I_{f,c,t}$ = indemnity payments for farmer *f* for commodity *c*
$NR_{f,c,t}$ = net return to labou and management for farmer *f*, commodity *c*, and year *t*;
$P_{actual_{c,t}}$ = market price for commodity *c* in year *t*;
$VC_{f,c,t}$ = variable cost for farmer *f* for commodity *c* in year *t*;
$FC_{f,c,t}$ = fixed cost for farmer *f*, for moddoity *c* in year *t*.

The yield data for the present study is taken from FAND and covers the period 1994-1998. The data set includes annual yield individual data for the cotton and tobacco sectors in the main Greek producing areas. FAND database classifies farms by commodity according to their source of revenue. A farm is classified as producing a particular commodity as long as two thirds of its revenues come from the production of this particular good. For each region average yield and coefficient of variance (CV) calculations are made for the individuals' farms and for the group of farms as a whole. The CV is used as a measure of variability and defined as the standard deviation divided by the mean. Price data are also analysed. For prices, deflated data from Greek National Statistical Service are used, referring to a country level, for the time period 1981-1999. In our simulation model we assume that yield follows a normal distribution function and a price lognormal distribution function. Simulation is carried out for individually based schemes and not for area-based schemes. For all calculations 1000 @RISK iterations are carried out.

Yield insurance premiums are deducted from the net return because they are costs of production. Premiums for yield insurance are equal to the product of loss costs commodity (cotton or tobacco) given a deductible with the average yield of the farmer, the election percentage for price chosen by farmer and the average price of commodity (equation 3). Loss costs for cotton reflect the within farm yield variability of a homogeneous group of farmers. They are expressed as a percentage and reflect the amount of premium that is required to offer a fair insurance programme (Meuwissen, *et al.*, 1999). Election percentage for yield insurance is the percentage of price against which yield shortfalls are indemnified. Premiums for yield insurance depend on the average yield of a farmer, the coverage level and the election price chosen by the farmer. If a producer does collect a yield insurance indemnity payment then it is added to the net return (equation 5). This will happen only if the actual yield falls below the insured yield. The indemnity is equal to coverage level multiplied by the election price with the actual price. We also assume that variable and fixed production costs are zero. The coverage level was set to 80%, which means that the deductible is equal to 20%. The election percentage is assumed to be 90% of the market price in order to avoid moral hazard problem.

The revenue insurance, tries to cover price times yield risks. The net return to labour and management under revenue is equal to the equation 6. We assume that there is no negative price /yield correlation. The guarantee level is 80% times the farm's average revenue. The election percentage refers to 90% of the revenue shortfalls. We also assume that variable and fixed production costs are zero. Premiums and indemnity payments are presented to equation 8 and 10 respectively (Meuwissen, *et al.*, 1999).

Gross revenue insurance

$$NR_{insurance\, f,c,t} = Y_{actual_{f,c,t}} * P_{actual_{c,t}} - Y_{actual_{f,c,t}} * VC_{f,c,t} - FC_{f,c,t} - PR_{f,c,t} + I_{f,c,t} \quad (6)$$

$$NR_{f,c,t} = Y_{actual_{f,c,t}} * P_{actual_{c,t}} - Y_{actual_{f,c,t}} * VC_{f,c,t} - FC_{f,c,t} \quad (7)$$

$$PR_{f,c,t} = LC(d\%)_c * el_r(\%)_f * \overline{R}_{f,c} \quad (8)$$

$$Tr_{f,c} = R_{actual_{f,c}} < R_{guarantee_{f,c}} \quad (9)$$

$$R_{guarantee_{f,c}} = (100\% - d\%) * \overline{R}_{f,c} \quad (9bis)$$

$$I_{f,c,t} = (R_{guarantee_{f,c}} - R_{actual_{f,c}}) * el_r(\%)_f \quad (10)$$

With:

$PR_{f,c,t}$ = premium for farmer *f*, commodity *c* and year *t*;
LC_c = loss cost for commodity *c*, given a deductible of *d*%
d% = yield deductible;
$\overline{R}_{f,c,}$ = average revenue of farmer *f* for commodity *c*;
$el_p(\%)_f$ = election percentage for price chosen by farmer *f*;
$Tr_{f,c}$ = trigger level for commodity *c*, chosen by farmer *f*;
$R_{actual_{f,c}}$ = actual revenue for farmer *f* of commodity *c*;
$R_{guarantee_{f,c}}$ = guarantee level of farmer *f* for commodity *c*;
$I_{f,c,t}$ = indemnity payments for farmer *f* for commodity *c*
$NR_{f,c,t}$ = net return to labou and management for farmer *f*, commodity *c*, and year *t*;
$P_{actual_{c,t}}$ = market price for commodity *c* in year *t*;
$VC_{f,c,t}$ = variable cost for farmer *f* for commodity *c* in year *t*;
$FC_{f,c,t}$ = fixed cost for farmer *f*, for moddoity *c* in year *t*.

6. *Results and Discussion*

Table 3 describes the yield data for the cotton and tobacco sectors in main producing areas and Table 4 the relative yield data. The variability of yields within farms is lower than the variability of yields for the total group of farms. This is expected because the CV of the total group represents not only good or bad producing years but also farms with high or low production. It is obvious from the data that there is difference in yield variability between the producing areas. For cotton, Makedonia-Thraki present higher mean yield with low yield variability while in Thessalia the average yield is lower with higher yield variability for the examined period. In the tobacco sector, the yield variability was in the same level in both the producing areas, but the average yield is higher in Sterea Ellada and lower in Makedonia-Thraki. Table 5 describes the price data for the cotton and tobacco sectors. Prices for cotton present low variability, 5.81%, while for tobacco the variability is higher, 19.63%.

Simulation results show that yield-only and gross revenue insurance schemes are able to reduce the volatility of farmers' income. Table 6 describes results for cotton farmers in the main producing areas. It presents three cotton farms from the data set that corresponds to a farm with low, average, and high yield variability respectively. The results indicate that from a farmer's point of view there is an incentive to buy yield insurance mainly for those that have high yield variability because it reduces the variability of income. As for cotton farmers with low yield variability it is not required to buy either yield insurance or revenue insurance. Table 7 illustrates results for cotton farmers under the possibility of occurrence of bad weather events during the examined period. Net return to labour and management variability for cotton farmers is higher when

Table 3. Yield for Cotton and Tobacco in Greece (1994-1998)

	n	**Average Yield (kgr/0.1ha)**	**CV (%)**	**CV within farms (%)**
Cotton				
Makedonia and Thraki	51	307.30	17.43	13.85
Thessalia	38	295.99	21.15	20.55
Tobacco				
Makedonia and Thraki	38	145.49	45.81	12.04
Sterea Ellada	26	235.61	32.56	12.96

Source: FAND

Table 4. Relative Yield for Cotton and Tobacco in Greece (1994-1998)

	n	**Average Yield kgr/0.1ha)**	**Min**	**Max**	**CV (%)**	**CV within farms (%)**
Cotton						
Makedonia and Thraki	51	100	49.95	182.55	15.03	13.85
Thessalia	38	100	48.8	137.91	19.08	20.55
Tobacco						
Makedonia and Thraki	38	100	60	154	12.74	12.04
Central Greece	26	100	54.81	143.21	13.36	12.96

Source: FAND

Table 5. Price for Cotton and Tobacco in Greece (1981-1999)

	Mean (€/kgr)		**CV (%)**	
	Current	Constant	Current	Constant
Cotton	0.64	0.82	34.65	5.81
Tobacco	1.82	2.89	57.96	19.63

Source: Greek National Statistical Service

there is a possibility of bad weather events, and insurance gives the opportunity to reduce the variability of income.

Table 8 describes simulation results for tobacco farmers. Net return to labour and management variability is higher for the region of Makedonia-Thraki than the region of Central Greece. Revenue insurance reduces net return variability better that the yield insurance. For tobacco farmers, the incentive to buy yield or revenue insurance is not so attractive because the net return variability has not significant changes. Under the possibility of bad weather conditions, which will influence the yield, yield insurance gives incentive to farmers to buy it because they will have reduction of their income variability (Table 9).

7. *Conclusions*

This paper provides an introductory analysis of insurance schemes in two basic Mediterranean agricultural sectors, cotton and tobacco. As it is expected for the near future, agriculture will face significant changes and a great exposure to risk. So, the development of insurance schemes may be a new risk manage-

Table 6. Yield and revenue insurance for Cotton farmers

	No Insurance	**Yield Insurance** [1]	**Revenue Insurance** [2]
	CV Net Return	CV Net Return	CV Net Return
Low yield variability			
Makedonia and Thraki	9.70%	9.68%	9.89%
Thessalia	13.52%	13.17%	13.83%
Average yield variability			
Makedonia and Thraki	13.18%	12.67%	12.90%
Thessalia	21.80%	18.88%	20.07%
High yield variability			
Makedonia and Thraki	23.06%	19.54%	19.77%
Thessalia	29.24%	23.41%	25.24%

[1] Loss costs for yield insurance are 1.312% for Makedonia and Thraki and 3.496% for Thessalia.
[2] Loss costs for revenue insurance are 1.316% for Makedonia and Thraki and 3.612% for Thessalia.

Table 7. Yield and revenue insurance for Cotton farmers with the occurrence of bad events[1]

	No Insurance	**Yield Insurance** [2]	**Revenue Insurance** [3]
	CV Net Return	CV Net Return	CV Net Return
Low yield variability			
Makedonia and Thraki	39.10%	28.85%	31.05%
Thessalia	38.08%	27.49%	29.28%
Average yield variability			
Makedonia and Thraki	42.05%	30.43%	32.57%
Thessalia	44.26%	30.90%	33.29%
High yield variability			
Makedonia and Thraki	48.21%	32.96%	34.70%
Thessalia	49.09%	33.45%	36.23%

[1] We assume that yield decreases once by 70% during the five years period.
[2] Loss costs for yield insurance are 4.162% for Makedonia and Thraki and 4.146% for Thessalia.
[3] Loss costs for revenue insurance are 4.178% for Makedonia and Thraki and 4.126% for Thessalia.

ment tool to help Greek farmers to remain in the agriculture sector. In Greece, there is no experience in agricultural insurance. We have tried to apply a simple simulation model to check if there are incentives for farmers to adopt insurance schemes, like yield or gross revenue, in order to improve the income stability.

Simulation results show that yield-only and gross revenue insurance schemes are able to reduce the volatility of farmers' income, either in a significant percent or not depending on specific product conditions. Under the scenario of bad weather conditions the variability of net return decreases significantly with insurance schemes. But from the simulation results we find out that an adverse selection problem is present. So, the application of any insurance scheme needs sufficient and reliable data to have been gathered and further research and tests of insurance schemes are required. Consequently, farmers need information on future uncertain conditions and the available new risk management tools for a stable and secure income level.

Table 8. Yield and revenue insurance for Tobacco farmers

	No Insurance	**Yield Insurance**[1]	**Revenue Insurance**[2]
	CV Net Return	CV Net Return	CV Net Return
Low yield variability			
Makedonia and Thraki	29.38%	29.39%	27.17%
Central Greece	20.10%	20.11%	19.87%
Average yield variability			
Makedonia and Thraki	30.60%	30.56%	27.77%
Central Greece	23.39%	22.94%	22.74%
High yield variability			
Makedonia and Thraki	39.26%	36.46%	33.67%
Central Greece	27.25%	25.88%	26.84%

[1] Loss costs for yield insurance are 1.186% for Makedonia and Thraki and 1.39% for Central Greece.
[2] Loss costs for revenue insurance are 1.906% for Makedonia and Thraki and 1.902% for Central Greece.

Table 9. Yield and revenue insurance for Tobacco farmers with the occurrence of bad events[1]

	No Insurance	**Yield Insurance** [2]	**Revenue Insurance** [3]
	CV Net Return	CV Net Return	CV Net Return
Low yield variability			
Makedonia and Thraki	47.44%	39.89%	42.43%
Central Greece	41.62%	33.41%	37.45%
Average yield variability			
Makedonia and Thraki	48.61%	40.44%	41.19%
Central Greece	40.63%	32.89%	36.39%
High yield variability			
Makedonia and Thraki	50.07%	40.75%	41.76%
Central Greece	46.45%	36.46%	41.55%

[1] We assume that yield decreases once by 70% during the five years period.
[2] Loss costs for yield insurance are 4.44% for Makedonia and Thraki and 4.366% for Central Greece.
[3] Loss costs for revenue insurance are 4.228% for Makedonia and Thraki and 4.538% for Central Greece.

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Market-Based Crop Insurance Appraisal Using Whole-Farm Planning

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Abstract

This paper is a study of the viability of market-based crop insurance using whole-farm planning. Utility-efficient programming (UEP) is used to determine demand on the basis of transaction costs and level of farmer's risk aversion. Farm-level data for the utility-efficient programming model were derived from a panel data set for specialised arable farms in the Netherlands. The data included information about the stochastic structure of yields and prices as well as other physical and financial parameters. The UEP results indicated under which conditions farmers were likely to participate. The results showed that the degree of risk aversion affected the optimal choice to retain yield risk or to transfer the risk by means of an insurance contract. Although the viability of market-based crop insurance is partly conditional upon the (currently uncertain) transaction costs, the fact that farmers under study were relatively wealthy reduces the chances of any substantial demand for such a market-based product. Alternative risk-coping options, such as use of credit to enhance farm-firm liquidity in adverse years, are likely to dominate a commercial crop insurance risk strategy.

1. *Introduction*

To safeguard against adverse weather conditions, various forms of subsidised multi-peril crop insurance exist in a number of countries, such as the U.S. and Canada. By contrast, such comprehensive schemes covering yield or revenue have till now been relatively uncommon in the EU. The commercial crop insurance schemes that do exist in the EU cover mainly crop losses resulting from hail and windstorms. However, there has recently been a considerable amount of interest in member states in the scope for commercial or subsidized crop insurance (Meuwissen et. al., 2003).

By taking up a market-based crop insurance contract a farmer will normally be accepting a small reduction in expected net returns, but is guarding against unfavourable outcomes. A risk-averse farmer would consider buying such a contract and the decision would depend on the level of the premium relative to the benefit perceived from the reduction in down-side risk (Arrow, 1996; Harrington and Niehaus, 1999).

Although sharing risks can increase a farmer's utility, (s)he is not likely to share all risks. It is (largely) up to each individual farmer to decide which risks, and which part of them, to share. Factors that may influence this decision include a farmer's degree of risk aversion, the costs involved in risk sharing, the relative size of a particular risk, the correlation of the risk with other risks, other sources of indemnity, a farmer's perception of the nature of the risks, and the farmer's income and wealth (Barry *et al.*, 1995; Hardaker *et al.*, 2004; Harrington and Niehaus, 1999).

Also important for the farmer's decision about which risks to share and which to bear is that this decision is part of the overall risk management problem facing of the farmer of selecting a risk-efficient portfolio of on-farm and off-farm risky activities and risk-reducing instruments. Thus, for example, a decision about whether to insure against a particular risk, and if so to what extent, cannot properly be made without reference to other risky choices. Arable farms in Europe are typically multi-commodity operations. Hence, crop mix selections are important in the context of risk management, as a diversified production program is risk reducing in itself. In general, it will be impossible to say whether or not the introduction of a new risk management instrument will be attractive to farmers[1]. It depends on the terms of the contract, the interactions with other risks on the farm and on the farmer's degree of risk aversion.

The objective of this paper is to analyse the viability of market-based crop insurance by assessing farm-level demand. To assess that demand, a farm specific portfolio approach is essential for the reasons just outlined and to account for the differences in the individual farm stochastic structure and operating constraints. To this end, utility-efficient programming (UEP) (Hardaker, 2004; Lien and Hardaker, 2001) is used to determine the demand for a market-based crop insurance contract as affected by transaction costs and farm circumstances, particularly including the farmer's degree of risk aversion. Farm level data are used to specify the states of nature that describe the joint distribution of net revenues from alternative cropping and crop insurance options, as well as other farm specific characteristics.

The paper is organised as follows: first, the utility-efficient programming model is elaborated. Subsequently, the analysed data are described. Finally the results are presented and discussed.

[1] The above statements imply that there are no universal rules about which risks to share and which ones not to. Only occasionally is it not completely up to the farmer what risks are managed and by what type of strategies. For example, lenders may require that farmers use one or more risk management strategies, such as crop insurance and forward contracting, when a loan is contracted (Harwood *et al.*, 1999).

2. *Material and methods*

2.1. *Utility-efficient programming*

The UEP model is formulated as follows (Lambert and McCarl, 1985; Hardaker *et al.*, 2004):

$$\begin{aligned} &\max\ E(U) = pU(z,r), \quad r \text{ varied} \\ &\text{subject to} \\ &Ax \le b \\ &Cx - Iz = uf \\ &x \ge 0 \end{aligned} \tag{1}$$

where: $U(.)$ is a monotonic and concave utility function; z is a vector of net income per year by state; r is a measure of risk aversion; p is a vector of state probabilities; A is a matrix of technical coefficients; x is a vector of activity levels to be determined; b is a vector of resource stocks; C is a matrix of net revenue per activity per state; I is an identity matrix; u is a vector of ones; and f is vector of fixed costs.

The utility function is defined for the measure of risk aversion, r, which can be, for example, the coefficient of absolute risk aversion (CARA), r_a, or the constant relative risk aversion (CRRA), r_r (Hardaker *et al.*, 2004). In the present study the following negative exponential function is used to incorporate CARA:

$$U = 1 - \exp(-zr_a)\,,\ r_a \ge 0 \tag{2}$$

where r_a is an assumed constant measure of absolute risk aversion over the range of z of concern derived from the utility function for wealth W.

In assessing the measure of risk aversion, it may be noted that the value of the function for relative risk aversion with respect to wealth $r_r(W)$ might reasonably be assumed to range from 0.5 (hardly risk averse at all) to about 4.0 (very risk averse), according to the risk attitude of the individual (Anderson and Dillon, 1992). Often $r_r(W)$ is assumed to be about one (somewhat risk averse) (Arrow, 1970), and it seems reasonable to that the particular value of the function would be relatively constant for small changes in W. The absolute risk aversion function is given by definition as $r_a(W) = r_r(W)/W$. Under the condition that preferences do not change whether the outcomes are expressed in terms of W or transitory income z, i.e. under the assumption of asset integration, it is assumed that $r_a(W) \approx r_a(z)$. Then assuming that variation in z is small relative to W so that $r_r(W)$ changes little with W, $r_a = r_a(z) = r_r(W)/W$ (Hardaker, 2000).

2.2. *Optimization model*

Data on specialised firms with arable crops covering the period 1990-2000 came from a stratified sample of Dutch arable firms keeping accounts for the

Dutch Agricultural Economics Research Institute (FADN). The firms typically remain in the FADN panel for approximately seven or eight years. For the analysis one 'average' specialized arable farm was selected with respect to size and cropping plan from the 718 available arable farms. The size of the selected farm was 38 ha. Also, this particular farm cultivated the main arable crops, which are winter wheat, sugar beet, consumption potatoes and onion seed.

Yield and prices of this specific farm were subsequently detrended and deflated (Kobzar et. al., 2004a). The UEP model was defined with a number of constraints. Land use was constrained by the total area of the farm (38 ha) and by crop rotation limits set in accord with information given in KWIN (2001). A limit on the maximum amount of sugar beet was based on individual farm quota. Most field operations have to be performed during a certain limited periods. To take into account the peak periods in labour and machine use, labour constraints were added to the model using data obtained from KWIN (2001). For a fuller description of this model, see Kobzar et. al. (2004b). The farm specific detrended gross margin components per crop and state are summarised in Table 1.

The model was formulated to optimize the portfolio of crops grown in the coming year, including options to insure a shortfall of the long-term average yield of each crop. Besides the four cropping activities in the UEP model as presented in Table 1, we added four additional activities to represent the outcomes under a yield insurance activity. The yield insurance scheme evaluated is assumed to cover losses below 85% of the long-term average individual farm yield.

3. *Results and conclusions*

In this section we present the impact of three main input parameters on the demand for a market-based crop insurance product. The first and second parameter under investigation comprise relative risk aversion with respect to wealth, $r_r(W)$, and wealth (W). We assumed three alternatives levels of $r_r(W)$, namely 0.5, 2 and 4. The corresponding levels for $r_a(z)$ are approximated ($r_a(z) = r_r(W)/W$). The wealth parameter was based on the FADN panel. In 2002, the total assets of an average Dutch arable farm are approximately 1 million Euro, of which 250,000 Euro is debt and 750,000 Euro is equity. The solvency ratio (equity-to-asset ratio) is therefore 75%, but a substantial heterogeneity exists between farms. Therefore the demand for insurance is determined for two alternative levels of wealth (associated solvency ratios were 33% and 75%, respectively). The third parameter is associated with the (currently uncertain) transaction costs of a market-based insurance contract. The premium for the hypothetical crop insurance option is composed of two parts, one designed to provide for the payment of losses and a second, referred to as loading, to cover the expenses of operation (e.g., administrative expenses, profit and a margin for contingencies).

Table 1. Distribution of activities by state of nature[1)]

		State								Mean	Std	CV
		1	2	3	4	5	6	7	8			
Winter wheat	Yield (Kg)	6 007	7 616	7 423	6 565	5 764	5 363	7 117	6 668	6 565	807	12%
	Price (Euro)	0.253	0.256	0.263	0.162	0.175	0.160	0.151	0.12	0.193	0.056	29%
	Variable cost (Euro)	275	196	327	157	239	291	304	283	259	58	22%
Sugar beet	Yield (Kg)	74 654	68 685	80 967		56 729	54 2045	56 593	69 815	65 166	9 773	15%
	Price (Euro)	0.049	0.054	0.047	0.047	0.0610	0.056	0.058	0.066	0.055	0.007	13%
	Variable cost (Euro)	376	303	212	244	211	275	323	281	278	56	20%
Consumption potato	Yield (Kg)	46 109	35 527	31 594	46 167	29 945	26 570	30 463	28 225	34 325	7 741	23%
	Price (Euro)	0.194	0.163	0.027	0.100	0.652	0.215	0.038	0.149	0.192	0.198	103%
	Variable cost (Euro)	2 217	2 313	2 191	1 452	1 077	1 619	1 264	848	1 623	562	35%
Onion seed	Yield (Kg)	29 709	31 024	39 463	40 796	36 011	23 898	58 236	39 695	37 354	10 276	28%
	Price (Euro)	0.211	0.345	0.287	0.260	0.308	0.361	0.315	0.331	0.302	0.049	16%
	Variable cost (Euro)	682	4 931	6 518	5 106	3 286	2 657	4 407	3 300	3 861	1 783	46%

1) The eight states are assumed to be equi-probable and these probabilities and states are assumed to capture the farmer's perception of the risks to be faced from unstable crop yields in the coming cropping year.

Table 2: Results of the UEP model for alternative assumptions.

$r_r(W)$	Solvency ratio	Loading	Percentage of hectares insured
4	33%	10%	74%
2	33%	10%	74%
0.5	33%	10%	64%
4	33%	25%	70%
2	33%	25%	66%
0.5	33%	25%	0%
4	75%	10%	69%
2	75%	10%	69%
0.5	75%	10%	0%
4	75%	25%	0%
2	75%	25%	0%
0.5	75%	25%	0%

That part of the rate that is intended to cover losses is called pure premium when expressed in absolute monetary values, and the expected loss ratio when expressed as a percentage. For example, Dutch agricultural hail insurance schemes operate with a long-term average loss ratio of about 55% (Swiss Re, 1997). The loading that is added to the pure premium is assumed to be 10% or 25% of the expected indemnity payments in order to determine the impact on demand.

A brief summary of the model results under alternative assumptions is presented in Table 2, focussing on the percentage of area insured.

One of the main observations is that the degree of risk aversion affects the optimal activity choice. A farmer who is hardly risk averse at all, $r_r(W)$=0.5, would only opt for partial insurance in the case of a relative low equity and low transaction costs. In all other cases for such a hardly risk averse farmer, it is not likely that crop yields will be insured.

Very risk averse farmers, $r_r(W)$=4, are more inclined to insure part of their crops even if they have a relative high level of wealth as long as the transactions costs are not excessive. In the case of relatively high transaction costs, there is demand for insurance only if the farmer's wealth is relatively low and (s)he is at least moderately risk averse ($r_r(W) \geq 2$).

In general, the results indicate that market-based crop insurance will not be attractive because of the expected relatively high transaction cost (for example, Dutch agricultural hail insurance schemes have a loading of 45%), the applied crop diversification in the portfolio and the fact that farmers under study are relatively wealthy and therefore are assumed to be not very averse to risk.

4. *Discussion*

Financial management options like the availability of a (expanded) line of credit would enhance a farm firm's liquidity in adverse years. Such a strategy, not accounted for in our annual model, might be dominant because of the relative low interest rate in comparison to the loading of a standard private insurance policy. Most of the adverse production years leading to potential indemnity payments under crop insurance cause only liquidity problems. Many arable farmers may well be able to 'ride out' the bad times by using savings or credit. Their access to such credit is likely to be good because they usually have substantial equity, mostly in the form of their investment in land. Use of insurance is likely to be of interest to such farmers only for catastrophic events which threaten the continuity of the firm, not for adverse years causing "normal" income variation.

For farmers, insuring their whole-farm income is likely to be more attractive (i.e. closer to optimising the welfare of the farm family) than insuring separate components of their income, such as the revenue or only the yield of a particular cropping activity. In the current study we focused on only the yield risk component. Although price components might be packaged and marketed via revenue insurance or whole-farm income insurance, the mechanism and thus risk loading differ from "traditional" indemnity insurance. The latter is based on the principle of pooling which enables any losses to be spread over a large group, assuming that a large proportion of the exposure units will not incur losses at the same time. But prices of commodities are completely systemic risks. Hedging by means of the futures market is a more appropriate risk financing tool (but could still be marketed under the umbrella of an insurance contract). A prerequisite is that a futures market exists for the specific cropping activities, which does not hold for most of the crops in the Netherlands.

Subsidising insurance schemes will increase potential participation. In the USA, private companies deliver and service subsidised crop and revenue insurance schemes. Subsidies are provided for the farmer-paid premiums, for delivery and administration, and for the private sector reinsurance. Farmers in the USA pay on average 25 per cent of the total cost of these risk management programs. In Canada, the government is the sole provider of multiple peril crop and revenue insurance policies. The subsidy position is similar to that of the USA although there are differences in exact arrangements in the different Provinces. Naturally, many farmers find it attractive to purchase crop insurance when the expected indemnities available exceed the cost of insuring. Serious questions, however, have been raised about the incentives in the USA programs (Meuwissen et. al., 2003; Skees, 1999):

1. government subsidies to insurance companies are provided in a way that leads to rent seeking behaviour by insurers;
2. schemes are not well designed with respect to adverse selection and moral hazard;
3. transaction costs are high (including monitoring and administrative costs);
4. the government in the USA continues to provide ad hoc disaster relief (thereby undermining the whole insurance system); and

5. the schemes are significantly distorting - the high subsidy element tends to encourage excess production and to drive up land prices. Moreover, there can be inappropriate encouragement for farmers to shift into more risky forms of production for which the ratio of indemnities to premiums are more favourable from their perspectives.

As a consequence we have what might be called "incentive problems": neither farmers nor insurance companies get the right incentives for responsible (socially efficient) risk management and as a consequence may be induced to misallocate resources.

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The Efficiency of the Futures Market for Agricultural Commodities in the UK*

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Abstract

This paper uses cointegration procedures to test for agricultural commodity futures market efficiency in the UK. Cointegration between spot and futures prices is a necessary condition for market efficiency where these prices are characterised by stochastic trends (Lai and Lai 1991). In addition, acceptance of the 'unbiasedness hypothesis' requires that the spot and lagged futures prices are cointegrated with the cointegrating vector (1, -1). Alternatively, Brenner and Kroner (1995) use a no-arbitrage cost-of-carry model to argue that the existence of cointegration between spot and futures prices depends on the time series properties of the cost-of-carry. According to Brenner and Kroner (1995), a tri-variate cointegrating relationship (the BK hypothesis) should exist among the spot price, the lagged futures price and the lagged interest rate (that component of cost-of-carry most likely to be non-stationary). These variables should be cointegrated with a cointegrating vector (1, -1, 1). Kellard (2002) finds that both bi-variate and tri-variate cointegrating relationships are found in a sample from the wheat futures market in the UK, and thus the so-called "cointegration paradox" emerges. As Kellard (2002) points out this paradox exists because it is theoretically impossible for two variables to be cointegrated with each other while simultaneously being cointegrated with a third variable. Using a larger sample of wheat futures market prices from LIFFE both the 'unbiasedness hypothesis' and the 'BK hypothesis' are examined. The results indicate that the 'BK hypothesis' should be rejected.

1. *Introduction*

The efficiency of commodity futures markets has been an issue of debate for sometime. As Wang and Ke (2003) argue, an efficient commodity futures price should act as an effective and 'unbiased' predictor for the future spot price and reflect the equilibrium value of supply and demand in the market. In other words, there should be no guaranteed profitable arbitrage opportunities generated by the trading process. In recognition that the spot and futures prices

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usually contain unit roots (Shen and Wang, 1990), cointegration between spot and futures prices is conventionally regarded as one of the necessary conditions for market efficiency (Lai and Lai 1991). It ensures at least a long-run equilibrium relationship between the two prices. Otherwise, the spot and futures prices will drift apart without bound, so that the futures price provides little information about the future spot price. In addition, acceptance of the 'unbiasedness hypothesis' requires that the spot and lagged futures prices are cointegrated with the cointegrating vector (1, -1) and also that there is an absence of short-run dynamics.

The empirical evidence with regard to the efficiency of futures markets is somewhat mixed. Some studies find evidence of efficiency (e.g., Kellard et al, 1999), while others do not (e.g., Baillie and Myers, 1991). The possible explanations for the mixed findings obtained in empirical testing of futures market efficiency include, the difference in time periods analysed and in the methodology used (Jumah *et al.* 1999), the presence of a risk premium (Krehbiel and Adkins, 1993), the inability of the futures price to reflect all publicly available information (Beck, 1994), the inefficiency of agents as information processors (Kaminsky and Kumar, 1990), and the neglect of interest rates (the nonstationary part of storage cost) which play an important role as they enter arbitrage relationships between spot and futures prices (Brenner and Kroner, 1995).

Among these explanations for the differing conclusions reached by empirical studies on the issue of futures market efficiency, the Brenner and Kroner (1995) (BK) explanation has attracted a lot of attention. Brenner and Kroner (1995) use a no-arbitrage cost-of-carry model to argue that the existence of cointegration between spot and futures prices depends on the time series properties of the cost-of-carry. As demonstrated by Park and Phillips (1989), a stationary variable can be omitted from a cointegrating regression without affecting either the consistency of the coefficient estimates or the power of the statistical hypothesis testing procedures. Thus the conventional test for market efficiency may find that spot and futures prices are cointegrated with the cointegrating vector (1, -1) if the cost-of-carry is stationary; otherwise, according to BK, a tri-variate cointegrating relationship (the BK hypothesis) should exist among the spot price, the lagged futures price and the lagged interest rate (that component of cost-of-carry most likely to be non-stationary) in what is termed a 'commodity arbitrage' model. These variables should be cointegrated with a cointegrating vector (1, -1, 1).

Empirical studies, such as Jumah *et al.* (1999), Kellard et al (1999) and McKenzie *et al.* (2002), provide support for the BK hypothesis. However, Kellard (2002) finds that both bi-variate and tri-variate cointegrating relationships exist in a small sample from the wheat futures market in the UK, and thus the so-called "cointegration paradox" emerges. As Kellard (2002) points out, this paradox exists because it is theoretically impossible for two variables to be cointegrated with each other while simultaneously being cointegrated with a third variable. Kellard (2002) puts forward an explanation for his finding but doubts the ability of cointegration-based tests to distinguish between the 'unbiasedness hypothesis' and the 'BK hypothesis'.

This paper uses a larger sample from LIFFE to examine the 'unbiasedness hypothesis' and the 'BK hypothesis' for the wheat futures market in the UK in order to shed further light on the paradox uncovered by Kellard (2002). In section 2 an overview of the unbiasedness hypothesis and the BK framework is provided. A description of the dataset is given in section 3. The results of the tests of wheat futures market efficiency are presented in section 4. Conclusions, in section 5, complete the paper.

2. *The Unbiasedness Hypothesis and the BK Hypothesis*

The unbiasedness hypothesis and the no-arbitrage cost-of-carry (or Brenner and Kroner (BK)) hypothesis are alternative models for examining the efficiency of futures markets. To some extent these models can be viewed as complementary rather than competing. In the following both models are briefly discussed. The unbiasedness hypothesis is, from a theoretical point of view, a joint assumption of both market efficiency and risk neutrality (Beck, 1994) and it is represented as follows:

$$S_t = a + \beta_1 F_{t-1} + \beta_2 \pi_{t-1} + v_t \tag{1}$$

where S_t and F_{t-1} are the natural logarithms of the spot and futures prices at time t and t-1, π_{t-1} is the zero mean risk premium and v_t is white noise. Given that spot and futures prices are usually found to be nonstationary and integrated of order one (Shen and Wang, 1990) a necessary condition for market efficiency, which does not require the explicit identification of the risk premium, is the existence of cointegration between spot and lagged futures prices with a cointegrating vector (1,-1) (Kellard, 2002). The risk premium can be ignored in the test equation because it is considered to be stationary in theory. The cointegrating equation can be specified as:

$$S_t = a + \beta_1 F_{t-1} + u_t \tag{2}$$

where $u_t = \beta_2 \pi_{t-1} + v_t$ and must be integrated to order zero.

The unbiasedness hypothesis requires that $a = 0$ (assuming the risk premium has a zero mean), $\beta_1 = 1$ and u_t should be serially uncorrelated. Rejection of the null hypothesis can therefore be explained by one of the following:

(1) the futures market is inefficient,
(2) a non-zero risk premium exists,
(3) both (1) and (2) are true.

The unbiasedness hypothesis implies that the current futures price of a commodity should equal the future spot price for a given commodity at contract maturity (McKenzie *et al*, 2002). It is only when futures markets are unbiased and efficient that minimum variance hedge ratios are optimal (Benninga *et* *al*, 1984). The optimality of these hedge ratios is important if the practice of futures market hedging is to provide a useful tool for price risk management. Many studies (e.g., Chowdhury, 1991; Krehbiel and Adkins, 1993) have found no evidence of cointegration between spot and futures prices, or have found cointegration but not with the cointegrating vector (1,-1).

Brenner and Kroner (1995) argue that profit maximizing investors will trade up to the point where they are indifferent between buying the commodity in the spot market (and incurring the associated storage costs while benefiting from convenience yields) and investing in risk free bonds and purchasing futures contracts to be settled later at the currently quoted price. This no-arbitrage situation leads to the following:

$$S_t - F_t = Q_{t-1} - R_{t-1} - C_{t-1} + Y_{t-1} + v_t \quad (3)$$

where Q_{t-1} is the marking-to-market feature of futures markets (which goes to zero as the contract approaches maturity), R_{t-1} is the interest rate, C_{t-1} is the storage costs as proportion of the spot price, Y_{t-1} is the convenience yield and v_t is white noise. The marking-to-market component is normally omitted because it is non-stochastic and small (though it may be reflected in any constant term included in the test equation). Most researchers are content to assume that C_{t-1} - Y_{t-1} is stationary, therefore if the spot and futures prices and the interest rate are non-stationary a (simplified) necessary condition for this model is that there exists tri-variate cointegration with the cointegrating vector (1,-1,1). This cointegrating regression is expressed as follows:

$$S_t = a + \beta_1 F_{t-1} + \beta_2 R_{t-1} + w_t \quad (4)$$

The BK hypothesis requires that $\beta_1 = 1$ and $\beta_2 = -1$. By implication $w_t = (C_{t-1} - Y_{t-1}) + v_t$ and are stationary. The interest rate, *R*, in equation 3 represents the 'risk premium' in the BK model. Therefore, the BK model can be thought of as a special case of the unbiasedness hypothesis (Chow, 2001). Consequently, testing for market efficiency requires the following to be examined:

If the interest rate is stationary, the natural logarithms of the spot and futures prices at any lead or lag must be cointegrated with vector (1, -1) before the market efficient hypothesis can be accepted.

If the interest rate is nonstationary then the natural logarithms of the spot price, futures price, and the interest rate should form a tri-variate cointegrated system with the cointegrating vector (1,-1,1).

As Kellard (2002) points out it is impossible from a theoretical perspective for two variables that are found to be cointegrated with each other to be simultaneously cointegrated with a third variable. Therefore, if the spot and futures prices are cointegrated we would not expect to find cointegration between the spot price, futures price and the interest rate. However, given the empirical irregularities found by Kellard (2002) we will perform cointegration tests on both equations 2 and 4 in section 4.

3. *Data*

In this paper, the spot price, S_t, is the weekly cash price for the UK in the termination week of the futures contract as published by Department of Environment, Food and Rural Affairs (DEFRA). The futures prices were obtained from wheat futures contracts traded in LIFFE. The frequency of each series corresponds to the number of delivery months. UK wheat futures contracts have six delivery months per year (January, March, May, July, September and November). The futures prices, F_{t-1}, are those observed two calendar months prior to the date of contract maturity. The cointegration regressions are given by equation 2 and 4. The interest rate is the Bank of England repo base rate. The British Bankers' Association defines REPO rates as, "*Repurchase agreements (repos) are collateralised lending transactions. One party agrees to sell securities (e.g. gilts) to the other against a transfer of funds. At the same time the parties agree to repurchase the same or equivalent securities at a specific price in the future*". These observations for each variable cover the period from November 1985 to January 2004 for all variables. The number of observations used in the analysis is 110.

4. *Results*

The first step in the analysis was to test the logarithm of each time series for the presence of a unit root using the Augmented Dickey-Fuller (ADF) test. The test equations passed residual tests for normality and serial correlation. The ADF test results, presented in Table 1, show that the interest rate, spot price and futures price series are all found to be I(1). Therefore, these test results concur with those of Aulton *et al.* (1997) and with those of Kellard (2002) who tested a similar wheat futures price series (from LIFFE) although over a different time period. ADF tests, not reported here, were also carried out on the first differences of the three time series and the results indicated that the differenced series were I(0).

The finding that the interest rate is I(1) suggests that the appropriate cointegrating regression for testing the efficiency of the wheat futures market at LIFFE is given by equation 4. However, given the empirical results obtained by Kellard (2002) and the paradox that he uncovered, one of the aims of this paper is to use both the specifications given by equations 2 and 4 in testing the efficiency of wheat futures market in the UK.

Using the Johansen approach (Johansen, 1988, 1991; Johansen and Juselius, 1990) tests for cointegration were carried out on the specifications represented by equations 2 and 4. The results of the application of Johansen's reduced rank regression method applied to equation 2 are presented in table 2, while the results for equation 4 are given in Table 4. The order of the VAR was predetermined by likelihood ratio (LR) tests that determined the validity of the restrictions imposed by successive reductions in lag length. These tests were carried out in conjunction with Lagrange Multiplier tests for autocorrelation. The tests

Table 1. Unit Root Tests (ADF)

Series	DF	ADF	k	5% Critical value
S_t	-2.397	-2.391	6	-2.89
F_{t-1}	-2.105	-2.185	6	-2.89
R_{t-1}	-1.587	-2.751	6	-2.89

Note: All tests include both a constant term and a time trend; DF is the Dickey-Fuller test statistic (H_0: series contains a unit root); ADF is the augmented Dickey-Fuller test statistic at the lag length that removes serial correlation; and, k is the lag length chosen.

Table 2. Test of Cointegration Rank: (S_t, F_{t-k})

Hypothesis	Trace	Max Eigenvalue	Lag Length	Comment
H_0: r = 0	94.24 (0.00)**	90.34 (0.00)**	1	Rank = 1
H_1: r = 1				
H_0: r = 0	42.29 (0.00)**	38.69 (0.00)**	2	
H_1: r = 1				
H_0: r ≤1	3.90 (0.440)	3.90 (0.439)	1	Reject non-cointegration
H_0: r ≤1	3.60 (0.486)	3.60 (0.485)	2	

Table 3. Wald Tests of Parameter Restrictions ($S_t = a + \beta_1 F_{t-1} + u_t$)

H_0: $a = 0$	H_0: $\beta_1 = 1$	H_0: $a = 0$ and $\beta_1 = 1$
1.64 (0.20)	2.37 (0.12)	27.43 (0.00)**

Note: Figures in parentheses are P-values.

suggested that the appropriate specification should be either VAR(1) or VAR(2) in all cases, so the results for both VAR lag lengths are given. The maximal eigenvalue and trace test statistics presented in Table 2 indicate that the null hypothesis of no-cointegration is rejected (in the case of {S_t, F_{t-1}} as specified in equation 2). In each case the null hypothesis of no cointegration (rank = 0) is rejected at the 1% level of significance. The finding of rank ≤ 1 cannot be rejected and this indicates that one cointegrating relationship is found in the case of the specification given by equation 2.

The separate and joint restrictions of $a = 0$ and $\beta_1 = 1$ imposed on the cointegrating regression given in equations 2 are tested using Wald tests. The results are presented in Table 3. The test results in Table 3 indicate that the separate restrictions of $a = 0$ and $\beta_1 = 1$ imposed on equation 2 hold, while the joint restriction of $a = 0$ and $\beta_1 = 1$ does not hold.

The maximal eigenvalue and trace test statistics presented in Table 4 indicate that the null hypothesis of no-cointegration (rank = 0) is rejected at the 1% level of significance (in the case of {S_t, F_{t-1}, R_{t-1}} as specified in equation 4). The finding of rank ≤ 1 cannot be rejected and this indicates that one cointegrating relationship is found in the case of the specification given by equation 4.

The separate and joint restrictions of $a = 0$, $\beta_1 = 1$ and $\beta_2 = -1$ imposed on the cointegrating regression given in equations 4 were tested using Wald tests and the results are presented in Table 5.

Table 4. Test of Cointegration Rank: (S_t, F_{t-1}, R_{t-1})

Hypothesis	Trace	Max. Eigen	Lag Length	Comment
H_0: r = 0 H_1: r = 1	105.1 (0.00)**	94.8 (0.00)**	1	Rank = 1
H_0: r = 0 H_1: r = 1	49.7 (0.00)**	40.9 (0.00)**	2	
H_0: r ≤1 H_1: r = 2	10.28 (0.62)	7.87 (0.57)	1	Reject non-cointegration
H_0: r ≤1 H_1: r = 2	8.76 (0.76)	6.08 (0.78)	2	

Note: Figures in parentheses are P-values.

Table 5. Wald Tests of Parameter Restrictions ($S_t = a + \beta_1 F_{t-1} + \beta_2 R_{t-1} + w_t$)

H_0: β_2 = -1	H_0: β_2 = 0	H_0: a = 0, β_1 = 1 and β_2 = -1	H_0: a = 0, β_1 = 1 and β_2 =0	H_0: β_1 = 1 and β_2 = 0
3 521.84 (0.00)**	0.0094 (0.92)	131 286.0 (0.00)**	27.19 (0.00)**	2.35 (0.31)

Note: Figures in parentheses are P-values.

The result of the Wald test of the joint restrictions of $a = 0$, $\beta_1 = 1$ and $\beta_2 = -1$ imposed on the cointegrating regression given in equations 4 is presented in column 3 of Table 5. In this case the null hypothesis is firmly rejected. A test of the separate restriction, $\beta_2 = -1$, showed that this was also rejected, while a test of the restriction, $\beta_2 = 0$, was could not be rejected. Therefore although cointegration was found among the variables in the specification given by equation 4 the parameter associated with the interest rate variable was not significantly different from zero. This means that the BK hypothesis must be rejected.

5. *Conclusions*

The analysis in this paper employs cointegration methodology to test both the 'unbiasedness hypothesis' and the 'BK hypothesis' to investigate long-run market efficiency in the UK wheat futures. The analysis indicated that the spot and lagged futures prices are cointegrated with the vector (1,-1), while the spot price, lagged futures price and lagged interest rate are cointegrated but not with the cointegrating vector (1,-1,1). The finding of cointegration means that one of the necessary conditions for market efficiency is met and it suggests that the futures market provides useful information about future spot prices for wheat.

The results in this paper do not lead to the same paradox uncovered by Kellard (2002). The non-rejection of cointegration between the spot and lagged futures prices with the vector (1,-1) implies rejection of cointegration among the spot price, lagged futures price and lagged interest rate with the cointegrating vector (1,-1,1). In this paper the former was accepted and the latter was rejected.

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Comparing Risk Perceptions and Risk Management in Organic and Conventional Dairy Farming: Empirical Results From Norway

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Abstract

This study was conducted to explore organic and conventional dairy farmers' perceptions of risk and risk management, and to examine relationships between farm and farmer characteristics, risk perceptions, and strategies. The data originate from a survey of conventional (n = 363) and organic (n = 162) dairy farmers in Norway. Organic farmers had the least risk averse perceptions. Institutional and production risks were perceived as primary sources of risk, with farm support payments at the top. Compared to their conventional colleagues, organic farmers gave more weight to institutional factors related to their production systems. Conventional farmers were more concerned about costs of purchased inputs and animal welfare policy. Organic and conventional farmers' management responses were more similar than their risk perceptions. Financial measures such as liquidity and costs of production, disease prevention, and insurance were perceived as important ways to handle risk. Even though perceptions were highly farmer-specific, a number of socio-economic variables were found to be related to risk and risk management. The primary role of institutional risks implies that policy makers should be cautious about changing policy capriciously and they should consider the scope for strategic policy initiatives that give farmers some greater confidence about the longer term. Further, researchers should pay more attention to institutional risks.

1. *Introduction*

Farmers' perceptions of and responses to risk are important in understanding their risk behaviour. In the literature much normative analysis (with mathematical programming etc.) has been done to show how farmers should behave under uncertainty (e.g. Hardaker *et al.*, 2004). Surprisingly, however, less work has been done to examine how farmers perceive risk and manage it in practice.

Organic farmers are exposed to additional and different sources of risk compared to conventional farmers. Restrictions on pesticide use, fertilisers, synthetic medicines, purchase of feeds etc. influence production risk. Smaller organic markets may mean greater price fluctuations. On the other hand, specific direct payments in organic farming result in greater income stability (Offermann and Nieberg, 2000, pp. 93). At the same time, and for both production types, uncertainty about future government payments may be of concern to farmers.

Surveys have been conducted asking about the types of risk perceived as most important by conventional farmers and about the management strategies the farmers use. Harwood *et al.* (1999) have summarised US studies. US farmers, included dairy farmers, were most concerned about commodity price risk, production risk, and changes in government laws and regulations. Arizona dairy producers perceived the costs of operating inputs to be the greatest source of risk (Wilson *et al.*, 1993). A 1996 USDA survey (reported in Harwood *et al.*, 1999) found that keeping cash on hand was the chief risk management strategy for every farm size, for every commodity speciality, and in every region studied. Use of derivative and insurance markets was also considered important. In a recent study (Hall *et al.*, 2003), beef producers in Texas and Nebraska perceived severe droughts and cattle prices as the most important risk factors. Maintaining animal health was viewed as the most effective strategy.

Dairy farmers in New Zealand ranked price risk and rainfall variability highest, met by routine spraying, drenching and maintaining feed reserves (Martin, 1996). Meuwissen *et al.* (2001) found that Dutch livestock farmers considered price and production risks to be most important. Producing at lowest possible costs and insurance were the most important risk management strategies. A study among Finnish farmers found changes in agricultural policy as the most important risk factor, while maintaining adequate liquidity and solidity were the most important management responses (Sonkkila, 2002).

A few studies have found that geographic location, farm type, institutional structures and other factors affecting the operating environment of farmers influenced farmers' perceptions of risk and risk management (Boggess *et al.*, 1985; Wilson *et al.*, 1993; Patrick and Musser, 1997; Meuwissen *et al.* 2001). The studies also pointed to "the highly complex and individualistic nature of risk perceptions and selection of management tools" (Wilson *et al.*, 1993).

As far as we know, no earlier studies have compared conventional and organic farmers' risk perceptions and risk management strategies. In Norway, no studies at all have explicitly investigated dairy farmers' risk perceptions and the ways they deal with the risks.

This relative lack of information about (especially organic) farmers' risky environment and their reactions to it means that there are few useful practical insights for policy makers, farm advisers and researchers. The objectives of this study are, through an exploratory and descriptive study, to provide empirical insight into: 1) Norwegian dairy farmers' risk perceptions and risk management responses; 2) differences in risk perceptions and management responses between conventional and organic dairy farmers; and 3) farm and farmer characteristics related to the perceptions and strategies. The data are analysed with modern multivariate techniques.

2. *Conceptual framework*

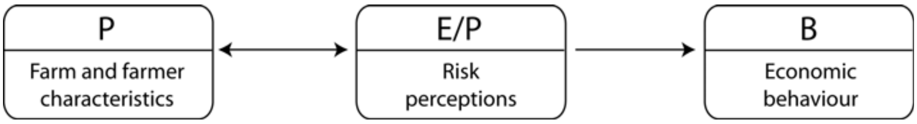
Economists have traditionally used one theory of risky choice to serve both normative and descriptive purposes (Thaler, 2000). Expected utility theory is the most widely accepted normative model of rational choice (Meyer, 2000) that economists have used also as a descriptive model of decision making under risk (Thaler, 2000). Numerous studies have, however, criticised the expected utility hypothesis on descriptive grounds because it fails to describe observed behaviour (Kahneman and Tversky, 1979; Allais, 1984; Moschini and Hennessy, 2001, Rabin and Thaler, 2001). The best way to describe decision-making behaviour, according to Slovic *et al.* (1982), March and Shapira (1987) and Priem *et al.* (2002), is to understand the individual's frame of reference for evaluating choices with uncertain outcomes because the decision maker's perceptual world is that person's reality and forms the basis for her or his choices.

This paper will use a descriptive approach, where we aim to characterise how Norwegian dairy farmers perceive and manage risk. Because of organic farmers' exposure to additional and different sources of risk compared to conventional farmers, we expect these to influence their risk perceptions and management responses. For example, organic farmers purchase less of variable inputs, and we thus expect organic farmers to be less susceptible financially to input price shocks. The lack of earlier comparative studies, however, makes it hard to develop firm hypotheses. Instead, we will explore and identify differences between organic and conventional farmers in their assessed importance of various sources of risk and their management responses of these risks.

We do not expect either group of farmers to be a homogeneous population since we expect different farm and farmer characteristics to influence their risk perceptions and management responses. Van Raaij's (1981) model of the decision-making environment for the firm is useful to study the relationship between farm and personal characteristics, risk perceptions and management responses (e.g., Wilson *et al.*, 1993). Figure 1 presents the groups of variables used in our research design. The other elements of Van Raaij's model are excluded.

First, P→E/P describes how farm and personal variables (P) impact on farmers' perceptions of risk factors (E/P). Second, the relationship P→E/P→B reflects how the farm/personal variables and risk perceptions influence economic behaviour (B), i.e., their risk management strategies. Best use of intuition and prior insights from research in other countries were used in the selection of variables.

Figure 1. Elements of Van Raaij's (1981) model of a firm's decision-making environment



3. *Materials and methods*

3.1. *Data*

The data reported here were collected as a part of a larger questionnaire survey of risk and risk management in farming. Samples were selected from Norwegian crop and dairy farmers. This paper examines data from dairy farmers; an analysis of the data from crop farmers is reported in Koesling *et al.* (2004). Because of small herd sizes in Norway, dairy farms were defined as farms having more than five dairy cows.

The 10-page questionnaire consisted of questions related to: 1) farmers' perceptions of risk (including questions on risk attitude and sources of risk); 2) farmers' perceptions of various risk management strategies; 3) farmers' goals, future plans and motivations for their farming system (organic or conventional); 4) animal disease management strategies; and 5) characteristics of the farm and farmer. Most questions were of the closed type, many in the form of seven point Likert-type scales. The questionnaire was both pre-tested internally and in sessions with farmers, and refined over several stages based on the comments and suggestions received.

The Norwegian Agricultural Authority (SLF) has a register of farmers who receive support payments (i.e. all farmers), including each farmer's stocking and cropping details. Dairy cow health and production records are registered in the Norwegian Herd Recording System, in which 96.5% of the dairy farmers participate (Østerås, 2003). These two data sets (2002-data) were merged with the survey data.

3.2. *Sample*

The questionnaire was first sent out in January 2003 to 616 randomly selected conventional dairy farmers and all 245 registered organic dairy farmers. Conventional farmers were selected from the SLF-register of farmers who received support payments based on their 2001 application. A month later a reminder post card was sent to all non-respondents. In March, non-respondents were mailed with a follow-up letter and another copy of the questionnaire.

From the original 861 dairy farmers approached (in 2001), 383 (62.2%) conventional and 161 (65.7%) organic farmers responded. Six conventional re-

Table 1: Number of unanswered questions on sources of risk[a] (n = 31) across risk management strategies (n = 25) within categories of groups

		Sources of risk					
	Groups	0	1-5	6-11	12-20	>20	**Total**
Risk management strategies	0	315	78	2	1	3	**399**
	1-5	65	33	2	0	1	**101**
	6-13	6	4	0	0	0	**10**
	>13	7	1	2	0	5	**15**
	Total	**393**	**116**	**6**	**1**	**9**	**525**

[a] A total of 33 variables were presented, but two crop farm specific sources of risk are excluded

spondents informed us that they had quit farming. Seven conventional and two organic farmers had quit dairying. Five dairy respondents had converted to organic farming methods and one from organic to conventional farming. Two originally non-dairy respondents had started organic dairy farming. Three conventional and three organic responses were discarded because of very incomplete returns. The questionnaires of 363 conventional and 162 organic farmers (in 2002/2003) were then available for statistical analysis. Because of the sampling strategy used and the high response rate, the samples are assumed to be representative of the conventional and organic dairy farmer populations.

3.3. *Statistical analyses*

All computations were conducted using the SAS statistical program package (v 8.2). As a first step, farmers' perceptions of risk and risk management were studied using descriptive statistical analyses. Mean values obtained in organic and conventional farming for a variable were compared by *t*-tests, omitting an observation if it had a missing value. Standard parametric statistical procedures were assumed appropriate for ordinal variables in the form of Likert-type scales (e.g. Patrick and Musser, 1997; Meuwissen *et al.*, 2001).

Common factor analysis, from an exploratory perspective, was employed to summarise the information in a reduced number of factors. The latent root criterion (eigenvalue > 1) was first used as a guideline in determining how many factors to extract. In order to have the most representative and parsimonious set of factors possible, factor solutions with different numbers of factors were also examined before structures were defined (Hair *et al.*, 1998). Orthogonal (varimax) rotation was used, to ensure *inter alia* that the factors were as independent as possible for subsequent use in regressions. Standardised factor scores for each farmer and factor were saved for subsequent multivariate analyses.

Some 40 % of the respondents did not answer one or more relevant questions about sources of risk or management responses (Table 1). In cases with missing data, most of the respondents failed to answer only a few items. If remedies for missing data are not applied, any observations with missing values on any of the items are omitted. Using only complete observations can produce bias in the results unless the missing observations are missing completely at random. There is also a loss of precision as the sample size is reduced (Hair *et al.*, 1998). Our approach for dealing with missing data in these factor analyses was first to delete cases having answered less than 20 of the risk source variables or 12 of the risk management strategies variables. Next, missing data points were replaced with the mean value of that variable based on all valid responses in the group (conventional or organic).

Organic and conventional farmers may have different risk perceptions but some preliminary analyses revealed very similar factor structures among risk sources and management responses. Therefore joint factor analyses for the two groups of farmers were carried out.

The factor scores from the risk attitude questions were submitted to a non-hierarchical cluster analysis to search for groupings of farmers with similar risk attitudes. The sequential threshold method combined with the least square optimisation criterion was used to select cluster seeds (Hair *et al.*, 1998). Creating the risk attitude variable by use of cluster analysis, rather than identifying the risk groups by using e.g. median split, reduces the chance of arbitrariness when identifying groups.

Multiple (ordinary least square and logistic) regressions were used to study associations between farm and farmer characteristics, risk perceptions and risk management, as outlined in figure 1. An observation was excluded from the analysis, if any variable needed for a regression was missing, for example a categorical farm or farmer characteristic. Simple correlation coefficients between all pairs of independent variables were low. Variance inflation factors were close to 1 and condition indices were low, indicating no multicollinearity problems (Belsley *et al.*, 1980). No heteroskedasticity was detected using the White test (White, 1980). The stepwise regression method was tested. Compared to the complete models, signs of the coefficients were identical, magnitudes of the coefficients were quite similar, and the levels of statistical significance of the independent variables were almost stable. The complete regression models were selected for reporting herein.

4. *Results and discussion*

4.1. *General characteristics of respondents*

The main characteristics of the dairy farm groups are compared in Table 2. The average farm size of conventional respondents was slightly larger than the average in Norway. Respondents were somewhat younger than the average dairy farmer.

Organic respondents farmed more land on average than conventional respondents. Average numbers of dairy cows were quite similar between the two

Table 2 : Comparison of average characteristics of dairy farms in survey with averages of dairy farms in Norway[a]

Characteristics	**Conventional**		**Organic**	
	Survey (n = 363)	Norway (18,300)[b]	Survey (n = 162)	Norway (325)[b]
Number of dairy cows[b]	16.9	15.8	16.8	16.8
Milk yield per cow[c] (kg)	6193	6150	5119	5070
Concentrates[c] (FUm[d]/cow)	1649	1706	887	866
Farmland (ha)[b]	25.8	23.3	30.3	30.2
Labour units (man-years)	2.1	-	2.1	-
Age of farmer[b]	47.5	51.6	47.2	52.1
Highest level of education[e] (%)	17 / 70 / 10 / 3	-	6 / 54 / 22 / 18	-
Agricultural education (%)	59.7	-	76.1	-
Farm income[f] (%)	54.8	-	46.8	-
Household income[g] (%)	42.2	-	50.3	-

[a] Information was also gathered on net worth and debt. Many refusals to answer precluded their use in the statistical analyses.

[b] Data (2002) from the Norwegian Agricultural Authority.

[c] Data (2002) from the Norwegian Herd Recording System.

[d] One feed unit milk (FUm) is defined as 6900 kJ of net energy lactation (Ekern, 1991).

[e] Primary school / high school / BSc / MSc.

[f] Percentage of respondents (spouse included) with farm income ≥ NOK (Norwegian kroner) 200 000. € 1 ≈ NOK 8.40.

[g] Percentage of respondents (spouse included) with household income ≥ NOK 350 000. Household income covers farm income, other forms of self-employment, wages, pensions, property income and capital income.

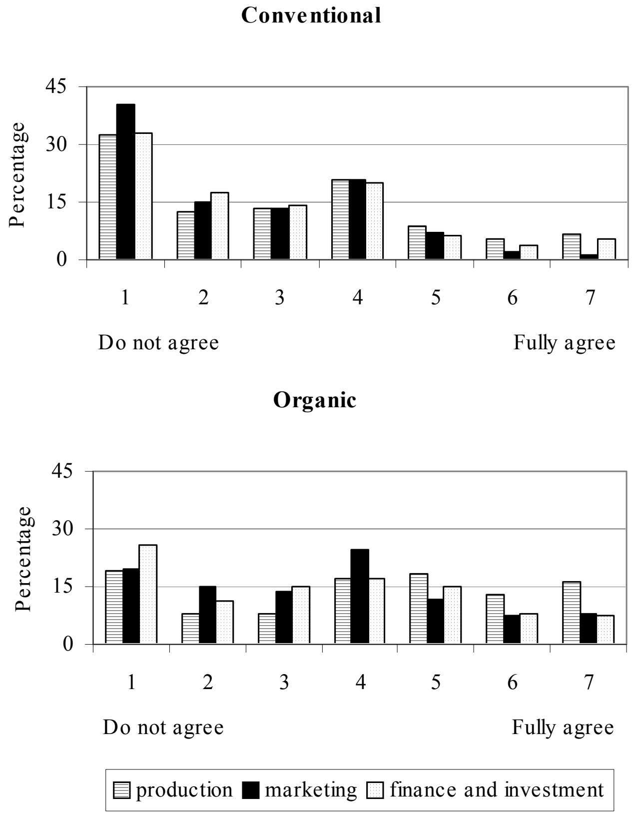
groups, but organic cows were fed less concentrate and produced less milk. Labour input and farmers' age were quite similar on conventional and organic farms. Organic farmers had most years of schooling and more of them had agricultural education. Most respondents were organised as family farms: 93% of conventional and 88% of organic farms. Partnerships occurred on 6% of the farms.

4.2. *Farmer's willingness to take risk*

Farmers were asked to assess their willingness to take risk, compared to others, on Likert-type scales ranging from 1 (do not agree) to 7 (fully agree). The statements were "I am willing to take more risk than other with respect to: 1) production; 2) marketing; and 3) finance and investment", respectively. Patrick and Musser (1997) and Meuwissen *et al.* (2001) used similar statements.[121] We assumed that most farmers are risk averse, but they vary in their willingness to take risk (Hardaker *et al.*, 2004, pp. 92). Since statements measured attitude toward risks compared to others, the term comparative risk aversion (CRA) was

[121] The measures used to elicit farmers' risk preferences in all these studies, including ours, is a simple approximation. More advanced methods to elicit farmers' risk attitude is discussed in, e.g., Moschini and Hennessy (2001) and Hardaker et al. (2004).

Figure 2. Percentage distribution of organic and conventional respondents' comparative risk aversion



used. Figure 2 compares the percentage distribution of organic and conventional respondents' answers in relationship to the statements.

Conventional dairy farmers generally perceived the extent to which they take risks to be less than that of others. By contrast, figure 2 shows that the responses of the organic dairy farmers had a more symmetric distribution over the scale of comparative risk aversion, especially with respect to production risks. Organic farmers' assessments were significantly less risk averse than their conventional colleagues (both production and marketing $P < 0.001$, finance and investment $P < 0.01$). Organic farmers have been few in numbers and the amount of experience with this form of production is somewhat restricted. Some willingness to take risk should therefore be expected among those adopting organic farming practices. Using historical data, Gardebroek (2002) also found organic farmers to be less risk averse than their non-organic colleagues.

Table 3: Mean score for conventional and organic farmers, and joint varimax rotated factor loadings for sources of risk (by declining importance for conventional farmers)

Sources of risk	**Conv.**	**Org.**	**Org.**	**Most important factors**[a]					
	mean[b]	mean	rank	1	2	3	4	5	6
Changes in gov. support payments	**5.90	5.56	(1)	0.02	**0.43**	0.00	0.21	0.20	0.19
Changes in tax policy	***5.86	4.99	(6)	0.15	**0.50**	-0.13	0.20	0.22	0.24
Milk price variability	***5.81	5.28	(2)	0.26	**0.45**	-0.08	0.19	**0.47**	0.01
Milk quota policy	***5.56	4.83	(9)	0.22	**0.50**	0.02	0.06	**0.31**	0.02
Meat price variability	***5.55	4.72	(10)	0.26	**0.43**	-0.08	0.20	**0.37**	0.06
Animal welfare policy	***5.40	4.17	(17)	0.22	**0.69**	-0.03	-0.10	-0.12	0.07
Costs of operating inputs	***5.23	3.98	(21)	0.27	**0.40**	-0.17	**0.36**	0.28	0.09
Injury, illness, death of operator(s)	5.18	5.05	(5)	0.15	0.16	0.09	0.07	0.17	**0.75**
Changes in consumer preferences	5.17	5.10	(4)	0.13	0.05	0.04	0.04	**0.58**	0.15
Non-domestic epidemic animal dis.	**5.10	4.53	(13)	**0.53**	0.19	0.06	0.07	0.01	0.27
Domestic epidemic animal diseases	***4.96	4.16	(18)	**0.74**	0.19	-0.02	0.08	-0.01	0.24
Forage yields uncertainty	4.86	4.84	(8)	**0.53**	0.02	0.09	0.17	**0.32**	0.06
Other gov. laws and regulations	*4.78	4.40	(14)	0.13	**0.52**	0.19	0.20	-0.02	0.17
Cost of capital equipment	***4.74	3.87	(25)	0.30	**0.37**	-0.09	**0.33**	0.21	0.10
Fire damages	***4.59	3.86	(26)	**0.44**	0.19	-0.01	0.19	0.03	**0.40**
Cost of credit (interest rate)	**4.51	3.97	(22)	0.22	0.08	0.02	**0.73**	0.08	0.07
Crop prices variability	4.47	4.25	(16)	d.	d.	d.	d.	d.	d.
Technical failure	***4.46	3.90	(24)	**0.42**	0.23	0.02	0.28	0.13	0.20
Meat production variability	***4.43	3.71	(27)	**0.57**	0.25	0.05	0.20	0.25	0.09
Family members' health situation	4.40	4.11	(19)	0.24	0.16	0.07	0.10	0.13	**0.56**
Marketing/sale	*4.35	4.65	(11)	0.09	0.01	0.18	0.01	**0.54**	0.08
Changes in technology	***4.35	3.68	(28)	d.	d.	d.	d.	d.	d.
Crop yields variability	4.33	4.37	(15)	d.	d.	d.	d.	d.	d.
Legislation in production hygiene	4.28	3.93	(23)	0.24	**0.62**	0.18	-0.06	-0.08	0.09
Production diseases	*4.23	3.61	(29)	**0.67**	0.20	0.03	0.11	0.14	0.06
Milk yield variability	*4.17	3.53	(30)	**0.52**	0.25	0.04	0.19	0.21	-0.03
Hired labour	3.86	4.06	(20)	d.	d.	d.	d.	d.	d.
Credit availability	3.57	3.28	(33)	0.22	0.09	0.16	**0.65**	0.02	0.11
Uncertainty about family relations	3.31	3.30	(32)	d.	d.	d.	d.	d.	d.
Leasing farm land	3.31	3.40	(31)	d.	d.	d.	d.	d.	d.
Add. organic farming payments	***2.67	5.24	(3)	0.07	0.05	**0.84**	0.02	0.05	0.05
Organic farming laws/regulations	***2.27	4.63	(12)	0.02	0.08	**0.88**	0.02	0.06	0.08
Price premiums organic products	***2.24	4.91	(7)	0.02	-0.07	**0.88**	0.08	0.09	0.00
Percent of total variance explained	-	-	-	11.9	10.7	9.2	6.2	6.0	5.3
Cum. % of the variance explained	-	-	-	11.9	22.6	31.8	38.0	44.0	49.2

[a] Factors 1 to 6 are production, institutional, organic farming, credit, consumer demand, and human resources, respectively. Factor loadings >|0.30| are in bold. "d." means that the variable is deleted from the factor analysis because of low factor loading and low communality or farm-type conditionality.

[b] Mean score (1 = no impact, 7 = very high impact) for conventional farmers (n = 363) and organic farmers (n = 162). Mean numbers marked with asterisks show that the mean scores of conventional and organic farmers are significant different at * P < 0.05, ** P < 0.01 and *** P < 0.001, based on independent samples t-test.

The three risk attitude questions all had significant positive correlations ($P < 0.001$) ranging from 0.57 to 0.62. Kaiser's overall measure of sampling adequacy (MSA) was 0.717, suggesting that the matrix was suitable for factor analysis (Hair *et al.*, 1998). Factor analysis of the variables resulted in a single factor with all three variables loading at 0.76 or higher and accounting for 73.7% of the total variance. The three risk attitude measures were summarised in a single variable (factor score).

The single factor scores from the factor analysis were used as input data in the cluster analysis; by this means it was possible to identify three distinct risk aversion clusters among the respondents. The cluster groups consisted of 210 farmers with "high risk aversion", 201 with "medium risk aversion" and 110 with "low risk aversion". Four respondents were excluded because of missing data. The three ordered categories of risk aversion were used in subsequent regressions.

4.3. *Perceptions of sources of risk*

In total, 33 sources of risk were presented to the respondents. Farmers were asked to score each source of risk on a Likert-scale from 1 (no impact) to 7 (very high impact) to express how significant they considered each source of risk to be in terms of its potential impact on the economic performance of their farm. The second and third columns of Table 3 compare average scores for conventional and organic farmers.[122] The fourth column shows organic farmers' ranking.

Uncertainty about the continuation of general government support payments stands out as the top-rated source of risk for both groups. Target prices and support schemes are decided in Norway through annual negotiations between the two farmers' unions and the Government. High average rankings related to milk and meat prices are thus linked to farm policy. Other highly ranked risks in general were institutional risks such as tax policy and milk quota policy.

Sources of risk that scored low include farmland leasing, family relations, credit availability, milk yield, production diseases, and hired labour.

Conventional farmers assigned more importance than organic farmers to many of the listed sources of risk. The less risk averse perceptions of organic farmers may have influenced the mean scores. The most pronounced differences were found in costs of operating inputs, animal welfare policy, and cost of capital equipment. The finding that organic farmers ranked input costs risk lower than conventional farmers is probably a result of production systems in organic farming with low levels of purchased inputs. At the time the survey was held a white paper on animal welfare was prepared (LD, 2002), maybe influencing the high score conventional farmers gave to animal welfare policy risks. Less pronounced anxiety among organic farmers for this source of risk is presumably because of already strict organic animal welfare standards. Organic farmers gave high scores to the specific, institutional "organic sources of risk" (the last three sources in Table 3). Beyond these, marketing/sales was the only source of risk where organic farmers' mean score was significantly higher than

[122] The standard deviations are not presented in Tables 3 and 4 because of the large size of the tables. The results are available from the authors.

that for conventional farmers, maybe reflecting the higher instability in organic product markets.

Comparisons of risks (and management strategies) with previous studies are difficult because different questions were asked. Further, different farming, cultural and risk environments complicate cross-national comparisons. However, the most outstanding finding, compared to previous US, NZ, and Dutch studies, is the very high scores of many institutional risks. Agricultural policy changes, however, scored high in Finland (Sonkkila, 2002).

Since farming is typically a risky business, governments around the world have intervened to varying degrees to try to help farmers cope more effectively with risk. In this context it is a paradox that farmers perceived institutional risks as the most important. The domination of institutional risks may be related to somewhat unpredictable changes in Norwegian farm policies and regulations, together with external pressures for deregulation and associated fears of farm support cuts. The finding should also be linked to Just's (2003) proposal that longer term swings (e.g. lasting changes in agricultural policy) represent a much greater risk to farmers than year-to-year variability in payoffs because the downside consequences may be sufficiently prolonged to cause farm failure.

Joint factor analysis was applied to the data to reduce the number of risk source variables. The overall MSA was 0.850, suggesting the matrix was suitable for factor analysis. The number of variables was reduced from 33 to 6. Some 49.2% of the total variance was accounted for. The latent root criterion suggested seven factors. The six-factor solution gave the most interpretable factors and was judged to be most useful. Variables conditional on farm type (crop yields and prices) were not included. Variables that did not load significantly on any factor (i.e. loadings <|0.30|) or whose communalities were low (<0.25) were also evaluated for possible deletion. Table 3 displays the six factors and their respective loading items after elimination of some variables.

The factors 1 to 6 are labelled "production", "institutional", "organic farming", "credit", "consumer demand", and "human resources" respectively. Factor 1, production, loads significantly from a variety of production variables and has the highest loadings of animal disease variables. A wide collection of public payment and government legislation variables indicates institutional risks in factor 2. Significant loadings of output and input prices could reflect the government's role in the pricing. Factor 3 is called organic farming because of the extremely high loadings of the three specific, institutional "organic" variables. Factor 4, credit, has large loadings of the interest rate and credit availability. Significant loadings of purchased inputs are likely to reflect the use of credit to these purposes in a farm business. Factor 5, consumer demand, involves high loadings of consumer preferences and marketing. Not surprisingly, some output price cross loadings are also significant. Heavy loadings of health and family variables and a cross loading of 0.40 of fire damage suggests human resources for factor 6.

Table 4 Mean score for conventional and organic farmers, and joint varimax rotated factor loadings for risk management strategies. Ranked by declining importance for conventional farmers

Risk management strategies	**Conv.**	**Org.**	**Org.**	**Most important factors[a]**						
	mean[b]	mean	rank	1	2	3	4	5	6	7
Liquidity – keep cash in hand	**6.50	6.19	(1)	0.08	0.20	0.07	0.20	-0.06	**0.50**	0.02
Prev./red. livestock diseases	*6.35	6.13	(2)	0.06	**0.64**	0.03	0.27	-0.09	0.22	0.10
Buying farminsurance	*6.13	5.80	(3)	0.19	0.22	0.05	**0.63**	-0.04	0.11	-0.04
Producing allower cost	**5.94	5.61	(5)	0.09	0.29	0.03	0.09	-0.02	**0.33**	0.18
Buying personal insurance	**5.92	5.50	(6)	0.16	0.12	0.07	**0.83**	0.12	0.08	0.16
Risk reducing technologies	5.73	5.67	(4)	0.23	**0.46**	0.12	0.12	0.06	0.10	0.18
Solvency – debt management	***5.65	5.16	(9)	-0.05	0.02	0.06	-0.02	0.13	**0.78**	-0.05
Prevent/reduce dis. and pests	5.52	5.39	(7)	0.07	**0.71**	0.24	0.05	0.12	0.04	0.05
Use of agron. Nutr. cons. Serv.	*5.44	5.06	(10)	**0.66**	0.13	-0.03	0.12	-0.01	0.00	0.10
Small gradual changes	5.38	5.18	(8)	d.	d.	d.	d.	d.	d.	d.
Cooperative marketing	***5.35	4.78	(12)	d.	d.	d.	d.	d.	d.	d.
Use of veter cons./serv.	***5.09	4.31	(16)	**0.65**	0.11	0.08	0.07	0.07	0.10	0.03
Asset flexibility	4.88	4.94	(11)	0.01	0.06	**0.47**	0.03	0.23	0.13	0.19
Shared eqmt. part.ship	4.87	4.64	(14)	0.13	0.14	-0.08	0.03	0.18	-0.01	**0.66**
Keeping fixed costs low	4.61	4.69	(13)	0.09	0.07	0.09	0.05	0.02	0.03	**0.39**
Use of econ. consult. services	4.44	4.14	(19)	**0.66**	0.00	0.11	0.14	0.20	-0.03	0.15
Enterprise diversification	4.28	4.41	(15)	0.04	0.11	0.21	-0.09	**0.33**	0.00	0.18
Storage	4.16	4.08	(20)	0.05	0.12	**0.58**	0.07	-0.11	0.08	-0.15
Prod. contracts	4.07	4.03	(21)	0.17	0.15	**0.42**	0.07	0.07	0.03	-0.04
Off-farm work	4.02	4.01	(22)	0.09	0.03	-0.02	0.05	**0.41**	0.10	0.10
Information	*3.79	4.22	(18)	0.19	0.14	0.24	-0.01	**0.34**	-0.06	0.17
Prod. and market flexibility	***3.40	4.24	(17)	-0.12	-0.02	**0.63**	-0.05	0.14	-0.05	**0.39**
Surplus mach.ry capacity	*3.39	3.05	(23)	d.	d.	d.	d.	d.	d.	d.
Off-farm investments	2.68	2.60	(24)	0.01	-0.10	0.05	0.04	**0.70**	-0.04	-0.05
Organise the farm as a corp.	2.39	2.20	(25)	d.	d.	d.	d.	d.	d.	d.
% of total var. explained	-	-	-	7.3	7.0	6.5	6.2	5.3	5.2	4.8
Cum. % of the var. explained	-	-	-	7.3	14.3	20.7	26.9	32.2	37.4	42.2

[a] Factors 1 to 7 are consultancy, disease prevention, flexibility, insurance, diversification, financial and fixed cost sharing. Factor loadings >|0.30| are in bold. "d." means that the variable is deleted from the factor analysis because of low factor loading and low communality.

[b] Mean score (1 = not important, 7 = very important) for conventional farmers (n = 363) and organic farmers (n = 162). Mean numbers marked with asterisks show that the mean scores of conventional and organic farmers are significant different at *P<0.05, **P<0.01 and ***P<0.001, based on independent samples t-test.

4.4. *Perceptions of risk management strategies*

Some 25 risk management strategies were presented for the farmers' consideration. Farmers indicated their perceived importance of each strategy on a Likert-scale from 1 (not relevant) to 7 (very relevant). Results are reported in Table 4.

Strategies generally perceived as very relevant were good liquidity, prevent and reduce livestock diseases, buy farm business insurance and personal insurance and produce at lowest possible cost. In recent studies of livestock farmers in other countries the same strategies were also perceived as most important (Meuwissen *et al.*, 2001; Hall *et al.*, 2003), even though national risk environments are quite different.

Farmers generally did not see corporate farm organisation, off-farm investments, surplus machinery capacity, collecting information, off-farm work and use of price contracts as important strategies. The low ranking of collecting information could be a negative response to the need to collect still more information (*inter alia* related to quality assurance schemes) than to the importance of collecting information per se. Time-intensive dairy farming does not lend itself to off-farm work strategies, but 43% of the respondents perceived off-farm work as an important strategy (a score of 5 or higher). The low mean score assigned to price contracts may be because of the extensive use of cooperative marketing among Norwegian farmers and the Norwegian agricultural policy system, but livestock farmers in more deregulated countries have also ranked derivative instruments low (Martin, 1996; Meuwissen *et al.*, 2001; Hall *et al.*, 2003).

Organic and conventional farmers perceptions of the importance of different management responses were much more similar than their perceptions about the sources of risk. Conventional farmers attached particularly greater importance than organic farmers to veterinary services, cooperative marketing and solvency (debt management). The differences may be attributable to differences between the two production systems and the high importance of "non-economic" goals among organic farmers. Organic farmers assigned significantly higher scores only to product and market flexibility and collecting information, but neither of these belonged to the risk strategies assigned high importance.

The overall MSA for the risk management variables was 0.736, suggesting the matrix was suitable for factor analysis. The joint factor analysis identified seven factors with eigenvalues greater than one accounting for 42.2% of the variance. This solution gave interpretable and feasible factors and was used in the further analysis. Candidates for deletion were assessed in the same way as for the sources of risk. Table 4 displays the seven factors and their respective loading items after deletion of some variables.

The factors 1 to 7 are interpreted as "consultancy", "disease prevention", "flexibility", "insurance", "diversification", "financial" and "fixed cost sharing" respectively. Factor 1, consultancy, has high loadings of the consultancy services (veterinarian, agronomy/nutrition, and economics). Factor 2 is named disease prevention because of large loadings of prevention/reduction of crop/forage and livestock diseases and pests. A significant loading of risk reducing technologies accompanies the disease prevention strategies. Factor 3, flexibility, includes on-farm strategies to enhance flexibility (storage included) and price contracts. Factor 4 has heavy loadings of insurance contracts, and is accordingly labelled insurance. Off-farm (investments and work) and on-farm strategies to spread risk are included in factor 5, diversification. A significant loading of collecting information is also included. Factor 6 includes financial aspects of the farm business (solvency, liquidity, and production costs). Controlling fixed costs through shared ownership of equipment and partnership

Table: 5 Results of multiple regressions for comparative risk aversion (CRA) and sources of risk against socio-economic variables[a], n = 457

Independent variables	CRA[b]	Sources of risk					
		Production	Institutional	Organic farming	Credit	Consumer demand	Human resources
Farming system[c]	***0.96	***-0.35	***-0.52	***1.40	*-0.23	0.02	-0.01
CRA: ma-m[d]	n.i.	0.01	0.09	-0.05	-0.09	**0.28	(*)0.16
CRA: la-m[d]	n.i.	0.05	0.00	0.00	0.10	**0.31	-0.04
Ownership[e]	-0.06	0.12	-0.24	-0.16	0.03	0.00	0.19
Nr. of cows	*0.03	-0.01	-0.01	0.00	(*)0.01	0.01	0.00
Farm exp.ce (yrs)	-0.00	0.00	0.00	0.00	0.00	0.00	0.00
Education[f]	-0.07	-0.01	0.10	0.02	0.07	-0.03	0.02
Ag. education[g]	0.13	-0.08	-0.09	(*)-0.14	0.07	0.13	0.00
Off-farm work[h]	(*)0.39	0.00	0.02	-0.13	0.03	(*)0.14	0.06
Off-farm invest.[i]	-0.02	0.01	0.04	0.08	***-0.29	-0.12	0.05
SGM dairy (%)[j]	0.34	-0.10	0.40	-0.19	-0.02	-0.31	-0.34
Farm income[k]	*-0.49	-0.04	0.04	0.01	0.05	-0.03	-0.04
H.hold income[l]	0.34	-0.14	-0.13	-0.12	-0.11	-0.05	-0.02
Geography[m]	0.30	*0.23	0.10	-0.02	-0.11	0.03	-0.10
R^2_{adj}[n]	***0.121	***0.029	***0.081	***0.433	**0.037	*0.023	0.000

[a] Variables and models significant at (*)P<0.10, *P<0.05, **P<0.01 and ***P<0.001. "n.i." stands for "not included".
[b] Measured as an ordered response variable where 1 denotes the most risk averse attitude, 2 the medium and 3 the least.
[c] Measured as a dummy variable where 1 denotes organic farming and 0 denotes conventional farming.
[d] Measured as two dummy variables "ma-m" and "la-m" where 0 denotes the medium risk averse attitude (m), and 1 denotes the most risk averse attitude (ma) and the least risk averse attitude (la), respectively.
[e] Measured as a dummy variable where 1 denotes partnerships and 0 denotes otherwise.
[f] Measured as a dummy variable where 1 denotes formal schooling beyond high school and 0 denotes high school education or less.
[g] Measured as a dummy variable where 1 denotes agricultural education and 0 denotes otherwise.
[h] Measured as a dummy variable where 1 denotes off-farm work (farmer and/or spouse) and 0 denotes no off-farm work.
[i] Measured as a dummy variable where 1 denotes off-farm investments the last five years and 0 denotes otherwise.
[j] Measured as percent of the farm's total standard gross margin (SGM) from the dairy enterprise.
[k] Measured as a dummy variable where 1 denotes farm income ≥ NOK 200 000 and 0 denotes otherwise.
[l] Measured as a dummy variable where 1 denotes household income ≥ NOK 350 000 and 0 denotes otherwise.
[m] Measured as a dummy variable where 1 denotes central location (no regional policy priority) and 0 denotes otherwise, cf. KRD (2003).
[n] The Nagelkerke approach was used to determine the coefficient of determination (Pseudo-R^2) in the ordered logit model.

loads high on factor 7, fixed cost sharing. Moreover, another fixed cost strategy, keeping fixed costs low (e.g. through hiring land and machinery), and a cross loading of product and market flexibility load significantly.

4.5. *Risk aversion and sources of risk in relation to farm and farmer characteristics*

A multi-response ordered logit model was used to examine the relationship between comparative risk aversion and socio-economic variables. For the sources of risk ordinary least square (OLS) multiple regressions were used. Regression coefficients and goodness-of-fit measures are presented in Table 5.

All models summarised in Table 5, except that for "human resources", were significant. Usually, goodness-of-fit is fairly low for discrete choice models (Verbeek, 2000, pp. 186). The specified logit model performed 12% better than a model that specified the probability of take up to be constant.

The goodness-of-fit coefficients in the significant OLS models were low, except "organic farming", suggesting very personal perceptions and/or that important variables explaining farmers' perceptions have been excluded. Exclusion of many socio-economic variables of potential importance was judged not to be very likely.

The extremely low debt/asset ratios and high liquidity measures often found in farming are, however, consistent with risk aversion (Musser and Patrick, 2002), as shown for a solvency measure in Meuwissen *et al.* (2001). These issues could not be examined in our study. Farmer-specificity of perceptions is in line with previous studies (Boggess *et al.*, 1985; Wilson *et al.*, 1993; Patrick and Musser, 1997; Meuwissen *et al.*, 2001).

Organic farmers had very significantly less comparative risk aversions (CRA) than conventional farmers, which is in agreement with the results presented in Fig. 2. Farmers having more dairy cows had a lower degree of CRA. Increased farm income implied, unexpectedly, higher degree of CRA. The last relationship may be of less economic importance, since it is the risk that threaten a farmer's long-term asset base that really matter (Just, 2003).

"Organic farming" was the only risk source organic farmers, compared to conventional farmers, perceived as significantly more important (column three to eight). In relation to organic farmers, conventional farmers perceived production, institutional and credit sources of risk as significantly more important, maybe related to their higher use of variable inputs.

Consumer demand was the only risk source factor that was significantly influenced by farmers' CRA. Both the most and least risk averse farmers found consumer demand risks more important than the medium risk averse farmers.

Of the other socio-economic characteristics, only off-farm investments and location had significant effects on the perceptions of risk sources. Farmers who had invested off-farm perceived credit risks as much less relevant, perhaps because their credit obligations are small. Farmers in central areas were more concerned about production risks, especially associated with the animal disease variables. The finding may be related to more frequent experiences with disease outbreaks in central areas (Norström *et al.*, 2000; Nyberg *et al.*, 2004) and therefore greater fear of these risk sources. Also, a higher frequency of livestock trade (Østerås, personal communication) and more densely populated areas may contribute to the greater disease concerns.

4.6. *Perceptions of risk management in relation to farm and farmer characteristics*

The last step was to use multiple linear regressions to relate the information on socio-economic characteristics and risk perceptions to management res-

Table 6: Results of multiple regressions for risk management strategies[a], n = 457

Independent variables	Risk management strategies						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Farming system[b]	(*)-0.22	(*)0.22	(*)0.24	-0.07	-0.17	-0.09	-0.06
CRA: ma-m[c]	*-0.18	*0.19	-0.07	0.13	-0.05	0.13	0.04
CRA: la-m[c]	0.04	*0.26	0.16	(*)0.20	0.10	-0.02	*0.22
Ownership[d]	-0.15	-0.09	-0.05	-0.12	0.05	-0.21	**0.45
Number of cows	0.00	0.01	0.00	*0.01	0.00	0.00	0.01
Farm experience (year)	-0.01	0.00	-0.01	*-0.01	**-0.01	*0.01	0.00
Education[e]	0.03	-0.12	0.02	-0.15	(*)0.17	0.15	0.11
Agricultural education[f]	0.02	-0.08	0.10	0.06	0.07	0.09	**0.21
Off-farm work[g]	0.06	0.03	**-0.27	**0.26	(*)0.14	-0.09	0.02
Off-farm investment[h]	0.11	-0.08	-0.02	-0.08	***0.40	-0.04	(*)-0.14
SGM dairy (%)[i]	0.01	*-0.65	*-0.64	-0.25	0.05	0.30	(*)-0.45
Farm income[j]	0.04	0.02	-0.06	0.09	-0.03	0.06	-0.03
Household income[k]	-0.03	-0.02	0.04	0.10	-0.01	-0.01	-0.03
Geography[l]	-0.07	0.07	**0.26	*-0.18	-0.06	-0.13	-0.07
1. Production[m]	***0.15	***0.18	***0.19	(*)0.08	0.06	**0.14	0.01
2. Institutional	0.03	*0.10	(*)0.09	0.01	0.04	***0.18	0.02
3. Organic farming	-0.03	-0.06	0.02	-0.07	(*)0.09	(*)-0.10	*0.11
4. Credit	***0.17	(*)0.09	0.07	0.05	0.03	-0.07	*0.11
5. Consumer demand	0.08	*0.10	0.06	0.05	0.01	-0.03	0.02
6. Human resources	0.03	0.04	0.00	(*)0.09	0.03	*0.11	-0.04
R^2_{adj}	***0.088	***0.082	***0.128	***0.085	***0.102	***0.119	***0.088

The strategies considered are (1) Consultancy; (2) Diseases; (3) Flexibility; (4) Insurance; (5) Diversification; (6) Financial; (7) Fixed cost.

[a] Variables and models significant at (*)P<0.10, *P<0.05, **P<0.01 and ***P<0.001.

[b] Measured as a dummy variable;1 denotes organic farming and 0 denotes conventional farming.

[c] Measured as two dummy variables "ma-m" and "la-m"; 0 denotes the medium risk averse attitude (m), and 1 denotes the most risk averse attitude (ma) and the least risk averse attitude (la), respectively.

[d] Measured as a dummy variable where 1 denotes partnerships and 0 denotes otherwise.

[e] Measured as a dummy variable where 1 denotes formal schooling beyond high school and 0 denotes high school education or less.

[f] Measured as a dummy variable where 1 denotes agricultural education and 0 denotes otherwise.

[g] Measured as a dummy variable where 1 denotes off-farm work (farmer and/or spouse) and 0 denotes no off-farm work.

[h] Measured as a dummy variable; 1 denotes off-farm investments in the last five years and 0 denotes otherwise.

[i] Measured as percent of the farm's total standard gross margin (SGM) from the dairy enterprise.

[j] Measured as a dummy variable where 1 denotes farm income ≥ NOK 200 000 and 0 denotes otherwise.

[k] Measured as a dummy variable where 1 denotes household income ≥ NOK 350 000 and 0 denotes otherwise

[l] Measured as a dummy variable where 1 denotes central location (no regional policy priority) and 0 denotes otherwise, cf. KRD (2003).

[m] Variables numbered "1-6" refer to sources of risk (from the factor analysis).

ponses. The regression coefficients and the goodness-of-fit measures of the models are presented in Table 6. All models were highly significant and all of them explained around 10% of the total variance.

Organic farmers tended to perceive flexibility and disease prevention as more important and consultancy as less important than the conventional farmers. Compared to other farmers, the most risk averse farmers perceived disease management strategies as significantly more important and found consultancy less important. The least risk averse farmers were more likely to view disease prevention and fixed cost sharing as important management responses.

All socio-economic variables, except education and the two income variables, had at least one significant relationship with the risk management strategies. In contrast, earlier studies have found some relationships between economic variables (like gross farm income and solvency) and farmers' perceptions of risk sources and management responses (Patrick and Musser, 1997; Meuwissen *et al.*, 2001).

Farmers in partnerships perceived fixed cost sharing as more relevant than the others (mostly family farms). Farmers with larger herds were more likely to perceive insurance as relevant. More experienced farmers were significantly less concerned about insurance and diversification but found financial management responses more important. Farmers with education in agriculture placed more emphasis on fixed cost sharing. Off-farm work was associated with more importance assigned to insurance responses and less importance given to (on-farm) flexibility responses. Not surprisingly, investing off-farm was highly associated with diversification strategies. The most specialised dairy farmers perceived flexibility and disease prevention as less relevant. Farmers in central areas found flexibility more important, while insurance was of less concern.

The final independent variables are the perceived risk sources. An essential question is: How do farmers cope with the institutional risks? The regressions suggested that institutional risks are highly related to financial management responses (solvency, liquidity, low cost production). Disease prevention was also of importance. The results indicate multidimensionality of institutional risks requiring multiple management responses. More creative ways to handle risk than the traditional ones referred to in the survey may also be needed (Boehlje, 2003).

Production risks were found to be highly associated with multiple management responses; consultancy, disease prevention, flexibility and financial strategies. No one-to-one correspondence between sources of and responses to risk has also been observed previously (Patrick and Musser, 1997). Organic farming risks were positively related to fixed cost sharing. Consultancy and fixed cost sharing were important responses to credit risks. The risk source consumer demand was positively associated with disease prevention, maybe related to increased consumer awareness of animal health problems that can be reduced through a healthier herd. Farmers who perceived human resource risks to be important appreciated financial risk management strategies.

5. *Conclusions*

Our results suggest that organic farmers perceived themselves to be less risk averse than their conventional colleagues. Both groups perceived institutional risks as primary sources of risk, with farm support payments top rated. Conventional farmers perceived many sources of risk as more important than organic farmers, the difference being most pronounced for costs of purchased inputs and animal welfare policy. Organic farmers gave more weight to institutional factors related to their production systems (organic farming payments, price premiums, and organic regulations).

Financial measures, disease prevention, and insurance were perceived as the most important risk management strategies. Organic and conventional farmers' management responses were relative similar but organic farmers rated flexibility as more important. Both institutional and production risks were associated with multiple ways to handle risk.

A number of socio-economic variables had significant effects on risk perceptions and management responses. More significant variables were found for management responses than for risk perceptions. The low explanatory power in the regression models may imply a high degree of farm-specific risk perceptions.

The high support payments and high degree of regulation of agriculture in Norway obviously impact upon our results. Nevertheless, the agricultural policy system is not very different from what is found in several other Northern countries. This implies that similar results could be found in other countries, as indicated in Finland (Sonkilla, 2002).

The study revealed notable differences between organic and conventional dairy farmers' risk perceptions, suggesting that government policies may have to be applied differently to the two groups. Both groups of farmers were, however, worried about the institutional risks, indicating the importance of an agricultural policy that is clear, stable and predictable. Policy makers should therefore be cautious about changing policy capriciously and they should consider the scope for strategic policy initiatives that give farmers some greater confidence about the longer term. One step in a more stable and predictable direction in Norway would be a change from annual to perennial agricultural negotiations between the farmers' unions and the government.

Risk research in agricultural economics and farm management has emphasised production and marketing risks (Musser and Patrick, 2002). Our findings suggest that more attention should be paid on studying institutional risks. Further, farm management consultants and advisers should make more use of decision analysis tools that incorporate institutional risks.

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