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A HOLISTIC APPROACH

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Foreword

This study is the first building block of a project on risk management in agriculture under the programme of work of the OECD Committee for Agriculture. It develops a conceptual framework to analyse risk management strategies, takes stock of current policy measures, and analyses the exposure of the agriculture sector to risk. This framework shall be used to further analyze agricultural risk management systems in specific countries and to investigate responses by farmers to different risk environments and their use of different instruments. The present study builds on *Income Risk Management in Agriculture* (OECD, 2000). Information on the risk management project can be followed in www.oecd.org/agriculture/policies/risk.

Jesús Antón of the OECD Secretariat leads the risk management project and co-ordinated the studies for this publication. He is also the author of Chapter 2. Catherine Moreddu, of the OECD Secretariat, is the author of Chapter 3, while Chapter 4 was written by Keith H. Coble and Barry J. Barnett from Mississippi State University. This publication was reviewed by the OECD Committee for Agriculture.

This study has benefited from discussions in seminars, conferences and meetings of the Working Party on Agricultural Policies and Markets. It has benefited from suggestions from many colleagues in the Trade and Agriculture Directorate of the OECD, in particular Carmel Cahill, Céline Giner and Shingo Kimura.

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Executive Summary

Managing risk is an important part of farming and its management is a concern for those governments which include this as one of their agricultural policy objectives. This report presents a framework for the analysis of risk management in agriculture that can be used for the analysis and efficient design of policies in this area. The principal concept is a holistic approach as opposed to a linear approach. A linear analysis dealing with only a specific source of risk, a specific farmer's strategy, or a specific policy measure is likely to lead to inefficient policy choices. Risk management should be analysed as a system in which there is interaction between many elements. These elements have been organised around three axes: the sources of risk, farmers' strategies and government policies. A number of issues and concepts are crucial to the understanding of these interactions and must be discussed from all three axes.

A holistic conceptual framework

The sources of risk in agriculture are numerous and diverse. The markets for agricultural inputs and outputs have a direct incidence on farming risk, particularly through prices. A diversity of hazards related to weather, pests and diseases or personal circumstances determine production in ways that are outside the control of the farmer. Unexpected changes may occur in access to credit or other sources of income that affect the financial viability of the farm. The legal framework or changes in it may lead to liability and policy risks. Instead of focusing the analysis on an exhaustive classification of risks according to different sources, the holistic approach focuses on the intrinsic characteristics of risk in particular, on the characteristics that have a direct incidence on the development of market instruments and on the capacity of farmers to manage risk. Some risks are non-systematic. Their occurrence and the associated damage are unknown to a great extent. This cognitive failure makes them very difficult to manage by either individuals or markets. Some weather related risks such as drought and floods have a systemic component in that they affect most farmers within an entire region or country. This type of risk is difficult to pool inside the sector. Others like hail are more idiosyncratic and easier to pool. Many risks are correlated. Some input and output prices may be positively correlated, and output and production are often negatively correlated, particularly at aggregate level. Accounting for these correlations is crucial in developing efficient risk management strategies. Some risks are catastrophic because they are very infrequent but cause a large amount of damage, and they are often systemic and non-systematic at the same time.

Risk management strategies start with decisions on the farm and the household: on the set of outputs to be produced, the allocation of land, the use of other inputs and techniques, including irrigation and the diversification of activities on and off-farm. Farmers can also manage risk through market instruments which include insurance and futures markets. However, not all risks are insurable through markets, the main reasons for non-insurability being the systemic nature, the lack of information on probabilities and information asymmetry with respect to those probabilities. It is therefore useful to segment all risks into three different layers according to the instruments most appropriate or available. Risks that are frequent but do not imply large losses are typically managed on the farm. Risks that are infrequent but generate a large amount of damage to farm income are likely to fall under the catastrophic risk layer, for which market failure is more likely. In between these two layers there are intermediate risks for which some insurance or market solutions can be developed. It is important to allow solutions to each type of layer to develop so that a variety of instruments is available to farmers.

There are two main rationales for a government role in agricultural risk management. First, if risk markets are not efficient government action may be Pareto improving. The incompleteness of risk markets is a fact. The main sources of market failure are information asymmetries and high transaction costs associated with gathering information or with pooling systemic risk. However, it is very likely that information asymmetries occur also in the relationship between citizens and government, and this adds to the challenge policy makers face in designing policies whose benefits outweigh their costs. There is therefore no simple rule about what constitutes appropriate government action. The second rationale relates to equity or redistribution: societies may express a social preference to assist those suffering some types of loss.

In practice governments often mix efficiency and equity considerations. There are actions oriented to the creation of markets: for instance, production and sharing of information, training in market instruments, legal frameworks for specific markets and competition policy. There are actions that modify the market incentives, particularly if they subsidize some market instruments like insurance policies or saving accounts, but also market interventions that stabilize prices. For risk reduction and mitigation, there are policy actions that are *ex ante* (disaster prevention and most agricultural policies) and other that are triggered or decided *ex post* (like countercyclical programs, the tax system or *ad hoc* payments). Risk coping refers to action for consumption smoothing and they include disaster relief. These latter actions are typically related to equity considerations but quick recovery may also have an efficiency dimension. Most governments have some instruments to deal with catastrophic risk. A trade off exists in this area between *ex ante* policies that avoid pressures for *ad hoc* assistance in the aftermath of an event, and *ex post* policies that are more adapted to the reality of the catastrophe.

A template for the analysis of risk management systems in different countries is developed. The template is organized around five clusters that are derived from the holistic framework. For each cluster a set of policy guidelines is proposed derived in turn from previous OECD work. A major thrust is that farmers should be empowered to take responsibility for risk management, and policy actions should enable correlations among farming risks to be exploited. A variety of instruments should be available to the farmer so that he can choose the instrument that best fits his needs. The system should facilitate the production and sharing of information. Policies should be targeted to specific objectives, whether specific market failures or equity concerns, and they should be efficient and minimally distorting. Trade-offs are likely to emerge between different objectives and guidelines and they need specific analysis in the context of the corresponding risk management system.

Risk-related policy measures

Within agricultural policies, various measures contribute to reducing risk for farm households either because they help reduce the incidence of risk or mitigate its consequences on farm household income. Information contained in the OECD PSE database, WTO notifications on domestic support commitments and previous OECD work is used to give an overview of the incidence of risk-related measures in OECD countries and selected emerging economies, and to evaluate the relative size of the price and budget transfers they generate in the different categories of support to agriculture. The role in risk management of measures which do not generate transfers, like regulations, or are not specific to agriculture is also discussed.

In the countries examined, risk-related measures that are available to farmers vary in nature and in relative importance depending on the risk exposure and the overall support environment. In recent years, risk-related measures accounted for two-thirds of total average support to OECD producers, as measured by the PSE, and their share in total was over 50% in almost all OECD and emerging economies. Market price support is the most widespread risk-related measure and in most OECD countries, it accounts for a large share of support. Regarding the relationship between support level and composition, some patterns emerge. There are:

- Countries with high support levels, which mainly rely on price support for risk reduction and offer few other measures (*e.g.* Japan, Korea).
- Countries with high levels of support, which provide both market price support and fixed rate payments in about equal measure (*e.g.* Iceland, Norway, Switzerland).
- Countries with levels of support close to the OECD average or below, which provide both market price support and fixed rate payments in about equal measure (*e.g.* EU).
- Countries with below OECD average levels of support, where market price support is not dominant and which make significant use of variable rate payments such as stabilisation payments, and insurance subsidies (Canada), in some cases with fixed rate payments as well (United States).
- Countries with low levels of both support generally and market price support, where risk-related measures account for less than half support. These are mainly emerging economies.
- Countries with very low levels of support, of which a high share relates to risk-related measures: The New Zealand PSE is mainly made up of pest and disease control or price support resulting from sanitary measures. Australia has developed a combination of safety-nets and disaster payments to help farmers face unexpected, often climate related, adverse events.

Regarding measures that reduce the occurrence of risk, governments finance inspection services in all countries and subsidise pest and disease control in many. Water management support, may include a reduced price for water use and investment assistance for irrigation infrastructure projects

In a context of decreasing market price support, fixed rate payments have increased in many OECD countries. Variable rate payments are concentrated in a small number of countries (mainly Canada and the United States), reflecting traditional higher exposure to climatic risk and recourse to insurance and stabilisation payments. The parameters on which variable payments are based are an increasingly diverse combination of output, current or non-current area, animal numbers, receipts or income.

Insurance subsidies are found in many countries but they differ widely in terms of coverage government involvement, including subsidy rate and level, implementation criteria and institutional system. In recent years, there have been efforts in some countries to increase the coverage of insurance systems and improve administration and adoption. Subsidies for futures option contracts are only found in Mexico for producers and in Brazil for processors, reflecting probably the limited direct use farmers make of these instruments.

Disaster relief payments are identified in almost all countries (the main exception being Switzerland), but these could be underestimated because they are reported as supplements to existing payments or included in aggregates such as infrastructure investment. Disaster relief can take many forms and support mainly consists in compensation for income losses or assistance for the restoration of damaged assets. Precise information on implementation criteria is often lacking, in terms of what defines a disaster, what are the mechanisms in place to assess the occurrence of a disaster and the definition of the damage, and to distribute the funds. The *ad hoc* nature of disaster or other emergency payments is difficult to identify in the PSE database.

Farmers can use the tax system to smooth their income in several countries. Depending on the country, those systems include the option to average taxable income over two or three years or to reserve a share of income in a saving account in years of high income and reincorporate that amount in taxable income any year in the following (usually five-year) period.

In the same way as risk-related measures are found in various categories of the PSE classification depending on implementation criteria, they can be found in all WTO boxes. The Amber Box usually includes price support as well as deficiency payments and stabilisation payments based on current output or area. Some stabilisation payments are also notified as Blue Box, for example stabilisation payments for rice in Japan. The Green Box includes items to notify support for extension, pest and disease control and inspection services, as well as a specific category for insurance subsidies and disaster relief payments. However, many insurance programmes do not meet the conditions to ensure they are minimally distorting and insurance subsidies are often notified as non-commodity specific *de minimis* support as in Canada and the United States.

The overview of risk related policy measures in this report focuses on a number of measures with risk-related characteristics but all measures have an impact on the risk environment and it is sometimes difficult to draw the line. Moreover, although measures, which do not generate transfers specific to agriculture, are briefly discussed, measures generating transfers included in the PSE database receive more attention. It is not, however, straightforward to identify risk-related measures in the PSE: the label variable rate helps but is not sufficient to capture all measures. In addition, risk-related measures may hide within an aggregate such as irrigation investments in infrastructure investments.

It should be reminded that transfers do not give a complete picture of risk-related measures and of their relative importance. In particular, they do not reflect the importance of each tool in risk management strategies as farmers or other private operators do not only rely on government for risk management and also use private tools and mechanisms. Finally, transfers do not reflect the relative effectiveness and efficiency of different measures in term of risk reduction or mitigation. Evaluating these would require in depth analysis of precise mechanisms for implementation, interactions between various types of measures at the farm household level, as well as of risk exposure, with and without existing measures. This will be the subject of future work on risk management.

Assessment of risk exposure in agriculture

The third chapter of this report synthesizes the evidence provided by existing scientific literature regarding the magnitude and casual factors underlying the risks faced by agricultural producers. Further, the existing scientific evidence regarding the risk preferences of agricultural producers is examined. The scientific evidence in many respects is thin at best and in many cases appears to be non-existent. The authors have consciously attempted to avoid allowing U.S. research to dominate the discussion, but in many instances it appears the literature is simply deeper there than in other locations. Further, it must be acknowledged that the literature is not robust across commodities. Not surprisingly, the research on major crops and livestock enterprise dominate the literature cited in this paper. It is also noted that much of the existing literature fails to examine farm household income or consumption as theory would suggest. In effect, studies that focus on a single risk such as price risk or a single output are inherently myopic and may over-estimate the value of risk management tools. Greater attention should be devoted to obtaining farm-level time-series data so that more realistic measures of risk reduction can be made. This is particularly true when farms are well diversified across enterprises.

Chapter 1.

Introduction

Agricultural production is subject to many uncertainties. Any farm production decision plan is typically associated with multiple potential outcomes with different probabilities. Weather, market developments and other events cannot be controlled by the farmer but have a direct incidence on the returns from farming. In this context, the farmer has to manage risk in farming as part of the general management of the farming business. Hazards and unforeseen events occur in all economic and business activities and are not specific to agriculture. However, farming risk and risk management instruments in the sector may have a certain number of specificities.

Many risks directly affect farmers´ production decisions and welfare. In response to the potential impact of these uncertain events farmers implement diverse risk management strategies in the context of their production plans, the available portfolio of financial, physical and human capital, and the degree of aversion to risk. These risk management strategies may include decisions on-farm, changes in portfolio structure, use of market instruments, government programs, and diversification to other source of income. Many general agricultural support policies have risk management implications and influence risk management decisions. Because of the complexity of these interactions governments need to make significant efforts to achieve coherence, particularly among different policies and between policies and market strategies. Agricultural risk is an interrelated "system" in which markets and government actions interact with risks and farmers' strategies. Government programs may underpin the development of market strategies, but they may also crowd out market developments or on-farm strategies. The result of these interactions is the set of risk management strategies and tools that is available and used by farmers. The available strategies are not the simple addition of government programs, market instruments and on-farm decisions; they are mutually interdependent and constitute a unique system.

Chapter 2 analyses some of the most important linkages in this system and to develop a holistic framework for its analysis. The main focus of the analysis is on the different strategies and options available to farmers to manage risk and the potential need for and shortcomings of government action. It begins with a section that lays out the basic framework and develops the main driving idea behind the holistic approach: accounting for the interaction between three axes in the risk management system: sources of risk, risk management strategies and tools, and government policies. The three subsequent sections develop each of these three axes by analyzing and organizing the main issues of each axis, emphasizing the interrelations between the elements within and across the axes. These include characteristics of agricultural risk, possible classifications of sources of risk, the implications of correlation among them, and some discussion on the links between agricultural risk and climate change. Risk management strategies are discussed, including market tools such as future markets and insurance, but also strategies to deal with non insurable risk and segmenting risk into layers. The fourth section focuses on the role of government in dealing with potential market failure or re-distributional (vulnerability) concerns. The last section provides a template to apply the holistic conceptual framework. This template is structured in five clusters to be analyzed when studying a risk management system in a given country. Additional concepts related to the economic analysis of risk are discussed in Annex 2.1, while Annex 2.2 is a stand alone analysis of price risk and price stabilization policies.

Farm households adopt diverse strategies to manage risk affecting their income and consumption. These strategies depend on the characteristics of risk they face, their attitude to risk and the risk management instruments and tools available. The potential contribution of governments to risk management includes: 1) ensuring a stable macroeconomic and business environment, with competitive markets and clear regulations; 2) facilitating access to market-based instruments such as insurance systems; and 3) providing specific measures to help farmers reduce their risk exposure or deal with the consequences of adverse events. The latter group of measures is considered here as risk-related as they impact directly to reduce price, yield or income variability, or to smooth consumption following an adverse event. At the same time, it should be kept in mind that all agricultural policies affect farm households' risk environment and behaviour.

Drawing on the conceptual framework developed in Chapter 2, Chapter 3 reviews various types of policy measures that directly affect price, yield or income variability, or smooth consumption and, as such, have a direct risk-related dimension. It provides an overall picture of the magnitude and type of price and budget transfers generated by those measures in various OECD countries and selected emerging economies, in the context of overall support and government intervention affecting farm households. It does not attempt to evaluate the risk-reducing impact of those measures, which will be the subject of future work on risk management. It does analyse how different types of policy measures can affect price, yield or income variability and provides an overview of their occurrence in various countries. Those risk-related policies identified in the OECD Producer Support Estimate (PSE) database[1] and the price and budgetary support they generate are discussed in the context of overall support estimates. The following section draws on World Trade Organization (WTO) notifications on domestic support commitments to identify the risk-related policies discussed earlier. The final section focuses on policies that are not specific to the agricultural sector and/or do not necessarily generate budgetary transfers such as regulations.

Chapter 4 assesses the exposure to risk in agriculture through a review of the empirical literature. It introduces the concept of risk and how can it be quantified and then examines the variability of the different components of farm income: input and output prices, yields, production, and off-farm income and investment. Information on variability of different sources of risk is completed with information about correlations and an overall assessment of the major factors affecting farm income risk. These observed variabilities are due to different underlying causes of risk: from weather, diseases and market shocks, to new concerns such as biotechnology, climate change or policy reform. Farmers may perceive these risks differently and their main concerns need not to be the sources of risk that generate most income variability. These perceptions and risk preferences are revised, and in the final section extracts from the main conclusions on the magnitudes of risks, correlations, causes, perceptions and needs of research and data are presented.

Note

1. Since the mid-1980s, OECD estimates support to agriculture and publishes results in annual reports for OECD countries and every two years for a number of emerging economies. Indicators of support for OECD countries are published in OECD (2008) and available on OECD web site at www.oecd.org/statisticsdata/0,3381,en_2649_33773_1_119656_1_1_37401,00.html

Chapter 2.

Risk Management in Agriculture: A holistic Conceptual Framework

A holistic framework for the analysis of agricultural risk management systems

A study on risk management necessarily starts by discussing terms and definitions to ensure consistency and avoid potential confusion in terminology. The first classical distinction is made between risk and uncertainty, and the associated vulnerability (Box 2.1). The objective of this paper is to analyse approaches to deal with uncertain outcomes in agriculture, the potential negative consequences for farmers and the capacity to cope with them. This broad objective includes issues related to the concepts of uncertainty, risk and vulnerability.

Box 2.1. Risk, uncertainty and vulnerability

It is often said that agriculture production is a risky business, that is, it is subject to *risk*. This means that due to complexities of physical and economic systems, the outcomes of farmers' actions and production decisions are uncertain, and many possible outcomes are usually associated with a single action or production plan. The *uncertainty* concerning outcomes that involve some adversity or loss that negatively affects individual well-being is normally associated with the idea of risk. Some (*e.g.* Knight, 1921) make the distinction between *risk,* that implies knowledge of numerical, objective probabilities, and *uncertainty,* that implies that the outcome is uncertain and the probabilities are not known. This distinction is not very operative since the probabilities are very rarely known and there is widespread acceptance of probabilities as subjective beliefs (Just 2001; Moschini and Hennessy 2001). Most authors find a more useful distinction between *uncertainty* as imperfect knowledge and *risk* as exposure to uncertain unfavourable economic consequences (Hardaker *et al.*, 2004). In practice both concepts are very much related and are used interchangeably, one with more emphasis on "probabilities" as the description of the environment, and the other with more emphasis on the "potential negative impact" on welfare.[1] There is no risk without some uncertainty and most uncertainties typically imply some risk.

A significant part of the literature on risk management is associated with social protection against poverty, particularly in developing countries (Dercon, 2005 and World Bank, 2000). In this context the term *vulnerability* is often used to define the likelihood that a risk will result in a significant decline in well-being, that is, resilience or lack of resilience against a given adversity. Vulnerability does not depend only on the characteristics of the risk, but also on the household's asset endowment and availability of insurance mechanisms.

1. In this same direction, economic text books typically talk about theory "under *uncertainty*" referring to analytical results developed under a factual description of the uncertain environment in which economic agents take decisions. The term *risk* in this context is applied to the preference of producers or consumers that may or may not like this uncertainty (risk aversion). It is also applied to assets whose returns are uncertain (risky assets that have variable returns). See, for example, Mas-Collel *et al.* (1995).

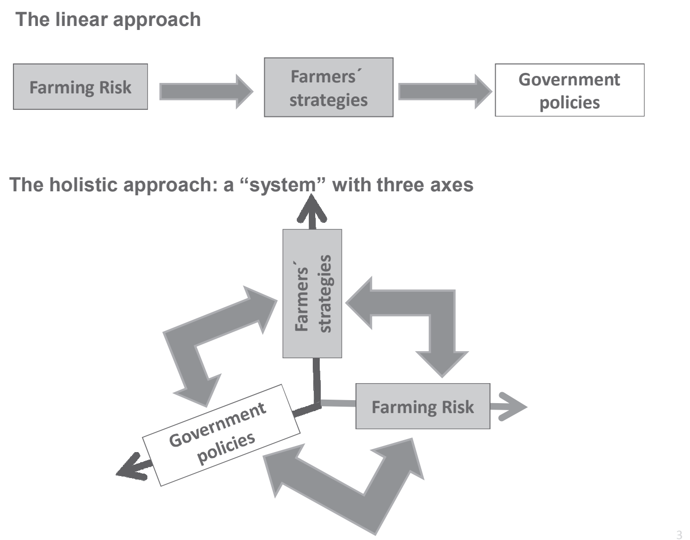
There is a growing literature that tackles risk related issues from a governance angle. It is mainly focused on risks with significant consequences for a society or an economy, that go well beyond consequences for an individual. These "systemic risks" can also be relevant in agriculture. In this literature risk management is part of a broader risk governance framework that typically includes at least three stages: risk assessment and evaluation, risk management and risk communication. These terms can be defined in different ways (*e.g.* International Risk Governance Council, 2008). Risk assessment normally refers to a systematic processing of available information to identify the frequency and magnitude of specific events, while risk evaluation consists of fixing priorities and defining societal "tolerance" for some risks. Risk management is the system of measures by individuals and organizations that contribute to reducing, controlling and regulating risks. Risk communication is the exchange and sharing of information about risk between decision makers and other stakeholders. The main focus this paper is on the risk management stage of risk governance, although risk assessment and communication issues are also discussed where appropriate.

The economic analysis of risk management requires some quantification of risk to which there are different approaches: from a complete distribution of the uncertain outcomes to a single indicator of variability (*e.g.* the variance). It also requires some definition of the preferences of farmers with respect to risk, typically summarized in a risk aversion parameter or other more sophisticated representation. Finally, economic analysis of risk is not only focussed on the use of formal or market risk management tools, but also other "self-protection" or "self-insurance" strategies or activities implemented by the farm household. These issues are further discussed in Annex 1 and are the basis for the economic analysis of the interactions between all the elements in the agricultural risk management system, which is the main focus of this document.

A risk management system is composed of many different sources of risk that affect farming, different risk management strategies and tools used and available to farmers, and all government actions that affect risk in farming. A standard approach to analyse risk management issues will involve three linear steps. First, measuring the risk or variability that needs to be managed. Second, use this information to analyse the optimal risk management tool for a given farmer, accounting for his endowments and risk preferences. Finally, decide on appropriate government policies to improve this risk management strategy. This is the linear approach defined by the straight line in the first part of Figure 2.1.

The linkage among these three sets of elements is not linear in nature. Therefore, the analysis cannot flow unidirectionally from the sources of risks to the available tools to deal with each risk, nor from the availability of tools and markets to the optimal government policies. The links move in all directions, and the system is better represented by the three dimensions or axes of a cube (second part of Figure 2.1). Continuous feed-backs among the elements in all axes lead to a simultaneous determination of risks, risk management strategies and policies. The availability, development and use of each instrument or strategy is determined to a great extent by the whole system that includes the nature of the risks, the extent to which they are correlated, farmers' endowments and preferences, market developments and government actions. There are many examples that illustrate these links. If, for a specific farmer, prices are strongly negatively correlated with production, revenue can be relatively stable and there may be less need to manage price risk. Diversifying output production can, in some cases, be a good strategy to reduce risk, and it may substitute for some of the demand for insurance. Measures that stabilize domestic prices are likely to crowd out the development of futures markets. It is often not possible to isolate and identify individual risks, single farmer's strategies and government policies, and a holistic approach is needed for the analysis of the system.

Figure 2.1.Two approaches for the analysis of agricultural risk management



Some government actions are specifically designed to deal with risk faced by farmers, others may have a direct impact on farming risk even if not specifically designed to do so. A risk management system can therefore be seen as a set of complex relations among the three different axes that involve the original sources of risk, the available tools and strategies, and the government measures. The simultaneous determination of the elements in these axes generates an identification problem when analyzing risk management. When certain events or measures of variability of relevant farming variables are observed, they already reflect the actions taken by the farmer to manage risk and the government measures and regulations that affect both farming risk itself and availability of risk management tools. Any reasonably precise measurement of farm income variability already includes to a great extent the impacts of existing risk management strategies and government programs in place.

This explains the need for a holistic approach to deal with risk management in agriculture. No single risk, strategy or policy can be properly analyzed in isolation. The whole set of elements and interactions needs to be accounted for. The purpose of this paper is to build a solid conceptual foundation for such a holistic approach to the analysis of risk management in agriculture. The following three sections are focus consecutively on each of the three axes in Figure 2.1, identifying the main elements, issues and interactions with other elements in the system.

Sources of risk

The risks and sources or risks that are relevant in agriculture have different characteristics, and they can be classified in very different ways. It is not necessary to opt for any particular classification of risk, and different ones can be used for different purposes. Some technical characteristics of risks apply across different classes and can be very significant in terms of the appropriate and available strategies to deal with each risk. Box1 discusses some of these characteristics. The rest of the section discusses possible classifications of the sources of risk, the implications of correlation among them, and the links between agricultural risk and climate change. Further discussion of price variability can be found in Annex 2.2.

Box 2.2. Some characteristics of risk

Newbery and Stiglitz (1981) make the distinction between *systematic* and *non-systematic* risks. Systematic risks are related to events that repeat over time with a pattern of probabilities that can be analysed in order to have a good estimate of the actuarial odds. On the contrary, non-systematic risks are characterised by very short or imperfect records of their occurrence and, therefore, difficulties in estimating an objective pattern of probabilities or distribution of outcomes. This distinction is similar to the distinction between risk and uncertainty and no clear cut line can be drawn between these two types of risk. The concept of *cognitive failure* follows the same line of distinction: it occurs when individuals do not know the probability or potential magnitude of a given event (Skees and Barnet, 1999). Decision makers often forget bad loss events and do not use this information in their decision making. Most other characteristics normally used to qualify risks are based on some knowledge of the right distribution of the risky events.

Rothschild and Stiglitz (1970) propose three equivalent definitions of "being riskier": a distribution of outcomes Y is riskier than X if: Y is just the addition of X plus a random noise; X is preferred by risk averse agents; and Y is obtained by shifting some weight from the centre to the extreme values of X. They also find that these definitions are not equivalent to a definition based on increasing variance, which is the most standard measure of risk.

It is often argued that it is downside risk that matters most. In fact *downside risk* is more likely to occur when the risky outcome depends on non linear interactions among several variables, and it can be particularly relevant in agriculture (Hardaker *et al.*, 2004). For instance, yields depend on several factors such as rainfall and temperature, but large deviations from central values of these variables in either direction have adverse effects. A "normal" season could be defined as a season with all variables having their expected values. This would be very unlikely to occur, and the probability of yields being below a "normal season" is likely to be large. In this case, the distribution of outcomes will be skewed towards the lower values of yields and downside risk becomes particularly relevant. But downside risk is part of the whole distribution of outcomes in a way that there is no downside risk without some associated upside risk. The point of reference will determine how much "risk" is considered in each side of the distribution.[1] This focus on down side risk has lead to measures of risk that are based on downside outcomes such as the "*value at risk*", in fact a percentile of outcomes (*e.g.* there is 1% probability of losing a given amount of money), which is very much used in portfolio analysis and decision making, particularly in the context of insurance and financial risk management (Jorion, 2001).

Risks are often characterised by their frequency, in terms of probability of occurring, and intensity, in terms of the magnitude of the loss. This is often a simplification of a more complex reality in which the whole distribution of probabilities and outcomes needs to be considered. Furthermore, the links among the distributions of different risks are very important for any risk evaluation. An individual risk that is independent or uncorrelated with any other risk is called idiosyncratic risk. But typically a risk has some degree of correlation with other risks. If there is a high degree of correlation among individuals in the same region or country, the risk is called *systemic risk*. But correlation can also occur over time (repetition of risk) or with other risks, and there can be positive and negative correlations.

It is frequent to find the term *catastrophic risk* both in the technical literature and, particularly, in the more policy oriented or general debates. A technical definition of a catastrophic risk is associated with the idea of a risk with low frequency but high losses. It relates to the extreme of the negative tail of the distribution of outcomes. However, the concept is sometimes linked also to high overall losses for a region or a country. In that case the risk is simultaneously catastrophic and systemic. Even if some authors prefer to define catastrophes as systemic events (Skees and Barnett, 1999), the distinction between an event that is a "catastrophe" for an individual or a local community from an event that is catastrophic for a whole region or a country is a useful one.

1. Menezes *et al.* (1980) develop three technical definitions of "increasing downside risk".

Different classifications of agricultural risks

OECD (2000) differentiated between risks that are common to all businesses (family situation, health, personal accidents, macroeconomic risks…) and risks that affect agriculture more specifically: production risk (weather conditions, pests, diseases and technological change), ecological risks (production, climate change, management of natural resources such as water), market risks (output and input price variability, relationships with the food chain with respect to quality, safety, new products…) and finally regulatory or institutional risk (agriculture policies, food safety and environmental regulations).

Both Huirne *et al.* (2000) and Hardaker *et al.* (2004) distinguish two major types of risk in agriculture. First, business risk includes production, market, institutional and personal risks. Production risk is due to unpredictable weather and performance of crops and livestock. Market risk is related to uncertainty about the price of outputs and, sometimes also inputs, at the time production decisions are taken. Institutional risk is due to government actions and rules such as laws governing disposal of animal manure or the use of pesticides, tax provisions and payments. Personal risks are due to uncertain life events such as death, divorce, or illness. Second, financial risks result from different methods of financing the farm business. The use of borrowed funds means that interest charges have to be met before equity is rewarded which may create risk due to leverage. Additionally there is financial risk when interest rates rise or loans are unavailable.

Musser and Patrick (2001) follow Baquet *et al.* (1997) and define five major sources of risk in agriculture. Production risk concerns variations in crop yields and in livestock production due to weather conditions, diseases and pests. Marketing risk is related to the variations in commodity prices and quantities that can be marketed. Financial risk relates to the ability to pay bills when due, to have money to continue farming and to avoid bankruptcy. Legal and environmental risk concerns the possibility of lawsuits initiated by other businesses or individuals and changes in government regulation related to environment and farming practices. Finally, human resources risk concerning the possibility that family or employees will not be available to provide labour or management.

Moschini and Henessy (2001) prefer to talk about sources of uncertainty in agriculture, singling out four different sources.

- Production uncertainty. The amount and quality of the output that will result from a given bundle of production decisions are not known with certainty. Uncontrolled elements such as weather conditions play a fundamental role in agricultural production.
- Price uncertainty. Production decisions have to be made far in advance of realizing the final product. The price of the output is typically not known at the time the production decisions are taken. Inelastic demand is often cited as a main explanation for agricultural price variability.
- Technological uncertainty. The evolution of production techniques may make quasi-fixed past investments obsolete. Research and development efforts are typically not made at the farm level but at the input supplier firm level.
- Policy uncertainty. Besides the general economic policies that affect agriculture as any other sector (taxes, interest rates, exchange rates…) agriculture is typically characterised by an intricate system of government interventions, changes in which may create risk for agricultural investment.

The more general literature on risk management, particularly when related to developing countries, typically includes non-agricultural specific risks in the classification. The World Bank (2000) and Holzmann and Jorgensen (2001) classify risks in six different types: natural, health, social, economic, political and environmental. They also cross this typology with an additional dimension of systemic characteristics of different risks: micro or idiosyncratic risk that affects the individual, Meso-risk affecting a whole community, and Macro or systemic risk affecting a whole region or country. All the risks they mention affect farmers in some way, particularly natural (rainfall, landslides, floods, droughts...), health (animal and plant) and environmental risks. Furthermore, most of these risks eventually take the form of economic risk that affects the stream of income, consumption and wealth.

Any classification of risks underlines the fact that an individual farmer may be facing very different risks at the same time. In these conditions, the optimal choice of a strategy to deal with them requires that correlations among risks be accounted for. An in-depth review of the literature on the sources of risk in agriculture, correlations among them and their relative importance is also presented in (OECD, 2008f).

Table 2.1. Some risks in agriculture: types of risk and idiosyncratic/systemic

Type of risk	Micro (Idiosyncratic) risk affecting an individual or household	Meso (Covariant) risk affecting groups of households or communities	Macro (Systemic) risks affecting regions or nations
Market/prices		Changes in price of land, new requirements from food industry	Changes in input/output prices due to shocks, trade policy, new markets, endogenous variability …
Production	Hail, frost, non-contagious diseases, personal hazards (illness, death) assets risks	Rainfall, landslides, pollution,	Floods, droughts, pests, contagious diseases, technology
Financial	Changes in income from other sources (non-farm)		Changes in interest rates/value of financial assets/access to credit
Institutional/legal	Liability risk	Changes in local policy or regulations	Changes in regional or national policy and regulations, environmental law, agricultural payments

Source: OECD Secretariat, adapted from Hardword *et al*. (1999) and Holzmann and Jorgersen, 2001.

In all possible classifications the boundary between different types of risk is blurred. Price or production risk is often associated with different singular events that are also denoted as risks. Table 2.1 proposes a presentation of agricultural risks that combines the systemic characteristics from Holzmann and Jorgersen, with four types of sources of risk identified in Hardwood *et al.* (1999) covering most of the categories of risk identified by different authors. The table singles out some events that could occur with some uncertainty and affect farm households' welfare. Idiosyncratic risk such as personal hazards, such as illness of the operator or the employees, are specific to individual farms or farmers and may actually be more important than systemic risks. Risks of a macroeconomic nature are typically systemic, they are often correlated across farms in a country and across sectors in the economy. They are not usually specific to agriculture. Macroeconomic risks can also be correlated for instance changes in input or output prices may occur simultaneously with changes in interest rates.

The relative importance of these risks can be measured by different indicators of variability. The degree of variability can differ across farms and also with the level of aggregation at which it is measured. For instance, yield variability at national level is typically not as large as at individual level. It also depends on the size of the country. The frequency and scale of certain risks may change as a consequence of broader, longer-run changes in the farming environment, such as deforestation or desertification climate change, agricultural trade liberalization, or greater concentration in the food industry.

There are some characteristics of risk that are very important in order to understand the possibilities for developing appropriate market instruments. At least four can be singled out. The first is the systemic nature of the risk: risks that are highly (positively) correlated across farmers are difficult to pool, while more independent risks can be pooled more easily. The second characteristic is the availability of information about the true distribution of the risk: if the information is not available (because there is little record of past events or because there are reasons to believe that information on the past is not relevant or misleading about the future), it is hard to imagine that a market instrument could be developed with an appropriate price. This is defined as non-systematic risk in Box 2.2. The third is the degree of asymmetry in the distribution of information: if significant information is not shared between the producer and other agents, or certain risk-relevant producer actions can be hidden, the likelihood of market failure increases. The fourth is the existence of potential buyers of the risk for whom the risk is of the opposite sign (highly negatively correlated with the risk faced by the farmer). These characteristics are illustrated in Box 2.3 through the comparison between the characteristics of risks that are embedded in output prices (demand shocks, new market developments…) and in production quantities (idiosyncratic weather conditions like hail or frost, systemic events like floods, droughts or contagious diseases…).

Box 2.3. The different nature of price and production risk

Price and production risk are two important components or types of farming risk. However they have different "origins": production risk is to a great extent determined by weather conditions and animal or plant diseases. Price risk originates in the markets for inputs and outputs and it has been argued that it could be generated endogenously by the dynamics of markets (see Annex 1.2 for a discussion of endogenous price risk). Price and production risk are different with respect to all the important characteristics mentioned above: systemic nature, information availability, information asymmetries and existence of potential buyers of the risk.

Price and production risks differ with respect to the degree of correlation that exists across farmers. Price risk is typically systemic due to the possibility of arbitrage. Normally this makes prices for all farmers move in parallel with very high correlation across farmers and regions whose markets are linked by trade. The farm specific price risk — or basis — is often stable because transportation or storage costs associated with a single location do not change dramatically from year to year. Production or yield risk has, in general, a larger idiosyncratic component. In addition to systemic events (like droughts and floods) that affect a whole region, there are also idiosyncratic ones (rain, hail, frost…). As a result, the basis that compares individual yields or production with more aggregate regional or national average yields can vary across space and time depending on specific local events related to weather or disease. It can easily occur that a farmer suffers a bad production year while his neighbours have an average year, while it is very unlikely that a farmer will receive a low price while his neighbours have much higher prices (except if they were covered by risk management tools such as futures or contracting agreements).

It is not easy to evaluate the availability of information about the magnitude of damage as a result of a risky event and the capacity to infer the distribution of future events. It could be argued that information is typically better for the distribution of production risk than for price risk. Farmers normally have good production records, and these records are often appropriate for estimating future variability of production and yields. Trends and long term changes due to climate change, animal diseases, technology or other reasons may make these records less valuable and make production risk less systematic in terms of its distribution. Past information on the distribution of risk is likely to be less valuable in the case of prices. The distribution of prices both in terms of the expected price and the dispersion is more difficult to infer from information about the past. Therefore, good forward looking information about price risk distributions may be in short supply.

The distribution of the available information differs for prices and production risks, and the scope for information asymmetries is very different. Price is generally known through the market mechanism. Therefore there is normally no, or little, asymmetry in the information that different agents have about prices. On the contrary, precise information about production and yield decisions, the history or specific characteristics of production in a given location are only known to each farmer. There is therefore, asymmetric information* and potential adverse selection when insuring this risk through the market. Additionally, prices generally cannot be manipulated or affected by the actions of a single producer. But production and yields are normally very dependent on individual actions. There is larger scope for moral hazard when insuring yield risk than price risk.

Price risk is relatively easier to pool with the "opposite" risk faced by buyers or consumers through futures, options or other contractual arrangements. Production risk is potentially more difficult to pool because there is no evident group of agents inside or outside the agricultural sector facing a risk that is negatively correlated with agricultural production risk.

The consequences of negative correlation among farming risks

Risks are very rarely completely independent from each other, particularly when measured in terms of their impact on the profit or income equations. In these equations all risks are expressed in terms of variability of price "p", production "q", cost "C" or other sources of income "O", and there are typically some correlations between these variables.

$$\pi_i = \sum p_i * q_i - \sum C_j + \sum O_k$$

For instance, output prices can be positively correlated with input prices. There are several illustrative examples that would fit with this situation. History and recent developments in energy and agricultural commodity prices seem to suggest a positive correlation between them. Another classical example is the case of specialized livestock farms for which feed input prices are often correlated with prices of outputs. We could rewrite the profit equation assuming — to illustrate and without loss of generality — that only two sources of risk affect the farm: the output prices and the cost of one specific input; the other elements in the equation are assumed to be known with certainty.

$$\pi_i = \sum p_i * \overline{q}_i - C_0 - \sum \overline{C}_j + \sum \overline{O}_k$$
$$Var(\pi_i) = Var(P) + Var(C_0) - 2Cov(P, C_0)$$

If the prices and the costs are independent (or not correlated), then the variance of profits would be the sum of the variance of the weighted average output price "P" and the variance of the uncertain costs C_0. In general, the variance of profits will depend also on the correlation or the covariance between prices and costs. A positive covariance will imply that there are situations in which low output prices are offset, to a certain extent, by low input prices. These situations will be more frequent than the opposite — low output high input prices. Therefore, the total variance will be smaller than the sum of the variances.

This type of result is more general than the above illustration about output prices and costs. It applies to any two variables that enter into the farm household income equation and which are negatively correlated. The variance of profits or income will not be the sum of the variances, but smaller, due to the negative covariance term. If risk management focuses on the stabilization of one of the variables while letting the others vary, the inherently stabilising property of the negative correlation term is ignored. In this case, a stabilization effort that concentrates on one variable leads to smaller gains in terms of total income stability, and may even increase variability depending on the net effect through variance and covariance. Annex 2.2, develops the case of negative price-yield correlations, extensively discussed in the literature (*e.g.* Newbery and Stiglitz, 1981). Some authors have found negative correlations among other components of farm household income. For instance, Freshwater and Jetté-Nantel (2008) find that net farming income, government payments and off-farm income are negatively correlated in Canadian farm households. Negative correlations between price and production of the same or different commodities, and between farming income and off-farm income can be very important income stabilization mechanisms available to farmers. Trying to modify the variability of one single component of the income equation may impede farmers from benefiting from these correlations.

Climate change and agricultural risk management

Climate change is a reality that may have some impact on agricultural risk. According to the Inter-governmental Panel for Climate Change (IPCC, 2007a), there is evidence that temperatures at the surface of the earth have risen globally, with important regional variations. In the last century, the level of precipitation has changed in most places: "significantly wetter in eastern North and South America, northern Europe and northern and Central Asia, but drier in the Sahel, southern Africa, the Mediterranean and southern Asia… widespread increases in heavy precipitation events have been observed even in places where total amount has decreased." "The extent of regions affected by droughts… tropical storms and hurricane frequencies vary considerably from year to year but evidence suggest substantial increases in intensity and duration since the 1970s". "In a warmer future climate, there will be an increased risk of more intense, more frequent and longer lasting heat waves… models project increased summer dryness and winter wetness in most parts of the northern middle and high latitudes. Summer dryness indicates a greater risk of drought… there would be an increase in extreme rainfall intensity".

These trends are consistent with observed data on frequency of catastrophic events in the world. The data from the United Nations International Strategy for Disaster Reduction show a dramatic increase in the occurrence of natural disasters, particularly of hydro-meteorological events during the last century. Hoyois *et al.* (2007) report important increases in hydro-meteorological disasters since the late 1990s as compared to the previous decade. However, the associated total damage has not increased significantly.

These global warming and catastrophic events trends are likely to impact agricultural and livestock production or yields and their variability. IPCC (2007b) estimates that "in mid- to high-latitude regions, moderate warming benefits crop and pasture yield, but even slight warming decreases yields in seasonally dry and low-latitude regions". According to the same report, most studies model the impact of changes in mean values of weather variables and few models have so far incorporated the impact of increased frequency of extreme events and weather variability on production. However "recent studies indicate that climate change scenarios that include increased frequency of heat stress, droughts and flooding events reduce crop yield and livestock productivity beyond the impacts due to changes in mean variables alone". Other factors apart from climate change (including technological developments) are also likely to affect agricultural productivity levels per hectare or per animal. Farmers will need to adapt to these changes in productivity levels in order to respond to a new environment with a new pattern of comparative advantage. From the point of view of risk management, however, it is not the structural long-term changes that may result from climate change that are of interest, but the extent to which variability will be affected.

The IPCC does not report on the expected changes in the variability of yields and livestock productivity due to climate change. At first glance nevertheless, it is likely that variability of production will increase due to more frequent extreme weather conditions or events (at least at the individual farm level), but this hypothesis has not yet been confirmed by IPCC reports. It has also been argued that there will be an increased prevalence of pests and diseases (OECD, 2008e). This scenario would require farmers to be more efficient in managing risk, but it does not necessarily imply more difficulty in finding the appropriate instruments and strategies. A new scenario of wider availability of information about the distribution of risk and increased awareness of farmers about risk, may stimulate the development of market solutions and new strategies to manage risk. But this is hard to assess with the scarce information available. It has even been argued that climate change and the corresponding increase in the frequency of extreme events may not increase variability of farm revenue or income at all (van Asseldonk and Langeveld, 2007). It has been also argued that governments and international organization may have a role in the production of additional information to facilitate the development of insurance solutions (Kunreuther and Michel-Kerjan, 2007) and enhance adaptation.

OECD (2008e) argues in favour of insurance playing a prominent role in any adaptation strategy to climate change. "Alternatively, government could subsidise the most extreme layer of risk to cover low probability, high consequences events. Public policy should not however, subsidise systemic risks, as it may reduce incentives to move away from activities that become progressively less viable under the changing climate". Adaptation strategies and decisions, however, must be taken under great uncertainty about the change and pace of change in the distribution of risk for any specific location.

Risk management instruments and strategies

The last section presents evidence of many potential sources of risk in agriculture. The farmer is the agent that is best positioned to know the dimension, characteristics and correlations of the risks that affect his farm. He is also the best positioned to evaluate the availability of different strategies to deal with this risk. It is the farmer's responsibility as manager of his own farming business to take the appropriate decisions to manage the risk associated with his economic activity: farming. The basic principles behind the generic strategies to reduce risk (risk sharing, risk pooling and diversification) are simple and well known to economists (Box 2.4). Furthermore, they have been, historically, extensively used by farmers.

Box 2.4. Generic strategies to reduce risk

This theory of choice under uncertainty is the basis for understanding the advantages of strategies such as risk sharing and risk pooling (Newbery, 1989). *Risk sharing* consists on spreading risk over a number of agents instead of concentrating it in one agent. Receiving half of a risky return $\underset{\sim}{W}$ implies bearing a variance that is a quarter of $V(\underset{\sim}{W})$, which reduces more than proportionally the risk premium for both agents. For example share-cropping arrangements allow production risk to be shared between the worker/tenant and the owner of the land, in a way that the total costs in terms of the sum of their risk premiums are reduced.

Risk pooling consists of bringing together the risky returns of two farmers that will then share the resulting outcome. The variance of the corresponding share of the pool is then smaller than the variance of each risky return. The reduction in the variance will be larger the smaller the correlation between the returns of the two farmers. The variance will be equal only in the unlikely case of perfect correlation between returns. Insurance companies operate by pooling the risks and then sharing them among a large number of shareholders. The more correlated across farms –or systemic- the risks are the more difficult to develop economically viable risk pooling instruments.

Diversification strategies also follow the same principle. A farmer diversifies when he uses his resources in different activities and/or assets instead of concentrating them on a single one. If returns of these activities or assets are not perfectly correlated, the variance of the overall returns is reduced and, therefore, the costs associated with risk are also reduced. There can also be diversification strategies in the input side of production. For instance in developing countries small holders typically have developed methods to diversify the gene pool of crops in order to be able to cope with adverse shocks.[1]

1. There is an option value to diversity. This creates a link between risk management and biodiversity and agri-environmental policies.

More concrete risk management strategies can be grouped into three categories (Holzmann and Jogersen, 2001): prevention strategies to reduce the probability of an adverse event occurring, mitigation strategies to reduce the potential impact of an adverse event, and coping strategies to relieve the impact of the risky event once it has occurred. Prevention and mitigation strategies focus on income smoothing, while coping strategies focus on consumption smoothing. Strategies can be based on arrangements made at different institutional levels: farm household or community arrangements, market based mechanisms and government policies. The main groups of tools and strategies available to the farmer are presented in Table 1.2. The menu of tools and strategies that are available can be different in different countries and for different farmers, for instance due to their size, location or availability of information, some farmers may have more difficult access to market instruments than other farmers. The farmer can choose among available instruments the combination of tools and strategies that best fits his risk exposure and his level of risk aversion.

Table 2.2. A menu of possible farm risk management instruments and strategies

	Farm/household/community	Market	Government
Risk Reduction	Technological choice	Training on risk management	Macroeconomic policies Disaster prevention (flood control…) Prevention of animal diseases
Risk Mitigation	Diversification in production Crop sharing	Futures and options Insurance Vertical Integration Production/marketing Contracts Spread sales Diversified financial investment Off-farm work	Tax system income smoothing Counter-cyclical programs Border and other measures in the case of contagious disease outbreak
Risk Coping	Borrowing from neighbours/family Intra-community charity	Selling financial assets Saving/borrowing from banks Off-farm income	Disaster relief Social assistance All agricultural support programs

Source: OECD Secretariat based on Holzmand and Jogersen (2001) and OECD (2001).

The characteristics of most of these strategies have already been discussed in OECD (2001) and in the updated overview of policy measures (OECD, 2009). The two main market tools to manage risk in agriculture are futures markets to deal with price risk and insurance markets to deal mainly with production risk. But there are some risks that may be difficult to insure through market mechanisms, which may require segmenting risks into different layers to manage each layer with different tools and strategies. Additionally, interactions among strategies need to be considered. All these issues are discussed in this section.

Hedging with future price contingent contracts

Farmers face price risk because there are biological lags that require that decisions about what and how to produce have to be taken far in advance of harvest. The simpler instrument available to deal with price risk is a "forward contract". In such a contract, the farmer and a buyer of the agricultural output agree in advance on the terms of delivery, including the price. Through this mechanism a farmer can decide to sell some of his production represented by a quantity "h" at a predetermined forward price "f". Only the quantity produced that has not been hedged "q-h" will be sold at the uncertain market price "p". A futures contract is essentially a standardised forward contract traded on an organized exchange such as the Chicago Board of Trade. The contract is standardised in terms of quantity, quality, and time and location for delivery. Buyers of commodities typically purchase futures contracts ("long" hedging) while sellers of commodities sell futures contracts ("short" hedging). A farmer hedging his price sells a futures contract when planting, but he needs not to deliver the commodity at the end of the contract; he typically undoes his position before then, by buying a futures contract for the same delivery date. The use of futures contracts implies that farmers retain some "basis risk" measured by the difference between the cash price for the farmer and the futures price "p-f". If there is no production risk, it can be shown that, regardless of the amount of production that is hedged, production decisions are determined by the futures price (Holthausen, 1979). However in reality the existence of production risk is crucial for determining the optimal hedging strategy and production decisions are affected by risk related variables.

The possibilities for covering price risk have been expanded with the use of options on futures for some commodities. Options give the right (but not the obligation) to sell a futures contract ("put" option) or to buy a futures contract ("call" option). The price at which the futures contract underlying the option may be sold or bought is called the "strike" price. Options truncate the probability distribution of price at the strike price, and they provide protection against adverse price movements (low prices for sellers/ put holders or high prices for buyers/call holders), while allowing the option holder to profit from favourable movements (high prices for "put" option and low prices for "call" option). Farmers can use put options to create a floor price for their product. The literature is not conclusive about the effectiveness of option contracts in reducing farming risk (Lapan, Moschini and Hanson, 1991). Options were blamed for the excessive volatility of grain prices around the Great Depression, and they were banned in the United States between 1936 and 1981.

In addition to sellers (producers) and buyers (livestock farmers, processors, exporters) of physical commodities -trying to reduce their exposure to cash price risk- speculators also participate in futures markets. Their objective is to make profits by buying futures when they believe the price will increase, and sell futures if they believe the price will fall. They can also use options with the same objective. Futures pools (or commodity funds) are managed by speculative futures funds similar to mutual funds in the stocks/bond markets: profits net of management costs are returned to the investors. Speculators bring more liquidity to futures markets, which make them more operational. The futures markets are not the most efficient instruments for acquiring the physical asset (the commodity), but they are instruments for risk management and investment. Sometimes the commodity is actually delivered by the trader, but delivery typically accounts for less than 1% of the total trading activity in most markets (Rose, 2008).

The survey by Carter (1999) finds some contradiction between the significant risk reduction effects of hedging that are estimated in the literature, and the small proportion of farmers that use it. The literature on the efficiency of futures markets is extensive and typically focussed on their accuracy in forecasting future prices. However, some argue (Tomek, 1997) that a poor price forecast performance is compatible with efficient futures markets: the forecast only need to be better than any alternative such as econometric forecast models. Carter argued that the literature was missing a greater focus on the fundamental economic issues such as: "Why do so few producers hedge? What is the impact of commodity funds? Does this managed technical trading lead to more stable prices or does it crowd out the fundamentals and lead to greater inefficiency?" Some of these issues are becoming increasingly relevant in the current situation of high agricultural prices. There is evidence of increasing volumes being negotiated in agricultural futures markets (Alizadeh and Nomikos, 2005; Rose 2008). This later author concludes that there is more investment capital in the agricultural futures markets now than previously, and a growing share of this increasing investment capital is being positioned on the long (purchasing) side. However, the linkage between cash and futures prices — theoretically due to arbitrage and the costs of carrying contracts until expiration — are far from clear. There is some recent evidence of an increasing lack of convergence between futures prices and cash prices at delivery date (Irwin *et al.*, 2008).

Insurance

Given the sensitivity of crop yields and livestock production to weather conditions and other hazards, there is a potential demand for crop insurance. While crop insurance exists in several countries, it seems to depend crucially on government support. Unsubsidized private insurance has mostly been limited to single-peril, like hail insurance. The main difficulty is argued to be the high transaction costs associated with crop insurance markets due to information asymmetries which makes private premiums too expensive relative to pay-offs, and therefore reduces or eliminates the demand from farmers at those prices. The demand for insurance is also affected by the relative costs of alternative strategies such as diversification and financial management. There is also a political economy element that underpins weak demand for crop insurance. Many governments are unwilling to ignore the *ex post* demand for monetary compensation following a disaster. Given the positive correlation among farm level crop failures in a region or country, this undermines the incentive to purchase crop insurance.

An insurance contract implies that the farmer pays a premium to buy the insurance. The contract gives right to an indemnity that is normally triggered by specific events (single-peril insurance) or by a fall of yields/production below a threshold level (multi-peril insurance). The quantity is linked to some calculation of the losses. The high costs of offering insurance contracts are associated, at least in part, with information asymmetries. Moral hazard in this context occurs when it is impossible or excessively costly to write a contract based upon everything a farmer might do that would affect his yields. Adverse selection occurs when contracts based on all the relevant environmental parameters are unfeasible. Both adverse selection and moral hazard have been widely reported and analysed in the literature on multiple peril insurance for many years (Knight and Coble, 1997).

Area yield insurance provides indemnities based on the average yield of a suitably wide area, eliminating the moral hazard problem and potentially reducing adverse selection (Mahul, 1999). However this is done at the cost of adding basis risk to be borne by the farmer. Similar arguments can be made about weather index insurance that is often put forward as a solution in developing countries (Barnett and Mahul, 2007; World Bank, 2005) and for which there are already many reported examples (Skees, 2007). Revenue insurance is also a popular concept because it directly addresses the combined price and production risk that is actually faced by farmers. Unlike any combination of futures and crop insurance contracts, revenue insurance could fully stabilise revenue. This can increase the welfare impact of a given expenditure on price or production risk management (Hennessy *et al.*, 1997).

Insurability of agricultural risks

Economics textbooks typically give a standard solution to manage uncertainty: developing markets –namely insurance markets- that facilitate the exchange of risk with other agents, realizing the potential gains from pooling or sharing the risk. However not all risks that affect agriculture have a corresponding insurance market. It may be that not all risks are insurable: insurance contracts for some risks do not exist because the insurance premium covering all the costs would be prohibitive. There are some conditions that are required — at least to a certain extent — for the insurability of a risk. They are not always expressed in the same terms (Skees and Barnett, 1999), but could be grouped as follows:

- The corresponding risks for different agents have to be independent or idiosyncratic. Risks that are highly correlated cannot be easily pooled and can generate large potential losses with very large liabilities for the insurer. These large scale liabilities are very difficult and expensive to reinsure.

- There must be information available or some method to estimate the probability of the risky event occurring and to evaluate the financial costs associated with each event. Estimating the distribution of risk is needed in order to be able to calculate the correct premium.
- Information has to be widely available among the agents in the market so that the potential for moral hazard and adverse selection is minimised.
- The probability of occurrence needs to be in a "medium" range: if it is too high the premium will not be affordable; if it is too low it will not be possible use the record of occurrences to estimate the likely distribution as accurately as possible.

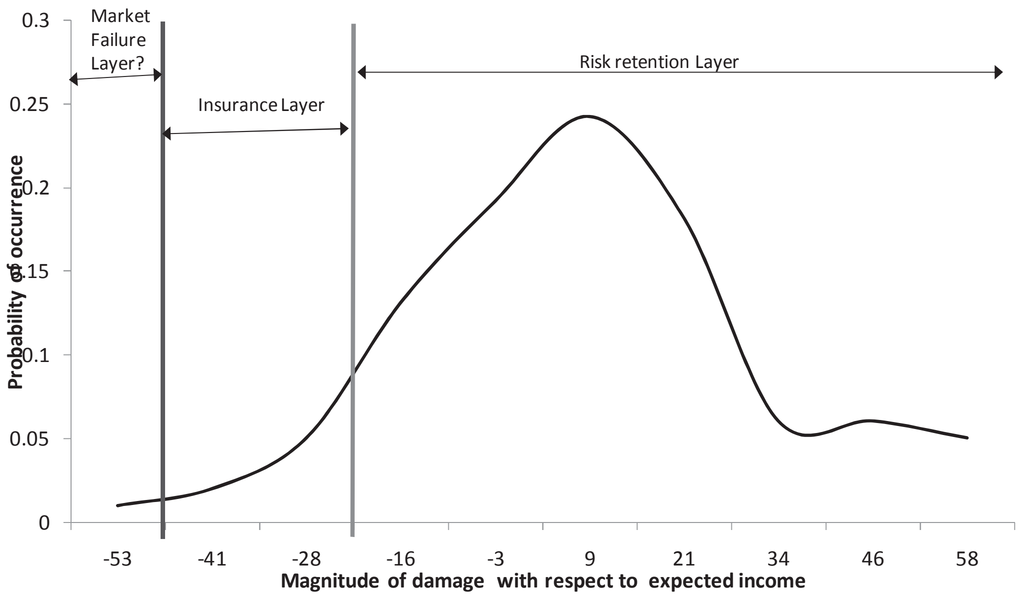
There is hardly any agricultural risk that complies with these strict requirements of insurability. Emphasis has often been posed on the symmetric information condition (Chambers, 1989). Miranda and Glauber (1997) emphasise the need for risk to be independent among the insured, arguing that due to correlations among individual yields, crop insurers face portfolio risk that is about ten times larger than that faced by private insurers offering more conventional lines of insurance (automobile, fire…). Reinsurers are reluctant to take portfolios with a probability of very large obligations. They draw a continuum of risks along an axis that moves from perfectly independent risk to perfectly correlated risk. Automobile, life and fire risks are very near the independent extreme, and appropriate for insurance solutions. Agricultural prices are very near the perfectly correlated extreme, and more suitable for options and futures markets. Crop yields are somewhere in the middle. Some particular weather hazards affecting yields such as hail or frost are more independent than others. Insurance against animal diseases, including contagious diseases, is also available in some countries, as in Spain and Germany (MAP, 2008).

Segmenting risks into layers

It is frequently argued in the literature that markets are more likely to fail in the case of catastrophic risk (World Bank, 2005). This argument is based on a basic risk management technique that consists of segmenting risk into different layers. This segmentation may help to match each set of risks with different "buyers" of risk or available management mechanisms. These layers could be defined in terms of the probability of occurrence and the magnitude of the losses, and therefore, the extent to which risk is catastrophic (Figure 2.2).

Figure 2.2. Probability density function and risk layers

An example: production risk simulations in Figure 2.1
Layers at 1% and 10% probabilities



- There are losses (or gains) that are part of the normal business environment; they are very frequent but cause relatively limited losses. Farmers should themselves manage this type of risk with the instruments and strategies that are available at the farm, household or community level, or through strategies that deal with income and consumption smoothing in the market (financial assets management, off-farm work) or through general government policies (tax system). This is "normal risk" or *risk retention layer*[1].
- The second layer corresponds to risks that are more significant and less frequent. Both frequency and magnitude are in the middle of the respective ranges. In this layer there is scope for farmers to use additional specific market instruments such as insurance or options that are particularly designed to deal with farming risk. This is the *market insurance layer*.
- The third layer includes risks that are catastrophic in nature because they generate very large losses, even if their frequency is low (see Box 2.2 for a definition of catastrophic risk). This type of risk is more difficult to share or pool through the market mechanism, particularly if it is systemic. There are arguments in favour of some government action in the case of catastrophic risk. This is the "catastrophic risk" or the *market failure layer*.

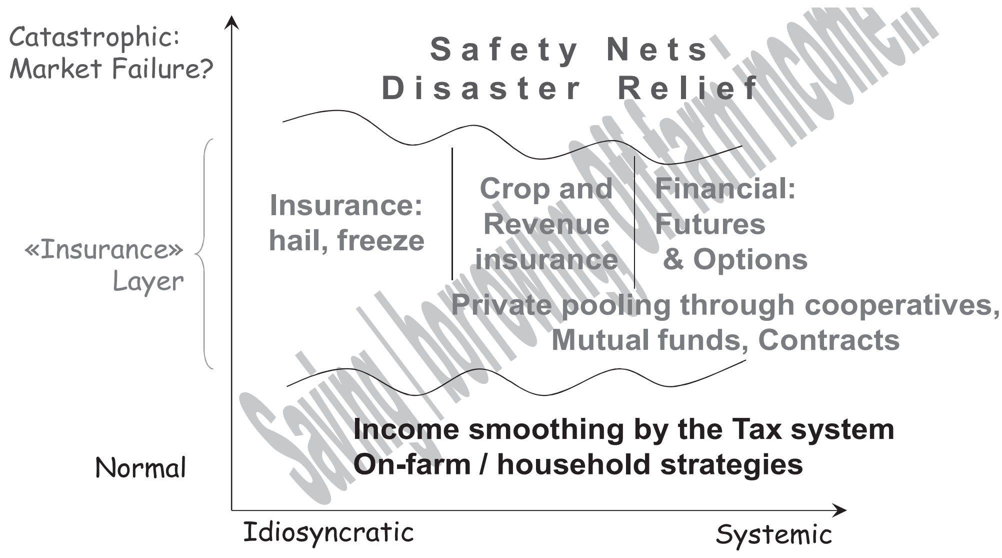
The distinction of risks with respect to two different criteria, their frequency of occurrence and magnitude of losses, could be contradictory if big losses were not associated with low probabilities. But many risks or combination of risks lead to a distribution of impacts where larger losses have lower probabilities. For example, Figure 2.2 draws the probability of occurrence of different levels of production in the same Montecarlo example used in Figure A2.4 (Annex 2.2). In this case, we can define three different layers that are ordered at the same time from higher to lower probability of occurrence and from smaller to larger magnitude of production loss. Most of the outcomes will be in the first layer where it is deemed that the risk should to be retained by the farmer. Only a minority of outcomes will be in the third, market failure layer.

This distinction is easy to implement to the extent that we have well defined boundaries among layers. This is not usually the case. The first difficulty is defining the underlying variable in the distribution of risk. Should we look at the distribution of production/yields, or at the distribution of income? The second difficulty is to have an up-to-date probability distribution and the third is to define the boundaries in terms of probability or in terms of losses. Finally, this distinction will be useful only if there are appropriate instruments to deal with each layer.

Mapping risks and risk management strategies

Segmenting risk into layers could be a first step to map risks to appropriate risk management instruments. Figure 2.3 crosses the three layers of risk with the continuum between independent and systemic risk, and makes an approximate mapping of risk management instruments. When markets fail in the presence of catastrophic risk, social safety nets and disaster relief would be important risk management instruments. However, depending on the farmer's situation, he could still have access to savings or to off-farm work and they could be or not appropriate to deal with a specific catastrophic event. In fact those instruments can potentially be available for any layer of risk and any degree of correlation.

Figure 2.3. Mapping risk management instruments



Source: Adapted from Cordier and Debar (2004).

The "insurance" or market layer may have different types of instruments for different degrees of correlation among the agents: from insurance for more independent hail or frost risk, to futures and options for correlated price risk; in the middle some hybrid insurance contracts for crop yields or revenue could be offered. Private pooling through co-operatives or mutual funds or through marketing contracts along the food chain can also be valuable instruments for some types of risk.

Finally, the normal risk layer, to be retained by the farmer, can typically be managed through normally available instruments such as the tax system that may have general or agriculture specific income smoothing properties. Saving and borrowing mechanisms are also normal instruments that should be perfectly available and are used by farmers in the same way as by other economic agents and households.

Interaction among risk management strategies

The development of different risk management tools depends crucially on the existence of other tools. For instance, a crop insurance policy can have very different attractiveness for the farmer in the absence or in the presence of a safety net. Table 2.3 shows a simple example based on the montecarlo simulations of Figures 2.2 and A4. When all revenue is coming from the market without a safety net, crop insurance is able to reduce the variance significantly (13% in the example) and increase the expected minimum revenue (by 16%). However, if a safety net is already reducing the variance of revenue (by 14% in the example), for the same price or premium, the marginal gains for the farmer from the insurance policy are much lower: the reduction of variance is smaller (8%), while the insurance is unable to increase the minimum revenue.

Table 2.3. An example of crop insurance in the absence and presence of a safety net

	Cost of fair insurance	Variance of revenue		Minimum revenue	
		level	change	level	change
Market					
without crop insurance		5 132 969		5 311	
with crop insurance	94	4 467 150	-13%	6 147	16%
Market + Safety net					
without insurance		4 408 420	-14%	7 041	33%
with crop insurance	94	3 980 541	-8%	7 041	0%

Methodological note: example based on Montecarlo simulations of Figure A4 in Annex 2. Crop insurance is designed as covering production losses beyond 70% of expected production, valued at expected prices. Safety net is assumed to cover revenue losses beyond 70% of expected revenue.

Coble *et al.* (2000) study the implications of yield and revenue insurance for producer hedging for some representative farms in the United States. They also find very strong interaction among policy measures. For instance, the existence of a strong coverage in revenue insurance reduces or even eliminates the demand for price hedging. The reason for this result is that revenue insurance is already covering and important part of the risk that can be hedged in future markets. The marginal gains for the farmer — in terms of reduced variability of income and expected utility — are much smaller in the presence of revenue insurance than in the absence of this instrument. The interaction can also take the opposite direction however: complementarity of instruments instead of substitubility. This is potentially the case of crop insurance and price hedging: additional crop insurance coverage can generate more demand for price hedging (OECD, 2005c).

The existence and development of some instruments or strategies to manage agricultural risk cannot be studied in isolation from the existence of other instruments. The interaction among instruments is a fundamental characteristic of risk management tools.

The potential role of government

As we have seen, standard welfare economics is not very promising nor directly applicable when analysing risk management issues. The market outcome may not be Pareto optimal, and we cannot be sure about the direction of the bias. In this context two questions are relevant in terms of the role to be played by the government. Does the economy provide the "correct" set of markets? If this is not the case, the government may try to establish or develop the basis for the creation of new risk related markets. Given the existing markets, are resources efficiently allocated? If not, there may be some role for government improving welfare. The main potential for market failure in risk related markets is due to the existence of information asymmetries and transaction costs associated with the access to market relevant information. The capacity of the government to improve resource allocation depends on access to information and its capacity or efficiency in creating or transferring information.

Government may have objectives other than increasing efficiency. It is common to have redistribution objectives, especially in the case of events that put particular economic stress on specific agents, *inter alia*, farmers. Sometimes these objectives are expressed in terms of reducing some particular risk or variability, per se. Or in more political economy terms, government's objective is to react with some relevant action when farmers "suffer" or are seen as "vulnerable". The extent to which these objectives are "good" objectives is a political question that economists cannot answer. For instance, the objective of reducing variability of prices faced by farmers may look economically awkward because farmers' welfare depends on his income or, even more precisely, on his access to consumption[2] and the corresponding variability. This depends on many other components and circumstances and it is not automatically correlated with price variability. But if this is the objective per se, economics has still a lot to say in terms of the effectiveness of a measure to achieve such an objective, impacts on farm household income variability, interaction with other strategies to reduce risk, and efficiency and redistribution implications.

This section also implements a positive observational approach to identify the potential role for the government: market creation, changing market incentives, reduction/ mitigation and coping with risk. Other issues discussed in this section are the interaction between government policies and market strategies, the support component of government risk management measures and the difficulties of dealing with catastrophic risk.

Information asymmetries and transaction costs

The difficulty in developing risk markets when information is asymmetrically distributed was already mentioned in the discussion above on insurance [3]. Since the farmer is better placed than anyone else to know about the distribution of his basis risk, information asymmetries or high information-related transaction costs are very likely to occur in relation to this basis risk.

Information is costly, not only because of information asymmetries, but also because of potential discovery costs for all agents. Information is crucial to develop efficient insurance contracts and risk related markets. The transaction costs of information can be large in agricultural insurance markets. They represent frictions in the functioning of the markets and can explain the existence of incomplete markets or incomplete contracts (Chavas and Bouamra-Mechemache, 2002). It can be shown that reducing transaction costs expands the feasible set of outcomes and, thus can enhance efficiency with Pareto gains. Furthermore, "competitive market structures (with a large number of traders) are unlikely to arise under high transaction and information costs".

When risks are positively correlated among agents, they are hard to pool with a view to reducing variance. Prices are typically highly correlated and are a source of systemic risk among farmers. But farmers' price risk is negatively correlated with the price risk of buyers of agricultural products. Pooling price risk between sellers and buyers is the basic idea behind the futures markets and vertical integration or contracting arrangements. In well developed markets this can be done with relatively low transactions costs.

At a regional or national level, production/yield risks are correlated. The exposure of companies insuring for this risk can be high and reinsurance, often through international reinsurance companies, may be needed to facilitate risk diversification, pooling and sharing. Yields across different regions in the world tend not to be correlated and there is more scope for risk pooling. However, despite the development of reinsurance markets, there may be high transaction costs associated with managing portfolios with significant elements of highly correlated agricultural risks. These transactions costs will be reflected in the market capacity to exchange these risks.

When transaction costs associated with developing or using market instruments are significant, more efficient solutions can be found within appropriate institutional frameworks. This is the main idea behind the new institutional economics (Menard and Shirley, 2005; Coase, 1937). Applied to risk management in agriculture it provides the basis for on-farm strategies, intra farm-household arrangements and decisions, and for specific agricultural contracts like sharecropping. Sometimes the transaction costs approach to information asymmetries is opposed to the traditional Principal-Agent model (Allen and Lueck, 2005), even if both approaches bring consistent explanations as to why a market does not exist and the possibility of developing alternative institutions and contracts that facilitate risk management. New institutional economics can help to clarify the potential role of government in building the appropriate institutions, particularly in terms of mechanisms to share information about risk.

Scope for market failure

There are several circumstances under which market failure might occur (Mas Collel 1995). The first and best known is the existence of externalities with some public goods characteristics when the actions of one agent affect the utility or production sets of other agents. In the area of risk in agriculture this could occur when one farmer's mitigation efforts also mitigate the risk faced by other farmers or agents in the economy. This can be the case in some specific examples such as the control of epidemic diseases or on-farm flood control investment (Morris *et al*., 2008): by reducing his own risk the farmer can also reduce the risk (and improve the welfare) of others. When a farmer vaccinates his animals, he simultaneously reduces the risk of contagion of his herd and prevents the spread of the disease to other herds. The arguments of some authors in favour of a public good aspect of risk in general (Newbery, 1989) are more difficult to sustain. The potential public good characteristics of risk become evident only in the case of a systemic catastrophic risk that affects a whole region or country. In this situation it can be argued that the welfare loss of those directly suffering the damage directly affects the welfare of other members of the society, or there is a social preference to help those affected. It can also be argued that a quick recovery after a systemic catastrophic event can facilitate a good working economy and generate positive spill-overs in other regions or sectors in the economy, so that the total damage is limited. It could even be argued that the continuity of the farming business could be questioned because of short term liquidity constraints. Some authors also argue for the public good characteristics of information about distribution of relevant variables such as prices (Newbery and Stiglitz, 1981)

The presence of market power may also lead to market failure. This can occur when, due to transaction costs or other reasons, only a small numbers of traders participate in the market (Chavas and Bouamra-Mechemache, 2002). This is not specific to risk markets, but it can be important when designing policy action: if the insurance companies are highly concentrated, they may be able to generate large margins and exploit rents. Other risk related markets such as those for futures and options, when they exist, tend to be more competitive with larger numbers of traders participating.

Asymmetric information is the third source of market failure. In general, the farmer knows better than any other agents (including insurance companies) the degree of risk exposure associated with his own production decisions (hidden information that may generate adverse selections). Farmers also have less incentive to avoid risk once they are insured (hidden actions that generate moral hazard). Those situations can generate market failure in the related risk markets. Asymmetries of information affect different types of risk in different ways. For instance price related risk does not usually generate information asymmetries since market prices are known by all agents at the same time. On the contrary yield/production related risk may have associated information asymmetries because the farmer has better knowledge about his own production risks than any other agent. The existence of "cognitive failure" can also contribute to generate information asymmetries. In these contexts, there is a potential role for government to help to establish, regulate and supervise risk markets, and to provide risk instruments when markets are constrained or fail. But it is also possible that "asymmetric information applies also to the relation between the citizen and the government leading to government failure and political risk" (Holzmand and Jorgensen, 2001).

The main theorem of welfare economics states that the resource allocations derived from a competitive equilibrium are always pareto-efficient. However this theorem only applies under certainty, that is, there is complete information and a complete set of markets (including all futures and risks). These conditions are extremely restrictive. We know that typically this is not the case: for instance futures markets extend only a few months into the future and only for some commodities. In this context, both the amount and the distribution of information are crucial to the existence and efficiency of markets. If markets are incomplete competitive equilibrium does not in general provide a Pareto optimal outcome. Constrained Pareto efficiency refers to efficiency under certain constraints, particularly in terms of the availability of risk markets. Under a constrained Pareto optimum the welfare of some agent cannot be improved without reducing the welfare of other/s, taken as given the available risk related markets. Theoretical results show that even this type of less demanding efficiency is not generally attainable through market equilibrium[4] (Newbery, 1989, and Newbery and Stiglitz, 1981), except under very restrictive conditions[5]. In this context government could potentially increase welfare of some agents without affecting the rest and move the economy towards a preferred social outcome. "Unfortunately, however, the direction of the bias may be towards too much or too little risk taking, so that there is no simple rule (such as subsidize risk taking) which always improves the allocation" (Newbery and Stiglitz, 1981). A government intervention will improve allocative efficiency if the government can access private information freely, or can produce or redistribute this information at a lower cost than private agents. Then, there is a role for government in helping to establish, regulate and supervise risk markets.

Scope for redistribution

Economics is not only about efficiency, but also about equity. It is well known that risk affects different producers differently, particularly the poorest[6]. A poorer producer has typically a larger probability that an adverse event that affects farming income pushes him below the poverty line or minimum consumption level that is "acceptable" or standard in a given society. A poorer producer has also less access to assets or financial instruments that can help to cope with the distress of an adverse event associated with agricultural production. Therefore poorer producers typically suffer more stress on their livelihoods and welfare both because they may experience larger relative losses from adverse events and because they have less access to relevant risk management strategies. This means they are more vulnerable with respect to agricultural risk (Dercon, 2005).

Societies may express a social preference to help citizens suffering from stress derived from "risk", and these may include farmers affected by agricultural risk. This is particularly the case when a given event pushes a farmer below some minimum consumption level that affects his capacity, economic and social, to respond. There is a basic equity argument in favour of measures to avoid this happening. In this context farmers are just one example of a general societal concern related to social protection. Social protection for farmers -or for any other citizens- should evaluate the overall situation of the individual, taking account of all sources of income and wealth and alternative strategies. The stage of development of a given country significantly affects the reference level for social protection and the capacity of the society to respond.

All societies have redistribution policies linked to taxation systems or social protection programs. Some of those are adapted to the particular needs of special groups or activities such as farmers. Equity considerations are the main driver of such policies which are normally linked to the overall household or individual income or wealth, or to the particular social situation of the household or the individual. These policies tend to smooth the income or consumption flow of individuals or households.

Price and production tend to be negatively correlated because of their interaction in the output market. This is particularly true for aggregate production: systemic production falls are associated with falling supply and subsequent high prices. Due to this negative correlation, in the absence of information asymmetries and transaction costs, insuring agricultural revenue (price and production risk together) would in theory be cheaper and more effective than insuring prices and yields separately. However, market solutions for price and production risk have, in general, been separated into two different markets[7]: futures and crop insurance markets. By their nature, these instruments are commodity specific and do not allow correlations between price and production/yield risks to be taken into account, nor correlations across different commodities.

A positive approach to the potential role for the government

The "role of government" can be analysed in a strict normative framework in terms of advising about the economic effects and implications of alternative policy measures. This will imply the selection of policy measures that are best in terms of improving efficiency and redistribution (normative approach). However, particularly in an area with as many uncertainties as "risk management", a positive political economy approach is also needed to understand the policy making process (Innes, 2003) and the risk governance implications (Renn, 2006). The social perception of risk events that require policy responses and the political pressure on governments result from the whole institutional and governance framework. Table 2.4 presents a set of policy actions on agricultural risk management that are observed in reality (OECD 2000 and OECD, 2008d). The table does not evaluate whether these measures are appropriate. It distinguishes between measures that are taken and implemented before the risky event takes place (*ex ante*), and measures that are taken or implemented *ex post* after the event has occurred (Cafiero *et al.*, 2007).

Table 2.4. Potential roles of government in risk management in agriculture, based on observed policy measures

	Market creation	Modifying market incentives	Risk reduction and mitigation (income smoothing)	Coping with risk (consumption smoothing)
Ex ante	• Stable macroeconomic policies and business environment • Risk management training and information to farmers • Facilitating the production and sharing of information on risks • Increase competition in the insurance market • Law and institutions for futures and options markets • Defining the limits of government and farmers responsibility in risk management • Private / public partnerships	• Subsidies to insurance • Subsidies to reinsurance • Subsidies on futures contracts • Participation in mutual funds • Incentives on saving accounts • Facilitate access to credit • Output Market interventions / Regulations (price stabilization) • Border measures (tariffs…)	• Disaster prevention (flood control…) • Prevention of animal diseases (domestic and border measures) • Legal form of farms Research and Development of new varieties or breeds • All agricultural support programs	• All agricultural support programs
Ex post - *triggered ex post*			• Countercyclical programs • Tax system for income smoothing	• Social assistance •
- *decided ex post*			• Border and other measures in case of contagious disease outbreak • Ad hoc payments for quick economic recovery	• Disaster relief (payments, subsidised credit…) • Other Ad hoc ex post payments

EFFICIENCY

EQUITY

All efforts by government in support of market creation or in modifying market incentives will be, by definition *ex ante* measures. In the areas of risk reduction and mitigation, and coping with risk, both types of measures, *ex ante* and *ex post*, are possible. Most of the government actions described in Table 2.4 relate to efficient risk management in agriculture. Equity considerations are likely to play a more important role as we move towards *ex post* interventions in which individuals have no margin of action, and risk coping strategies for consumption smoothing are needed.

Market creation

If there are missing markets for risk management, the government may have a role in helping the development of new markets. Markets, including risk management markets for agriculture, develop much more easily in the context of a stable macroeconomic and business environment. Providing this environment is an important role for government. It is known that information weaknesses are the main causes of market failure in agricultural risk management. government could play a role through direct research and production of the missing information. Government could also facilitate arrangements for sharing information that would otherwise be asymmetrically distributed between agents, such as farmers and insurance companies. Public/private partnerships are also possible. These arrangements generate confidence in the fairness of the market instruments and in so doing may stimulate demand.

On the demand side, farmers can improve their risk management skills through training and information about the working of different risk management instruments (including futures, options, and insurance). This can contribute to a more stable and robust market demand and, consequently, facilitate the development of the market. On the supply side, enforcement of fair competition among insurance companies should make products more attractive for farmers. In some particular markets (such as futures and options) government may need to provide the appropriate legislation and institutions, to facilitate the development of the market.

It is important to define the boundaries between the government's role and the farmers' responsibility for risk management. Farmers will take the most appropriate risk management decisions, as part of a good whole management strategy for the farm and the farm household. If there is a good and credible definition of responsibilities, the corresponding costs will be internalized by the farmer, increasing his awareness and willingness to pay for appropriate solutions.

Getting the market incentives "right"?

In any case government action will not be able to generate a complete set of risk markets. In this imperfect world, government may have a role in trying to alter incentive prices – through taxes and subsidies - in order to bring the economy to a more efficient outcome, or just to achieve some specific risk coverage objective. It is often assumed that the absence of some risk management markets automatically means that insurance levels are sub-optimal. Therefore governments provide subsidies to stimulate demand for risk management tools. The existence of these subsidies does not, however, imply that they are well targeted to the observed market failures properly or that they improve efficiency.

Several OECD countries subsidize crop insurance (the United States, Canada, Mexico, Spain, France, Japan…) to different extents and with different arrangements. The level of subsidy is not the only important element determining the impacts of a given insurance system. The nature of the arrangements in terms of facilitating information sharing, reducing the scope for moral hazard and adverse selection, increasing competition in the insurance market, creating trust in the insurance system, and affects other government programs and payments, are also important elements to analyse. The subsidy can cover the administration costs associated with the insurance, but often goes beyond this level (Glauber, 2004). It is not clear if general subsidies solve the market failure, except in the case that they are linked to arrangements that improve efficiency in the use and distribution of information.

Some countries provide some re-insurance subsidies, normally through re-insurance arrangements with government participation. Re-insurance can help with the potential market failure due to systemic agricultural risk, particularly in the case of catastrophic risks. Facilitating re-insurance makes insurance policies cheaper. Miranda and Glauber (1989) include re-insurance in their definition of appropriate new roles for government. Instead of providing crop insurance subsidies that fail to tackle the information asymmetries, government could facilitate the creation of area yield and weather-indexed insurance. It is argued that such measures are much cheaper alternatives and more efficient in tackling asymmetric information. Mahul (2001) goes further and proposes dividing individual risk into two components: idiosyncratic risk that can be mutualised through insurance, and systemic risk that can be covered through this type of index insurance or catastrophic bonds and options. There may be some role for the government, at least as regulator, to facilitate the development of these products in the insurance markets.

It is less frequent to subsidize futures contracts, but there are some countries that provide such support. This is the case of Mexico which facilitates the subscription of futures and options in the US futures markets, with a subsidy.

Farmers may create mutual funds to insure some types of risk. These funds are owned by the participants. When mutual funds have a regional or local dimension, farmers may know each other, thus reducing the scope for moral hazard or adverse selection. Regional mutual funds may have the disadvantage that risks are correlated among the participants. In some countries, *e.g.* the Netherlands, there are mutual funds for contagious animal diseases. These funds receive some government financial participation under a cost sharing agreement (van Dongen, 2008). In the case of contagious diseases there is a potential government role to create incentives for early notification of any outbreak and for encouraging self protection (Goodwin and Vado, 2007). This type of "compensation" may allow the external costs of late notification to be incorporated into the relative incentive faced by the farmer. Other government actions such as compulsory notification and strong economic fines for non compliance may be difficult to implement due to information asymmetries.

Some governments (*e.g.* Australia and Canada) provide subsidies or tax incentives on saving accounts with the objective of improving the financial management of farm households. In practice farmers do not always avail of these mechanisms to smooth their disposable income when farming income is reduced due to a risky event. But, if they are attractive financially, they become one element in the overall portfolio (OECD, 2005).

Many OECD governments have tried to stabilize the output price faced by the farmer, in response to price risk. This is the case of Loan Deficiency Payments in the United States, and the intervention price system in the European Union (no longer applicable for many products). Countercyclical output payments do not directly affect consumption and they do not require border measures. On the other hand, market intervention measures through public stocks affect consumer prices and typically require border measures. Annex 2.A contains a detailed discussion of the arguments concerning the role of government in price stabilization in the context of price volatility.

Risk reduction and mitigation

Governments are sometimes seen as having some responsibility for carrying out the appropriate works and implementing the appropriate legislation to reduce the probability and/or the adverse impact of hazardous events. This is often argued to be the case for catastrophic events, that is events with low probability, but potentially large, systemic losses, and particularly when individual actions may have negative (positive) effects on others. Two types of government actions may be possible in this context: direct government action and changing the incentive structure for farms. The positive external effects of these actions, in terms of reducing the negative impacts on other producers, are typically not internalized in individuals' (farmers') decision making. In this context there is potential for a role of government in terms of legislation, public works and incentives.

One example is flood control for which there are different alternatives. In some cases public works can help to reduce the risk of flood. Actions on the farm to reduce water run-off can also reduce and/or mitigate flood risks. Some of these actions may generate externalities that could require some appropriate incentives.

In the area of prevention of animal diseases possible measures include both domestic and border measures when there is a risk of a disease being imported from abroad. There is a large literature dealing with optimal policies to manage this type of risk as discussed in OECD (2007), showing that a detailed risk assessment and cost benefit analysis is required to decide optimal policy mixes before and after an outbreak occurs (Wilson and Anton, 2005). As mentioned before, putting appropriate compensation mechanisms in place in advance of any outbreak can generate incentives for early notification and early action, with small private marginal costs compared to big potential external benefits across the sector.

There are many legal measures to facilitate risk reduction and mitigation. For instance, the legal framework for farm ownership can facilitate more appropriate risk management. For example, providing appropriate legal form for farms allows the business risk associated with farming to be separated from the consumption risk faced by the farm household.

Once the risky event has occurred, the tax system provides some mitigation of effects on net income due to its progressive nature in most countries. Sometimes, the fiscal or social security provisions covering farming activities are different from those covering other sectors. This special treatment affects the capacity of those systems to deal with risks from farming. For example if farmers are not really in the tax system, or if taxes are based on standard, nominal calculations, there is little scope for using the system for income smoothing purposes. If there are *ex post* efficiency considerations about externalities associated with quick economic recovery, then other measures to facilitate quick re-investment are sometimes implemented *ex post* or on an *ad hoc* basis.

Coping with risk (consumption smoothing)

Once all available measures or instruments to reduce or mitigate risk have been exhausted, only consumption smoothing strategies are available to cope with any remaining problem. Of course, all agricultural support programs contribute, to some extent, to consumption or income smoothing. Coping with risk refers to situations in which measures are needed to ensure minimum consumption requirements of farmers or their families and they are, by definition, related to equity considerations.

Once a risky event has occurred, government may have strong political incentives to provide some assistance. *Ex post* government actions may include social assistance, disaster relief (payments, subsidised credit…) and/or *ad hoc ex post* payments. If the purpose is to help to adjust from a hazard that may reduce household consumption towards poverty (equity concern), the criterion for such aid should be proximity to the poverty line, and equity considerations would suggest that in a first best policy option all farm household income and/or wealth should be included in the assessment.

Interaction among government actions and market strategies

All agricultural support measures affect risk in some way. OECD (2004) estimates the impacts on variability of aggregate receipts of different categories of PSE support measures. It was found that most PSE categories reduce aggregate revenue variability. In particular, market price support was found to reduce variability in all the cases that were analysed. However, variability reduction is not proportional to the amount of support and therefore there are payments and programs that are more risk related than others. If a measure reduces risk, there will be a risk related response with impacts on production and on the use of other risk management strategies.

Interaction among policy measures has been shown to be very significant (OECD, 2005, Coble *et al.*, 2000). In particular there is scope for crowding out market measures that cover the same type of risk as government programs: deficiency payments or price stabilization schemes tend to crowd out price hedging through futures and options. There is also evidence that insurance subsidies may increase specialization of the farm (O'Donoghue *et al*., 2009). This effect of crowding out other strategies diminishes the capacity of such mechanisms to reduce variability and improve welfare.[8]

The three layers of risk represented in Figure 2.2 illustrate the interaction between measures and strategies. If government actions cover risk layers 1 (catastrophic) and 3 (normal risk retention layer), the scope for insurance markets to develop and be viable is reduced. If government action takes the form of insurance subsidies and they expand too much, there may be little space for developing instruments for the third layer that, in principle, should be retained by the farmer. Defining and limiting the boundaries of government responsibility leaves room for markets and for on-farm strategies developed and implemented by farmers themselves.

Disentangling risk management from "support"

Most of the policy measures listed in Table 2.4, particularly in the second column on market incentives, implies some net support to farmers. It is important to distinguish between agricultural support and measures more targeted to reduce risk or to improve risk management in agriculture. The measures that imply a net transfer to farmers are likely to have some positive impact on farmers' income and welfare[9]. This makes them attractive to farmers independently of their risk management characteristics. And this additional stream of income enters into the set of farmers' risk management strategies, particularly for more decoupled programs that are more transfer efficient. For this reason it is not easy to disentangle the risk management component from the support component of many measures (OECD, 2009).

For instance, most price stabilization instruments have a support component that makes them attractive to farmers, independent of the potential countercyclical characteristics of this support. Insurance subsidies that lead to net premiums for farmers that are smaller than the expected indemnities are attractive for producers whatever their risk preferences because there is a positive expected value from this insurance policies. However, more stable supported prices and insurance also both serve directly a risk management purpose. An appropriate evaluation of alternative policy measures in terms of risk management requires that both the support component and the risk reduction component be considered. However disentangling these two components can be difficult in practice.

If the government objective is to support farmers' expected income, the most transfer efficient policy should be selected. On the contrary, if the government objective is to reduce individual income risk, measures targeted to this objective should be selected. Antón and Giner (2005) compare the income and risk reduction impacts of insurance subsidies and fixed area payments. They find that area payments are more income transfer efficient, while insurance subsidies are more effective in reducing income variability. However, total farmers' welfare is found to benefit more from area payments than from insurance subsidies (see also Glauber, 2004).

Dealing with catastrophic risk

There is no single precise way of defining a catastrophic event, in general, and in agriculture in particular. To be catastrophic an event is very likely to be also systemic,: it is infrequent and severe for individuals, and it is also severe for a country or a region as a whole. From a political economy perspective, an event is catastrophic if it triggers some special catastrophic aid or program. The triggering threshold may be explicitly defined, but this is very rare. Yet most governments have provided catastrophic aid at some moment in the past. The *ex post* reaction of governments to "catastrophes" is, in this sense, part of the risk management system which farmers take into account when planning their own decisions and strategies. The explicit or implicit definition of "catastrophe" reflected in what governments do, has an impact on the farmers perception of the boundaries of his own risk management responsibility. The definition of the responsibility of each agent is crucial for the development of a private demand for insurance and other efficient risk management instruments and strategies.

In practical terms, there would seem to be a general consensus that some types (or layers) of risk (termed catastrophic) cannot be managed by individual private actions or markets. Skees and Barnett (1999) emphasize the relevance of "in between" catastrophic risk, neither highly independent nor highly correlated. In their view these are the most frequent type of "catastrophe". These events are likely to violate several insurability requirements — they are too systemic to facilitate reinsurance, and it is difficult to estimate probabilities and losses associated with the risk, and probabilities of occurrence being in the "medium" range. The distribution of low probability — high losses is unknown and, therefore, hard to manage and expensive to reinsure. Due to this so called cognitive failure, such risks are often underestimated and poorly managed. Getting rid of this risk in the "tail" can reduce the scope of cognitive failure and facilitate the development of market instruments (Skees, 2008).

The distinction between risk and crisis is sometimes made for policy analysis (Cafiero *et al.,* 2007; European Commission, 2005). It is argued that a crisis is "unforeseen" and it exceeds the individual capacity to cope. This idea of exceeding the capacity to cope is obviously only applicable *ex post*. Once the event has occurred, all *ex ante* decisions, strategies and measures are found to be insufficient to cope with the situation and smooth consumption to acceptable levels. The impossibility to cope with risk *ex post* calls for an equity or "social solidarity" action. The very existence of this impossibility, its probability and scope depend, however, crucially on *ex ante* decisions and strategies.

The trade-off between measures *ex ante* and *ex post* is an essential part of the policy discussion on managing catastrophic risk. Innes (2003) underlines the political economy dimension of this debate: "because *ex ante* insurance coverage diminishes the political will for *ex post* emergency relief, government insurance programs may be designed, in principle, to deter disaster relief". The argument is the following: insurance is not supposed to cover for non-insurable risks like most catastrophic risks, but if government provides insurance subsidies, they could be designed to minimize the need for *ex post* disaster aid. Some anecdotal studies on EU member countries suggest that insurance subsidies may have deterred *ad hoc* disaster payments (Garrido and Bielza, 2008; JRC 2006), but there is no rigorous empirical evidence. For example, Spain provides strong ex ante insurance subsidies but much smaller *ex post* disaster aid, while the opposite occurs in the United Kingdom.

The same trade-off between *ex ante* insurance subsidies and *ex post* disaster assistance is discussed for the United States by Glauber (2004). Crop insurance is considered preferable to *ex post* disaster assistance because it provides *ex ante* risk protection. However, it is argued that despite the expansion of insurance subsidies since the Federal Crop Insurance Improvement Act of 1980, they have failed to replace disaster assistance. The explanation is the existence of asymmetric information. A new role is therefore proposed for government in managing catastrophic risk, in the development of area-yield and weather index insurance contracts that minimize both adverse selection and moral hazard. Governments are aware of this trade-off, which is why, in some cases, disaster payments are reduced for insured farmers by the amount of the indemnities, or/and in other cases, eligibility for disaster payments is limited to the insured (Goodwin *et al*., 2007). The impacts and incentives created by these provisions deserve further investigation. The 2008 Farm Bill foresees a more integrated approach to disaster assistance and other risk management policies.

In an attempt to reduce political economy pressure after a "disaster", some governments publish *ex ante* the type and scope of the government *ex post* action for different scales of weather hazards and natural disasters (MAF New Zealand, 2007). The Australian Department of Agriculture publishes *ex ante* all available disaster assistance (DAFF Australia, 2008). Exceptional Circumstances programs are triggered by events that meet certain criteria, mainly that they have to be rare (once every 20 or 25 years), severe (in terms of farm production and income) and not predictable. Conditions for receiving the corresponding relief payments are similar to the general unemployment benefit scheme. The National Rural Advisory Council has the final say on whether an exceptional circumstance has occurred, but the procedure has to be initiated by farmers or community groups. The Productivity Commission of Australia is conducting an inquiry into government drought support that, according to the draft report (Productivity Commission, 2008) may propose revisions of these policies, including revisions of the rules concerning the definition of exceptional circumstances.

In practice the boundaries of an exceptional circumstance event, a catastrophe, a disaster or a crisis are never well defined, and the institutional framework and the political economy are key factors influencing the decision to provide disaster relief or not.

A template to apply the holistic approach

This paper has discussed a complex set of issues related to agricultural risk management along three axes: sources of risk, risk management tools and strategies, and the role of government. The complexity of the interactions between and among the elements of the three axes suggests that the approach to the analysis of risk management systems in given countries should be holistic as was done in OECD (2003b) and proposed above. The basic principle of this holistic approach is to consider each element as part of a system which can only be understood and the policy implications inferred, if those links are explicitly taken into account. In particular, policies have to be analysed on the basis their objectives, accounting for the interactions with other sources of risk that may not be the main focus of the policy, other risk management tools and strategies on-farm and off-farm, and other policy instruments and support programs.

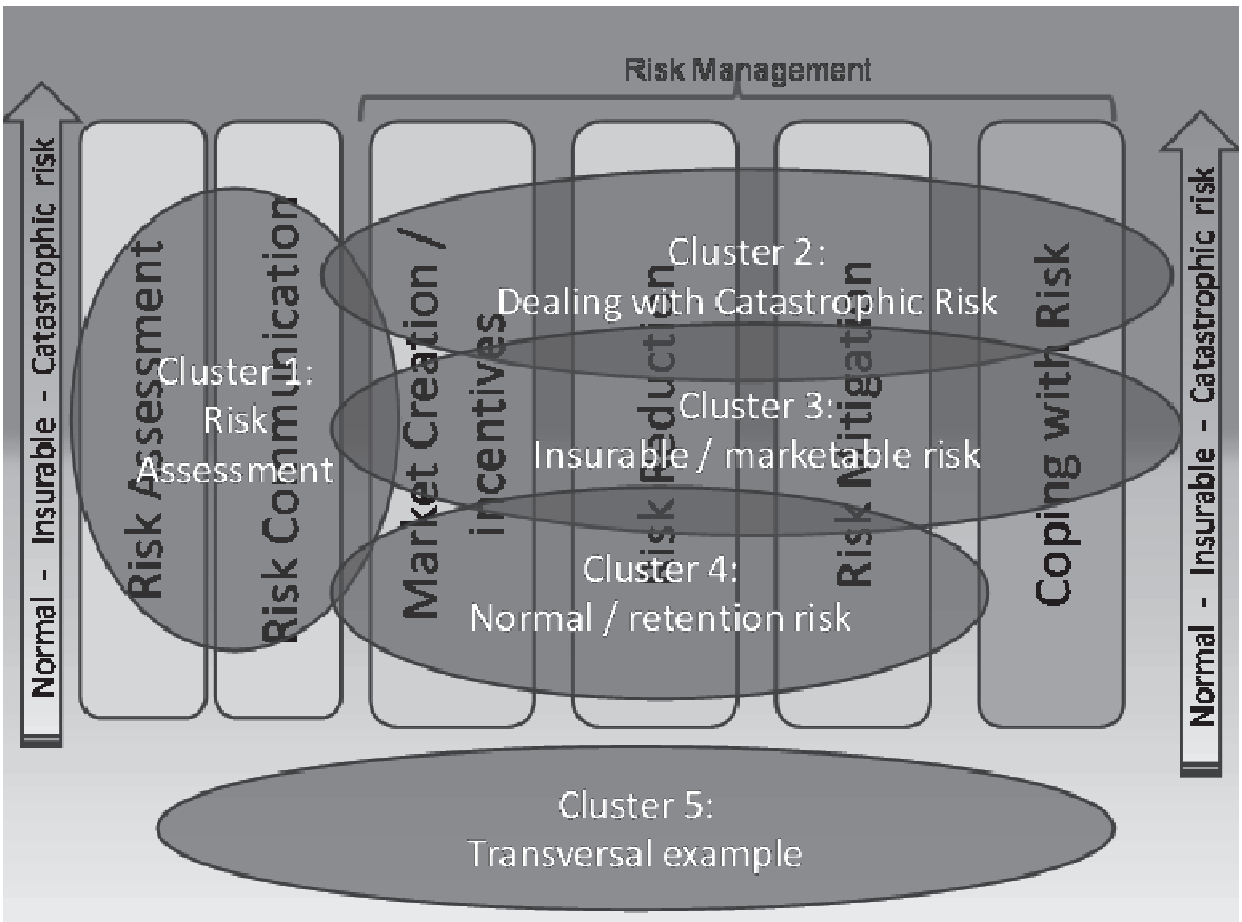
The literature and experience have shown that it is practical to classify risk into different layers according to the nature of the different tools and strategies that can potentially emerge (Figure 2.3). Catastrophic events (unlikely events associated with big losses) are more likely to be associated with market failure and to political economy/redistribution arguments for government action. A second layer includes risks for which specific agricultural risk management market solutions are possible. The final layer is the risk retention layer of "normal" risks that have to be managed by any farmer.

Using this holistic approach, different types of analysis can be carried out. Two types are suggested here. First, a thematic review of risk management in agriculture that would apply the same holistic template to a set of countries, in order to learn about how complex interactions work in different countries. Second, empirical and/or model based analysis of some of the issues and links raised by this conceptual framework. Both types of analysis have been included in the Program of Work of the Committee for Agriculture 2009/10. This section develops a template to apply the holistic approach to the analysis of the agricultural risk management system in a given country.

The template for the thematic review on agricultural risk management systems is organised around a set of five successive clusters which include numerous interactions around a single part of the system. These include a risk assessment cluster, three clusters focused on each of the three risk layers (retention, insurance and catastrophic) and a final transversal cluster specific for each country. In each cluster particular attention will be given to the maximum number of risks included in Table 2.1 that are relevant. It is likely to be necessary to analyse the details of each cluster separately for crop and livestock production. This approach is a first approximation to a template for the analysis of agricultural risk management systems. This template will be further developed and improved in future work when it is applied to specific countries.

The clusters, which are presented graphically in Figure 2.4, should be analysed consecutively and they are graphically represented in Figure 2.4 The potential roles for government are shown on the horizontal axis in the form of boxes: risk assessment, risk communication and four areas of risk management: market creation, risk reduction, risk mitigation and coping with risk. The different layers of risk are on the vertical axis: from normal to catastrophic risk. The whole set of links associated with the corresponding risk layer and the potential government role should be analysed for each cluster, accounting for all possible tools and strategies. In other words, a complete cube of links needs to be considered in each cluster.

Figure 2.4. A template of clusters



Cluster 1: Risk assessment: information and communication

This is the first stage of any risk management decision process. Under this cluster the operational definition of the different types of risk including "catastrophic risk" will be explored for the country in question, in order to be able to identify roles and actions that will be discussed in each of the risk layers in the later clusters. This risk assessment cluster will cover all issues related to:

- The production and availability of information about risk in agriculture.
- The identification by government or private agents of the main types of risk (droughts, floods, diseases, prices…).
- The definition of catastrophic risk and other layers of risk and the implications in terms of the responsibility of farmers, government or non-government agencies.
- The communications efforts of government and private agencies to improve risk awareness and clarify risk responsibilities among farmers.
- Available knowledge about risk perceptions and risk preferences of farmers in the country.

In particular the analysis of this cluster will try to answer the following questions:

- What are the agencies/institutions or others agents that provide information about the sources and distribution of risk in agriculture?
- What sources of risk have less available information and are more likely to be affected by cognitive failure? What are the government initiatives to tackle this issue?
- Are the main sources of risk (for crops and livestock) easy to identify and isolate from minor sources of risk? If so, which are those? What is specific in these countries as compared with others (with data)?
- What are the main "risk" priorities for the government? Are they expressed explicitly? How are they defined? What information is needed and which agents participate in the process of defining priorities and objectives?
- Are there private or public initiatives to improve farmers' knowledge on risk management?
- Is there any attempt to define explicitly the boundaries between the different layers of risk, particularly catastrophic risk? What are the implicit/*de facto* boundaries (in terms of the source or risk, the frequency and the magnitude of the loss) that define a risk as catastrophic/disaster/ exceptional circumstances?

Cluster 2: Dealing with catastrophic risk

Catastrophic risk relates to low probability, high loss events and — to a certain degree — correlated risk. However, the boundaries of catastrophic risk need to be defined. This boundary is not strictly a technical or theoretical issue and it is hard to create a definition valid for any country. The definition could relate to the probability in the tail of the distribution (*e.g.* the worse events that occur with a probability of 5% or every 20 years). Under this cluster the following issues will be analysed:

- The available information about location, frequency and impacts of past catastrophes affecting agriculture.
- The types of risks or events that are targeted by agricultural disaster aid.

- The available instruments to deal with catastrophic risk.
- The agencies, institutions and procedures involved in decision making after a catastrophic event affecting agriculture, including all levels of government and non governmental agencies.
- A review of interventions in response to “disaster” or “catastrophe” in agriculture. Type of event, frequency, type of government action and costs.
- The relationship/coordination with instruments, institutions and procedures for non catastrophic risk.
- The relationship/coordination with catastrophic risk management outside the agricultural sector, and with economy wide welfare programs.

In particular the following questions will be posed:

- For which risk or levels of risk (*e.g.* from the list in Table 2.1) appropriate market instruments have not developed or, in practice, they are not insured through risk management instruments (insurance, futures/options, contracting, co-operatives, mutual funds)?
- What type of events is covered in practice by catastrophic/disaster/exceptional circumstances aid?
- Are there markets/private mechanisms to cover some of these risks? Insurance, mutual funds?
- Are there public/private partnership arrangements for insurance or other risk management tools?
- Which agency or institution, if any, leads decision making in the case of catastrophic events affecting agriculture? How is a catastrophic event in agriculture identified? Are there threshold indicators and of what kind? Is it based on weather conditions, physical losses, revenue, income?
- What are the implementation criteria of disaster aid programs in agriculture?
- Are animal related catastrophes dealt with differently from plant related catastrophes? In what sense and why?

The specific roles, actions and options of different actors (government, markets and farmers/community) in terms of risk reduction, risk mitigation and risk coping will be examined. In this sense, maximum coverage will be provided to strategies or tools lying inside all the intersection cells in the following table of actors and roles:

Actors/roles	Market creation/ incentives	Risk reduction	Risk mitigation	Coping with risk
Government				
Market				
Farmer/community				

Cluster 3: Insurable or marketable risk

This cluster studies how insurable and marketable risks are or can be handled through instruments specifically designed for sharing farming risk: insurance, futures/options, contracting, co-operatives, mutual funds... This will require an analysis of:

- The type of risks and events that are or are not traded through risk market instruments.
- The availability of market or mutual instruments to deal with risks in this country, including data on the degree of use of each instrument.
- The reasons why some of these instruments are absent.
- The role that government plays in the creation of these markets and instruments.
- The government intervention in subsidising these instruments (if any): private/public partnerships and arrangements and data on subsidies and economic performance.

In particular:

- What risks (*e.g.* from the list of Table 2.1) are insured by a significant proportion of farmers? Provide available quantitative data.
- What are the market instruments and tools used by farmers? Insurance, futures/options, contracting, co-operatives, mutual funds, other?
- What sectors and risks have the possibility of being insured? How popular are these insurance instruments among farmers? Why?
- Are there futures markets available? How much are they used by farmers? Why?
- Are there price support policies that smooth or truncate price fluctuations? Are there other type of sectoral arrangements including production quotas or market interventions?
- Does the government intervene in agricultural risk markets? How and how much?
- What is the market structure for risk management tools such as insurance? Are there several competing companies? How is competition ensured among them?
- Are there consortiums or agreements among companies? What is their purpose and scope?
- Are there public–private partnerships? How do they work?

Similarly to cluster 2, the specific roles, actions and options of different actors (government, markets and farmers/community) in terms of market creation, modifying market incentives and risk reduction/ mitigation/coping will have to be examined for insurable risks. Again, maximum coverage should be provided to the strategies or tools in each intersection cells in the following table. For the first two columns the main entries will be in between government and markets.

Actors/roles	Market creation	Modifying market incentives	Risk/reduction/mitigation/ coping
Government			
Market			
Farmer/Community			

Cluster 4: Normal risk/risk retention

This layer needs to be defined by default: all risks that are not in the catastrophic or the marketable layers are *de facto* in the normal risk retention layer. Farmers handle this risk and smooth income over time using techniques and decisions on-farm and in the farm household, or using non-sector specific instruments such as the tax system or the financial markets. The following questions will be analysed:

- The role and provisions of the tax and social security systems for farmers. Are they different than in other sectors? Are they different for big and small farmers? Other specificities: Is income smoothing allowed? How and for how many farmers?
- The role of banking and the financial system.
- Are farmers using non-farm income and assets for income smoothing purposes?
- Are government general agricultural support policies an important income smoothing mechanism?
- Is there evidence of the use of potential risk reduction techniques by farmers, such as irrigation, pesticides or diversification?

Cluster 5: A representative policy example

Very often policy measures in a given country are concentrated around a specific element of one of the three axes of risk management systems (sources of risk, tools, and government actions). This can be due to different reasons. In those cases it can be very useful to analyse how risks, instruments and government/private roles are articulated around this main focus. The approach here too will be holistic, with particular attention to the interaction with other risks, other instruments/strategies and government actions/roles. Under this cluster one of the following will be chosen for each specific country to be studied in detail in institutional and quantitative terms:

- Specific risk: *e.g.* drought, contagious diseases.
- Specific instrument: *e.g.* insurance, mutual funds, futures markets.
- Specific government objective: *e.g.* reducing information asymmetries/ transaction costs, avoiding farmers consumption falling beyond a threshold, reducing farmers exposure to price risk.

Analysis of each cluster

Each cluster will be analysed on the basis of the holistic conceptual framework and set of issues developed in previous sections, and with respect to a set of evaluation guidelines, some of them already identified in OECD (2000). An effective and efficient risk management system in a given country should be oriented by the following guidelines:

- Empower farmers to take their individual responsibility on risk management as part of normal business management.
- Facilitate farmers taking advantage of negative correlations among different types of risks, asset returns and sources of income.
- Facilitate the availability of a variety of instruments, including the development of market instruments.
- Provide a sound business environment with competitive markets and clear regulations.

- Facilitate the flow of information about risk, and the creation of knowledge and human capital on risk management.
- Policies should be targeted to the specific objectives: well identified market failures (asymmetric information, systemic risk, externalities…), well identify equity concerns, or other well defined objectives.
- Policies should be cost efficient, all costs and benefits should be taken into account including distortions and transaction costs.

The application of these principles to each of the clusters and to the system as a whole will allow strengths and weaknesses of specific agricultural risk management systems to be identified. These principles may result in policy trade-offs between different guidelines and objectives. Lessons can be learned from applying this holistic approach to the experience in different countries, and recommendations are likely to arise in relation to each of the five clusters and the potential trade-offs to be faced by policy makers.

Notes

1. This term is taken from World Bank (2005).
2. Individual farmer's access to consumption, or simply "consumption", is normally the reference for government action for equity or redistribution purposes. The emphasis is made in view of the need to satisfy "minimum" consumption requirements. To facilitate measurement, this reference is sometimes expressed in terms of income.
3. See Annex 1 on the economics of information asymmetries.
4. Mas Collel (1995) has a slightly different definition of constrained efficiency: "the presence of asymmetric information often results in market equilibria that fail to be Pareto optimal. As a consequences, a central authority who knows all agents' private information … and can engage in lump-sum transfers among agents in the economy, can achieve a Pareto improvement over these outcomes. In practice, however, a central authority may be no more able to observe agents' private information than are market participants… An allocation that cannot be Pareto improved by an authority who is unable to observe agents' private information is known as a constrained (or second-best) Pareto optimum… a constrained Pareto optimal allocation need not to be fully Pareto optimal."
5. According to a strict definition, these conditions refer to missing markets being "redundant" or unnecessary (Newbery and Stiglitz, 1981)
6. See World Bank (2000) for a discussion on the importance of providing secure living conditions as an important dimension for reducing poverty.
7. Revenue insurance tries to combine price and production risk into a single insurance product. In general, this approach has been subsidized.
8. There are concerns about the interaction between risk management instruments such as insurance of futures and environmental outcomes (Babcock *et al*., 2003). Some argue that insurance programs and agrichemicals are substitutes and farmers who purchase insurance are likely to reduce the application rates of fertilizers and pesticides. Others, on the contrary, argue that risk management instruments encourage farmers to increase output, including through further use of agrochemicals.
9. The magnitude of this income effect depends on the income transfer efficiency of the measure. Income transfer efficiency is generally defined as the share of the total transfers from consumers and taxpayers derived from a policy measure that reaches the pocket of farmers in terms of higher income.

Annex 2.A

Framing the Economic Analysis of Risk

Quantification of risk

The idea of risk is always associated with a loss due to a bad outcome and, therefore, somehow linked to the perception of the impact and the objectives of the farmer. Holzmann and Jogersen (2001) propose different measurements of risk depending on what they call the "risk management objective" of the household. Each of them implies a different nuance in the definition of risk:

- Minimising the possible loss can be an important objective for very poor and vulnerable households and it has the advantage of not requiring information on probabilities. Risk is measured in this context as the quantification of the loss under a bad outcome.

- Minimising the probability of income losses that bring consumption below a given threshold can be a relevant objective for individuals and households that are not far from the poverty line. Risk is measured then as a probability of a bad outcome represented by consumption falling below a given threshold.

- Maximising the utility derived from uncertain income is the typical risk management objective for households with higher income levels, for whom downside risk does not imply falling into poverty. In this case risk is measured through the variability of income that can be characterised by the moments of the distribution of income, particularly the second moment that measures dispersion (variance, standard deviation or coefficient of variation). However, a complete characterization of the uncertainty of outcomes would require knowing the whole distribution of outcomes (through the probability density function). This latter case is probably the one that most accurately represents the situation of farmers in most OECD countries.

The degree of knowledge about the uncertainty and about the measure of risk can differ and it can be difficult to determine. Costs of accessing and processing information will influence the famers' knowledge about the uncertainties that affect him. However, a rational farmer will normally use all information available to him. In order to represent uncertainty in a statistical distribution, the notion of probability as a frequency of occurrence is a useful and operative approach and it need not be incompatible with a subjective probability approach that assumes farmers make their best guess[1]. The idea of risk exposure is associated with an objective description and measurement of the main risks and uncertainties affecting a single economic agent, and it is normally measured in terms of the expected distribution or variability of income or its components.

There is always uncertainty or imperfect knowledge about the future, particularly when looking several years ahead. But the idea of risk is not associated with changes in relevant parameters or structures over time, or the adjustment of prices responding to market fundamentals. A time trend implies changes in mean values of prices, yields or other variables and may require production or structural adjustment decisions on farms rather than risk management strategies. However, the distinction between trend or structural changes, and the variability with respect to this trend is not always immediately obvious and may require appropriate methods and mechanisms to discriminate between the two.

Sometimes the word risk is used in a more concrete way either in the singular "one risk" or in the plural "risks" in order to make reference to singular events that may occur, rather than to the outcomes associated with these events. For instance, the term "risk of a drought" is referring to this event and not to the consequences in terms of levels of production, revenue or income. An animal disease outbreak, a flood or a financial crisis are possible events that may have a negative impact on farming income and are often denoted as "risks".

Risk preferences

Maximization of expected utility (EU) has become the standard paradigm for analysing economic response under uncertainty (Meyer, 2002). The main advantage of this approach is that the formal framework needs only a relatively standard utility function under certainty[2] plus the structure of the uncertainty represented in the statistical distribution of outcomes. This is sufficient to represent the preferences of farmers under uncertainty. The characteristics of the preferences that are particularly relevant for decisions under uncertainty are typically summarized as risk aversion. A risk averse person prefers a certain outcome over an uncertain outcome (lottery), both with the same expected value. If risk aversion is measured with respect to wealth, the utility is represented as a function of this wealth and the aversion towards risk can be captured by the concavity of the utility function. The most used indicators of risk aversion are the so called absolute risk aversion A and relative risk aversion R coefficients[3].

Hardaker (2000) identifies relative risk aversion R=1 as "normal" or "somewhat risk averse", while R=2 as "rather risk averse" and R=4 as "extremely risk averse"[4]. Empirical studies find that farmers are risk averse (R>0), and in most cases the estimated coefficients are larger than one[5] (see Annex II in OECD, 2004). However, risk aversion varies from individual to individual and from one country to the next as shown in OECD (2004)[6]. If farmers are risk averse, the income risk they face has welfare costs that define their maximum willingness to pay for the elimination of this risk. Risk aversion may depend on the level of wealth and it is often assumed that farmers' risk aversion decreases with wealth (decreasing absolute risk aversion, DARA). Preferences have then to be defined with respect to final wealth outcomes rather than in terms of incomes.

The certainty equivalent of a given uncertain wealth prospect $\underset{\sim}{W}$ is defined as the certain level of wealth that would make the farmer indifferent between the two: $EU(\underset{\sim}{W})=U[CE(\underset{\sim}{W})]$. For a risk averse farmer, the certainty equivalent of an uncertain wealth is smaller than the expected wealth, and the difference between the two is called the risk premium: $RP(\underset{\sim}{W})=E(\underset{\sim}{W})-CE(\underset{\sim}{W})$. The risk premium represents the cost of risk measured in terms of wealth.

The expected utility function is often approximated by its second order Taylor expansion (Freund 1956) which can be written in terms of its certainty equivalent as: $CE(\underset{\sim}{W}) \approx E(\underset{\sim}{W})-0.5*A*V(\underset{\sim}{W})$. This gives an approximate risk premium equal to half of the absolute risk aversion times the variance across the different possible wealth outcomes[7]: preferences (risk aversion coefficient) and variability (variance of wealth) are the main determinants of the costs associated with risk and the corresponding maximum willingness to pay for a certain outcome. This approximation to the value of the risk premium has been the focus of an extensive literature on decisions under uncertainty that concentrates on only two characteristics of each choice: the mean and the variance of the final wealth.

The mean-variance approach can be helpful in decision analysis. A mean-variance efficiency frontier can be constructed by excluding all pairs of mean and variance that can be beaten by other combinations of activities with higher overall mean and/or lower overall variance. The mean variance efficiency framework has been used for portfolio analysis in which each possible asset in the portfolio is characterized by these first two moments of the distribution (Markowitz, 1952). The optimal portfolio of activities is determined by the farmers' choice among efficient combinations of mean and variance (*e.g.* Nartea and Webster, 2008, Blank 2001). Other more sophisticated stochastic dominance efficiency methods have been developed in order to discriminate between distributions of wealth (Moschini and Hennessy, 2001). The idea is defining some criteria that define a distribution as inferior to other more efficient distribution of outcomes.[8] It is then said that this later stochastically dominates the former.

Economic analysis of decisions under uncertainty

The existence or risk and uncertainty poses particular challenges to economists. Risk and uncertainty are always linked to imperfect information in different forms. The well functioning of markets requires an efficient use of information. This section discusses the main economic questions raised by agricultural risk, including information asymmetries, transaction costs, market failures, distribution issues and the functioning of futures and insurance markets.

Farmers' production decisions and welfare are affected by the existence of risk. Even if the farmer was indifferent with respect to risk (risk neutral), the presence of risk could have an impact on production decisions due to its impact on expected marginal productivity when randomness occurs inside the production or costs functions (Moschini and Hennessy, 2001; Just, 1975). If, additionally, farmers are risk averse, risk can have larger effects on production and investment decisions. Agricultural risk can also directly affect, however, farm household consumption capacity at a given point in time and, therefore, welfare. There is the, a potential demand for risk management instruments and strategies. Farming risks do not necessarily translate into consumption risk because risk averse farmers will implement strategies to smooth consumption over time to improve welfare. Risk management activities do not seek to increase profits *per se*, but to shift profits from more favourable situations or states of nature, to less favourable ones, increasing the expected well-being of the risk averse farmer.

Markets for risk and information asymmetries

Any market requires some resources to operate, particularly in terms of producing and disseminating the appropriate market information. Insurance markets are markets for risk and they typically face large costs due to the existence of information asymmetries. In other words, economically relevant information that cannot be observed by the farmer and the insurers at the same time. For instance, once insurance is contracted, the farmer has an incentive to take less care to avoid contingencies that may give raise to claims. The insurer cannot observe all the actions of the farmer to ensure that he takes appropriate care. The farmer has "hidden actions" that generate a well known economic difficulty for the development of insurance markets known as moral hazard[9], which requires the development of appropriate more sophisticated incentive mechanisms.

Farmers, however, may also have "hidden information" about their own characteristics as farmers. These characteristics may result in different agents having very different probabilities of making a claim. However, since the insurer cannot observe them, he has to offer the same contract to all agents. Farmers with a small probability of making a claim may not wish to take out such insurance and, hence, only farmers with high probabilities will be insured. This situation is called adverse selection and it can sometimes be solved through signalling mechanisms.

When farmers or households are able to hold and hide private information directly linked to the probability or the loss associated with risk, risk markets may not exist or may tend to function poorly and with significant transaction costs. This departure from the ideal Arrow-Debreu world of symmetric information and complete markets has important implications for risk management in the real world. Under these circumstances insurance becomes only one possibility to address risk. Other devices and institutions such as debt and labour contracts, or informal agreements within families or social groups may emerge to circumvent costly state verifications. Informal risk sharing instruments may substitute for market-based instruments, particularly in the early stages of development.

However, all types of risk have a systemic component where information is normally symmetrically distributed among agents, and an idiosyncratic component or basis risk that has a larger local and, maybe, asymmetric distribution. In the case of price risk, hedging is typically provided against futures prices. However, those are generally different than cash prices faced by farmers. The difference is called "basis" and is due to transportation costs, time/storage, quality and other circumstances associated with the specific farmer. This basis can be stable or changing, but is normally well known by the individual farmer. In the case of yield related risk, in some countries there are weather-based index insurances that are able to cover for weather hazards that affect an area in a systemic way. There is always some basis risk specific to the farmer due to imperfect correlation between his losses and the weather indexes.

Risk management beyond markets

The economics of agricultural risk need not to be only, or mainly, about how risk markets work or do not work. There are many non-market actions and strategies that are used to manage risk. For instance, Ehrlich and Becker (1972) identified some of these activities as "self-insurance" (actions that reduce the magnitude of the losses) and "self-protection" (actions that reduce the probability of loss occurring). This distinction is not always operative, and many actions have both self-insurance-and-protection effect. For instance the use of fertilizers may affect both the probability and the magnitude of a crop nutrient deficiency. The general concept of self-insurance, however, as the set of individual farmer's actions that can reduce his risk exposure is relevant because of its substitution relationship with market instruments and because of the information asymmetries that may be attached to these actions.

The economics of agricultural risk covers many possible actions in the context of the farm or the farm household, the local community or family arrangements and the whole set of markets (local labour markets, land renting markets, insurance, futures, financial), including particular types of contracts. Farmers need to be aware of all these possibilities and be able as much as possible, to take advantage of them in order to manage risk. However, very often the main focus of the economics of risk is about the scope of markets as instruments to trade risk among agents. The possible incompleteness of risk markets and the imperfections of capital markets are then argued to be relevant for risk management in agriculture. The main well known difficulty on agricultural risk markets is access to information. These difficulties may not prevent risk related markets from emerging, such as insurance and futures markets.

Notes

1. The decision maker, the farmer in this case, will translate all available information (including information about frequencies) into numbers in the [0,1] interval, adding up to unity.
2. This function is often called the von Neumann-Morgenstern utility function (von Neumann and Morgenstern, 1944), it is defined as a monotonically increasing function of a monetary measurement of the outcome and it is cardinal (defined up to increasing linear transformations). Some authors argue that there are observed behaviours that cannot be explained by the expected utility (EU) paradigm (Buschena, 2002). Generalizations of the EU model have also been proposed (Machina, 1987; Quiggin, 1993).
3. Let us define utility U as a function of wealth W: U(W). Then (Arrow and Pratt, 1965) define absolute risk aversion as $A(W)=-U''(W)/U'(W)$, and relative risk aversion as $R(W)=W*A(W)$. This latter indicator is a pure number, independent of units and has been used for international comparisons.
4. See, for example, Yesuf and Bluffstone (2007) for another classification of relative risk aversion.
5. Just and Pope (2003) and Just and Peterson (2003) argue that the standard risk analysis could overestimate risk aversion if observed risk responses are attributed entirely to the curvature of the utility function. Omitted variables such as human capital could also play a role. More general criticism of up to date risk research in agricultural economics can be found in Just (2003).
6. See Table 2.3 in OECD (2004) where a wide range of estimated risk aversion parameters form the scientific literature is presented.
7. The risk premium is: $RP(\utilde{W})\approx 0.5*A*V(\utilde{W})$. A proportional risk premium is sometimes calculated by dividing the risk premium by the expected value of wealth (Hardaker, 2000; Newbery, 1989): $PRP\approx 0.5*R*CV2(\utilde{W})$. Where CV is defined as the coefficient of variation, that is, the quotient between the standard deviation and the mean.
8. First degree stochastic dominance is consistent with any utility function that is increasing in expected wealth. Second degree stochastic dominance is consistent with any utility function with risk aversion. Further degrees of stochastic dominance are more demanding in terms of the properties of the utility function. See Robinson and Myers, 2002.
9. Ehrlich and Becker (1972) define moral hazard in terms of situations in which the insurer does not have the possibility to use information on individual self-protection actions to determine the individual price of insurance.

Annex 2.B

Price Volatility and Price Stabilization

Price variability is a main source or risk in agriculture. Main production decisions in most farming activities are taken well in advance to the sale of the product, and there is always uncertainty about the price. During the seventies, in the context of the commodity boom of 1972-75, many have argued in favour of some government action to stabilize prices. The 1974 World Food Conference in Rome discussed the establishment and management of an international reserve stock to stabilize grain markets. The 1976 meeting of the UNCTAD in Nairobi were dominated by the discussion of a proposal to introduce an Integrated Program for Commodities (IPC), with subsequent international commodity agreements with the purpose of stabilizing markets. The debate was never closed, but in practice the international commodity arrangements (ICAs) have gradually suspended their historical objective of price stabilization. In the 1990's only two ICAs (on cocoa and natural rubber) included provisions for price stabilization and the newest agreements (coffee, sugar and grains) were considered to be of mere administrative nature (UNCTAD, 1998). Some authors argue that these agreements did not work to stabilize prices due to both inherent market uncertainties and lack of adequate resources (Sarris, 1998; OECD, 1994). The declaration of the recent high level Conference on World Food Security hosted by FAO in June 2008 mentions price volatility only in the context of pleading for the avoidance of restrictive trade measures that could increase price volatility and, additionally, it makes a general call "to undertake initiatives to moderate unusual fluctuations of the food grain prices" in the context of strengthening food security.

The arguments in favour and against price stabilization policies have been posed on the table by prominent economists and highly reputed journals. At the academic level the discussion tends to be rather nuanced with counterbalancing arguments, while in the policy debate positions are sometimes biased by ex ante assumptions about the ability of markets to cope with risk. A significant part of this literature dates from the late seventies and early eighties.

Is there market failure in price-risk markets?

This is often the starting point of the debate, but unfortunately the question can only be partially answered. The first theorem of welfare economics tell us that competitive markets will result in Pareto optimal allocation of resources. But the application of this theorem under uncertainty requires a complete set of futures and risk markets and perfect information (MasCollel, 1995). We know this is not the case; for example, futures markets extend only a few months into the future and only for some commodities. Even a less restrictive concept of efficiency, such as Pareto constrained (or second best) efficiency, is not always attainable with competitive markets under uncertainty. According to Newbery and Stiglitz (1981) "… it is only in very special circumstances that the market allocation will attain even the weak sense of optimality". In the absence of these circumstances, the government can potentially increase the welfare of some agents without affecting the rest and move the economy towards a preferred social outcome. However, these authors are pessimistic about the ability of public policy to improve matters. Their arguments, and those of others, are discussed in this section.

Is price stabilization welfare enhancing?

The arguments in favour of price stabilization policies often start from rather simple partial equilibrium welfare analysis such as in Massell (1969): under linear demand and supply curves, a central government fixing prices and managing a (costless) buffer stocks would improve net welfare for consumers and producers together. This result is true even without accounting for the welfare gains from potential reductions of variability in income and consumption of risk averse agents. But the distribution of the gains and losses depends crucially on the origin of the risk (demand benefit consumers, while supply shocks benefit producers). Blandford and Currie (1975) make a strong defence of government intervention — in particular a fixed price guaranteed with deficiency payments/taxes — on the basis of welfare analysis for risk averse farmers. They argue that governments could always fix a price below expected world prices, but above certainty equivalent prices. Such a scheme will benefit producers and taxpayers while consumers would continue to pay world market prices (under the assumption of a small country). Production would be increased towards more efficient levels and exports would be reduced: there would be not only net welfare gains for the economy, but also an immediate Pareto improvement.

This type of producer welfare gains from price stabilization can easily be analyzed graphically in the context of supply side risk. Newbery and Stiglitz (1981) question this result since it depends on the linearity of the demand curve: other forms of the demand curve (*e.g.* isoelastic demand with elasticity of less than unity) may lead to the opposite result. Innes (1990) presents a more sophisticated analysis of output deficiency payments under risk aversion and finds that welfare gains can occur if markets are incomplete and price and income elasticities are low. However, risk averse producers may lose due to the negative correlation between prices and production.

Most studies recognise the limitations of these results in terms of optimality of stabilization policies. In practice, there are non negligible costs associated with storage and payment programs, and more fundamentally governments may not know the expected value of the market price to be stabilized. This lack of information may generate inefficiencies in the transmission of price signals to producers and consumers in the context of evolving demand and supply. More general frameworks and more sophisticated analysis show that price stabilization is not always welfare enhancing, depending crucially on the combination of farmers' preferences and technology (Chambers and Quiggin, 2003). Furthermore, evaluating the welfare impacts of changes in risk in the absence of appropriate contingent markets requires sophisticated valuation techniques in order to evaluate costs and benefits of stabilization (Chavas and Mullarkey, 2002). Despite the existence of illustrative examples showing that price stabilization can be welfare enhancing, the literature in this field does not allow confirming that the welfare impacts will be positive.

Does price stabilization have international implications?

Welfare results are typically calculated at the domestic national level. However, any price stabilization scheme will have implications in terms of production, consumption and exports or imports. If the country is "small" these effects can be ignored. If the country is "big" relative to the world market or many countries use similar price stabilization schemes, they will all have an impact on total trade and in volatility of world market prices. Several studies have pointed out this "exporting volatility" effect of price stabilization policies. OECD (2005) states that "domestic price stability is purchased at the expense of international price instability". This is an important issue for developing countries because of the greater vulnerability of very poor farm households to market price fluctuations transmitted from world markets". OECD (2004) gives an estimation of the increased variability (up to double) of world market prices due to observed stabilization of domestic prices for some agricultural commodities. Welfare impacts of stabilization policies should also consider the spill-over effects of these policies into international markets and into domestic markets of countries that cannot afford price stabilization schemes.

Table 2.B1. Changes in Market Price Support and in border prices

Percentage changes from 2006 to 2007

	MPS	Border prices
Australia	-89.7	8.9
Canada	-29.8	51.0
EU	-15.4	6.7
Iceland	-22.8	33.5
Japan	-11.8	14.7
Korea	-1.1	14.5
Mexico	-25.6	12.0
New Zealand	-39.5	7.1
Norway	-37.2	37.1
Switzerland	-40.1	42.8
Turkey	16.2	38.8
United States	91.5	24.3
OECD	-6.6	15.0

Blandford (1983) provides two possible policy responses to world price instability in this context. "If the degree of instability in world markets is viewed to be unacceptable to the world as a whole then it is clear that multilateral action must play an important role". The first measure suggested is trade liberalization in order to open domestic markets to the variability generated in world markets. The alternative proposed is the establishment of international grain stocks or greater co-ordination of national stocks in order to promote greater world price stability. The last two decades seem to have moved away from this second alternative as shown by the evolution of ICAs that have, in general, abandoned their original price stabilization objectives. The option for the first alternative was timid; despite the disciplines imposed by the Uruguay agreement on agriculture and the gradual movement away from most distorting forms of support in some countries, most OECD countries continue to smooth the effects of world market price variability on their own farmers (OECD, 2004). This is done through variable border measures and/or domestic administrative price mechanisms. This smoothing effect happened even in 2007 when world price were high. This is shown even at the aggregate PSE level in Table 2.B1. The general increase in border prices in 2007 across all OECD countries was not fully transmitted to domestic markets in most OECD countries, which is reflected in reductions in market price support in most countries in the same period[1]. In some countries payments based on output that directly increase producers' incentive price are relatively relevant like in the United States or Mexico. These output payments also experienced significant reductions in these countries (OECD, 2008a).

Do agricultural prices behave as prices in efficient markets?

Prices in efficient markets are able to reflect all the information available at the time the price is formed. If market price movements do not efficiently reflect changes in the available information, then they lose an important part of their role as signals. OECD (1993) finds that agricultural commodity "prices display a higher frequency of large fluctuations than that expected under the theoretical normal probability distribution… in this they conform to the behaviour of speculative prices". It is also found that episodes of high and low volatility generally characterize those prices. "The dynamics of the commodity prices in the short term appear to conflict with the standard assumptions of efficient markets". More recent studies analysing the issue of efficiency in agricultural commodity prices are not available. If price changes do not efficiently reflect changes in underlying supply and demand and fluctuate widely and frequently, farmers may not make efficient production decisions. They may incur adjustment costs associated with inefficient decisions on investment or disinvestment. These costs may also need to be considered when analysing costs and benefits of different risk management strategies and policies.

A more sophisticated critique of the functioning of agricultural world market prices is based on the way expectations are constructed in the context of agricultural market, where there is normally a lag between production decisions and sales. For instance, simple adaptive expectations about prices generate the well known cobweb results of fluctuating prices that can even be instable when supply is inelastic as compared to demand. In this case price varies because of two different reasons: cobweb fluctuations that are endogenous to the market, and exogenous risk associated with demand or supply (Newbery and Stiglitz, 1981). This type of framework would typically generate stronger negative correlations between price and output, which tends to stabilize revenue.

Some authors (Boussard, 1996) have added to this context the hypothesis of risk averse producers with naïf expectations about the variance of prices. They develop a theoretical model in which farmers take production and investment decisions generating the possibility of chaotic movement of market prices for some parameter values. They argue that, unlike exogenous risk, this type of potential endogenous risk is unlikely to be reduced with the size of the world market. Boussard *et al.* (2006) use the GTAP database to build a standard general equilibrium model (GE) and a modified version of the model to include this type of naïf price and variance expectations with risk averse producers and investors. They simulate liberalization scenarios with the standard GE and with their disequilibrium modification. The resulting price series in the latter are much more volatile than in the standard model, and nearer actual price volatility. Additionally, the variability of prices is not reduced in the liberalization scenario. Price expectations that differ systematically from realised values are the core of endogenous price risk models. Several types of expectations have been used in the literature with different implications: extrapolative or naïf expectations, adaptive expectations, implicit expectations, rational or quasi-rational expectations and future price based models. Most empirical work has concentrated in testing for rationality of expectations. To date a clear answer to this challenging question has not been provided although the evidence does suggest that agents attempt to act rationally, for instance Nervole and Bessler (2001): "Agents in experimental markets look as if they are trying to build rational components into their forecast… The current price then was adjusted for the expected effects of important supply and demand forces".

The theoretical basis of this modelling is solid. However there are some weaknesses in the empirics. First there are many ways to model endogenous market risk and it is hard to know why a particular specification is retained given that other forms of expectations and investment adjustments could also be assumed. Second, the classical rational expectation critique is applicable: in the long run systematic errors would not be repeated by farmers and arbitrators that are trying "to bring rational components into their forecast". The weakest part of this modelling exercise is the lack of empirical basis for the modelling choices that determine endogenous risk. On the contrary, there seems to be empirical evidence of correlation between observed price movements and exogenous shocks, even if they cannot be fully explained and predicted. For instance, current developments in cereal prices are related to recent development in oil prices, bio-fuel policies and droughts in some countries (OECD, 2008b). The empirical question of how expectations are formed is still open and deserves further attention from researchers.

Price volatility and futures markets

In the recent months there has been increasing concern about agricultural markets price volatility (see Box 2.B1 for a technical definition). It was already raised by FAO (2007) in its Food Outlook report of November, in which the point was made that implied volatilities (calculated on the basis of the options market about prices in the future) seemed to have been gradually increasing in the last decade for wheat, maize and soybeans. This trend was moderate for historical volatilities (calculated on the basis of past month observed prices), except for dairy products in 2006 and 2007.

Box 2.B1. Technical definition of volatility

Volatility is a measure of variability or dispersion in the same sense as the variance. The concept of volatility is normally applied to the estimation of variability in a time series such as prices. It measures the standard deviation of the percent changes in prices between consecutive periods of time. It responds to the following formula (Kotzé, 2007):

$$\sqrt{V[\ln(p_t / p_{t-1})]}$$

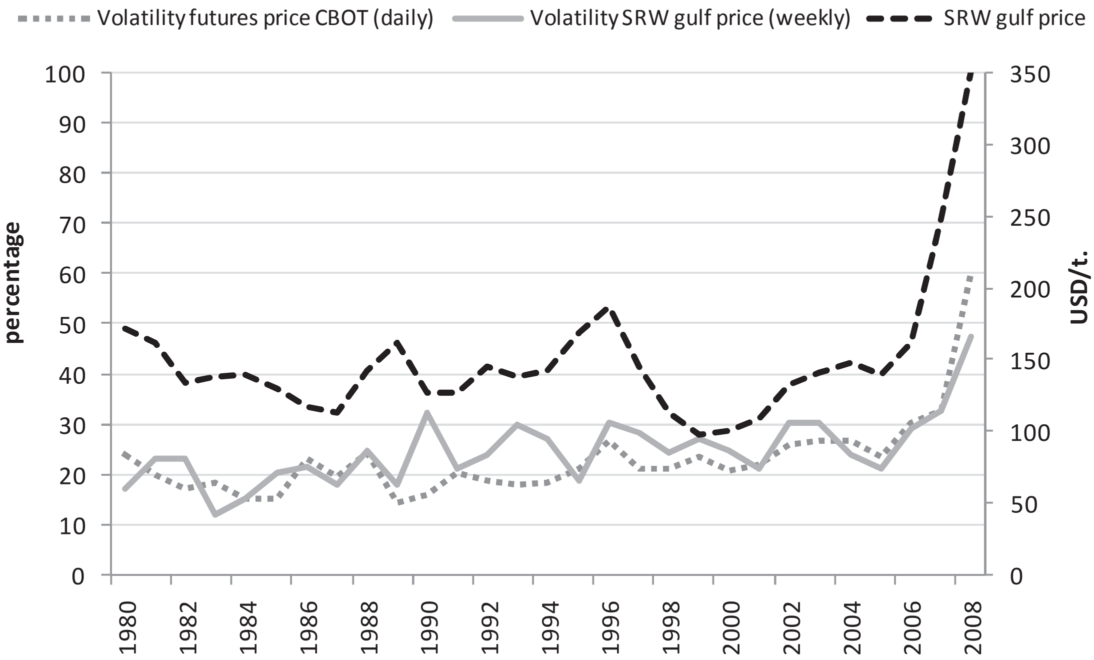
Historical volatility is calculated applying this formula to past data. The periods "t" are typically days, weeks or months. The variance is calculated over a historical set of consecutive periods, e.g. a month of daily data. In order to compare volatility calculated with data based on different periods, volatility is annualized using a constant multiplicative factor "h" measuring the number of period in a year. For daily data the number of trading days in a year is used (h=252); for weekly and monthly data h is equal to 52 and 12, respectively:

$$Volatility = \sqrt{h * V[\ln(p_t / p_{t-1})]}$$

Implied volatility is a more sophisticated concept based on option pricing models. It is an estimation of the volatility of the price that is compatible with observed option prices.

The alarm was raised when historical volatility of wheat prices in the Chicago Board of Trade (CBOT) doubled to 73% in February 2008 as compared to January and historical levels of volatility. In this same month the price of wheat in the CBOT touched a maximum above 400 USD/t. (Figure 2.B1). The volatility of cash prices in the export market experienced the same jump during these first months of 2008[2]. Even if this level of volatility is high compared to the historical levels (since 1980 when the CBOT series starts), the CBOT recorded much higher volatility in November 1999 (230%).

Figure 2.B1. Annualised price volatility and cash prices of wheat

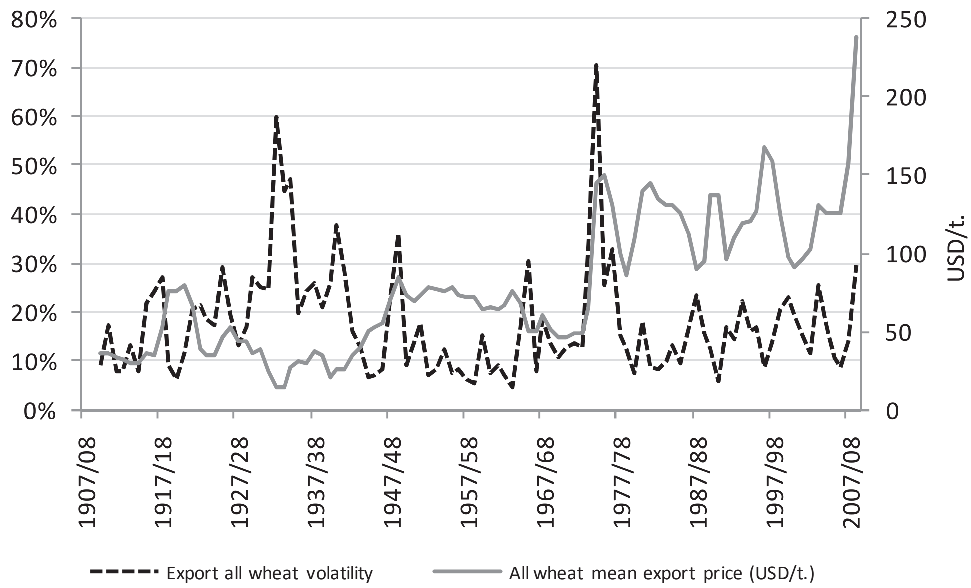


Source: OECD, using data from the International Grain Council and Chicago Board of Trade.

FAO (2008) revisited its analysis of volatility showing a significant jump in historical volatility of wheat and rice in the first months of 2008, but reductions in dairy products and hardly any change in oilseeds and meats. Implied volatility doubled in the first months of 2008 for wheat, maize and soybeans. Figure 2.B2 shows a longer run perspective on volatility with data for one century on the price level and volatility of US wheat exports. Volatility index showed peaks in crop years 1931/32 (with minimum historical nominal prices) and in 1973/74 (with maximum historical real prices). In 2007/08, historical maximum nominal prices are attained, but volatility has not increased dramatically across the whole crop year. No data is available yet for 2008/09.

Futures markets allow some of the risk involved in this price volatility to be covered. The existence of basis risk, the transaction costs and the incompleteness of futures markets do not prevent these markets from playing a potentially important role in helping some farmers and other agents to hedge some of their price risk (Sarris *et al.*, 2005). However, the role of the futures market is wider than a mere risk management tool. First, it is also a price discovery mechanism that allows information about both financial and physical assets to flow. And second, it is an instrument for financial investment. Because of these three roles, the futures market not only responds to the fundamentals of the physical agricultural commodity markets. The link with the physical markets is maintained by the possibilities of arbitrage over time (the "cost of carry") and, particularly, through the small share of transactions that end in a delivery of physical commodities (OECD, 2008c). There is some historical evidence that the existence of futures markets does not cause increased volatility in cash markets. There is evidence that in the last few years the role of non-commercial investors with a "long" position is growing in the futures markets. There are also studies that show a weak the link between cash and futures prices (Irvin *et al.*, 2007): futures prices and cash prices do not always converge at the expiration of the futures contracts (CFTC, 2008) and, in recent years, the basis price risk is increasing. Other studies question these results: speculative positions may not have grown so much in relative terms and long side positions are matched by corresponding short side positions (Sanders *et al.*, 2008).

Figure 2.B2. Historical volatility of US all wheat export price and nominal level of prices



Source: OECD from USDA monthly data.

Does price stabilization stabilize farmers' income?

This is a main limitation of price stabilization programs. It was strongly argued by Newbery and Stiglitz (1981) that producers are not concerned so much about the variability of prices, except to the extent it implies a variability of income and, therefore, potential consumption. It is well known that prices and production are negatively correlated because an important part of the uncertainty is due to movements along the demand curve. This correlation results in some of the variability of prices offsets the variability in production and, in fact, may contribute to stabilizing revenues. This negative correlation is observed empirically, and is stronger at the aggregate level, but it is still negative, while smaller at farm level. Coble *et al.*, (2007) show some empirical correlation results for the United States for the last thirty years. National yields are negatively correlated with prices (up to -0.36 correlation for soybeans), while the correlations are typically smaller at the farm level, but still negative (up to -0.13 for maize). Further empirical evidence on farm level correlation is shown in Table 4.9 in Chapter 4; in the United States the strongest negative correlations occur in major production regions for maize and soybeans (up to -0.50), and localized markets such as for speciality crops (up to -0.70). The specific location of the farm, the type of production and the size and characteristics of the market will determine the size of these correlations.

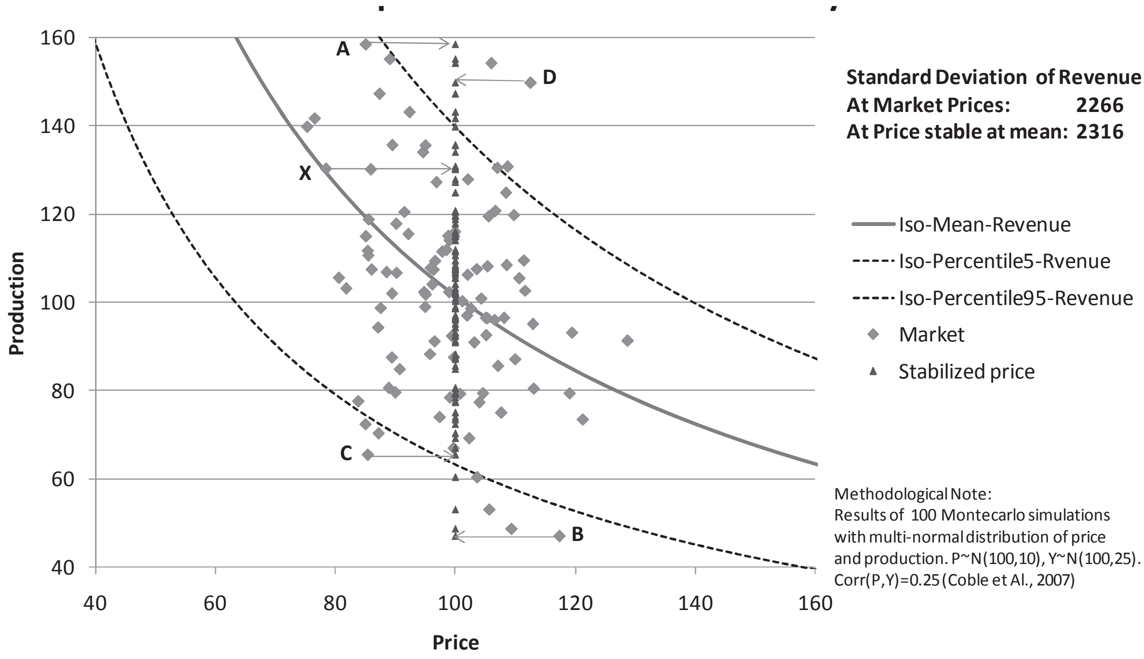
If the government objective is focused on income variability of poor farmers, more specific correlations for the target group of farmers could be calculated. The capacity of price stabilization programs to reduce the variability of farm revenue is far from being automatic and requires analytical and empirical investigation. The existence of basis risk not associated with the stabilized price may further reduce this capacity.

The implications of a negative price yield correlation can be illustrated using Montecarlo sample simulations. Figure 2.B3 reproduces a hundred draws of prices and production under the assumption of a multinomial normal distribution and negative correlation between price and yield of 0.25, an order of magnitude shown in the empirical literature. A set of market outcomes is plotted showing this weak negative correlation. The "iso-mean-revenue" curve shows the points that would generate constant revenue equal to the mean observed revenue. Similar revenue curves are plotted for the 5 and 95 percentiles to show an interval of constant revenues. Any measure stabilising price at its expected value will have an impact on revenue in each particular outcome. Even in the case of a market outcome of revenue equal to its expected value, represented by point X in the figure, revenue is affected. In this case price is below average, but exactly compensated by an increase in production; price stabilization "destabilizes" revenue to values well above its average.

The market price is below its average at point A, but the yield is well above its own average, so that the revenue is also above average; if price is stabilised at its expected value, point A is moved to the right, bringing it further away from the average revenue represented by the iso-revenue curve. Market revenue in A was in the 90% interval of most frequent outcomes around the mean; after stabilization, revenue is above the 95 percentile. In point B prices are high but production is rather low, with revenue being below its average; lowering price to its average will move point B away from the average represented by the curve. On the other hand price stabilization will move outcomes like C and D nearer to the constant revenue curve. The net effect on the variance of revenue depends on the exact distribution of outcomes. A negative covariance between price and production makes situations like A and B more likely, and therefore, price stabilization can potentially increase the variance. In the example of Figure A2.3, the variance of revenue is increased when stabilizing prices at their expected value (although this example is illustrative as it depends on the specific parameters such as the relative variance of price and production. It can also occur when stabilization is by the truncation of the distribution at a "minimum" price through a deficiency payment.

Some theoretical models have exploited this negative correlation between price and yield to study the impacts of free trade on stabilization and welfare, particularly the different correlation depending on the size of the market. Newbery and Stiglitz (1984) build an illustrative two country trade model with two commodities produced (one risky in terms of yields and another safe). In each country price-yield negative correlation is very strong (assumed to be 100%) as is the correlation between yields in the two countries. Under autarky farmers income is perfectly stable because the price-yield correlation is fully exploited. In this particular model, trade brings perfect price stabilization at the cost of introducing variability in farmers' income. This result is due to the assumptions of perfect price–yield correlation under autarky (small national market) and zero price-yield correlation under trade (bigger world market). This model illustrates how a stable price may result in unstable income. Most studies show that enlarging the size of the market (particularly by trade) tends to stabilize prices (*e.g.* Srinivasan and Jha, 2001).

Figure 2.B3. An example of price stabilisation and its implication for revenue stability



The case against farm household income stabilization impacts of price stabilization is reinforced when other sources of income are considered. Farmers diversify crops to account for the negative production and price correlations that could potentially be exploited; price stabilization has potential to reduce the use of this type of strategies that reduce revenue variability. If futures markets are already doing part of the job, government price stabilization will add a smaller contribution to income stabilization. Farmers in developed countries normally can count on capital and credit markets to smooth consumption over their life cycle, which jeopardized the marginal contribution of price stabilization to farmers' consumption smoothing. Other sources of income (including off-farm income) are also used by farmers to stabilize their consumption.

Price stabilization can also have impacts on output variability. If as expected farmers take more risky decisions and techniques as a response to stable prices, output is likely to become more variable, contributing to jeopardize any reduction in income variability. On the contrary, if price variability had a market endogenous component of the "cobweb" type, price stabilization may create a more stable pattern of supply.

This paper deals with risks associated with the farmer as producer, and then the appropriate question is about the reduction in producers' income variability. But current volatility concerns are to a great extent associated with consumers' food consumption stability, particularly for the poorest. Newbery and Stiglitz (1981) argue that if a significant part of the variability of prices is due to demand responses to consumers' income changes, price stabilization could in fact make consumers worse off. This paper does not tackle the issue of poverty alleviation and the extent to which price stabilization is an instrument well targeted for this purpose.

Picking up the right price: the costs of price stabilization and the political economy

Any benefit of price stabilization schemes is typically analysed in the context of choosing the right expected price. It seems unlikely that any government or stock management agency has the appropriate information to know the right mean price in the market, so that the stabilization scheme is built upon interventions when prices deviates from its mean. The information requirements need permanent updating to adjust intervention price to market conditions. If prices are not picked up at the right level, any efficiency gain from reducing the noise of risk in the price signals could be offset by efficiency losses due to a wrong level of price (Romstad, 2008). Additionally, once the government has the capacity to determine a price, there will be pressure groups trying to influence this decision and bias the price choice in their own benefit.

In the absence of this information, if the scheme tries to stabilize the price at a level well below the expected price, speculators will bet for a future increase of prices and try to benefit from private storage until the stabilization scheme runs out of stocks. On the contrary, if the level of price is picked up well above the expected price, speculators will get rid of all private stocks and try to sell maximum output at current prices, obliging the scheme to have ever growing stocks. This type of schemes typically requires additional measures to limit the capacity of speculators of seeking rents and increasing the management costs of the scheme. This may include border measures, and supply management in the form of quotas or set aside requirements. The intervention price schemes of the Common Agricultural Policy of the European Union in the eighties are good examples of such developments.

These costs of managing stocks will not exist in the case of price stabilization schemes based on payments to producers such as deficiency payments. Price stabilization for producers could be achieved with a variable payment/levy scheme without handling cumbersome stocks. However, all other limitations and potentialities of price stabilization schemes discussed in this section also apply to a payment scheme.

What do we learn from a holistic approach?

This section is focused on a specific source of risk (price volatility) and a specific type of policy instrument (price stabilization schemes). This linear approach contrasts with the holistic approach proposed in this paper which implies looking at both the source of risk and the policy instruments in a broader context of correlations among risks, and interactions among risk management strategies and government policy instruments. This example illustrates how the broader context is required for a balanced evaluation of the effects of a policy measure.

Focussing risk management policies on a single source of risk and a single instrument considered in isolation from other relevant sources of risk may induce unintended results in terms of revenue variability and welfare. Output prices may be correlated with other sources of risk, such as production and some input costs. Some farmers may be taking advantage of some of these correlations to reduce their exposure to risk. If output prices are stabilized, these correlations are eliminated and these risk reducing advantages are lost. This can have different impacts on farmers' income stability, including different impacts for different farmers.

All available risk management strategies need to be considered when analysing policy options. Naïf analysis that assumes all other risk management decisions of farmers (and other agents) are constant is misleading. There will be a response to a price stabilization scheme in terms of the whole farming strategy of many farmers. Risk averse farmers may take riskier production decisions in a context of stabilized prices, which may impact the variability of production. Price stabilization may crowd-out the use of other risk management instruments such as production diversification, futures or long term contracts. The net effect on farmers' income variability is largely unknown.

Price stabilization schemes generate a particular institutional framework that will affect the development or non-development of other institutions and markets. These schemes typically require a set of additional measures affecting the frame in which markets operate. They affect the whole set of agricultural support measures and the capacity of pressure groups to bias decision making in their benefit. Overlapping with other policy measures such as progressive tax systems also requires further attention.

Unfortunately risk management in agriculture is an area in which policy decisions have to be taken in the context of great uncertainty and imperfect information. Price volatility is a clear example. There is scope for markets to failure in providing instruments to deal with price risk efficiently. The most straight forward response to this potential market failure seems to be a price stabilization scheme. However, given the uncertainties and strong interactions among sources of risk, risk management tools and government actions, its impacts and implications are not straight forward and require in depth analysis including appropriate analysis of the trade-offs in a holistic framework.

Notes

1. The only exceptions are the United States and Turkey. The United States result is due to the composition of its market price support, mainly milk, with important changes in marketing margins, and sugar, with declining border prices.
2. Volatility in the CBOT is calculated with daily price data and then converted into annual basis using the number of days in a year. Volatility with weekly data or with monthly is calculated in a similar manner accounting for the number of intervals per annum. Even if this annualization of the data facilitates comparisons, the concept itself changes with the interval of data.

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Chapter 3.

An Overview of Risk-Related Policy Measures

Which policy measures have a direct risk dimension?

All agricultural policy measures have an impact on risk.[1] Some measures, however, are specifically designed to reduce price, yield or income variability, or to smooth consumption, and thus help farmers manage risk, either because they prevent or reduce the occurrence of risk (risk reduction), or because they limit the effect of risk on income (risk mitigation) or consumption (risk coping). Risk reduction measures would be, for example, disease control measures such as vaccination, which aims to limit the occurrence and spread of animal diseases and thus prevent/reduce potential losses in livestock receipts. Market price support (MPS) measures, which stabilise domestic prices, also reduce domestic price risk. Risk mitigation and coping can operate through established (*ex ante*) mechanisms such as insurance schemes or income stabilisation programmes, or through *ex post* interventions such as *ad hoc* assistance to compensate income losses.

In this chapter, the policy measures that are specifically designed to reduce price, yield or income variability, or to smooth consumption are referred to as "risk-related" measures. Following the conceptual framework developed in OECD (2009a), they are classified as either contributing to risk reduction or risk mitigation/coping. [2] Among risk reduction measures, MPS is identified separately as it dominates any other risk reduction measure in many countries in terms of support level.

Other support measures that provide a stable (fixed rate) transfer to income can also have risk impacts and enter into farmers' risk management strategies. This is the case for direct income payments, in particular those that are highly decoupled. Decoupled income payments provide stable support, which contributes to reducing the coefficient of variation (ratio of standard deviation to mean) of farm receipts, as it increases the mean. They may also change farmers' aversion to risk. They are not, however, considered in this study as risk-related measures, as they are not designed to reduce variations in farm receipts.

The classification of risk-related measures mentioned above is used in this report to present an overview of the policies that reduce risk or mitigate the consequences of risk faced by farm households in OECD countries and selected emerging economies. This report is based on information from the OECD PSE database, WTO notifications on domestic support commitments and former OECD studies (notably OECD, 2001 and 2005).

The PSE database contains information on transfers to producers arising from policy measures that support agriculture. In the database, each individual measure is classified into one of the categories of support defined in Box 3.1, which are based on the following implementation criteria:

- the transfer basis for support: output, input, area/animal numbers/revenues/incomes, non-commodity criteria;
- whether the support is based on current or historical (fixed) basis; and
- whether production is required or not.

In addition, a number of labels may be applied to individual policies to provide further specification of the way each measure is implemented: with or without production limits or input constraints, whether payments have fixed or variable rates (Box 3.1). [3]

Information contained in the PSE database is used to measure the share of risk-related policies in total support to producers. Each individual measure in the various PSE categories is considered, and classified according to its risk-related features. In addition, the variable rate label is used to identify policies with countercyclical features: as the rate of support varies inversely with a change in price, yield, net revenue or income, these measures are designed to reduce price, yield or income variability.

Information on the share of support from policies identified here as risk-related in the overall domestic support notified to the WTO.

This section briefly describes the various types of measures identified as reducing price, yield or income variability or smoothing consumption (called here risk-related policies) in place in OECD countries and selected emerging economies and, based on Tables 3.1 and 3.2, comments on their occurrence.

Box 3.1. Classification of agricultural policy measures in the Producer Support Estimates (PSE)

The PSE includes the following categories

MPS **Market price support:** transfers from consumers and taxpayers to agricultural producers from policy measures that create a gap between domestic market prices and border prices of a specific agricultural commodity, measured at the farm gate level.

PO **Payments based on output**: transfers from taxpayers to agricultural producers from policy measures based on current output of a specific agricultural commodity.

PI **Payments based on input use**: transfers from taxpayers to agricultural producers arising from policy measures based on on-farm use of inputs:

-- **PIV Variable input use** that reduces the on-farm cost of a specific variable input or a mix of variable inputs.

-- **PIF Fixed capital formation** that reduces the on-farm investment cost of farm buildings, equipment, plantations, irrigation, drainage, and soil improvements.

-- **PIS On-farm services** that reduce the cost of technical, accounting, commercial, sanitary and phytosanitary assistance and training provided to individual farmers.

PC **Payments based on current A/An/R/I,[1] production required**: transfers from taxpayers to agricultural producers arising from policy measures based on current area, animal numbers, revenue, or income, and requiring production.

PHR **Payments based on non-current A/An/R/I,[1] production required**: transfers from taxpayers to agricultural producers arising from policy measures based on non-current (*i.e.* historical or fixed) area, animal numbers, revenue, or income, with current production of any commodity required.

PHNR **Payments based on non-current A/An/R/I,[1] production not required**: transfers from taxpayers to agricultural producers arising from policy measures based on non-current (*i.e.* historical or fixed) area, animal numbers, revenue, or income, with current production of any commodity not required but optional.

PN **Payments based on non-commodity criteria**: transfers from taxpayers to agricultural producers arising from policy measures based on the long-term retirement of factors of production from commodity production; the use of farm resources to produce specific non-commodity outputs of goods and services, which are not required by regulations; and transfers provided equally to all farmers, such as a flat rate or lump sum payment.

Definitions of labels attributed to individual measures

With or without current commodity production limits and/or limit to payments: defines whether or not there is a specific limitation on current commodity production (output) associated with a policy providing transfers to agriculture and whether or not there are limits to payments in the form of limits to area or animal numbers eligible for those payments.

With variable or fixed payment rates: Any payments is defined as subject to a variable rate where the formula determining the level of payment is triggered by a change in price, yield, net revenue or income or a change in production cost.

With or without input constraints: defines whether or not there are specific requirements concerning farming practices related to the programme in terms of the reduction, replacement, or withdrawal in the use of inputs or a restriction of farming practices allowed. The payments with input constrains are further broken down to 1) Payments conditional on compliance with basic requirements that are mandatory (with mandatory); 2) Payments requiring specific practices going beyond basic requirements and voluntary (with voluntary).

With or without commodity exceptions: defines whether or not there are prohibitions upon the production of certain commodities as a condition of eligibility for payments based on non-current A/An/R/I[1] of commodity(ies).

Based on area, animal numbers, receipts or income: defines the specific attribute (*i.e.* area, animal numbers, receipts or income) on which the payment is based.

Based on a single commodity, a group of commodities or all commodities: defines whether the payment is granted for production of a single commodity, a group of commodities or all commodities.

1. A (area), An (animal numbers), R (receipts) or I (income).
Source: OECD (2008).

Risk reduction measures

These measures reduce the occurrence of risk as they increase domestic price stability, limit production losses, reduce marketing uncertainties, and encourage the adoption of risk management techniques. Government intervention in risk reduction includes price stabilisation; inspection and food safety measures; and support to production and marketing techniques. A number of specific measures to reduce the occurrence of risk are identified in OECD countries and selected emerging economies (Tables 3.1 and 3.2 respectively). These are:

- market price support measures, through price stabilisation;[4]
- market interventions such as private storage or non-marketing of agricultural products;
- support to production techniques such as water management (irrigation, drainage, flood control and other); purchase of certified seeds and animal breeds; pest and disease control;
- technical assistance and extension; and
- inspection of agricultural products and food safety measures.

Market price support measures, through price stabilisation

In addition to supporting domestic prices, *i.e.* raising them above world price levels, price support measures often contribute to domestic price stabilisation, via the mechanisms described below. Price stabilisation need not involve support, but *de facto* does in most countries. As defined in OECD (1994), an income stabilisation measure that does not provide long-term support is a one that follows a trend reflecting the long-term evolution of prices. Positive and negative government transfers to farmers would be mutually offsetting over time and costs would be limited to administrative costs.

Price support measures generally reduce the transmission of world price changes in domestic markets and thus reduce domestic price variability. Domestic measures such as administered prices triggering intervention purchase and public storage reduce domestic price fluctuations by preventing prices from falling below a given limit.

Export subsidies also stabilise domestic prices as they facilitate exports of excess supply and thus export domestic variability onto world markets. Export taxes or bans are used to prevent domestic prices from increasing as much as world prices.

While simple tariffs do not necessarily reduce domestic price variability, high levels of protection, which strongly limit imports (in particular tariffs that are so high as to be prohibitive), isolate domestic producers from world price variability, but not from domestic variability. Since the Uruguay Round Agreement on agriculture in 1995, which banned countercyclical border measures (variable levies), maximum tariffs are fixed (*i.e.* bound), but countries can react to world price fluctuations by modifying applied tariffs and applying special safeguard measures within WTO rules. All countries examined have price stabilising support for at least some commodities.[5]

Market interventions such as private storage or non-marketing of agricultural products

Farmers generally use marketing techniques, such as spreading sales over time, to deal with short-term price variability. Government assistance to private storage is thus considered as a risk reduction measure. While spreading sales is a very widespread risk management strategy used by farmers and agro-food industries, very few countries subsidise private storage, and when they do, it is to a very limited extent. Payments for the non-marketing of agricultural products (when prices are low) are rare. Under the reformed common market organisation for fruit and vegetables implemented at the beginning of 2008 in the European Union (EU), for example, market withdrawals for fruits and vegetables can only be carried out by producer organisations, with limits set on the volume of withdrawals and EU funds available.

Support to production techniques

Various production techniques help farmers reduce the risk of production failure. They include opting for production that is better adapted to the land and climatic environment. This may involve using high quality seeds and breeds also adapted to the specific conditions in the field; managing water supply to crops through irrigation and drainage; and the prevention, monitoring and treatment of pests and diseases. Regarding the choice of seeds and breeds, risk management strategies can be diverse and often involve various trade-offs between productivity, marketability, resistance to pests and disease and preservation of diversity that may contribute to future pest and disease resistance. Subsidies to inputs (*e.g.* seeds or irrigation water) and investment assistance (for irrigation projects) reduce the costs for farmers of adopting these risk management techniques, but their main objective is usually to raise productivity.

These risk management techniques are widely used by farmers. In many countries, governments provide support to farmers for the adoption of these techniques (*e.g.* irrigation investments), or provide the service directly (pest and disease control). In the EU, support for the adoption of these techniques or the provision of these services is mainly the responsibility of member states.

Technical assistance and extension

Among the many areas in which they advise farmers, extension services play an important role in disseminating information on production and marketing techniques for risk management, and in encouraging their adoption. In the area of risk management, they also have a more general role in advising farmers on best strategies outside this classification of government intervention.

Inspection and food safety measures

Inspection and food safety regulations contribute to reducing marketing risk. Governments set minimum food safety standards and monitor compliance. In addition to developing its own standards, the food industry contributes to financing and implementing food safety regulations, but inspection of agricultural products is supported by governments in all examined countries.

Risk mitigation/coping measures

These measures contribute to smoothing income or consumption by helping farmers to get insurance against drops in price or yield and by providing assistance in the event of income losses. Tables 3.1 and 3.2 distinguish *ex ante* mechanisms for mitigating the consequences of risk and *ex post* interventions, such as *ad hoc* payments. However, the distinction is sometimes difficult to make, for example in the case of disaster payments made after the damage has been registered but using established mutual funds.

Ex ante measures

The main types of *ex ante* measures for smoothing farm household income are:

- payments with a variable rate (or countercyclical payments) compensating for all or part of the income losses suffered according to a pre-established formula;
- subsidies for risk management tools such as insurance systems or futures markets;
- income tax smoothing systems; and
- income diversification support.

Payments with a variable rate (or countercyclical payments)

Some programmes are implemented explicitly to stabilise farmers' receipts (*ex ante*). They only generate transfers when receipts are lower than a target level. Variable rate (or countercyclical) payments are identified in the PSE database using a label defined in Box 3.1. This label may apply to all categories of PSE measures, but in the context of this report, only payments based on output (PO), area, animal number, receipts and income (PC, PHR, PHNR)[6] that have a variable rate are considered. Some sort of countercyclical payment is currently used in many of the countries examined, with the exception of Iceland, Norway, Switzerland, Chile, China, South Africa and Argentina. However, the extent to which they are used varies a lot by country (see next section). In particular, countercyclical payments in the EU are mostly payments for disaster relief by member states.[7]

Risk management tools: subsidies to insurance systems or futures contracts and options

Futures markets are used to reduce price risk by co-operatives and wholesalers, but also by individual farmers, often on large farms. Some governments encourage farmers to use futures markets, mainly by providing information and technical advice. Canada and the United States have offered pilot programmes to subsidise premiums on option contracts. In the 1990s, the Cattle Option Pilot Program in Canada offered a customised option contract to cattle producers, who had to pay the premium and the transaction fees but no registration fees. It was discontinued because of low participation rates. The Dairy Option Pilot Program was introduced in the United States under the Fair Act 1996. The government paid up to 80% of the premium of each option and broker fees up to USD 30 per option. It ended in 2007.

Among the countries examined, the only one, which currently provides subsidies for options contracts to farmers is Mexico. The Agricultural Products Option Programme (APOP) provides subsidies to farmers who buy commodity options on United States futures markets. ASERCA acts as an intermediary between the producers and United States brokers and subsidises part of the option premium (OECD, 2001, Box 9). The programme started in 1994 with cotton and has been mainly used for wheat, maize, sorghum and cotton, but an increasing number of additional commodities are covered: beef, coffee, orange, pork, safflower and soya in 2007. In Brazil, the risk premium for private option contracts is subsidised for agro-food industries.

Subsidies to agricultural insurance systems are more widespread. They may include subsidies to premiums, reinsurance or administrative costs. There is a wide variety of insurance systems in countries examined, with large differences in coverage and implementation systems.

In many countries, private insurance systems cover losses from specific natural events that farmers cannot influence, such as hail, drought or floods. Some are subsidised, but not all. Multi-risk, crop insurance schemes, which compensate for losses in yield whatever the cause, always operate with government support. Government involvement in insurance systems can include setting a legal framework, subsidising farmers' premium and/or insurance companies' administration costs as well as providing reinsurance. In most countries examined, insurance systems are operated by private insurance companies, but in Canada, the government manages insurance programmes directly.

Some countries like Canada, the United States and Spain have a long history of subsidised crop insurance systems. They are being developed in other countries like France. While there is no insurance system at the EU level, many EU member states subsidise agricultural insurance systems to some extent (Table 3.2). In Canada and the United States, more comprehensive systems also cover losses in revenue or net income.

There are also insurance systems that are not specific to the agricultural sector, for example against risks that affect buildings (fire, water damage, hurricanes) or household members (health insurance, labour replacement). Some countries like the United States provide subsidies to these insurance systems.

Box 3.2. Examples of income tax smoothing systems in OECD countries

In Australia, the Income Tax Averaging Scheme is a long-standing tax concession, which allows farmers to be taxed at their average rate of income over a rolling five-year period (OECD, 2001). In case of natural disasters, income from forced disposal or death of livestock or sales of wool can be deferred or spread, and income from insurance recoveries can be spread. Individual farmers in Ireland have the option of being taxed on the basis of averaging farming profits or losses over three years, as long as neither farmer nor spouse have another trade or employment. A similar option is offered to individual farmers in the United Kingdom, but with a two-year averaging period. This is not specific to farmers (writers also benefit) but they are the main users. Special rules apply to "hobby" farmers to limit the use of continuous farm losses to reduce taxation on other income. Tax averaging in the United States is available for sole farmers and partnerships over a three-year period. This is only applicable to farmers and farm income. In the Netherland, income averaging over a three-year period for taxation purpose is allowed for all business income, including from farming.

In Australia, the Farm Management Deposit Scheme, which replaced the Income Equalization Deposit Scheme in 1999, allows farmers to reduce their tax liabilities by setting aside money in high income years and withdrawing it as income in low income years.

The Income Equalisation Scheme in New Zealand allows farmers, fishers and foresters who are eligible taxpayers to even out fluctuations in income by spreading their gross income from year to year. They are allowed to deposit income from farming, fishing or forestry with Inland Revenue into a special account. The deposit is held for a maximum period of five years and earns interest at 3% per annum on amounts left on deposit for more than 12 months. The interest paid becomes part of the deposit for tax purposes. Deposits are tax deductible in the year for which they are made and withdrawals (including interest) are assessable in the year for which they are made. The adverse event income equalisation scheme operates in conjunction with the standard income equalisation scheme. It allows the deferral of income tax on additional income which is generated by the forced sale of livestock from the year of sale to the year the livestock is replaced. Those deposits earn interest at a rate of 6.5% per annum from the date of receipt until the deposit is refunded.

In Sweden, a tax allocation reserve (or profit equalisation system) was introduced in 1994 in place of earlier reserve systems (The Investment Reserve System (1979-90) and the Tax Equalisation System (1991-93)). It applies to business profit of any enterprise. Legal entities may deduct up to 25% of annual taxable income (farm profit) in a given year and private entrepreneurs and people who own a share of a partnership may deduct up to 30%. Such deductions shall be included to taxable income no later than the sixth year after they were made (update from OECD, 2001, Box 7).

In France, an income tax smoothing system was introduced in 2002 and refined in 2006 (*déduction pour aléas*, DPA).[1] Farmers taxed on the basis of real profits (standard or simplified), who have subscribed an insurance plan for damages to crops and losses from animal death, can deduct a portion of their profits from their annual taxable income and place it in a professional savings account. From 2006, up to EUR 26 000 can be saved annually for both the DPA and another tax deduction scheme for investments (*déduction pour investissement*, DPI). Money placed in the saving account can be used in cases of climatic (hail, frost), economic (break in land rent contract), sanitary (contagious disease) or family (divorce, invalidity) unforeseen problems, within five to seven years depending on the problem. Sums on these accounts become taxable when used or if not used, after seven years.

In Canada, NISA allowed farmers to set aside money in individual accounts to be withdrawn in low income years. The government also contributed to NISA accounts. Taxes on government contributions and interests earned were deferred until funds were withdrawn by participants. In 2003, the NISA programme was replaced by the Canadian Agricultural Income Stabilization (CAIS) programme and all NISA funds must be withdrawn by 31 March 2009. In various circumstances, farmers can defer taxation of some receipts from one year to the other with the effect of smoothing annual income. This applies to compensation payments for the compulsory destruction of livestock and to receipts from sales of breeding livestock in drought stricken areas.

1. http://www.impots.gouv.fr/

Source: OECD (2005) and national tax web sites

Income tax smoothing systems

They consist in allowing taxable income to be spread over a multi-year period, thereby smoothing disposable income. They can be specific to farmers within the tax system or they can apply to any business profit. They were identified in several countries in an OECD report looking as taxation systems and tax concessions in agriculture (OECD, 2005). Tax averaging systems are available in Australia, Ireland, the Netherlands, the United Kingdom and the United States, while income equalisation systems are available in Australia, France, New Zealand and Sweden. In Canada, a tax deferral applies to government contributions to a risk management programme (Net Income Stabilisation Account, NISA) until 2009 and to specific disaster relief payments. A brief description of these systems is given in Box 3.2.

Support to diversification of activities

Diversification into activities with different risk characteristics is a traditional risk management strategy. Increasingly, farm households rely on various sources of income. While their motivations are diverse, securing higher and more stable income levels is an important one.[8] There is evidence that, at the aggregate level, off-farm income stabilises farm household income as it is often more stable than farm income[9]. It may even be countercyclical in some cases. In some countries, such as Chile and a number of EU member states, support is granted to develop alternative sources of income within the agricultural sector or outside. As support to diversification of activities outside the agricultural sector is not included in the PSE, this list may not be exhaustive.

Ex post measures

The main types of *ex post* measures for smoothing income or consumption are:

- disaster relief payments;
- *ad hoc* assistance; and
- other measures such as debt relief, social assistance or labour replacement services.

Disaster relief payments and ad hoc payments

Ad hoc payments are made in response to an emergency situation such as a sharp reduction in farm income whatever the cause: output price decreases, input price increases, animal disease outbreaks, etc. When the cause is a natural disaster, this is considered as a disaster relief payment. *Ad hoc* payments compensate all or part of the losses with no systematic mechanism in place to trigger them and set the amount. *Ad hoc* support can also come from reductions in input costs. For example, in recent years fuel tax rebates for farmers have been raised in several countries as prices increased. In France, temporary reductions or deferrals of social contributions have been used in times of income crisis.

Disaster relief payments are made to compensate for losses in income (and are often paid on the basis of current or past hectares, animal heads or farm receipts) or assets (investment assistance), due to natural disasters. In a few countries they help farmers buy new variable inputs. They are implemented in many ways, including specific payments, supplementary payments within existing measures, investment grants, or interest concessions on loans to meet investment, consumption or input purchase needs. In some countries, there are procedures and specific funds for the provision of disaster payments. In France, a mutual disaster fund (*Fonds national de garantie des calamités agricoles*) receives contributions from producer levies and government subsidies. In Australia, a specific disaster relief scheme delivers Exceptional Circumstances assistance.[10] When disaster payments are made as part of an existing scheme/fund, they are considered as having variable rates in the PSE database. When they come from *ad hoc* funds and are made outside an established mechanism, disaster payments are considered as having fixed rates.

Most countries, with the exception of Chile, Switzerland and Ukraine, use disaster payments (Table 3.1). In EU member states, they are funded and implemented at the national level, and are not part of the Common Agricultural Policy (Table 3.2). Payments identified as *ad hoc* are mainly used in Canada and to some extent in Chile, the EU and Russia. It is not clear whether in the PSE database all disaster or *ad hoc* payments are identified as such. They may be included in aggregate items such as interest concessions or infrastructure assistance.

Other risk-related measures

- Support to farm relief services, which advise farmers in adverse situations about their options and often provide short-term assistance/credit.
- Debt rescheduling/write-off, which alleviates debt burden.
- Labour replacement services, which provide support for replacing farmers in case of health problems.
- Social assistance, which consists in providing transitional/short term assistance to smooth consumption.

Other agriculture-related measures, which do not necessarily generate transfers to farmers, may reduce risk for farmers by providing information, capacity-building and clear regulations that contribute to stabilising their business environment. Finally, many economy-wide policies and regulations contribute to reduce risk for farmers to the extent they provide a stable macro-economic environment, well-functioning markets, education, or health systems and general social support.

Table 3.1. Risk-related policies in OECD and selected emerging economies, 1986-2007

	Risk reduction										Reducing consequences of risk (mitigation/coping)														
	Production and marketing techniques								Inspection	Price stab.	Ex ante									Ex post					
	Private storage / Non-marketing		Water management		Certified crop seeds/animal breeds		Technical assistance/ Extension	Pest and disease control	Inspection	Market price support	Variable rate (countercyclical) payments				Subsidies to risk management tools: Insurance	Subsidies to risk management tools: Futures m.	Income tax smoothing[8]	Income diversification support[9]	Farm relief service	Disaster relief		Ad hoc assistance	Social assistance Labour replac.[9]	Debt rescheduling / write-off	
PSE category		PSE cat.		PSE cat.		PSE cat.	PIS	PIV	GSSE	MPS	PO	PC	PHR	PHNR	PIV	PIV	PHRN or excluded	GSSE or excluded	PIS		PIF/PC	PC/PHR/ PHNR	PIV/PC		PSE cat.
OECD countries																									
Australia			IR	PIF[1]/PIS[2]/GSSE			x	x	x	x				x			x		x	x	PIV/PIF/ PC/PHNR	x	x		
Canada[5]							x	x	x	x (partly)	x	x	x	x	x (PC)					x	PIF/PC/PHNR	x		x	PIF
EU[10]	NM/PS (MK)	PO	IR	PIF	x	PIV	x	nat.	x	x	x				nat.			x		x			nat.		
Iceland							x	x	x	x										x	PIF		x		
Japan			IR/DR	PIF/GSSE			x	x	x	x	x	x			x					x	PIF/GSSE				
Korea			IR/DR	PIV/GSSE	x	PIS	x	x	x	x	x				x (PC)					x	PC				
Mexico			IR	PIV/PIF/GSSE	x	PIV/PIF	x	x	x	x	x	x			x	x				x	PC		x (PC)	x	PIF
New Zealand			IR/DR/FL	GSSE				x	x	x		x					x			x	PC			x	PO/PHR
Norway	PS	PO						x	x	x										x	PIF/PC		x (PC)		
Switzerland					x	PIS	x	x	x	x															
Turkey			IR/OT	PIV/PIF	x	PIF/PIV			x	x		x			x (PC)					x	PIF				
United States	PS	PIF	IR/FL	PIV/PIF/PIS/ GSSE[3]			x		x	x	x	x		x	x (PC)		x			x	PO/PC				
Emerging economies																									
Brazil	PS	PIV	IR	GSSE			x	x (GSSE)	x	x	x	x[6]			x (+PC)	x (CSE)								x	PC
Chile			IR	PIF/PIS/GSSE			x	x	x	x					x			x (PIF)		x	PC				
China			IR	PIF/GSSE[4]	x	PIV	x	x	x	x										x	PC		x		
Russia			IR	PIF/GSSE	x	PIV		x	x	x		x[7]			x					x	PIS/PC	x (PIV)		x	PIV/PC
South Africa			IR	PIV/GSSE					x	x		x[7]								x	PIF/PC				
Ukraine			IR/DR	PIS/GSSE				x (GSSE)	x	x	x				x									x	PIV/PC
Argentina (1995-2003/04)							x	x	x	x (tobacco)					x					x					
Israel (1999)			IR/DR				x	x	x	x	x									x					

Notes to Table 3.1

Nat.: national measure; MK: Milk; IR: Irrigation; DR: Drainage; FL: Flood control; OT: Other water management systems. NM: non marketing; PS: private storage (EU POSEI).

PIV: Payments based on variable input use; PIF: Payments based on fixed capital formation; PIS: Payments based on on-farm services, PO: Payments based on output; PC: Payments based on current area planted/animal numbers/ receipts/ income (A/An/R/I); PHR: payments based on non-current A/An/R/I, production required; PHRN: payments based on non-current A/An/R/I, production not required; GSSE: General Services Support Estimate.

1. Debt write-off on water facilities for primary producers and tax deductions for capital expenditures.

2. Water fund to invest in water infrastructure, improved water management and better practices.

3. Research and infrastructure.

4. Water management expenditures are not identified separately in fixed capital formation or infrastructure support.

5. For NISA, fixed government contributions to the system are considered under insurance. For other stabilisation programmes, countercyclical payments received by farmers are considered.

6. Insurance payments.

7. Disaster payments.

8. Taxable income can be averaged over several years (Box 2).

9. In the EU, Measures for Promoting the Adaptation and Development of Rural Areas under the Rural Development Regulation include support for the Setting-up of Farm Relief and Farm Management Services, and for the diversification of activities.

10. More details on national or co-financed measures are presented in Table 3.2.

Source: OECD, PSE database 2006 and 2008; WTO notifications on domestic support commitments; OECD (2005).

Table 3.2. Risk-related policies in EU member states, 1986-2007

	Risk reduction							Reducing consequences of risk (mitigation/coping)									
	Production and marketing techniques					Inspection	Price stab.	Ex ante						Ex post			
	Private storage / Non-marketing	Water management	Certified crop seeds/animal breeds	Technical assistance/ Extension	Pest and disease control	Inspection	Market price support	Variable rate (countercyclical) payments	Subsidies to risk management tools: Insurance	Subsidies to risk management tools: Futures m.	Income tax smoothing[1]	Income diversification support[2]	Farm relief service	Disaster relief	Ad hoc assistance	Social assistance Labour replac.[2]	Debt rescheduling / write-off
PSE category	PSE cat.	PSE cat.	PSE cat.	PIS	PIV	GSSE	MPS	PO PC PHR PHNR	PIV	PIV	PHRN or excluded	GSSE or excluded	PIS	PIF/PC	PC/PHR/ PHNR	PIV/PC	PSE cat.
EU MS																	
Austria					x				x			x		x PC			
Belgium					x				x					x PC			
Czech Rep.		IR PIF	x PIV		x				x					x PC			x PIF
Denmark				x	x								x	x PIF		x	
Finland				x								x		x PC		x	
France	PS (CH) PO	IR PIF		x	x				x		x	x	x	x PIF (credit)		x	
Germany				x	x				x			x		x PIF/PC			
Greece	PS (CH) PO	IR PIF	x PIV	x	x									x PIF			x PIF
Hungary		IR/DR PIF	x PIV (credit)	x	x				x					x PIF/PC		x	
Ireland		DR PIF		x	x						x						
Italy	PS (CH) PO	IR PIF		x	x							x		x PIF		x	
Luxembourg					x				x				x				
Netherlands				x	x				x		x	x		x PC			
Poland		DR/OT PIF	x PIV (credit)	x	x				x					x PIF			
Portugal	PS (CH) PO	IR/DR PIF		x	x				x								
Slovak Rep.		IR PIV/PIF	x PIV (credit)	x	x				x							x	
Spain	PS (CH) PO	IR PIV/PIF		x	x				x			x		x PIF		x	
Sweden				x	x						x	x	x			x	
United Kingdom		DR/OT PIF		x	x						x	x	x				
Non OECD EU MS																	
Bulgaria		IR PIV/PIF	x PIS											x PC			
Cyprus				x	x				x								
Estonia			x PIV													x	
Latvia		OT PIF	x PIV/PIS	x	x				x					x PIV/PC			
Lithuania			x PIV	x	x				x								
Malta				x	x												
Romania		IR PIV/PIF	x PIV		x				x					x PC			
Slovenia		IR/OT PIF		x	x				x							x	

MK: Milk; IR: Irrigation; DR: Drainage; FL: Flood control; OT: Other water management systems. NM: non marketing; PS: private storage (EU POSEI).

PIV: Payments based on variable input use; PIF: Payments based on fixed capital formation; PIS: Payments based on on-farm services, PO: Payments based on output; PC: Payments based on current area planted/animal numbers/ receipts/ income (A/An/R/I); PHR: payments based on non-current A/An/R/I, production required; PHRN: payments based on non-current A/An/R/I, production not required; GSSE: General Services Support Estimate.

1. Taxable income can be averaged over several years (Box 2).

2. In the EU, Measures for Promoting the Adaptation and Development of Rural Areas under the Rural Development Regulation include support for the Setting-up of Farm Relief and Farm Management Services, and for the diversification of activities.

Source: OECD, PSE database 2008; OECD (2005).

Risk-related policies in the PSE

Most risk-related measures discussed above generate support to individual farmers, which is included in the Producer Support Estimate (PSE). In the PSE database, transfers from individual measures are classified in various categories defined in Box 3.1. this database is used here to identify transfers under various risk-related measures. In the PSE database, support for risk reduction techniques, such as irrigation or pest and disease control, is often based on input use, while risk mitigation/coping support is generally based on output, area, animal numbers, farm receipts or income (Tables 3.1 and 3.2). Risk-related measures may also generate support to agricultural producers collectively, in which case it is included in the General Services Support Estimate (GSSE). This is in particular the case for inspection services, some collective pest and disease control measures, and investments in large irrigation infrastructure projects. While some elements of research and training can also help reduce risk faced by farmers, these are generally not identified separately and are not considered here.

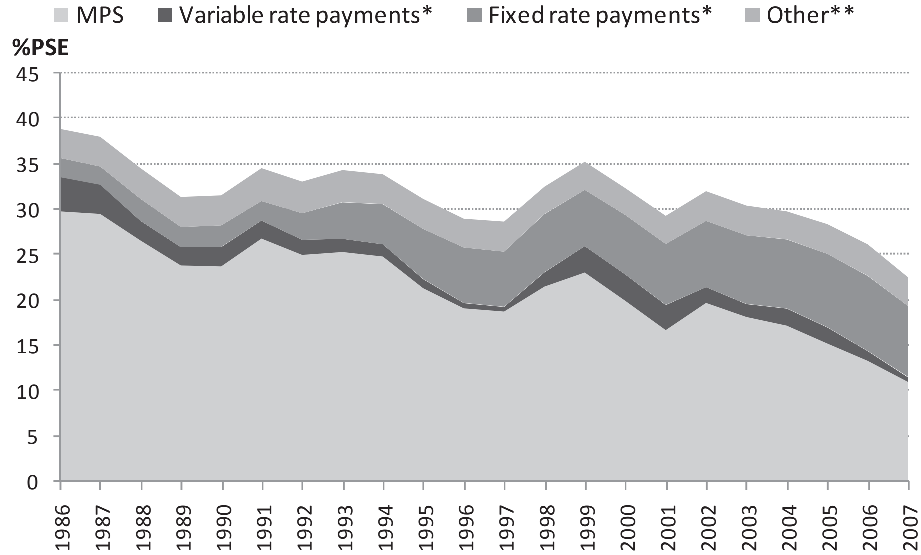
This section first presents estimates of the share in total support of risk-related measures, notably market price support (MPS) and payments with a variable rate. To provide more insight into the various types of risk-related measures, it then classifies individual measures from various PSE categories into risk-related categories identified above[13] and analyses the share of support from those various categories of risk-related measures in the overall support environment. MPS is reported as a risk-reduction measure because of its contribution to price stabilisation. However, when looking at trends in world prices, it is clear that in many countries, MPS is well above the level needed to stabilise prices around their longer-term trend. Reflecting the dual nature of this type of support in most countries market price support is reported separately from other risk-related measures.

Share of MPS and variable rate payments in the PSE

Figures 3.1, 3.2 and 3.3 illustrate how PSE categories and labels can be used to identify some of the broad types of risk-related policies identified above, such as MPS and variable rate payments (*i.e.* payments based on output, area, animal numbers, revenue or income with a variable rate label). These two categories of risk-related measures are shown, for comparative purposes, alongside measures with fixed rate (*i.e.* payments based on output, area, animal number, revenue or income with a fixed rate label), which are not considered in this study as risk-related instruments, and with a category “other”, which is a residual. This residual includes policies identified above as risk-related, which are identified separately in Tables 3.3 and 3.4.

Figure 3.1 shows that overall in the OECD area, MPS is the risk-related measure that generates the largest share of support. Its share in the PSE as a percentage of farm receipts (%PSE) has, however, been decreasing over the period 1986-2007, while payments with a fixed rate have increased. By design, the share of payments with a variable rate varies counter-cyclically with market conditions. While fixed rate payments based on output, area, animal numbers, receipts or income were slightly less than the same group of payments with a variable rate in the mid-1980s (1986-88), they were almost five times higher in the 1990s (1992-97) and close to six times higher in the 2000s (2002-07).

Figure 3.1. Share of MPS and variable rate payments in the %PSE of the OECD area, 1986-2007



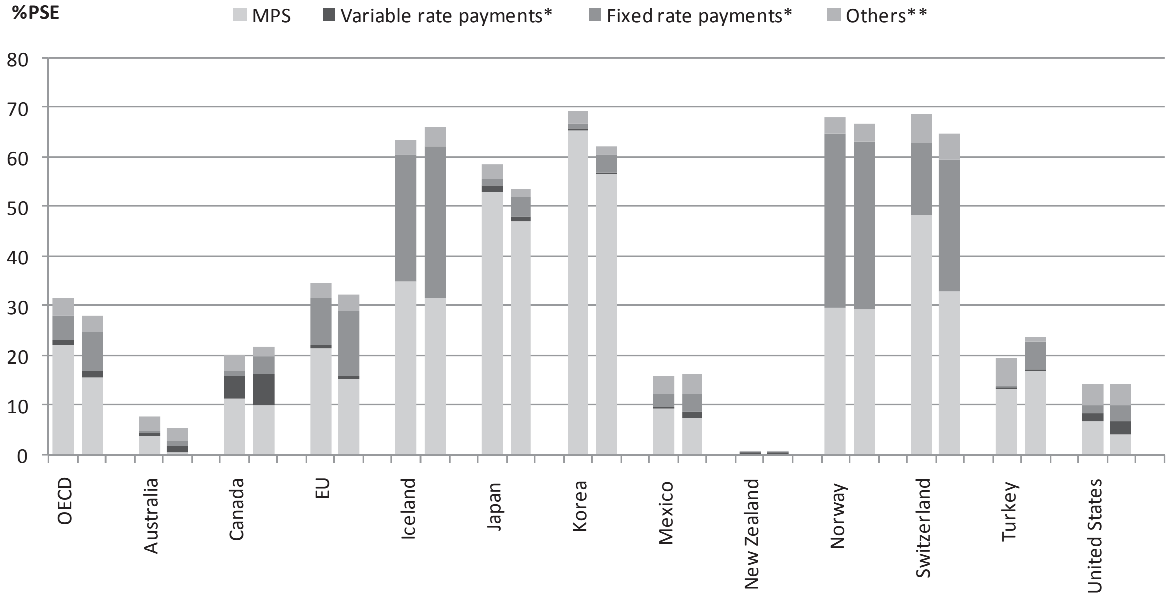
%PSE: PSE as a percentage of farm receipts.
* Within PO, PC, PHR and PHRN categories.
** Payments based on input use (PI), payments based on non-commodity criteria (PN) and miscellaneous payments (PM).

Source: OECD, PSE database 2008.

There are large differences between countries in the level and composition of support (Figures 3.2 and 3.3). While support to producers as a percentage of farm receipts varies greatly among OECD countries, from 1% in New Zealand to over 60% in Iceland, Korea, Norway and Switzerland, MPS remains an important component in most countries except Australia (Figures 3.2 and 3.4). In the emerging economies examined, MPS fluctuated a lot in the 1990s, reaching large negative numbers in some countries, and domestic markets were isolated from world prices. In 2002-05, MPS was generally positive except in Ukraine, and support levels as a percentage of farm receipts were below 10% in most countries except Russia where it was below 20% (Figure 3.3).

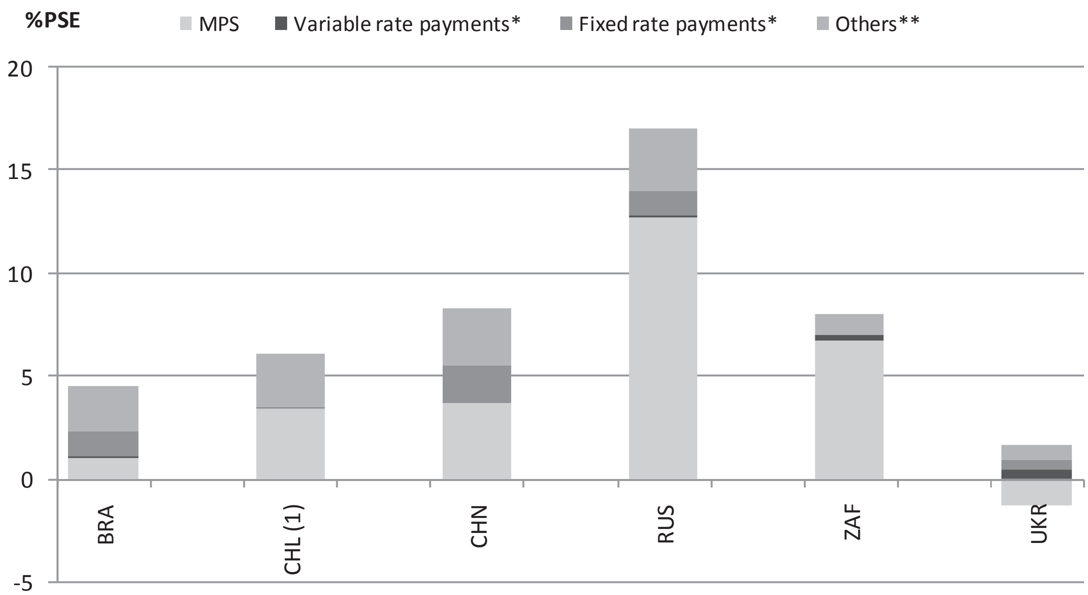
Payments with a variable rate are negligible in most countries examined. Canada and the United States are the two countries where they are most significant, both in absolute terms and as a percentage of the PSE. In both countries, they co-exist with MPS and fixed rate payments. Variable rate payments are also significant in Australia and Mexico. In a context of decreasing MPS, variable rate payments have increased in Australia, Canada, Mexico and the United States between the two periods 1992-07 and 2002-07. In Japan, they account for a small, but steady share of a PSE largely dominated by MPS. Korea's PSE is largely made of MPS, while the EU, Iceland, Norway and Switzerland use both MPS and fixed rate payments to support their farmers. In Brazil, Canada, Turkey and the United States, variable rate payments partly correspond to insurance payments, while in Russia, South Africa, and partly in EU member states, Mexico, Korea and the United States, they bring disaster relief (Tables 3.3 and 3.4).

Figure 3.2. Share of MPS and variable rate payments in the %PSE of OECD countries, 1992-97, 2002-07



The left bar is the average of 1992-97, the right bar is the average of 2002-07.
%PSE: PSE as a percentage of farm receipts.
* Within PO, PC, PHR and PHRN categories.
** Payments based on input use (PI), payments based on non-commodity criteria (PN) and miscellaneous payments (PM).
Source: OECD, PSE database 2008.

Figure 3.3. Share of MPS and variable rate payments in the %PSE of selected emerging economies, 2002-05



%PSE: PSE as a percentage of farm receipts.
1. Average of 2002-06.
* Within PO, PC, PHR and PHRN categories.
** Payments based on input use (PI), payments based on non-commodity criteria (PN) and miscellaneous payments (PM).
Source: OECD, PSE database 2006.

Share of risk reducing and risk mitigation/coping support in OECD indicators of support

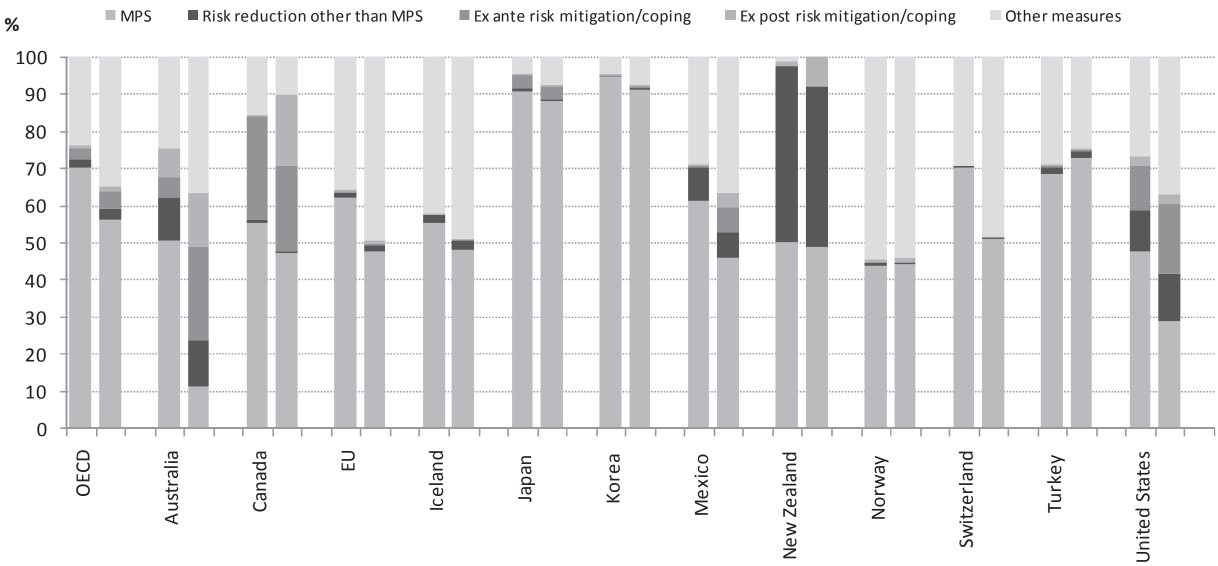
Using the same the classification of risk-related measures as in Tables 3.1 and 3.2, Tables 3.3 and 3.4 identify support associated with measures used respectively for risk reduction, and for risk mitigation and coping, and including both support to producers (PSE) and general services (GSSE). The shares of these groups of risk-related measures in the PSE and the GSSE are also presented graphically in Figures 3.4 to 3.8.

Overall, risk-related measures accounted for two-thirds of support to OECD producers in 2002-07, compared to three-quarters a decade earlier (Figure 3.4, Table 3.3). Their share exceeds 50% in all OECD countries (except Norway, where it was slightly below). In emerging economies, the share of risk-related measures in total support has also been above 50% in most recent years. Countries with a share of risk-related measures over 80% include Japan, Korea, Russia and South Africa, where MPS accounts for close or over 90% of the total of those measures, as well as Canada and New Zealand, where over half of risk-related support comes from non-MPS measures

The importance of MPS in OECD countries is confirmed (Figure 3.4). While its share in the OECD PSE decreased from 70% in 1992-07 to 56% in 2002-07, its share in risk-related support decreased from 92% to 86%. In 2002-07, MPS accounted for over 40% of the PSE in all OECD countries except Australia, where it was slightly over 10%, and the United States where it was slightly below 30%. Support for measures helping farmers deal with the consequences of risk is negligible in a majority of OECD countries. It is significant as a share of producer support in Australia, Canada, Mexico, New Zealand and the United States (Figure 3.4) and as a share of budgetary support (Figures 3.5 and 3.6). *Ex post* measures, which include disaster relief, *ad hoc* assistance, social assistance and debt relief, are mainly used in Australia, Canada, New Zealand and emerging economies.

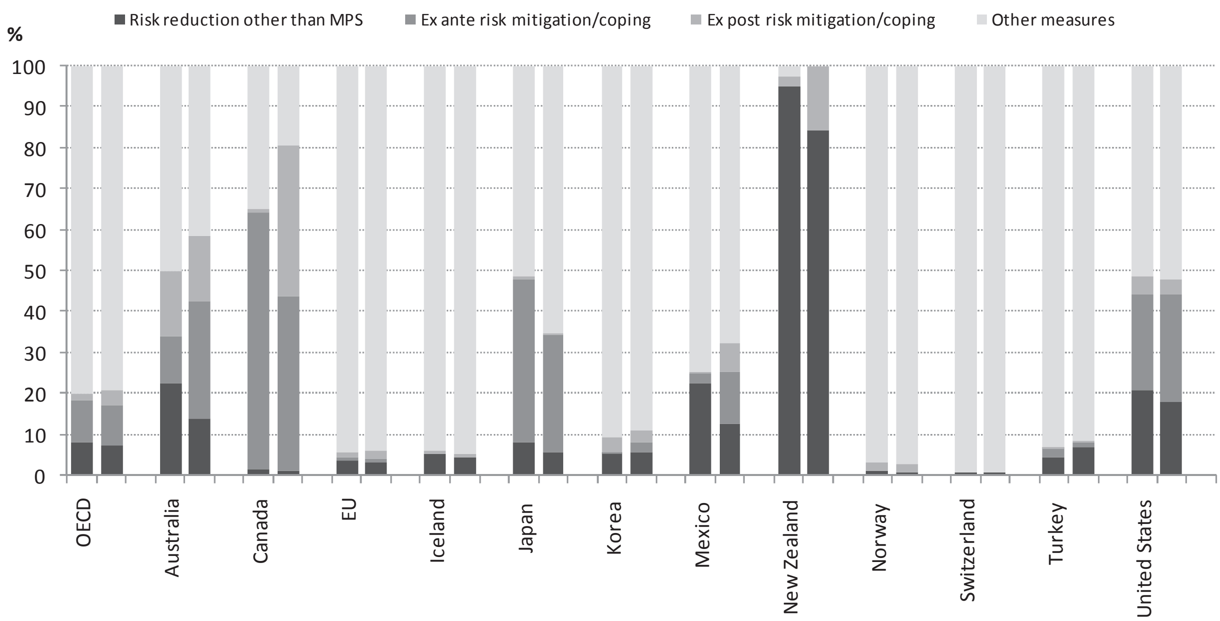
Risk reduction support other than MPS includes mainly government expenditures on pest and disease control, extension and water management. It is significant in Australia, Mexico, the United States, where support to technical assistance dominates, and particularly important in New Zealand, where support for pest and disease control measures is of the same magnitude as MPS. In New Zealand, risk-related measures, which include MPS, pest and disease control and some disaster payments, make up for almost all support to producers, which is 1% of farm receipts. In the emerging economies considered, risk reduction measures other than MPS are particularly significant in Chile, where they consist of technical assistance to farmers. Government support to technical assistance provided to individual farmers is also significant in Brazil and China, but does not exist in Russia, South Africa and Ukraine. For emerging economies, Figure 3.6 showing the composition of support to producers excludes MPS because of negative numbers (Table 3.4).

Figure 3.4. Share of risk-related policies in the PSE of OECD countries 1992-07 and 2002-07



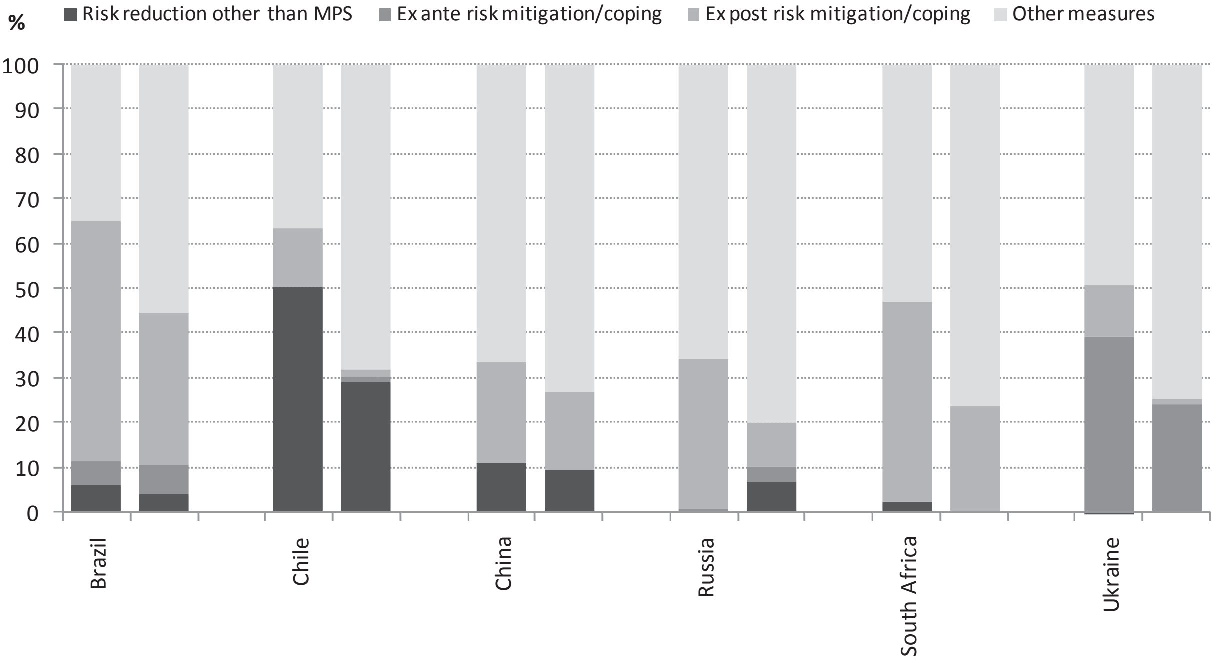
The left bar is the average of 1992-97, the right bar is the average of 2002-07.
Source: OECD, PSE database 2008.

Figure 3.5. Share of risk-related policies in budgetary support to producers of OECD countries 1992-07 and 2002-07



The left bar is the average of 1992-97, the right bar is the average of 2002-07.
Source: OECD, PSE database 2008.

Figure 3.6. Share of risk-related policies in budgetary support to producers in selected emerging economies, 1992-97 and 2002-05



The left bar is the average of 1992-97 in Chile, Russia and Ukraine, 1993-97 in China, 1994-97 in South Africa and 1995-97 in Brazil; the right bar is the average of 2002-05 in all countries except Chile, where it is the average of 2002-06.

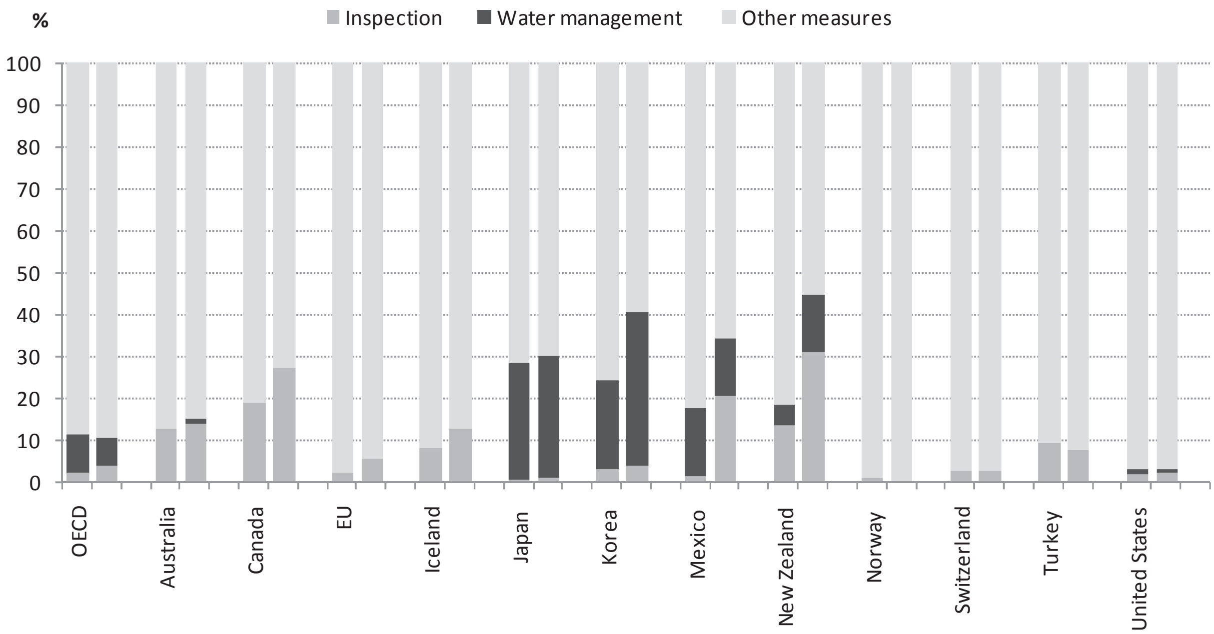
Source: OECD, PSE database 2006.

Some risk reduction measures are included in general services to agriculture as they benefit farmers collectively: this is the case of inspection services, some pest and disease control measures and water management infrastructure assistance (Figures 3.7 and 3.8).[14] The latter account for a notable share of GSSE in Chile, Japan, Korea and Mexico. In other countries, the aggregate for infrastructure assistance may include support for irrigation systems, but it is not possible to identify it separately. Inspection services account for a growing share of GSSE in many countries.

Support to *ex ante* risk mitigation systems includes payments with a variable rate, as identified in Figures 3.2 and 3.3, although some disaster payments with a variable rate are classified as *ex post* in Figures 3.4 and 3.5 and Tables 3.3 and 3.4. This is because disaster payments are granted after the disaster has occurred and damage has been estimated. However, the frontier between *ex ante* and *ex post* measures is not always clear. Insurance and futures options subsidies are also classified as *ex ante* risk mitigation measures. *Ex ante* risk mitigation support is particularly significant in Canada and the United States, and to a lesser extent in Australia and Mexico.

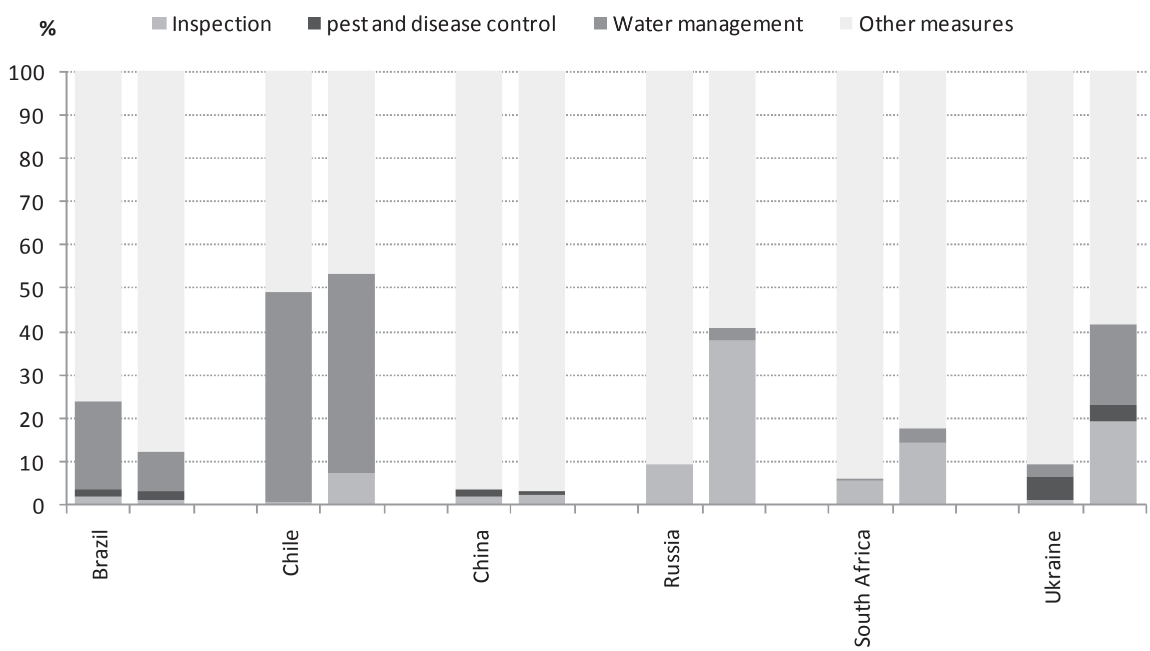
Subsidies to purchase futures option contracts are only available in Mexico and have gained importance in recent years. Most risk mitigation payments are, however, *Ingreso Objetivo* payments, which are paid per tonne with a variable rate. Brazil also subsidises risk premium for private options contracts for co-operatives and agro-food industries so government expenditures on these subsidies is included in the consumer support estimate (CSE).

Figure 3.7. Share of risk-related policies in the GSSE of OECD countries 1992-97 and 2002-07



The left bar is the average of 1992-97, the right bar is the average of 2002-07.
Source: OECD, PSE database 2008.

Figure 3.8. Share of risk-related policies in the GSSE in selected emerging economies 1992-97 and 2002-05



The left bar is the average of 1992-97 in Chile, Russia and Ukraine, 1993-97 in China, 1994-97 in South Africa and 1995-97 in Brazil; the right bar is the average of 2002-05 in all countries except Chile, where it is the average of 2002-06.
Source: OECD, PSE database 2006.

Table 3.3. Transfers from risk-related policies in OECD countries, 1992-97 and 2002-07

Million EUR	Australia		Canada		European Union*		Iceland		Japan		Korea	
	1992-97	2002-07	1992-97	2002-07	1992-97	2002-07	1992-97	2002-07	1992-97	2002-07	1992-97	2002-07
Risk reduction measures in PSE	**772**	**298**	**1 876**	**2 513**	**58 005**	**51 308**	**67**	**85**	**44 592**	**32 484**	**16 734**	**16 498**
-- MPS	***633***	***145***	***1 852***	***2 485***	***56 773***	***49 454***	***64***	***81***	***44 228***	***32 224***	***16 681***	***16 405***
-- Other risk reduction measures	***139***	***152***	***25***	***28***	***1 232***	***1 854***	***3***	***4***	***364***	***261***	***53***	***93***
Private storage/non marketing	0	0	0	0	0	0	0	0	0	0	0	0
Water management[1]	0	34	0	0	205	187	0	0	206	118	48	65
Certified seeds/breeds	0	0	0	0	0	77	0	0	0	0	0	0
Technical assistance/extension	81	57	22	3	163	401	1	3	134	104	5	27
Pest and disease control	57	61	3	26	863	1 189	2	1	24	39	0	0.5
Risk reduction measures in GSSE	**33**	**83**	**239**	**483**	**164**	**605**	**1**	**2**	**4 106**	**2 671**	**569**	**1 073**
Water management[2]	0	6	0	0	0	0	0	0	4 033	2 604	504	969
Inspection (GSSE)	33	78	239	483	164	605	1	2	73	66	64	104
Ex ante **risk mitigation/coping measures in PSE**	**70**	**319**	**930**	**1 191**	**359**	**465**	**0**	**0**	**1 790**	**1 263**	**0**	**39**
Variable rate payments based on output[3,4]	0	0	135	0	210	157	0	0	1 176	751	0	0
Variable rate payments based on current A/An/R/I[3,5]	0	0	587	1 011	0	0	0	0	0	24	0	0
Variable rate payments based on non-current A/An/R/I, production required[3,6]	0	0	0	87	0	0	0	0	0	0	0	0
Variable rate payments based on non-current A/An/R/I, prod. not required[3,7]	0	138	207	94	0	0	0	0	0	0	0	0
Insurance subsidies[8]	0	0	0	0	149	308	0	0	615	488	0	39
Futures markets subsidies	0	0	0	0	0	0	0	0	0	0	0	0
Income tax smoothing schemes	70	181	0	0	0	0	0	0	0	0	0	0
Ex post **risk mitigation/coping measures in PSE**	**97**	**181**	**11**	**1 012**	**418**	**1 131**	**1**	**1**	**40**	**23**	**35**	**41**
Disaster relief payments	96	177	4	536	337	940	1	1	40	23	35	41
Ad hoc assistance[9]	0	0	7	475	0	0	0	0	0	0	0	0
Social assistance/labour replacement	0	3	0	0	80	191	0	0	0	0	0	0
Debt rescheduling/write-off	0	0	0	1	0	0	0	0	0	0	0	0
Total PSE	**1 246**	**1 256**	**3 337**	**5 255**	**91 397**	**104 094**	**117**	**167**	**48 736**	**36 644**	**17 611**	**17 973**
Total risk-related measures in PSE	**939**	**797**	**2 817**	**4 717**	**58 782**	**52 904**	**68**	**85**	**46 422**	**33 770**	**16 769**	**16 578**
% share of risk-related measures in PSE	*75*	*64*	*84*	*90*	*64*	*51*	*58*	*51*	*95*	*92*	*95*	*92*
% share of risk-related measures other than MPS in PSE	*25*	*52*	*29*	*42*	*2*	*3*	*3*	*3*	*5*	*4*	*0*	*1*
% share of MPS in PSE	*51*	*12*	*55*	*47*	*62*	*48*	*55*	*48*	*91*	*88*	*95*	*91*
% share of MPS in risk-related measures	*67*	*18*	*66*	*53*	*97*	*93*	*95*	*95*	*95*	*95*	*99*	*99*
Total GSSE expenditures	**272**	**561**	**1 271**	**1 775**	**8 484**	**11 348**	**12**	**16**	**14 519**	**8 876**	**2 352**	**2 662**
Risk related measures in GSSE	**33**	**83**	**239**	**483**	**164**	**605**	**1**	**2**	**4 106**	**2 671**	**569**	**1 073**
% share in GSSE	*12*	*15*	*19*	*27*	*2*	*5*	*8*	*13*	*28*	*30*	*24*	*40*

A/An/R/I: Area/Animal number/Receipts/Income

* EU12 for 1992-94; EU15 for 1995-2003, EU25 for 2004-06 and EU27 in 2007.

1. Subsidies to water use and investment assistance in irrigation and drainage systems on the farm.

2. Infrastructure assistance for water management off the farm.

3. Payments of this PSE category that have a variable rate label, except those included in the disaster relief payments or insurance subsidies items in this table.

4. Includes for example the EU production aid for banana; and the Farming Income Stabilization Programme (JRIS) and the Sugar Cane Farm Income Stabilization Programme in Japan.

5. Includes the Canadian Agricultural Income Stabilisation (CAIS) programme, The Ontario Risk Management programme, the *Assurance-Stabilization des revenus agricoles* (ASRA), NISA and crop insurance payments in Canada; and the Rice Farmers Management Support in Japan.

6. Includes the AgriInvest Kickstart Program and the Canadian Farm Families Options Program in Canada.

7. Includes the Australian Dairy Industry Restructure Package; and the Western Grain Transition Program in Canada.

8. Includes subsidies to national insurance schemes in the EU; and insurance subsidies in Japan. In Canada, payments from insurance programmes are considered under variable rate payments.

9. Includes the Alberta Farm income Assistance Program, the agricultural Policy Framework Transition Funding, the Cost of Production Payment, the Farm Income Payment, the Grains and Oilseeds Payment Program, and Provincial CAIS enhancements.

Table 3.3. Transfers from risk-related policies in OECD countries 1992-97 and 2002-07 (*cont.*)

	Mexico		New Zealand		Norway		Switzerland		Turkey		United States	
	1992-97	2002-07	1992-97	2002-07	1992-97	2002-07	1992-97	2002-07	1992-97	2002-07	1992-97	2002-07
Risk reduction measures in PSE	**2 861**	**2 862**	**52**	**62**	**1 107**	**1 111**	**3 252**	**2 231**	**3 607**	**6 674**	**14 109**	**13 352**
-- MPS	**2 506**	**2 496**	**27**	**33**	**1 088**	**1 101**	**3 238**	**2 217**	**3 531**	**6 501**	**11 476**	**9 240**
-- Other risk reduction measures	***355***	***366***	***25***	***29***	***18***	***10***	***14***	***14***	***76***	***173***	***2 633***	***4 113***
Private storage/non marketing	0	0	0	0	9	0	0	0	0	0	0	3
Water management[1]	224	62	0	0	0	0	0	0	48	38	334	238
Certified seeds/breeds	5	6	0	0	0	0	0	0	24	128	0	0
Technical assistance/extension	97	97	0	0	0	0	12	6	0	0	1 902	3 005
Pest and disease control	29	201	25	29	9	10	1	9	4	6	397	866
Risk reduction measures in GSSE	**121**	**234**	**14**	**54**	**1**	**0**	**9**	**8**	**121**	**87**	**713**	**928**
Water management[2]	113	93	4	17	0	0	0	0	0	0	267	237
Inspection (GSSE)	8	140	10	38	1	0	9	8	121	87	446	691
***Ex ante* risk mitigation/coping measures in PSE**	**35**	**378**	**0**	**0**	**0**	**0**	**0**	**0**	**40**	**28**	**2 948**	**5 879**
Variable rate payments based on output[3,4]	6	291	0	0	0	0	0	0	0	0	211	2 650
Variable rate payments based on current A/An/R/I[3,5]	0	0	0	0	0	0	0	0	40	26	2 325	0
Variable rate payments based on non-current A/An/R/I, production required[3,6]	0	0	0	0	0	0	0	0	0	0	0	0
Variable rate payments based on non-current A/An/R/I, prod. not required[3,7]	0	0	0	0	0	0	0	0	0	0	0	1 930
Insurance subsidies[8]	29	37	0	0	0	0	0	0	0	3	412	1 298
Futures markets subsidies	0	51	0	0	0	0	0	0	0	0	0	0
Income tax smoothing schemes	0	0	0	0	0	0	0	0	0	0	0	0
***Ex post* risk mitigation/coping measures in PSE**	**9**	**204**	**1**	**5**	**26**	**31**	**0**	**0**	**0**	**10**	**553**	**856**
Disaster relief payments	3	94	1	5	21	12	0	0	0	10	553	856
Ad hoc assistance	0	0	0	0	0	0	0	0	0	0	0	0
Social assistance/labour replacement	6	13	0	0	5	19	0	0	0	0	0	0
Debt rescheduling/write-off	0	97	0	0	0	0	0	0	0	0	0	0
Total PSE	**4 080**	**5 421**	**53**	**67**	**2 476**	**2 487**	**4 594**	**4 336**	**5 145**	**8 932**	**24 089**	**31 860**
Total risk-related measures in PSE	**2 905**	**3 444**	**52**	**67**	**1 132**	**1 142**	**3 252**	**2 231**	**3 647**	**6 712**	**17 610**	**20 087**
% share of risk-related measures in PSE	*71*	*64*	*99*	*100*	*46*	*46*	*71*	*51*	*71*	*75*	*73*	*63*
% share of risk-related measures other than MPS in PSE	*10*	*17*	*48*	*51*	*2*	*2*	*0*	*0*	*2*	*2*	*25*	*34*
% share of MPS in PSE	*61*	*46*	*50*	*49*	*44*	*44*	*70*	*51*	*69*	*73*	*48*	*29*
% share of MPS in risk-related measures	*86*	*72*	*51*	*49*	*96*	*96*	*100*	*99*	*97*	*97*	*65*	*46*
Total GSSE expenditures	**688**	**683**	**75**	**122**	**131**	**194**	**377**	**327**	**1 313**	**1 139**	**24 317**	**31 411**
Risk related measures in GSSE	**121**	**234**	**14**	**54**	**1**	**0**	**9**	**8**	**121**	**87**	**713**	**928**
% share in GSSE	*18*	*34*	*18*	*44*	*1*	*0*	*2*	*2*	*9*	*8*	*3*	*3*

A/An/R/I: Area/Animal number/Receipts/Income

1. Subsidies to water use and investment assistance in irrigation and drainage systems on the farm.

2. Infrastructure assistance for water management off the farm.

3. Payments of this PSE category that have a variable rate label, except those included in the disaster relief payments or insurance subsidies items in this table.

4. Includes for example *Ingreso objetivo* payments in Mexico and various payments in the United States such as loan deficiency and market loss payments.

5. Includes potato, sugar and tobacco compensation payments in Turkey; and former deficiency payments in the United States.

6. No measures in this category in the countries above.

7. Includes Countercyclical payments introduced in the 2002 Farm Bill in the United States.

8. Includes ANAGSA/AGROASEMEX insurance subsidies in Mexico; and Crop insurance and Adjusted gross revenue insurance payments in the United States.

Source: OECD, PSE database 2008.

Table 3.4. Transfers from risk-related policies in selected emerging economies 1992-97 and 2002-05

Millions EUR	Brazil		Chile		China		Russia		South Africa		Ukraine	
	1995-97	2002-05	1992-97	2002-06	1993-97	2002-05	1992-97	2002-05	1992-97	2002-05	1994-97	2002-05
Risk reduction measures in PSE	**-3 911**	**603**	**325**	**201**	**-2 702**	**12 488**	**-4 652**	**4 433**	**892**	**577**	**-3 021**	**-667**
-- MPS	**-4 019**	**526**	**308**	**164**	**-3 073**	**11 147**	**-4 680**	**4 333**	**891**	**577**	**-3 021**	**-667**
-- Other risk reduction measures	***108***	***77***	***17***	***37***	***371***	***1 341***	***28***	***101***	***1***	***0***	***0***	***0***
Private storage/non marketing	0	1	0	0	0	0	0	0	0	0	0	0
Water management[1]	0	0	2	7	0	0	0	0	1	0	0	0
Certified seeds/breeds	0	0	0	0	0	0	15	33	0	0	0	0
Technical assistance/extension	108	76	15	22	275	1 218	0	0	0	0	0	0
Pest and disease control	0	0	0	8	96	122	13	68	0	0	0	0
Risk reduction measures in GSSE	**565**	**131**	**19**	**49**	**202**	**454**	**100**	**324**	**28**	**78**	**29**	**147**
Water management[2]	477	96	19	42	0	0	0	22	1	14	9	66
Pest and disease control	44	22	0	0	96	122	0	0	0	0	16	13
Inspection (GSSE)	44	13	0	7	106	331	100	302	26	64	3	69
Ex ante risk mitigation/coping measures in PSE	**93**	**117**	**0**	**1**	**0**	**0**	**7**	**44**	**0**	**0**	**623**	**204**
Variable rate payments based on output[3,4]	61	42	0	0	0	0	0	0	0	0	623	204
Variable rate payments based on current A/An/R/I[3]	0	0	0	0	0	0	0	0	0	0	0	0
Variable rate payments based on non-current A/An/R/I, production required[3]	0	0	0	0	0	0	0	0	0	0	0	0
Variable rate payments based on non-current A/An/R/I, prod. not required[3]	0	0	0	0	0	0	0	0	0	0	0	0
Insurance subsidies[5]	33	75	0	1	0	0	7	44	0	0	0	0
Futures markets subsidies	0	0	0	0	0	0	0	0	0	0	0	0
Income tax smoothing schemes	0	0	0	0	0	0	0	0	0	0	0	0
Ex post risk mitigation/coping measures in PSE	**926**	**635**	**4**	**2**	**772**	**2 559**	**1 660**	**139**	**15**	**26**	**186**	**12**
Disaster relief payments	0	0	4	2	329	871	11	4	15	26	0	0
Ad hoc assistance	0	0	0	0	0	0	2	0	0	0	0	0
Social assistance/labour replacement	0	0	0	0	443	1 688	0	0	0	0	0	0
Debt rescheduling/write-off	926	635	0	0	0	0	1 648	135	0	0	186	12
Total PSE	-2 284	2 377	341	291	311	25 535	235	5 759	924	687	-1 435	178
Total risk-related measures in PSE	**-2 892**	**1 355**	**329**	**204**	**-1 930**	**15 047**	**-2 984**	**4 617**	**907**	**603**	**-2 212**	**-452**
% share of risk-related measures in PSE	*n.a.*	*57*	*96*	*70*	*n.a.*	*59*	*n.a.*	*80*	*98*	*88*	*n.a.*	*n.a.*
% share of risk-related measures other than MPS in PSE	*n.a.*	*35*	*6*	*14*	*n.a.*	*15*	*n.a.*	*5*	*2*	*4*	*n.a.*	*n.a.*
%share of MPS in PSE	*n.a.*	*22*	*90*	*56*	*n.a.*	*44*	*n.a.*	*75*	*96*	*84*	*n.a.*	*n.a.*
%share of MPS in risk-related measures	*n.a.*	*39*	*94*	*80*	*n.a.*	*74*	*n.a.*	*94*	*98*	*96*	*n.a.*	*n.a.*
Total GSSE expenditures	2 364	1 050	39	92	5 713	13 794	1 065	794	453	441	300	353
Risk related measures in GSSE	**565**	**131**	**19**	**49**	**202**	**454**	**100**	**324**	**28**	**78**	**29**	**147**
% share in total GSSE	*24*	*12*	*49*	*53*	*4*	*3*	*9*	*41*	*6*	*18*	*10*	*42*

n.a.: not applicable because of negative numbers; A/An/R/I: Area/Animal number/Receipts/Income

1. Subsidies to water use and investment assistance in irrigation and drainage systems on the farm.

2. Infrastructure assistance for water management off the farm.

3. Payments of this PSE category that have a variable rate label, except those included in the disaster relief payments or insurance subsidies items in this table.

4. Includes Marketing loans subsidy from preferential interest in Brazil; and deficiency payments for crop and livestock products in Ukraine.

5. Includes PROAGRO insurance payments, Rural insurance premium and Insurance payments Garantia Safra in Brazil; Agricultural Insurance Programme COMSA, CORFO, MINAGRI in Chile; and Compensation of insurance payments and Crop insurance subsidies in Russia.

Source: OECD, PSE database 2006.

Insurance subsidies are relatively common in the countries examined. They exist in 17 EU member states, five non-EU OECD countries (out of 11) and five emerging economies out of the 8 examined (Tables 3.1 and 3.2). However, the level of subsidies varies greatly by country, depending on the development of insurance schemes. In most countries, subsidies to insurance schemes are included in the PSE as payments based on variable input use, insurance being considered as a variable input. In these cases, government expenditures transferred every year to insurance companies operating insurance schemes are considered. However, in several countries (Brazil, Canada, Turkey and the United States), insurance subsidies are reported as a share of the payment received by farmers from insurance schemes in the year the payment is granted, and are thus considered as payments with a variable rate. Insurance payments are paid per hectare in the case of crop insurance, or based on receipts or net income in the case of revenue/income insurance.

In Australia, government transfers to income tax smoothing schemes[15] are included in the PSE. The tax system of other countries also allows for spreading taxable income over several years, but the transfers they may generate are not included in the PSE, either because the system is not specific to farmers (Netherlands) or because, while the option is only available to farmers, the value of the tax concession is not estimated. Payments with a variable rate other than insurance payments and disaster relief payments include various deficiency and stabilisation payments paid per tonne, per hectare, per animal head or based on receipts or income. When based on current parameters (*e.g.* current area), they meet the difference between current receipts/income (per hectare) and a reference, often historical, level.

Payments based on output with a variable rate are found mainly in Japan (*e.g.* price stabilisation for fruits and vegetables, payments for rice, manufacturing milk, sugar cane), Mexico (*Ingreso objetivo* payments), Ukraine and the United States (loan deficiency payments, marketing loan gains, storage payments). Most payments based on current area, animal numbers, receipts or income with a variable rate are in Canada, where they include crop insurance payments (based on area) as well as various federal and provincial revenue insurance payments such as the Net Income Stabilisation account (NISA) and the Canadian Agricultural Income Stabilization (CAIS), the "*assurance stabilisation du revenu agricole*" (ASRA) in Quebec and the Ontario Risk Management Program. They are operated by the federal government and/or by provincial governments, with contributions from farmers. As such, they are considered as government programmes and payments are not identified as insurance subsidies in Table 3.3. Canada and the United States also make variable rate payments based on non current parameters for which production is not required (respectively the CAIS Inventory Transition Initiative in Canada, and the Countercyclical payments introduced in the 2002 Farm Bill and Crop market loss assistance in the United States).

Support to *ex post* risk mitigation systems considered here includes disaster relief payments, *ad hoc* assistance, social assistance specific to farmers and debt management measures. While *ad hoc* assistance payments are mainly found in Canada, disaster relief payments are more widespread. Disaster relief payments are negligible in countries with high support levels, as well as in New Zealand and Turkey. Conversely, they account for a significant share of support in Australia, where support levels are relatively low at around 5% of farm receipts. In recent years, disaster relief mainly came from the "Exceptional circumstances" programme, which provides short-term assistance to long-term viable farm businesses to cope with rare circumstances that are beyond the scope of normal risk management practices.[16] In the EU, disaster relief payments are funded at the national or regional level and many member states have granted such payments over the period (Table 3.2). Among emerging economies considered, China is the only one with significant levels of disaster relief assistance (Table 3.4).

In countries which use disaster relief assistance to a larger extent, the level of these payments has increased in the 2000s compared to the previous decade.

Social assistance includes short term relief assistance to help farm households cope with emergency situations and poverty alleviation measures. In Australia, the Farm Family Restart Scheme (or Farm Help) provides short term financial assistance in the form of income support and investment grants to re-establish outside agriculture (as well as training and advice) to help farmers with financial problems, either by improving the financial performance of their farm enterprise, finding alternative sources of off-farm income or re-establishing outside farming. In Mexico, agricultural producers or workers are paid the minimum wage to participate in community work in extremely poor areas during the period of low agricultural activity. This could be considered as a measure to diversify income sources rather than a safety-net in case of temporary problems as in the Australian case.

Labour replacement assistance provides subsidies to replace the farmer in case of illness or accident. Such assistance has been available over the period considered (1986-2007) in a number of EU member states, in Iceland and in Norway. Debt rescheduling or write-off has generated significant levels of support during the two periods considered in Brazil and Russia and to a lesser extent in Mexico and Ukraine (Tables 3.3 and 3.4).

Risk-related policies in WTO notifications on domestic support commitments

Since the Uruguay Round Agreement on Agriculture in 1995, member countries notify their domestic support to the WTO. These notifications report annual levels of agricultural domestic support, whether subject to reduction commitments or not. Support under measures subject to the reduction commitment is reported as the current total Aggregate Measurement of Support (AMS), often referred to as Amber Box. Measures exempt from the reduction commitment include:

- measures exempted because they qualify under the criteria set out in Annex 2 to the Agreement (often referred to as Green Box measures);
- measures respecting conditions for exemption set for direct payments under production-limiting programmes (often referred to as Blue Box measures); and
- for countries with developing country status, measures notified under "development programmes" as part of Special and Differential Treatment (often referred to as Development Box measures).

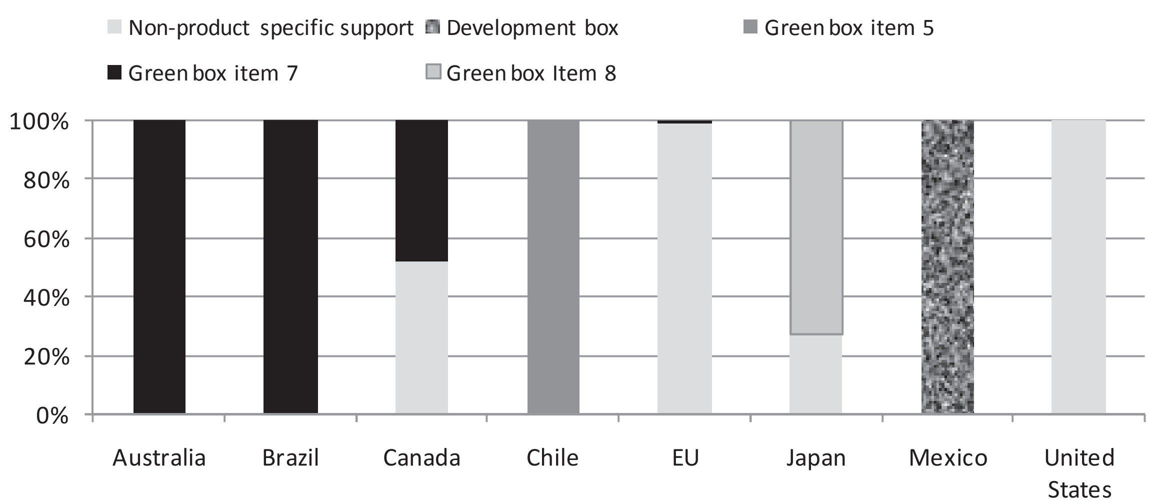
Moreover, product-specific and non-product specific AMS support that accounts for less than 5% of the value of production (referred to here as *de minimis* support) is exempted from the current total AMS.

As OECD indicators of support, WTO notifications on domestic support commitments include information on transfers associated with risk-related measures. These measures can be found in all categories of support (referred to here as boxes). Price support is reported as AMS support, while support to general services, including government expenditures on inspection services, pest and disease control, or training, extension and advisory services, is notified in the Green Box. The Green Box includes two categories of measures specifically designed to include insurance subsidies, income safety-nets and disaster relief payments with strictly defined implementation criteria (Annex 2, paragraphs 7 and 8 of the Agreement on agriculture).[17] However, as these categories are defined by strict implementation criteria to ensure they are minimally distorting, many insurance subsidies do not qualify.

Depending on implementation criteria, stabilisation and insurance payments can be either in the AMS support, the Blue Box or the Green Box. Deficiency payments or stabilisation payments based on output are generally notified in the Amber Box. Some payments such as crop insurance subsidies are notified as non-product specific AMS support. For many countries, non-product specific AMS support is exempted under the *de minimis* provisions and is therefore not counted towards the ceiling commitment. In Mexico, subsidies on insurance premiums, available to all producers, including AGROSEMEX, are notified in the Development Box. In Japan, the rice farming income stabilisation programme is notified in the Blue Box. Payments made in case of financial hardship such as the AAA Farm help programme in Australia[18] or agricultural social programmes in Argentina and Korea are notified in the Green Box as decoupled income support (Annex 2, paragraph 6 of the Agreement on agriculture).

Table 3.5 identifies the share of some risk-related measures in different WTO categories of support. In Japan, the rice farming income stabilisation programme is the only programme included in the Blue Box. Most crop and revenue insurance subsidies are notified as non product specific support in Canada, the EU and the United States, where they account respectively for 36%, 58% and 29% of support in this category. Other stabilisation or compensation payments such as NISA and CAIS payments in Canada, and 2002 Farm Bill countercyclical payments in the United States, are also in this category. Canada and Australia are the only countries, where support from income insurance and income safety-net programmes accounts for a significant share of the Green Box, while payments for relief from natural disaster are significant in more countries. The diversity of situations regarding the classification of insurance subsidies is illustrated by Figure 3.9, which shows the share of each WTO box and specific items within the Green Box in the total of insurance subsidies.

Figure 3.9. Distribution of insurance subsidies in WTO boxes



Average of period 2000/1-2006/7 in Australia, 2000-04 in Brazil, 2000-04 in Canada, 2000-06 in Chile, 2000-05 in the EU, 2000-06 in Japan, 2001-04 in Mexico, and 2000-05 in the United States.

Within Green Box measures, defined in Annex 2 of the Uruguay Round Agreement on Agriculture, Item 5 includes direct payments to producers; Item 7 includes government participation in income insurance and income safety-net programmes; and Item 8 includes payments (made either directly or by way of government financial participation in crop insurance schemes) for relief from natural disasters.

Source: WTO notifications on domestic support commitments.

Table 3.5. Share of risk-related support in WTO notifications

	Argentina	Australia	Chile	Canada	EU	Japan	Korea	Mexico	Norway	United States
	2000/1-2003/4	2000/1-06/7	2000-06	2000-04	2000-05	2000-06	2000-04	2001-04	2000-04	2000-05
% share in current total AMS of:										
- MPS[1]	0	0	--	47	88	64	100	0	95	49
- Deficiency or stabilisation payments[2]	0	0	--	52	1	22	0	64	--	51
% share in product-specific *de minimis* of:										
- Deficiency or stabilisation payments[3]	0	0	--	82	0	87	4	80	0	79
% share in non product-specific AMS[4] of:										
- Deficiency or stabilisation payments[5]	--	0	0	26	0	0	0	0	0	64
- Insurance subsidies[6]	--	0	0	36	58	100	0	0	0	29
% share in the Blue box of:										
- Deficiency or stabilisation[7]	--	--	--	--	--	100	--	--	--	--
% share in the Development box of:										
- Insurance subsidies	--	--	0	--	--	--	0	4	--	--
% share in the Green box of:										
- income insurance and income safety-net programmes	0	8	1	22	0	0	0	0	0	0
- Payments for relief from natural disasters	1	17	0	0	2	2	8	0	1	3
- General services	81	54	97	55	21	79	58	28	21	17
. Pest and disease control	41	9	0	2	6	1	2	7	6	n.a.
. Training services	0	2	22	3	1	0	1	0	1	n.a.
. Extension and advisory services	4	7	4	8	1	11	1	0	2	n.a.
. Inspection services	1	4	19	20	1	0	2	0	0	n.a.

n.a.: not available separately

-- no support notified in this category or not applicable.

1. MPS (and equivalent measurement of support in the EU).

2. Market Revenue Program, *ASRA*, Ontario Grain Stabilization Payments and Provincial Direct Payments in Canada; Direct aid for banana in the EU; price-related payments and deficiency payments in Japan; *Ingreso Objetivo* payments in Mexico; ; and loan deficiency payments, marketing loan gains, trade adjustment assistance, certificate exchange gains, commodity loan forfeit in the United States.

3. Same as above, for different commodities depending on the year; beef deficiency payments in Korea.

4. Non-product specific support is often excluded from reduction commitments on *de minimis* grounds.

5. NISA and CAIS in Canada; Crop market loss assistance before 2002 and from 2002 countercyclical payments in the United States.

6. Crop insurance and production insurance in Canada; National insurance subsidies in the EU; Agricultural Insurance Scheme in Japan; Crop and revenue insurance subsidized by the Federal Crop Insurance Program in the United States.

7. Rice farming income stabilisation programme in Japan.

Source: WTO notifications on domestic support commitments.

Support to general services forms the main part of the Green Box in many countries. The highest shares for pest and disease control and/or inspection services are found in Argentina, Australia, Canada and Mexico. Research, which is only an important component of expenditures in the Green Box, might also include a risk-related dimension.

WTO notifications on domestic support are a rich source of information on risk-related measures, and the support they generate, as they contain details on the various programmes and their implementation criteria. However, exploiting this information is time-consuming as it is not in a readily available database format.

Other risk-related policies

In addition to policies considered in previous sections as generating transfers specific to the agricultural sector, various other measures contribute to farmers' risk management strategies, without being specific to the agricultural sector (*e.g.* health insurance) or without generating any direct transfers (*e.g.* regulations).

Competitive markets and clear regulations

As stressed in OECD (2001), "a primary role for the government in risk management is to provide a sound business environment with competitive markets and clear regulations." This involves ensuring macro-economic stability and basic general services such as health, education and legal systems, as well as well-functioning and competitive markets for agricultural inputs and outputs.

Contingency markets, such as futures, insurance, bonds and stock markets, are essential for risk management. It is thus particularly important to ensure those markets are developed and competitive. Government has a crucial role in designing clear and efficient regulations to that effect, enforcing them and monitoring the functioning of those markets. The role of government subsidies in agricultural insurance systems has been mentioned earlier. Regulations affecting general insurance systems (*e.g.* for health, housing, non-agricultural damage) also enter into risk management strategies by farm households.

As credit is a basic component of risk management strategies, any measure or regulation that facilitates access to credit for farm households contributes to risk management. This includes encouraging the development of off-farm income sources, or implementing any regulation that clarifies farmers' property rights over land and other assets. Clarifying individual land ownership has been an important issue in transition economies and is still a challenge in some emerging economies. Establishing longer term rental contracts also helps stabilise the situation of farm operators, who rent some or all of the land they farm, and give them better access to credit.

Regulations that provide a clear legal status for the farm enterprise and for family workers also reduce risk levels for the farm household. The status of family labour with regard to labour rules and social protection may be ambiguous in some countries. In recent years, efforts have been made in France to clarify the situation of spouse and other family members working on the farm and improve their inclusion in the social system. Developing legal forms of associations for farm businesses can also contribute to improving the social coverage of farm partners, limiting individual responsibility in case of bankruptcy and facilitating farm transmission. This explains why the share of farms with the legal status of a company has been increasing, notably in France where they accounted for one third of all main occupation farms in 2005 (Agreste, 2008). Labour regulations governing hired farm workers also affect the risk environment of the farm enterprise.

Another area where government play an important role in reducing risk for farmers is in defining the general (contracting) rules that govern the relationships between the farm holder, its input suppliers and output purchasers, and ensuring they are enforced. There are various degrees of integration along the food chain, with possible transfer of risk.[19] OECD (2001) found that while vertical coordination may reduce price risk, it may increase marketing risk. Moreover, risk transfer is influenced by the distribution of market power along the chain.

Information

Governments play an important role in providing the information farmers need to implement risk management strategies or in facilitating access to information. In addition to basic statistics on agricultural markets, this information includes weather forecast and alert systems; alerts on pest and disease outbreaks and spreads; price and market forecasts, as well as information on risk management techniques and programmes available in the country. Increasingly, ministries' web sites are a major channel for the transmission of this kind of information.

Knowledge

Risk management strategies combine a mix of basic, well-known techniques as well as increasingly sophisticated ones. Exposure to various types of risks and ways to deal with them evolve rapidly. It is a challenge for farmers to maintain, develop and transmit their expertise in traditional techniques as well as acquire new innovative techniques. Responding to demand from farmers, extension covers capacity-building in risk management. In many countries governments support extension activities but farmers' organisations and the agri-food industry often play a major role, both in funding and implementation.

Pest, disease and food safety regulations

Pest and disease control is primarily the responsibility of individual farmers, as it affects marketing risk and farm income. However, there are regulations for pests and contagious diseases that can easily spread. Examples are obligatory vaccination or import bans. Other regulations regarding pest and disease control are in areas where human health is threatened through direct contagion (tuberculosis) or through food (Bovine Spongiform Encephalopathy). Food safety regulations affect marketing risk, and indirectly income risk. Inspection systems are in place in every country to monitor the enforcement of food safety regulations and control the safety of marketed products. Governments usually play an important role in those systems.

Social and health policies

In most countries, farm families are covered by the general welfare system for health insurance and pension schemes, and for other social programmes that may exist in the country like child allowance, education grants, minimum income support, etc. In other countries like Austria, Finland, France, Germany, Italy, Japan, Norway, Poland and Switzerland, farm families are not part of the general system but subscribe to specific schemes (Table 3.6 in OECD, 2005). Finally, in a few countries, farmers belong to the general system but can benefit from additional support in case of low income.

The income support component of the Farm Family Restart Scheme in Australia can be considered as a social programme specific to farm families. The Farm Assist Programme in Ireland is a social programme specific to farmers in terms of the qualifying criteria, but which grants the same level of assistance as to households in the rest of society. It provides a minimum income level equivalent to the social welfare payment rate per week used by the Department of Social and Family Affairs (DSFA, 2005) to farm households, who satisfy a means test taking account of all sources of household income and assets. In Switzerland, a special supplementary payment system for child allowances applies to low-income farmers.

It is often difficult to estimate whether farm families are well covered by existing social systems and whether they are treated favourably or unfavourably relative to other families. The fact that they have high farm assets may disqualify them from some types of social support. In some countries with specific agricultural system, farm families pay lower social contributions, but also receive lower benefits. As self-employed workers, farmers may pay higher contributions than salaried workers. When asked about their motivation for diversifying income sources, farm households in the United States often cite social coverage as an incentive to engage in salaried off-farm work.

Notes

1. The risk effects of various measures have been estimated in a series of studies on decoupling (notably OECD, 2002 and 2004); the main results are summarised in OECD (2006).
2. Table 2 of OECD (2009a) classifies the main groups of tools and strategies available to farmers for risk management according to these principles. Table 4 classifies policy measures illustrating the potential roles of government in risk management in agriculture along these lines.
3. The most recent analysis of agricultural policy developments in OECD countries, which are evaluated annually on the basis of changes in PSE levels and composition, is published in OECD (2008).
4. Deficiency payments are considered as a risk mitigation measure, typically as payments based on output with a variable rate. While they stabilise prices faced by producers in much the same way as MPS, this occurs in reaction to a change in market prices.
5. In the special case of New Zealand any price stabilising support is the indirect consequence of sanitary measures designed to protect local poultry and native birds from exotic diseases.
6. PC: Payments based on current area, animal number, receipts and income; PHR: Payments based on non-current area, animal number, receipts and income, production required; PHNR: Payments based on non-current area, animal number, receipts and income, production not required.
7. The only countercyclical payment in the Common Agricultural Policy is the POSEI payment for bananas in remote islands
8. Motivations for diversification of activities by farm households are explored in OECD (2009b).
9. In comparing the annual variability of farm household income and farm income in a number of OECD countries, OECD (2003) shows the stabilising effect of off-farm income.
10. Exceptional Circumstances assistance in Australia is presented as part of an overview of income risk management practice and policies in Australia contained in OECD (2001, Section D.2 in Part II). OECD (2007) explains the process for identifying and assessing the specific circumstances triggering support.
13. Tables 3.1 and 3.2 indicate in which PSE categories the various types of risk-related measures are most often classified.
14. Support to water management can take several forms: reduced price for irrigation water used (classified as a variable input subsidy in the Producer Support Estimate (PSE), assistance (interest concessions or grant) for investment in irrigation or drainage systems on the farm (classified as support for fixed capital formation in the PSE) or general services in the form of large scale water management projects that provide irrigation water and prevent floods (infrastructure in the General Services Support Estimate, GSSE).

15. These are the Income Equalisation Deposits Scheme, replaced in 1999 by the Farm Management Deposit Scheme, as well as the Income Tax Averaging Scheme for primary producers (Box 3.2).

16. To qualify as exceptional circumstances, "the event must be rare (it must not have occurred more than once on average in every 20 to 25 years; it must result in a rare and severe downturn in farm income over a prolonged period of time (*e.g.* greater than 12 months); it cannot be planned for or managed as part of farmers' normal risk management strategies; and must be a discrete event that is not part of long-term structural adjustment processes or normal fluctuations in commodity prices" (DAFF, 2005). OECD (2007) summarises the process for defining exceptional circumstances and the conditions for receiving support.

17. These are "Government financial participation in income insurance and income-safety-net programmes" (Annex 2, paragraph 7 of the Agreement on agriculture) and "Payments for relief from natural disaster" (Annex 2, paragraph 8 of the Agreement on agriculture).

18. This programme provides a short-term welfare safety net for low-income farmers experiencing financial hardship and who cannot borrow further against their assets. The support is provided while they decide whether to improve their farms' financial position, obtain off-farm income or exit.

19. Strategies of risk transfer along the food chain are analysed in OECD (2001), Part II.A.

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Chapter 4.

An Assessment of Risk Exposure in Agriculture Based on a Review of the Literature

What is risk?

General perceptions of risk

Agriculture is often noted as a textbook case of economic activity fraught with risk. Agricultural producers regularly demonstrate concern for the economic uncertainty of the industry and major risk management tools such as futures markets have their origins in the agriculture sector. Similarly many farm support programs are justified primarily as risk safety net for agricultural producers. While risk has clear academic definitions as discussed in the next section, lay perceptions of risk are often associated with potential negative outcomes but often not articulated in probabilistic terms. This is in spite of the fact farmer behaviour is often clearly reflective of perceived subjective risk and demonstrated risk aversion.

Economic interpretation of risk

Various authors have addressed the implications and definition of risk in agriculture. For example, Robison and Barry (1987) define uncertainty and risky events in the following manner, "Events are uncertain when their outcome is not known with certainty. Uncertain events are important when their outcomes alter a decision maker's material or social well-being. We define as risky those uncertain events whose outcomes alter the decision maker's well-being" (p. 13). Robison and Barry also go on to note that other definitions of risk consider variances, likelihoods of loss, and safe levels of income or specific requirements on probability distributions. These, however, are argued to be tools with which to classify or order risky choices.

Newbery and Stiglitz (1981) argue that producers are concerned with income variability and how it affects consumption rather than risk factors such as price or yield. In their book, which primarily addresses price stabilization, they argue that price variability itself is not the appropriate metric to judge risk. Newbery and Stiglitz also discuss the distinction between risk and uncertainty, but take a subjective probability approach as suggested by Savage (1954) to indicate that the distinction is largely irrelevant. They state that individuals form subjective probability judgments and on the basis of those judgments are willing to make explicit or implicit bets on the outcome. Newbery and Stiglitz do make a strong assertion that it is relevant to distinguish between systematic and non-systematic risk. They argue systematic risk follows a predictable pattern with known relationships where non-systematic variability arises from shocks and other variability in markets supply or demand due to unforeseeable forces that come to bear on market prices.

Hardaker, Huirne, and Anderson (1997) define uncertainty as imperfect knowledge and risk as uncertain consequences, particularly exposure to unfavourable consequences. Hardaker, Huirne, and Anderson also go on to define several primary causes of risk in agriculture. In particular, they identify production risk stemming from the unpredictable weather and uncertainty about the performance of crops or livestock due to pests and diseases. Secondly, they denote price or market risk due to farmers having to make decisions about input uses without knowing the price of inputs, or more importantly outputs. They also point out that governments are a source of institutional risk for farms in that they may change the policy environment in which farms function. Hardaker, Huirne, and Anderson also characterize human or personal risk as issues associated with individuals that may affect the farm business. For example, they note death of owner, divorce, prolonged illness, or carelessness of a hired employee as a risk to the farm business. Interestingly Hardaker, Huirne, and Anderson argue that the aggregate effect of production, market, institutional, and personal risk is called business risk. Then they distinguish financial risk, which is related to the source and the methods of financing the farm operation.

Harwood *et al.* (1999) describe agricultural risk in the following terms, "Risk is uncertainty that "matters," and may involve the probability of losing money, possible harm to human health, repercussions that affect resources (irrigation, credit), and other types of events that affect a person's welfare. Uncertainty (a situation in which a person does not know for sure what will happen) is necessary for risk to occur, but uncertainty need not lead to a risky situation.

Chavas (2004) defines risk as representing any situation where some events are not known with certainty. He goes on to discuss the distinction between risk and uncertainty and states that there is no clear consensus on this issue. Rather, Chavas suggests that there are two schools of thought, one arguing that risk and uncertainty are not equivalent and that the distinction between the two is the ability to make a probability assessment. Chavas goes on to argue that the debate about the distinction between risk and uncertainty ultimately boils down to an argument about the existence and interpretation of probability. He concludes that this discussion is insightful, but has not led to much empirical analysis and thus he does not draw a sharp distinction between risk and uncertainty and uses the terms interchangeably.

Quantifying risk

Given the general acceptance of a probabilistic definition of risk, there are a number of different metrics that have been used to describe agricultural risk. Often in the simplest risky scenario where there are two possible outcomes, probability can be diagrammed in a decision tree, which can then be expressed in terms of the probability that one will observe one possible outcome versus another. When risks are more complicated but discrete, alternatives can also be described in a decision tree context by identifying each of the discrete possible outcomes. Often such a design is used when it can approximate a more continuous set of outcomes.

In agriculture we observe many risks where the set of outcomes are continuous rather than discrete. For example, prices or yields might be viewed as being continuous across a wide range with a probability distribution that can best be described graphically by a probability density function (PDF) or a cumulative distribution function (CDF). While a PDF or a CDF provides a mathematical representation of risk that can be viewed visually, it does not provide a simple metric that quantifies risk. In applied risk analysis a number of numerical measures have been proposed and used over time. These measures are generally consistent with the definition of Rothschild and Stiglitz (1970) who define risk in terms of a mean-preserving spread as moving probability away from the centre of a PDF to the tails while leaving the mean unchanged Currently in applied risk analysis, the variance or the standard deviation are often used as a measure of riskiness. In the case of a normal probability distribution, the mean and the variance fully describe the PDF. However, when risks are non-normally distributed the variance doesn't fully reflect the dispersion of the probability distribution.

Often, risk analysis focuses on negative or bad outcomes. Because of this, we often see various metrics that in some fashion measure the probabilities of bad events. In some literature, such as Lien, and Hardaker (2001) the probability of bankruptcy has been used as a single quantifiable measure of bad events. Likewise an increasing amount of literature uses value at risk (VaR) to identify some criterion level of risk based on a percentile, such the 5^{th} to the 10^{th} percentile, of the CDF (Vedenov and Barnett, 2004; Giot, 2003; Manfredo and Leuthold, 1999, 2001). This, again, gives a simple numerical metric by which one can judge the probability of bad outcomes.

There are a number of more complex issues involved in describing agricultural risk probabilities. The most obvious is the potential for correlation between random variables underlying the farm's income distribution. In a simple case, assume that both price and yield are random and that they are not independent of each other. In that case to fully reflect the risk that the farm observes in its income, one would need to take into account the correlation between those two random variables. Ultimately, correlation between the random variables on the farm becomes an empirical question, but adds a significant degree of complexity to characterizing the riskiness of the farm. For example, it is quite plausible that the income of a farm is conditioned upon a number of commodities where both price and yield are random. Empirical data tends to suggest that yields of crops on a farm are likely to be highly positively correlated with each other. In some instances yield and prices for a commodity would be negatively correlated with each other. And it is quite likely that agricultural output prices would be positively correlated with each other due to common shocks. In the context of a normal distribution, the multivariate correlations are quite straightforward to model. However, when one moves beyond the multivariate normal, modelling is much more complex as described in Anderson, Coble, and Harri (2008).

What is not risk

The fact that the mean or expected value of an economic variable has a trend or a cyclical behaviour (it is non-stationary) does not necessarily imply risk. An economic variable may follow well-defined linear or cyclical patterns. For example trends may occur in prices and are pervasive in crop yields (Just and Weninger, 1999; Ramirez, Misra, and Field, 2003; Sherrick *et al.*, 2004). Predictable cycles in livestock prices are common due to seasonal production (Crespi, Xia, and Jones, 2008; Rosen, Murphy, and Scheinkman, 1994). Seasonality in the mean level of price and price variability has been repeatedly found in crop agriculture (Anderson and Danthine, 1983; Anderson, 1995; Streeter and Tomek, 1992). This work suggests that prices of seasonally produced goods tend to rise post harvest to cover the cost of storage and prices tend to be more volatile during the growing season. The result is that if the variable consistently follows the pattern there is no risk, even though the realized value may vary over time. Risk implies some degree of randomness, so that any specific realization of the variable may differ from the expected value. The expected value may be stationary or non-stationary. Regardless, the defining characteristic of a risky variable is that realizations may differ from the expected value. Thus, the works cited general estimated trends and cycles and then compute variability after removing the trend or cycle.

A conceptual framework

Businesses manage portfolios of activities from which they seek to generate net returns. Consider a farmer who manages a portfolio consisting of *n* crop and/or livestock production activities. Each activity A_i (i = 1, 2, . . . n) generates a periodic net return $r_i = \mathrm{Re}\,v_i - C_i$ where $\mathrm{Re}\,v_i$ is gross return and C_i is the cost of production. $\mathrm{Re}\,v_i = \pi_i P_i$ where π_i is the quantity of output produced and P_i is the price at which the output is sold, so $r_i = \pi_i P_i - C_i$. For crops, $\pi_i = A_i Y_i$ where A_i is the area measured in hectares used to produce crop *i* and Y_i is the yield per hectare. For both crop and livestock activities the periodic net return r_i is stochastic because each of the right-hand side variables (output, price, and cost) are stochastic. For crops, output π_i is stochastic because yield Y_i is stochastic. For livestock, π_i is stochastic due to death loss or variability in rates of gain due to uncertain factors such as disease or extreme weather events.

Consider a single activity *i* for which there are *k* possible discrete levels of net return. The variance of net returns for activity *i* is calculated as $\sigma_i^2 = \sum_{j=1}^{k} \alpha_{ij} \left[r_{ij} - E(r_i) \right]^2$ where α_{ij} is the probability of net return level *j* for activity *i* and $E(\bullet)$ is the expectations operator. Since $r_{ij} = \pi_{ij} P_{ij} - C_{ij}$ the variance in net returns can be rewritten as $\sigma_i^2 = \sum_{j=1}^{k} \alpha_{ij} \left[(\pi_{ij} P_{ij} - C_{ij}) - E(\pi_i P_i - C_i) \right]^2$. Without expanding the mathematics further, note that the variance of net returns for activity *i* is a function of production variance, price variance, cost of production variance, and the pairwise covariances between production, price, and cost of production. If the covariance between production and price is zero, we say that production and price are unrelated or independent of each other. If the covariance between production and price is negative (positive) then the variance of gross returns is lower (higher) than if production and price were independent.

The net return on the entire portfolio of farm crop and/or livestock production activities is $R = \sum_{i=1}^{n} w_i r_i$ where w_i is the proportion of the total value of the portfolio that is invested in activity *i* and $\sum_{i=1}^{n} w_i = 1$. The variance of net returns for the portfolio is calculated as $\sigma_R^2 = \sum_{j=1}^{n} \sum_{k=1}^{n} w_j w_k \sigma_{jk}$ where σ_{jk} is the variance in net returns on the single production activity when $j = k$ and the pairwise covariance in returns when $j \neq k$ with $\sum_{j=1}^{n} w_j = 1$ and $\sum_{k=1}^{n} w_k = 1$. Thus, the overall variability in net returns for a portfolio of farm production activities is a function of the variance in net returns for each of the various production activities, the proportion of the overall portfolio that is invested in each activity, and the covariances between the gross returns for each of the activities. Recall that the variance of net returns for each activity is itself a function of production variance, price variance, cost of production variance and the pairwise covariances between production, price, and cost of production.

Notice that by including off-farm sources of income among the *n* activities, one can calculate the variability in net income for the farm household's entire portfolio of farm and non-farm sources of income. The impact of off-farm income on overall household net income variability will depend on the variability of off-farm income relative to net farm income and the covariance between off-farm and farm income sources.

Economists typically assume that individual decision-makers maximize a generalized expected utility function defined over the distribution of *R* and subject to relevant constraints, with $\frac{\partial E(U)}{\partial E(R)} > 0$ and $\frac{\partial E(U)}{\partial \sigma_R^2} < 0$. That is, expected utility is increasing in expected returns and decreasing in the variability of returns. The latter implies that decision-makers are risk-averse.

Results from empirical studies that have estimated various factors affecting farm household net income variability are then reported. Specifically, these factors are the variability in output prices, input costs, production, and off-farm income as well as pairwise covariances between prices of different commodities, production of different commodities, and price and production of the same commodity. The causes of output price, input cost, and production variability are considered, followed by an analysis decision-makers risk perceptions and risk preferences. The final section contains concluding comments.

Estimation of variability in price, yield and off-farm income

Determinates of farm income variability

As will be evidenced in the following summary, the existing literature on farm income variability has focused primarily on output price risk and production or yield risk. Both of these risks are generally perceived as risks that profoundly affect the financial well-being of the farm family. Other risks, such as input price risk, have received much less attention. This is likely due to the fact that these other risks tend to exhibit less variability over time, although periodic shocks stimulate brief periods of intense research activity.

Data sources and the effect of aggregation on risk measures

Most applied agricultural risk analyses are based on historical series of yield or price data. These historical data typically must be analyzed using quite sophisticated techniques to account for predictable trends (as in technology induced changes in expected yield over time) and cycles (such as seasonal patterns in crop prices reflecting storage cost). For example, as shown in Harri *et al.* (2008), analysts have removed a time trend from historical yield series when assessing the variability of yields. The time trend stands as a proxy for a number of factors that influence agricultural crop yields, but typically it is assumed that the time trend is primarily capturing adjustments in biological yield potential through time. Likewise, price risk is often measured by using historical series of price data. The most prevalent adjustment in price data is to account for the strong potential for auto-correlation.

An alternative data source is subjective probabilities obtained directly from decision makers. This approach, that focuses on methods for eliciting from decision makers the probabilities that they perceive are associated with various potential outcomes, has been used in far fewer studies (Fackler, 1991; Anderson, Dillon, and Hardaker, 1977). Several techniques have been used to encode the probability assessment of a risky decision.

Regardless of the data source, it is important to account for the impact of spatial aggregation bias on risk measures. In agricultural contexts, this is particularly important for yield risk measures.[1] At higher levels of aggregation, poor yields in some areas are offset by good yields in others thereby reducing the overall variability. Various studies have demonstrated an aggregation bias in yield variability (Carter and Dean, 1960; Eisgruber and

Schuhman, 1963; Debrah and Hall, 1989; Marra and Schurle, 1994; Rudstrom *et al.*, 2002; Popp, Rudstrom, and Manning, 2005; Knight *et al.* 2008). Coble, Dismukes, and Thomas (2007) estimated acreage-weighted yield coefficients of variation (CVs) for U.S. maize, soybeans, and cotton at different levels of aggregation. Their findings, shown in Table 4.1, clearly show the impact of aggregation bias on CVs. Average yield CVs measured at the farm-level are more than double those measured at the state-level and more than three times those measured at the national-level.

Table 4.1. The effect of aggregation on yield risk

Level of aggregation	Yield coefficients of variation		
	Maize	Soybeans	Cotton
Farm	0.25	0.25	0.39
County	0.15	0.13	0.26
State	0.12	0.11	0.16
National	0.08	0.07	0.11

Source: Coble, Dismukes, and Thomas (2007), Based on 1975-2004 data.

Aggregation bias makes it extremely difficult to make meaningful spatial comparisons of yield risk magnitudes. Obviously, any spatial comparison of yield risk must take into consideration the level of aggregation (*e.g.* farm, provincial, or national) at which yield is being measured. But even this is often not sufficient. The size of nations, provinces, and farms varies tremendously. In many lower income countries, farms may be no larger than 1-2 hectares while in some OECD countries farms of 500-1 000 hectares are not uncommon. However, even within OECD countries, there is tremendous variability in farm sizes. All of this implies that caution should be used when attempting to make spatial comparisons of yield risk magnitudes. A clear conclusion resulting from this literature is that when assessing the risks faced by producers, farm-level data is the appropriate level of yield aggregation to use when assessing producer risk. Much more readily available aggregate data will severely underestimate the risks producers face.

Output prices

Output price risk can be conceptualized as arising in large part due to the biological lags inherent in most agricultural production and price behaviour. A commitment of inputs may occur months before the farmer has a product to sell. During that period, output price changes may be dramatic. This impact is magnified for tree crops or other commodities that have multiple year time lags between investment and the onset of production. Prices may respond to shocks in demand or supply and differ from yield risk in several fundamental ways.

First, for most major agricultural commodities there are well functioning integrated world markets that result from trade. Thus, though located around the world, producers of a crop like wheat will experience positively correlated price shocks. This is in contrast to yield risk which tends to be much more localized. However, this statement is less true for isolated economies or non-commodity crops that have a unique niche market.

Secondly, a related characteristic of price risk is that the magnitude of price risk for a commodity will tend to be similar for producers worldwide. That is, in an integrated world commodity market the magnitude of price risk is likely to be more homogeneous than the degree of yield risk which tends to vary due to local factors such as weather, soils, and production systems. If information were perfect the difference in commodity prices would simply reflect transportation cost. In practice, many factors cause deviations from the perfect information case; for example, quality variation, vertical integration, and in some cases market power exerted by purchasers. However, there is empirical evidence that many commodity price movements are strongly spatially correlated. An important by-product of the positive correlation is that aggregate price data are much more informative about producer price risk than aggregate yield data are about producer yield risk.

A third distinction is that probability distributions of agricultural prices tend to be much more consistent than those for crop yields (see Goodwin, Roberts and Coble, 2000 in comparison to Harri *et al.*, 2008). That is, as one moves from one crop or region to another little can be said *a priori* regarding the shape of yield distributions. Conversely, commodity prices tend to be right skewed to the point that the right skewed log-normal distribution is well accepted as an appropriate assumption when modelling price distributions.

Measured levels

While various studies have attempted to measure output price risk, it is difficult to make meaningful comparisons across these studies due to differences across countries and over time in government market intervention policies. Many OECD countries have significantly reduced their interventions in markets for agricultural commodities over the past 10-20 years. Thus, when comparing studies of market price risk it is important to note which price (world price or domestic price) is being considered and any market interventions that may have been in place during the time period over which price variability is being measured.

It has long been argued that when countries adopt trade distortions that insulate domestic prices from world market supply or demand shocks this will tend to increase price variability for the rest of the world (*e.g.* OECD, 2004; Bale and Lutz, 1979). However, the impact of domestic price stabilization interventions on world price variability depends on the nature of the intervention. Border protections will almost certainly externalize price variability on to world markets while accumulation and de-accumulation of stocks could reduce world price variability (Johnson, 1975).[2]

In recent years several studies have attempted to measure the impact of market and trade liberalization on agricultural commodity prices (*e.g.* Beghin and Aksoy, 2003; Blake, McKay and Morrissey, 2002; Hertel *et al.*, 2000). However, most of these studies have focused on how liberalization affects the level of commodity prices rather than the variability of prices.

OECD (2004) studied the impact on world price variability of removing domestic market interventions and border protections in Switzerland, Japan, Canada, Mexico, the United States, and the countries of the European Union. These changes would allow supply or demand shocks to be completely transmitted into the domestic markets of these countries. The study found that such complete price transmission reduced world price variability for wheat, coarse grains, oilseeds, and rice by 45%, 32%, 23%, and 21%, respectively. Sarris (2000b) notes that during the 1990s world trade in cereals became more liberalized and many governments also reduced their interventions in domestic cereal markets. Sarris' empirical analysis indicates that these changes had no effect on world cereal price variability.

Barrett (1997) notes that, within a particular country, liberalization typically includes several different reforms making the predicted impact on both levels and variability of domestic commodity prices ambiguous. Using data from Madagascar, Barrett finds that over the long run liberalization increased both the mean and the variance of food prices as the government had a policy regime that held retail and farm prices at artificially low and stable levels. Ray *et al.*

(1998) and Yang, Haigh, and Leatham (2001) find that the reduced market interventions contained in the 1996 U.S. farm bill increased domestic price variability for maize, soybeans, and wheat but not for cotton.

Vrolijk and Poppe (2008) use European Farm Accountancy Data Network (FADN) data for the period 1996-2004 to analyze net farm income variability in Europe. While the time period is relatively short, farms participate in the FADN panel for several years allowing for time-series analysis of individual farms. They find that horticulture and intensive livestock farms have the largest variability in net farm incomes. Since these sectors are not regulated by the CAP, the variability in net incomes is driven primarily by price variability. Interestingly, they also found that while output variability was highest in southern Europe and some of the Nordic countries, the highest net farm income variability was in north-western Europe. This is because farms in north-western Europe tend to be more highly leveraged and have smaller margins. Thus, they are more vulnerable to price and yield shocks.

Differences across commodities

Table 4.2 presents a summary of findings from studies that have reported price coefficients of variation for various crops. Deaton and Laroque (1992) report price CVs over the period 1900-1987. Price CVs for cotton, maize, rice, and wheat were all similar. The price CV for sugar was much higher. Hazell, Shields, and Shields (2005) note a downward trend in the real price of wheat, maize, and rice over the period 1971-2003. They also find that price variance, though still fairly high, is declining. Empirically, they estimate the price CVs of wheat, maize and rice to be 29%, 23% and 33%, respectively, over the period 1971 to 2003. Ray *et al.* (1998) report CVs of U.S. marketing season average prices for various commodities over the period 1986-1996. These findings are generally consistent with those of Deaton and Laroque in that maize and wheat have similar price CVs while the price CV for cotton is lower. Hubbard, Lingard, and Webster (2000) report CVs of monthly prices for Romania over the period 1991-1995. The results for maize and wheat are similar to those from other studies. The reported price CV for potatoes is very high relative to other commodities.

We found no publications that compare long-run price variability across livestock commodities. There are probably several reasons for this. First, in many countries governments establish support prices for highly perishable livestock commodities such as milk. These supports distort estimates of price variability. Second, in most OECD countries, poultry and hogs are produced and sold in vertically coordinated markets that are controlled through production and marketing contracts. While it is still possible to find spot market data for these commodities, economists increasingly question whether these data are representative of the broader vertically coordinated markets. This is especially true with regard to price variability. Thus, in recent years most of the literature on these markets has shifted away from analyzing spot market prices to analyzing the principal-agent relationships that exist in contractual relationships. While increasingly vertically coordinated, the cattle sector currently has more spot market transactions than the poultry or hog sectors. However, even for cattle markets the recent literature has focused on identifying price cycles or variability in basis (the difference between the local cash prices and futures prices) rather than on variability in price *per se*. Finally, relative to crop commodities, price variability in livestock commodities tends to be characterized by short-run price shocks caused by food safety scares or temporary restrictions on trade. As is discussed later, a literature exists that examines the impact of such shocks on livestock sectors but given the short-run nature of the shocks this literature does not report long-run estimates of price variability.

Table 4.2. Summary of studies comparing price risk across crop commodities

Author(s)	Commodity	Location	Years	Price measure	Data manipulation	CV
Deaton and Laroque (1992)	Cotton	World	1900-1987	Annual average over calendar year	Deflated	0.35
Deaton and Laroque (1992)	Maize	World	1900-1987	Annual average over calendar year	Deflated	0.38
Deaton and Laroque (1992)	Rice	World	1900-1987	Annual average over calendar year	Deflated	0.36
Deaton and Laroque (1992)	Sugar	World	1900-1987	Annual average over calendar year	Deflated	0.60
Deaton and Laroque (1992)	Wheat	World	1900-1987	Annual average over calendar year	Deflated	0.38
Hazell, Shields, and Shields (2005)	Maize	U.S. Gulf ports	1971-2003	Annual average from August-September	Deflated and linearly detrended	0.23
Hazell, Shields, and Shields (2005)	Rice	Bangkok	1971-2003	Annual average from July-August	Deflated and linearly detrended	0.33
Hazell, Shields, and Shields (2005)	Wheat	U.S. Gulf ports	1971-2003	Annual average from June-May	Deflated and linearly detrended	0.29
Ray *et al.* (1998)	Cotton	United States	1986-1996	Annual average over marketing season	Detrended	0.101
Ray *et al.* (1998)	Maize	United States	1986-1996	Annual average over marketing season	Detrended	0.133
Ray *et al.* (1998)	Soybeans	United States	1986-1996	Annual average over marketing season	Detrended	0.124
Ray *et al.* (1998)	Wheat	United States	1986-1996	Annual average over marketing season	Detrended	0.146
Hubbard, Lingard, and Webster (2000)	Maize	Romania	1991-1995	Monthly average	Deflated	0.31
Hubbard, Lingard, and Webster (2000)	Potatoes	Romania	1991-1995	Monthly average	Deflated	0.53
Hubbard, Lingard, and Webster (2000)	Wheat	Romania	1991-1995	Monthly average	Deflated	0.26

Table 4.3 reports price CVs for selected countries and commodities calculated by the authors from Food and Agriculture Organization (FAO) non-detrended annual average price data for the period 1991-2005. Comparing price CVs across commodities is complicated by differences that exist across countries. For example, livestock and meat price CVs are generally lower than crop price CVs for the European countries shown in Table 4.3, but this is not necessarily true in other regions. Apples tend to have higher price CVs than field crops in Europe and Japan but not in Australia, Canada, Mexico or the United States. Maize price CVs are generally higher than wheat and oats price CVs, although not in the United States.

Table 4.3. Annual average price coefficient of variation 1991-2005

	Apples	Cattle meat	Maize	Oats	Pigs	Potatoes	Rice	Sheep meat	Turkey meat	Wheat
Australia	0.18	0.23	0.20	0.25	0.11	0.13	0.25	0.24	0.20	0.19
Canada	0.08	0.09	0.31	0.09	.016	0.06		0.14	0.09	0.21
Denmark	0.23	0.22		0.26	0.19	0.28		0.25	0.15	0.24
France	0.30	0.14	0.25	0.24	0.21	0.38	0.20	0.14	0.15	0.26
Germany	0.32	0.21		0.26	0.21			0.12	0.12	0.23
Italy	0.29	0.13	0.37	0.20	0.20	0.20	0.21	0.10	0.16	0.25
Japan	0.17	0.09	0.10	0.11	0.09		0.24	0.09	0.23	0.13
Mexico	0.16	0.14	0.36	0.12	0.13	0.18		0.13	0.21	0.19
Spain	0.29	0.30	0.26	0.23	0.14	0.26	0.25	0.36	0.17	0.25
Sweden	0.32	0.32		0.27	0.37	0.27		0.20	0.28	0.24
United States	0.17	0.13	0.14	0.18	0.17	0.12	0.25	0.23	0.13	0.19

Source: Authors' calculations from non-detrended FAO data.

Differences across time

Hubbard, Lingard, and Webster (2000) report that the coefficient of variation of world wheat prices has changed over time. From 1960-1971 it was only 0.17. From 1972-1975 it was 0.25 and from 1976-1996 it was 0.32.

In contrast, Hazell, Shields, and Shields (2005) using world price data for 1971-2003 found no evidence that price variability had increased in recent years for wheat, maize, and rice.

Schnepf (1999) examined U.S. monthly average price data to measure real price CVs for soft and hard red winter wheat as well as maize and soybeans. The results were reported by decade from 1913 to 1997. Notably, the price CVs tended to move together. The lowest risk periods were the 1950s and 1960s when all four crops were found to have a CV of 5% or less. The riskiest periods were the 1930s and the 1970s, when the CV rose to around 15%, three times greater than the lowest risk periods.

Sarris (2000a, 2000b) also concludes that while there are factors that would tend to increase the world instability of cereal markets, there are other counteracting factors that would tend to diminish it. Further, the empirical evidence suggests that there does not seem to be a general trend toward increasing world cereal market instability.

Jordaan *et al.* (2007) examined futures price data from the South African Futures Exchange for yellow maize, white maize, wheat, sunflower seed, and soybeans. Using GARCH models, they found that the volatility in the prices of white maize, yellow maize and sunflower seed have varied over time. The volatilities of wheat and soybean prices were found to be constant over time. The price of white maize was found to be the most volatile, followed by yellow maize, sunflower seed, soybeans, and wheat respectively.

Subervie (2007) reports the percentage price deviations for cocoa, coffee, rice, cotton, tea, and groundnuts over the 1961-2002 period. Notably, the 1975-81 period was the most variable sub-period for all six crops. Of the six crops, coffee was most volatile and rice the least so.

Differences across locations

Table 4.3 allows for comparisons of price CVs across selected countries. In general, Japan seems to have the lowest price CVs with the North American countries generally having lower price CVs than the European countries.[3] Looking at specific commodities, Japan, Australia, and the North American countries generally have lower price CVs for apples and wheat than the European countries. For oats Australia has a higher price CV, similar to many of the European countries. Japan, the United States, and Australia have maize price CVs that are lower than those in Canada, Mexico, and the European countries. Australia and the North American countries have lower potato price CVs than the European countries. Rice price CVs are similar across all of the countries that report rice data. In the livestock sectors, pigs have lower price CVs in Australia, Japan and the North American countries compared to the European countries. The same is true for cattle meat except that Australia's price CV is more in line with the European countries. The results for sheep meat and turkey meat are more mixed with some European countries having some of the lowest price CVs and other European countries having some of the highest price CVs.

Summary of output price risk

Output price risk has unique characteristics relative to yield risk. Unless countries impose severe border controls, price variability will tend to be positively correlated across countries for most major agricultural commodities. Examples of this include rice in Japan and EU prices in the 1980's. In contrast, yield risk tends to exhibit less spatial correlation. Similarly, the magnitude of price risk tends to be similar across countries for major agricultural commodities whereas the magnitude of yield risk may vary greatly within and across countries. This implies that aggregate price data are much more informative about producer price risk than aggregate yield data are about producer yield risk. Finally, economists tend to agree that commodity price distributions are right skewed (*e.g.* log-normal distribution). This generally does not change across locations. However, the shape of yield distributions can vary greatly across locations (Goodwin, Roberts, and Coble, 2000).

The available evidence suggests that livestock and meat products tend to exhibit less price risk than crops. Fresh fruits, vegetables, and other specialty crops tend to exhibit higher price risk than commodity crops such as cotton, maize, wheat, and soybeans. An important determinant of output price risk is the extent to which the product can be stored for long periods of time without significant reductions in quality. Fresh fruits and vegetables have high price risk because they cannot be stored for long periods of time. For storable commodities merchants can arbitrage price differences over different time periods. This is not possible for fresh produce.

Data from FAO suggest that European countries generally experienced higher price variability from 1991-2005 than did Japan and North American countries. However, such cross-sectional comparisons are always problematic due to differences in market interventions across countries.

As one attempts to measure the relevant measure of price risk confronted by agricultural producers, we again appeal to the conceptual framework described above. Often price variability is reported on a daily, monthly, or annual level. We would argue that the appropriate level of price variability is the one consistent with the time horizon for the decision being made.

In agriculture that can vary. However, in many agricultural contexts the planning horizon is approximately a year. For example, in crop agriculture the time lag from the point of allocating land to various crops until the crop is finally harvested and marketed is often approximately a year. In livestock, production cycles vary from less than a year for poultry and hogs to more than a year for beef and dairy. Thus, we conclude that price variability estimated using annualized prices is generally preferable to price variability estimated over shorter intervals.

A related question is what price data are relevant to the producer's decision making. Readily available price data are generally international, national, border or futures prices. Conceptually, one would prefer local cash prices to measure the risk exposure of producers. However, the more general problem is that of basis risk — variability in the spread between local cash price and the more aggregate price series. Note that basis is often driven by factors such as transportation cost and the ability to arbitrage across geographical markets. A constant level of basis does not pose risk for producers; however producers are subject to risk from fluctuations in various factors such as transportation costs, availability of storage capacity, or interruption of transportation service such as rail or barge traffic.

Input prices

Our search of the literature reveals that much less attention has been given to input price risk than to either output price risk or yield risk. This is consistent with the study by Coble *et al.* (1999) that asked producers to rank risks in terms of potential effect on farm income. They found that producers' rank input price risk third behind output price risk and yield risk.

In terms of risk magnitude, Dhuyvetter, Albright and Parcell (2003) estimated models that forecast diesel fuel, natural gas, and anhydrous ammonia prices. Summary statistics from their data show a CV of 0.187 for Kansas diesel, 0.489 for natural gas, and 0.270 for anhydrous ammonia. Oehmke, Sparling and Martin (2008) recently examined Canadian fertilizer price risk and documented price shocks of greater than 70% between the 2007 and 2008 crop years. They also found the monthly CV of natural gas prices over 1994-2006 to range from 30 to 99% with the greatest volatility in February.

Data from the USDA allows an analysis of selected fertilizer prices from 1960 to 2007 in Table 4.4 To assess changes in the riskiness of fertilizer prices over time, the mean, standard deviation, and coefficient of variation was computed for the 1960 to 1996 period and then for 1997-2007. Several insights arise from this comparison. First, fertilizer price coefficients of variation are typically as high as or higher than many commodity price coefficients of variation. The second conclusion drawn from this table is that the coefficient of variation has not increased dramatically in the last decade (in some cases it has declined). However, the mean prices of various fertilizers have increased for all of the fertilizers examined here.

Table 4.4. Select fertilizer prices 1960-2007

Period	Statistic	Anhydrous ammonia	Ammoniu m nitrate	Super-phosphate (44-46%)	Diammonium phosphate (18-46-0)
60-96	Mean	228.91	178.32	207.14	238.23
60-96	Standard Deviation	68.21	55.04	66.58	66.19
60-96	Coefficient of Variation	0.30	0.31	0.32	0.28
97-07	Mean	350.45	254.18	273.18	283.55
97-07	Standard Deviation	111.07	68.90	56.48	60.89
97-07	Coefficient of Variation	0.32	0.27	0.21	0.21

Source: USDA Economic Research Service.

A related summary of data is conducted for diesel fuel prices in Table 4.5. Since diesel is a primary fuel used in farm implements such as tractors, these price are reflected in the cost of tillage and various farm operations. The data here allows cross-country comparisons, but for a shorter time period than the previous table. First it appears that diesel prices are similar in both the mean and CV across Europe and the U.S. However, it is also notable that the measured CV for diesel is among the highest observed in this report.

Table 4.5. Diesel fuel prices for various countries 1996-2008

Date	Belgium	France	Germany	Italy	Netherlands	UK	US
Mean	1.62	1.46	1.53	1.69	1.68	1.50	1.35
Standard Deviation	0.86	0.85	0.84	0.92	0.89	0.82	0.81
Coefficient of Variation	0.53	0.59	0.55	0.55	0.53	0.55	0.60

Source: Energy Administration U.S. Government. http://www.eia.doe.gov/emeu/international/oilprice.html;

It is also important to recognize that the output price variability of crops often can be considered an input price risk for the livestock sector. Feed grains and soybeans often serves as the primary energy and protein source in the poultry, dairy, pork, and grain-fed cattle industries. It is typical for feed cost to be the largest single variable input cost in livestock production systems. Therefore, the analysis of output price risk for crops in the previous section applies directly to the input price risk for the livestock industry.

Production risk

Crops

Distributional form

When attempting to model crop yields an important issue is the assumed shape of the yield distribution. It is easier to work with normal distributions because they can be fully described using only two parameters (mean and variance). Also, with multiple normally distributed random variables calculation of the pairwise covariances is straight-forward.

However, a significant body of literature has argued that crop yields are not normally distributed. A standard argument is that yield distributions will tend to be left-skewed because yields can be as low as zero but there is some biological limit to how high yields can go. This argument further suggests that the magnitude of skewness likely depends on the level of aggregation at which yields are measured. It is not difficult to imagine yields near zero for a specific plot but it seems quite unlikely that yields near zero would occur when measured at provincial or national levels. Thus, while skewness may still exist in aggregate yields, one would generally expect yield distributions to be more symmetric at higher levels of aggregation.

Using experimental plot data Day (1965) found evidence of right-skewness in Mississippi cotton yields. However, the far more common finding has been that yields are left-skewed. Gallagher (1987) demonstrated that national U.S. soybean yields are left-skewed. Nelson and Preckel (1989) and Nelson (1990) found evidence of negative skewness in farm-level maize yields from five Iowa counties. Taylor (1990) found negative skewness in maize and soybean yields for Macoupin County, Illinois but positive skewness for wheat yields in the same county. Moss and Shonkwiler (1993) found evidence of negative skewness in national

U.S. maize yields. Ramirez (1997) found evidence of left-skewness in Midwest maize and soybean yields. Wheat yields, however appeared to be symmetric. Wang *et al.* (1998) found evidence of negative skewness in maize yields for Adair County, Iowa. Goodwin and Ker (1998) used non-parametric methods to estimate state- and county-level yield distributions for several commodities. Negative skewness was common though there were cases of slight positive skewness (especially at the state-level of aggregation).

Just and Weninger (1999) argued that methodological problems existed with all previous studies of yield distributions. They contended that when these methodological problems are adequately addressed, insufficient evidence exists to disprove normality of crop yields. Several subsequent studies attempted to address the methodological concerns raised by Just and Weninger (1999). Ramirez, Misra, and Field (2003) reconfirmed the earlier finding by Ramirez (1997) that Midwest maize and soybean yields are left-skewed. Ramirez, Misra, and Field (2003) also found that Texas plains dryland cotton yields were right-skewed, a result that they ascribe to right-skewness in rainfall distributions for the region. Using farm-level yield data from Kansas, Atwood, Shaik, and Watts (2003) found evidence of left-skewness for irrigated maize, irrigated sorghum, dryland sorghum, irrigated wheat, and dryland wheat yields. Using farm level data from Illinois, Sherrick *et al.* (2004) found evidence of left-skewness in both maize and soybean yields. More recently, Harri *et al.* (forthcoming) examined maize, soybean, cotton and wheat yield and find decidedly mixed results with a tendency for low risk crops to be left skewed and high risk crops to be right skewed.

Magnitude of crop yield risk across commodities and locations

As indicated above, most studies have found that yields are not normally distributed. This finding raises questions about how to meaningfully compare magnitudes of yield risk. If yields are not normally distributed then the variance, standard deviation, or CV may not be sufficient indicators of risk. Higher moments of the distribution also affect risk exposure. Despite this, most studies report yield risk using CV because it is difficult to compare higher moments across different distributions.

The magnitude of yield risk depends on a number of agronomic, climatic, and management factors. For example the uses of irrigation, timeliness of planting, and quality of in-season crop inspection are all factors that may affect risk. As mentioned earlier, it also depends critically on the level of aggregation at which yield is measured. This latter point suggests that one should be cautious about drawing conclusions based on cross-sectional comparisons of crop yield risk. It also points to the influence of farm size and spatial dispersion of the farm plots as factors affecting farm risk.

Allen and Lueck (2002) report state (province)-level yield CVs for several crops produced in Louisiana, Nebraska, South Dakota, and British Columbia. A summary of these data is reported in Table 4.6.

Other studies that have estimated yield CVs include Nelson and Preckel (1989) who fit farm-level maize yield data for five Iowa counties to a beta distribution. The resulting CVs ranged between 0.11 and 0.27. Using farm-level yield data from Illinois, Sherrick *et al.* (2004) estimated maize CVs that averaged 0.17 and soybean CVs that averaged 0.14. Hart, Hayes, and Babcock (2006) modelled yield distributions for a representative farm in Webster County, Iowa. They assumed that yields were distributed as a beta and then solved for the distributional parameters that would generate actual federal crop insurance premium rates for 65% coverage. The estimated maize yield CV was 0.27 and the estimated soybean yield CV was 0.25.

As indicated earlier, yield risk measures are affected by aggregation bias so one should be cautious about making spatial comparisons. However, this sample of studies from North America does illustrate some important points. First, some crops have more yield risk than others. In North America, rice, cotton, and wheat are generally considered riskier than sorghum and soybeans. Second, some production practices reduce yield risk. Table 4.6 demonstrates that for a given crop irrigated production typically has lower yield risk than dryland production. Third, some regions have more yield risk than others. For example, Table 4.6 shows that wheat production in Nebraska is less risky than wheat production in British Columbia, Louisiana, or South Dakota.

Table 4.6. Comparison of yield risk across regions

Author(s)	Commodity	Location	Years	Level of aggregation	Data manipulation	CV
Allen and Lueck (2002)	Sorghum (all)	Louisiana	1975-1991	State	None reported	0.06
Allen and Lueck (2002)	Sugarcane	Louisiana	1975-1991	State	None reported	0.10
Allen and Lueck (2002)	Soybeans (all)	Louisiana	1975-1991	State	None reported	0.12
Allen and Lueck (2002)	Hay	Louisiana	1975-1991	State	None reported	0.12
Allen and Lueck (2002)	Cotton	Louisiana	1975-1991	State	None reported.	0.20
Allen and Lueck (2002)	Wheat	Louisiana	1975-1991	State	None reported.	0.21
Allen and Lueck (2002)	Rice	Louisiana	1975-1991	State	None reported	0.28
Allen and Lueck (2002)	Maize (all)	Louisiana	1975-1991	State	None reported	0.29
Allen and Lueck (2002)	Sorghum (irrigated)	Nebraska	1975-1991	State	None reported	0.08
Allen and Lueck (2002)	Sorghum (dryland)	Nebraska	1975-1991	State	None reported	0.15
Allen and Lueck (2002)	Soybeans (irrigated)	Nebraska	1975-1991	State	None reported	0.09
Allen and Lueck (2002)	Soybeans (dryland)	Nebraska	1975-1991	State	None reported	0.17
Allen and Lueck (2002)	Wheat	Nebraska	1975-1991	State	None reported	0.11
Allen and Lueck (2002)	Maize (irrigated)	Nebraska	1975-1991	State	None reported	0.11
Allen and Lueck (2002)	Maize (dryland)	Nebraska	1975-1991	State	None reported	0.24
Allen and Lueck (2002)	Oats	Nebraska	1975-1991	State	None reported	0.16
Allen and Lueck (2002)	Sorghum (all)	South Dakota	1975-1991	State	None reported	0.20
Allen and Lueck (2002)	Soybeans (all)	South Dakota	1975-1991	State	None reported	0.14

Table 4.6. Comparison of yield risk across regions (*cont.*)

Author(s)	Commodity	Location	Years	Level of aggregation	Data manipulation	CV
Allen and Lueck (2002)	Wheat	South Dakota	1975-1991	State	None reported	0.25
Allen and Lueck (2002)	Maize (irrigated)	South Dakota	1975-1991	State	None reported.	0.02
Allen and Lueck (2002)	Maize (dryland)	South Dakota	1975-1991	State	None reported.	0.14
Allen and Lueck (2002)	Oats	South Dakota	1975-1991	State	None reported	0.19
Allen and Lueck (2002)	Hay	British Columbia	1980-1991	Province	None reported	0.15
Allen and Lueck (2002)	Barley	British Columbia	1980-1991	Province	None reported	0.22
Allen and Lueck (2002)	Wheat	British Columbia	1980-1991	Province	None reported	0.18
Allen and Lueck (2002)	Maize (all)	British Columbia	1980-1991	Province	None reported	0.27
Allen and Lueck (2002)	Oats	British Columbia	1980-1991	Province	None reported	0.21
Allen and Lueck (2002)	Apples	British Columbia	1980-1991	Province	None reported	0.18
Allen and Lueck (2002)	Canola	British Columbia	1980-1991	Province	None reported	0.25
Nelson and Preckel (1989)	Maize	Iowa	1961-1970	Farm	CV based on historical data fit to a beta distribution	0.11-0.27
Sherrick *et al.* (2004)	Maize	Illinois	1972-1999	Farm	Detrended, reported CV is average of farm-level CVs	0.17
Sherrick *et al.* (2004)	Soybeans	Illinois	1972-1999	Farm	Detrended, reported CV is average of farm-level CVs	0.14
Hart, Hayes, and Babcock (2006)	Maize	Iowa	NA	Farm	CV based on a beta distribution with parameters that would generate the U.S. crop insurance premium rate for the farm	0.27
Hart, Hayes, and Babcock (2006)	Soybeans	Iowa	NA	Farm	CV based on a beta distribution with parameters that would generate the U.S. crop insurance premium rate for the farm	0.25

Summary of crop production risk

Due to heterogeneity across species and locations, it is extremely difficult to draw general conclusions about crop yield risks. There is increasing evidence that crop yield distributions are generally left-skewed though there are almost certainly some species and locations that would be exceptions (Harri *et al.*). Meaningful comparisons of yield risk magnitudes must account for aggregation bias. However, even if one can control for aggregation bias it is difficult to make general conclusions about which crops and locations are more or less risky. One crop may be more risky than another crop in one location while the opposite may be true in a different location. One location may be more risky than another location for a specific crop but the opposite may be true for a different crop. Common causes of yield risk include drought, excess moisture, disease, pests, hail, freeze, and flooding (USDA, RMA). Production inputs (irrigation, pesticides, improved seeds, etc.) and associated management strategies can reduce the magnitude of yield risk caused by some (but not all) perils.

Livestock production risk

Throughout much of the world, livestock production losses are far less common than crop production losses. In many OECD countries, swine, chickens (both broilers and layers), turkeys, and dairy cattle are kept in either total or partial confinement facilities. This greatly reduces their exposure to weather-related perils, predators, and at least some diseases. Beef cattle are still largely kept in either fenced fields where they graze on improved pastures or (in the western U.S.) open range lands. Thus, beef cattle are more susceptible to death loss caused by extreme weather events. They are also more susceptible to reduced weight gain due to the effects of extreme weather events on the quantity and quality of grass and forage production. For livestock, disease risk often poses the threat of infrequent but severe losses (Gramig *et al.* 2006; Shaik *et al.* 2006). Further, farmers are often required to destroy diseased and healthy animals to avoid spread of infectious disease. Often government compensation is offered, but for a variety of reasons this indemnification is often imperfect (Ott, 2006). The effect of confinement appears to have a mixed effect on risk exposure. Animals are in close proximity to each other which can intensive the spread of disease. However, confinement can also allow greater bio-security which reduces the spread across farms. Confinement also results in more intensive management which is likely to improve disease management. The relative effect of confinement on risk ultimately is somewhat conditioned on the means by which the disease is spread. For example, some diseases can be spread by unsanitary equipment. Others require animal contact. This may take the form of within-species or cross-species transmission

Off-farm income and investments

Off-farm labour income and investment (savings or borrowing) are quite common among farm families in OECD countries. This is in contrast to many developing countries where liquid financial markets are often lacking. Note however, that much of the literature that is available on the issue of off-farm labour and correlation with farm revenue is focused on subsistence agriculture not located in OECD countries. Conceptually, a risk neutral farm family might hold off-farm investments or provide off-farm labour due to an allocation of resources to the highest rate of return. For example, some family member may earn a greater return in off-farm labour than from on-farm activities. Likewise, savings and borrowing may be maintained for purposes of liquidity and convenience, but clearly they also have the effect of smoothing consumption across time thus helping farm families to manage their risk exposure. While this report is primarily directed at quantifying the risk environment of farm firms, we note that inter-temporal consumption smoothing is possible and therefore studies focused solely on static risk measures will tend to overestimate risk and the benefit of risk management strategies.

Off-farm labour

The incentives and opportunities for farm households to engage in off-farm labour are diverse. Several authors have addressed the risk mitigating effect of off-farm income and investments. Fundamentally, off-farm labour represents a diversification of the financial portfolio into a revenue stream with low variability and that has a low correlation with farm income. Conceptually, the labour devoted to off-farm work could have been devoted to the farm production activities.

In a study of Dutch farms, Woldehanna, Lansink, and Peerlings (2000) found that expected short-run farm profit and on-farm labour supplied by a household head have a strong negative impact on the off-farm work decision of a household. Whereas, non-labour income, on-farm labour supplied by other family members and agricultural education do not show any significant impact on the off-farm work decision. However, family size and general education show a positive effect on the desire of households to participate in off-farm work. They go on to conclude that government subsidies aimed at increasing household's income through price policies may have a negative impact on the off-farm employment of farm households. Whereas, direct income support such as the Agenda 2000 CAP reforms are most likely to increase off-farm employment of farm households in the Netherlands. Mishra and Goodwin (1997) studied Kansas farmers and reached a similar conclusion that if farmers are risk averse, then greater farm income variability should increase their willingness to work off-farm.

Using panel data from Israel, Ahituv (2006) was able to examine the evolution of farms over time. This analysis suggests that some family farms tend to expand over time and specialize in farming, whereas other farm households downsize their farming operation and increase their engagement in the off-farm labour market. Therefore, the size distribution of farms was converging towards a bimodal distribution.

El-Osta, Mishra, and Morehart (2008) examined data from the U.S. 2004 Agricultural Resource Management Survey. They found expected government payments decreased the likelihood of off-farm work strategies involving work by the husband only or by both husband and wife relative to a strategy of no work by either husband or wife.

Key, Roberts, and O'Donahue (2006) use data resulting from a large increase in U.S. Federal crop insurance subsidies as a natural experiment to identify the importance of risk for farm operator labour supply. Subsidy increases induced greater crop insurance coverage, which in turn reduced farmers' financial risks. It was found that greater insurance coverage reduced the off-farm labour supply of operators who produced at least USD 100 000 of output and increased the labour supply of small-farm operators who produced less than USD 25 000 of output.

Lien *et al.* (2006) also noted the distinction of full and part-time farmers in a study of Norwegian famers. He concludes that "full-time and part-time farmers' goals, risk perceptions, and risk management strategies differ significantly. Further, compared to full-time farmers, part-time farmers plan more frequently to downsize their farm operations, which may be a necessity to cope with multiple job situations."

Serra, Goodwin and Featherstone (2005) studied Kansas farm records and show a clear result that higher household wealth reduces the likelihood that the household seeks a job off the farm. They suggest that wealthier farms are less risk averse than poorer ones, which may reduce their incentive to seek a more stable source of income than farming. Alternatively, wealth may be a source of household non-work income reducing the motivation for working off the farm. They go on to examine the net effect of the 1996 FAIR Act on off-farm labour and conclude that it was minimal.

Mishra and Godwin (1997) use U.S. farm-level data from Kansas to evaluate the willingness of farm families to work off-farm. A major conclusion is that there is a positive relationship between off-farm labour supply and farm income variability. *Ceterus paribus*, this suggests riskier farms choose to work more in off-farm employment. Their results also suggest farms with higher debt to asset ratios work off-farm more hours.

Mishra and Sandettro (2002) evaluated national-level U.S. farm and non-farm income for a long time-period (1933-1999). They show several periods of sharp year-to-year changes and then periods of greater stability. Their analysis of the relationship between farm and non-farm income suggests that non-farm income has become a greater proportion of family income over time. In a breakdown by farm type, dairy farms, poultry and vegetable producer tend to use off-farm income less than row crop producer. Again using aggregate data, the covariance between farm and off-farm income is estimated and found to take a negative sign if estimate across the 1960-1999 period or the more recent periods. This is suggestive of the risk reduction created by off-farm income.

In a study of Dutch farms, Woldehanna, Lansink, and Peerlings (2000) found that expected short-run farm profit and on-farm labour supplied by a household head have a strong negative impact on the off-farm work decision of a household.

Off-farm investment

Barry and Baker (1984) provided a lucid description of the ways a farm can use debt and savings as a means to manage risk. Farms using credit and other fixed-obligation financing can concentrate the firm's equity in agricultural production assets and thereby increase agricultural risk exposure. Varangis, Larson, and Anderson (2002) note that increasing financial leverage magnifies the impact for the owner of variability in firm returns. It follows that if the return on total assets is above the borrowing rate, wealth will increase. If rate of return is less than the borrowing rate this can ultimately lead to bankruptcy.

Savings for the farm firm are typical described as financial assets held in a financial investment that earns a rate of return and is typically fairly liquid. As such it can potentially be risk reducing by diversifying the firm's portfolio into assets outside of agriculture. Further many financial investments such as savings, treasury bonds have low levels of return variability which augments the risk-reduction effect.

Nartea and Webster (2008) note that investment in other industries is also possible and can likewise have a risk reducing effect for the farm family. They find low correlations between rates of return on farm and financial assets available in New Zealand which suggests that significant reduction of income variability might follow their inclusion in farmers' portfolios. They conclude farmers showing high degrees of risk aversion would gain utility by including financial assets in their portfolios. Specifically they examine financial investments such as ordinary industrial shares, government bonds and bank bills. They find a low correlation between rates of return on farm assets and these financial assets. This suggests that significant reduction of income variability might follow their inclusion in farmers' portfolios. Bonds rather than ordinary shares are the main contributors to portfolios which maximize utility for individuals classified as 'somewhat' risk averse.

Painter (2000) concluded that investments in farmland are negatively correlated with returns with other equity markets. Thus, when added to an equity portfolio, the risk is reduced while maintaining the same rate of return on investment. However, Painter also notes that farmland investment have potential problems including illiquidity, poor marketability and asset lumpiness.

Langemeier and Patrick (1990) used panel data for Illinois grain farms to investigate the marginal propensity to consume which measures the inter-temporal consumption smoothing of the farm. Their results indicate farm family consumption responded little to changes in income. In a related study Carriker *et al.* (1993) use Kansas data to estimate the marginal propensity to consume from different sources of income and found the propensity to consume from off-farm income and government payments were significantly greater than the propensity to consume from farm income.

In a more recent study, Sand (2002) investigated the traditionally low marginal propensity to consume (MPC) observed in farms. In a panel of Norwegian farm households, Sand found a similar result to Carriker *et al.* (1993), that the marginal propensity to consume from farm income is lower than for off-farm income and that average MPC is low but increasing over time in these households.

Summary of off-farm labour and investment

A review of the existing literature on off-farm labour and investment by agricultural producers suggests that either off-farm labour or investment can provide an effective risk mitigation strategy. Incentives to work off the farm appear related to the opportunity cost of the individual's time and the availability of off-farm opportunities. Interestingly, the literature suggests that off-farm labour and government support for producers tend to be substitute risk mitigation alternatives. The literature does not reveal significant differences in behaviour or risk effects across regions or over time. Among the factors affecting the correlation between farm and off-farm income is whether the off-farm source of income is itself related to agricultural production. For example, working at the local grain elevator may not diversify the family income and consumption as much as working as a school teacher because earnings at the grain elevator are more positively correlated with farm income. Estimates of the correlation between farm and off-farm income are generally not available in the literature. This is likely due to the many potential sources of off-farm income and the long time-series of data that would be required to make meaningful estimates. Freshwater and Jetté-Nantel (2008) attempt to address this fundamental weakness in the literature. However, it appears that their analysis also lacks a sufficiently long time series of farm-level data from which to estimate these correlations.

Off-farm investment is financial assets also provides an effective diversification strategy for farm families in much the same way off-farm labour does. However, the investment in financial investments is often readily available even when off-farm labour opportunities are limited. As with off-farm income, an important aspect of off-farm investments is the degree of correlation between the off-farm investment and on-farm investments. For example, investment in a local agri-business firm that is tied to the commodity produced on the farm will likely diversify the family income much less than an investment in a non-agriculturally related investment. Again there is a dearth of appropriate data available.

Correlation of uncertain variables

The co-movements of random variable potentially has a profound effect on the variability of an aggregate summation or product of random variables. At the farm-level, this may be seen when prices and yield for a crop are correlated with each other and revenue is the product of price times yield. Similarly as one sums the revenue from multiple enterprises; the correlation of these revenue streams impacts the whole farm revenue. For example, a mixed crop and livestock farm may gain a substantial risk benefit if net revenue from the crops and livestock are independent of each other or even negatively correlated.

Price-price correlations

Crops

The correlation of crop prices is conceptually driven by market forces and the end use of the crop. For example, grains that are close substitutes tend to have prices the move together, while the prices of a fibre crop like cotton tend to be weekly correlated with feed and food use crops. Trade also profoundly affects the co-movement of commodity prices. A highly localized market will, *ceteris paribus*, have prices that are less correlated with prices in other geographical regions. This may arise naturally due to factors such as perishable nature of the commodity or transportation cost. It may also arise due to protectionist government policy which insulates producers from world market price signals. Table 4.7 shows some results for U.S. price correlations from the model described in Coble and Dismukes (2008). Based on price and yield shocks from 1975 through 2005 the prices simulated in a large sample are all positively correlated. However, the correlation of cotton to the other crops is typically much lower. Conversely, maize prices are highly correlated with soybeans and wheat.

Table 4.7. U.S. price — price correlations

Maize	Maize	Maize	Cotton	Soybean	Wheat
Soybean	Wheat	Cotton	Soybean	Wheat	Cotton
0.719	0.701	0.232	0.514	0.581	0.048

Source: Authors calculations from Coble-Dismukes (2008) model.

Livestock

The relationship of livestock prices can be largely conceptualized through the demand relationships of substitute goods. Thus, beef, pork, and poultry price co-movements are driven by this relationship. Substitutes ultimately tend to have prices that move together as the prices of one meat group "pulls" the price of others. Likewise animal agricultural tends to depend on common feedstuffs — grains and crop protein such as soybeans. Thus production costs for these commodities are also tied together as feed prices do not vary dramatically across species. As with crops, the relationship between livestock prices can also be influenced by international trade policy.

Yield-yield correlations

Crops

Crop yield correlations at the farm level tend to be driven by the degree to which the crops are susceptible to common perils due to similarity in planting season or degree of drought tolerance. Table 4.8 illustrates this point by averaging farm-level correlations produced by the Coble-Dismukes (2008) model for select U.S. states. This model uses empirical correlations between price and county yield which is then adjusted to the farm level by following the procedure of Miranda (1991). The results show that, in many states, maize and soybean yields demonstrate a strongly positive correlation. These crops are often grown on the same farm and are subject to many of the same production risks. In contrast, wheat is never observed to have a correlation greater than 0.351 with another crop. This is likely caused by the predominance of winter wheat in U.S. production which results in differing growing seasons and causes of loss.

Table 4.8. Average farm level yield correlation for selected U.S. states

State	Maize soybean	Maize wheat	Maize cotton	Cotton soybean	Soybean wheat	Wheat cotton
Georgia	0.711	N.A.	0.374	N.A.	N.A.	0.245
Illinois	0.684	0.142	N.A.	N.A.	0.003	N.A.
Iowa	0.642	N.A.	N.A.	N.A.	N.A.	N.A.
Kansas	0.581	0.044	N.A.	N.A.	-0.102	N.A.
Mississippi	0.507	N.A.	-0.050	0.511	N.A.	N.A.
North Carolina	0.475	-0.082	0.445	0.613	0.236	0.180
North Dakota	0.857	0.351	N.A.	N.A.	0.279	N.A.
Ohio	0.758	0.328	N.A.	N.A.	0.279	N.A.
Texas	0.559	0.043	0.353	0.727	N.A.	0.244

Source: Authors calculations from Coble-Dismukes (2008) model.

Livestock

Our search of the literature revealed no studies reporting yield-yield correlations among livestock enterprises. Clearly a lack of scientific attention has been directed in this area. We presume this is due to several factors. First livestock production is increasing in confinement operations which rarely mix species. Secondly, livestock production is often complimentary with crop agriculture and found integrated with crops rather than other livestock on most commercial farms. Finally, crop agriculture is much more likely to measure yield variability than livestock. Livestock disease risk is likely a severe but infrequent loss which may not be well described with a standard deviation nor is a correlation likely to reveal much when losses are infrequent unless one has a time-series longer than typically observed.

Price-yield correlations

Crops

Price-yield correlations at the farm level appear to best be conceptualized as an indirect relationship rather than a causal relationship. Theory clearly suggests a negative correlation between aggregate supply and price. However, agricultural is typically characterized by many small producers whose output decisions will have no effect on aggregate price. This would seem to suggest statistical independence of producer yields and price received. This is, however, contradicted by empirical evidence of negative correlation (Coble, Heifner, and Zuniga, 2000). This can be reconciled if one examines the correlation of a farm's yield with aggregate yield. Geographically or politically isolated markets are likely to exhibit higher correlations between individual farm yields and aggregate supply. However, even in open markets, some crop producing regions tend to dominate. Since some weather events such as droughts or excessive moisture are spatially correlated, producers outside of major production regions are less likely to observe negative price-yield correlation. Conversely, producers in the heart of a major production region are more likely to experience weather or other production shocks that are spatially correlated across a significant number of producers and in aggregate cause a price response. For example, a study by Blank, Carter and MacDonald evaluates several specialty crops grown in California. While most were observed with negative covariances almonds and oranges are found to have the most negative price-yield covariance of the crops studied.

Hazell (p.100) summarized the implication of price yield correlation on agricultural producers as follows:

If prices and yields are negatively correlated, the unit revenue forecast will be less than the average price. In this case, rational farmers will produce less of the commodity than calculations based on average prices would suggest, a point often overlooked by many economists and policymakers. The opposite will happen when the correlation is positive. Farmers should produce more of the commodity than calculations based on average prices would suggest. Note that these supply effects will arise even if farmers are risk-neutral. The correlation effect will be amplified if farmers are also risk-averse. Using time series data from a wide range of countries, Scandizzo, Hazell, and Anderson (1984) provide some evidence that farmers in industrialized Western economies do take account of price and yield correlations but that farmers in developing countries and in the centrally planned economies do not.

Xing and Pietola (2005) investigated optimal forward hedging by Finnish spring wheat farmers and observed a price-yield correlation of -0.36. Bielza and Sumpsi (2007) report a range of price-yield correlations between -0.023 and -0.548 in Spanish olive oil production. Fleege, Richards, Manfredo, and Sanders (2004) examined the use of weather derivatives in western U.S. specialty crops. They reported Pearson correlation coefficient estimates between price and yield of -0.70 for nectarines, -0.032 for raisin grapes, and -0.39 for almonds. Weisensel and Schoney (1989) found no correlation between wheat yields and prices in Saskatchewan, Canada, but lentil yields and prices are inversely correlated with a correlation coefficient of -0.30. Hart, Hayes, and Babcock report a price-yield correlation for maize of -0.51 and -0.12 for soybeans for an Iowa farm.

A summary of price-yield correlation for various studies is reported in Table 4.9. The strongest negative correlations tend to occur in major production regions such as the central U.S. and for more localized markets such as for some specialty crops. Many major commodities with widely dispersed production tend to have correlations near zero.

Table 4.9. Summary of price-yield correlations estimate from various studies

Study	Level	Years	Location	Maize	Soybeans	Cotton	Wheat	Other
Bielza and Sumpsi (2007)	Farm level	1991-1998	Spain olive oil					-0.023 to -0.548
Coble and Dismukes (2008)	Simulated farm	1975-2004	U.S.					
			GA	-0.018	0.111	0.013	0.067	
			IL	-0.500	-0.461	.	-0.043	
			IA	-0.407	-0.394	.	.	
			KS	-0.280	-0.358	.	-0.279	
			MN	-0.296	-0.271	.	-0.367	
			MS	-0.036	-0.110	-0.155	.	
			NC	-0.091	-0.338	-0.302	0.207	
			ND	-0.223	-0.337	.	-0.428	
			OH	-0.400	-0.397	.	-0.147	
			PA	-0.435	.	.	0.314	
			TX	0.048	0.161	-0.096	-0.336	

Table 4.9. Summary of price-yield correlations estimate from various studies (*cont.*)

Study	Level	Years	Location	Maize	Soybeans	Cotton	Wheat	Other
Hart, Hayes, and Babcock (2006)	Simulated farm	1980-2001	U.S. Iowa	-0.51	-0.12			
Fleege, Richards, Manfredo, and Sanders (2004)	Farm level	1980-2001	U.S. Specialty Crops					-0.70
			Nectarines					-0.032
			Raisin Grapes					-0.39
			Almonds					
Weisensel and Schoney (1989)	Farm-level	1970-1980	Canada					
			Wheat				0.0	
			Lentils					-0.30
	Farm-level	1995-2001	Finland					
Xing and Pietola (2005)			Spring Wheat				-0.36	

Livestock

As suggested earlier, modern confinement production systems for poultry, hogs, and dairy have greatly reduced production risk. Production systems that are forage-based remain more exposed to weather uncertainty. Price variation is then less subject to production shocks, but remains subject to aggregate demand shifts such as consumer food safety scares and to trade shocks. Thus, price-yield correlations in such an environment have not received much attention in the literature.

Farm-nonfarm income

We found several studies regarding the incentives for off-farm labour by farm households. However, these studies tend to not report a correlation with on-farm sources of income. Intuitively, off-farm income is presumed to be relatively stable and largely uncorrelated with on-farm income.

Ability of the farm to adjust to risk

That farmers do not adjust their quasi-fixed input as market conditions change is a long-standing issue in agricultural economics literature. Johnson (1956) is often credited with conceptualizing this issue. Given that agriculture tends to increasingly involve major capital investments (land and machinery) this issue remains. While numerous studies (Vasavada and Chambers, 1986; Howard and Shumway, 1988; Nelson, Braden and Roh, 1989) find evidence of asset fixity, the relationship to risk management is somewhat more tenuous. For example, Boetel, Hoffmann and Liu (2007) find evidence of asset fixity in the U.S. pork industry. Foster and Rausser (1991) point out the implication of farm failure to the fixity problem and Robison and Brake (1979) consider the problem in a portfolio theory framework. Chavas (1994) connects this literature to the real option valuation literature. Finally, the most recent work in this area by Musshoff and Hirschauer (2008) concludes that asset fixity has slowed the adoption of organic production in Germany and Austria.

Comparison of agricultural risk to other industries

Our investigation found little literature addressing the riskiness of farm versus non-farm firms. Goodwin examined bankruptcy rates and concluded that farm firms are less likely to fall into bankruptcy than non-farm firms. Presumably government subsidies are one reason for this. An earlier study by Shepherd and Collins (1982) suggested some correlation between farm and non-farm bankruptcy. They estimated that a 1% increase in the nonfarm bankruptcy rate was associated with a 0.44% increase in the farm bankruptcy rate over the1946-78 period. Stam and Dixon (2004) support this by showing farm bankruptcies have often occurred during periods of general economic downturns affecting many sectors of the economy.

Overall assessment of major factors affecting farm income risk

Importance of quantity and price risk in agriculture

Our evaluation of the literature leads to the conclusion that in crop agriculture, output price and yield risk are the major factors driving the farm firm's risk exposure. The attention devoted to price and yield risk in the literature suggests this as well as surveys asking producers to rate or rank the risks they face. We also take the efforts to develop crop insurance and futures markets as *prima facie* evidence that price and yield risk are major concerns for crop producers (although we will admit crop insurance has been highly subsidized and yet has low participation in many countries). Much less attention has been devoted to input price risk. Our assessment of fertilizer and fuel prices suggests the magnitude of fertilizer price risk is similar to the coefficient of variation for most prices and yields. However, diesel fuel price CVs appears relatively high. Interestingly, this seems contrary to perceptions and the amount of research attention devoted to input prices. We suspect that this can be interpreted as resulting from a couple of factors. First, fuel and fertilizer are among many inputs and the volatility of production cost is dampened relative to output and output price risk for crop producers. In many cases fuel or fertilizer prices may only be fractionally transmitted to net returns variability depending on the cost share of those inputs. Second, in many cases the window of input price risk is relatively short as compared to price and yield risk. Often, the majority of fertilizer and fuel costs are incurred within a few months of the onset of production. Conversely, yield and price risk is often not resolved for 6-7 months in crops and sometimes longer in livestock production. Thus, there is more time for prices to evolve away from expectations.

Implications of correlations

Recent literature has focused increasing attention on price-yield correlation and in many studies negative correlation is found in major production regions or in more localized markets. This tends to dampen revenue risk, but it also complicates risk management as price and yield risk tend to be more amenable to differing risk management tools. However, in many locations and agricultural commodities price and yield independence appears in the historical data.

To a great extent yield and price risk have been mitigated by differing risk tools (Coble, Heifner and Zuniga, 2000). For example, government programs have typically provided multiple–peril yield insurance and private firms offer some single peril (*e.g.* hail and frost) yield protection. In yields there is a least some degree of independence of losses which is essential for functioning insurance markets. Many separate government programs have provided output price support either directly or indirectly. Further futures markets are well suited to provide price risk protection due to the high degree of spatially correlation. To producers confronted with correlated prices and yields, revenue protection often appears efficient due to the cases where separate price and yield protection fail to protect against some low revenue scenarios. However, we are unaware of any significant private efforts to provide revenue risk management tools.

Positive correlations between the prices of similar crops and between yields on the same farm tend to profoundly affect the revenue variability of a farm. Combining enterprises with less positively correlated prices and or yields will provide greater risk reduction through diversification. For example, combining crops and livestock has been a longstanding risk mitigation strategy (Hart, Babcock, and Hayes, 2006). However, it appears that movement to larger and vertically integrated livestock production systems for the sake of cost efficiency has reduced the opportunity for many farms to diversify in that manner. However, agricultural producer still have the opportunity to diversify into non-agricultural investments and off-farm labour markets. These strategies continue to appear feasible and widely used.

Recent developments in agricultural risk

Looming issues that appear to have the potential to alter the risk context for farmers are varied. However, the current concern about climate change has already sparked a surprising number of studies which are, however, somewhat inconclusive with regard to the impact on production risk. Biotechnology appears to increase mean yields and several studies suggest this technology is risk decreasing. However, this is difficult to assess as adoption and technological advances are occurring so rapidly we do not have long time series of data to assess the issue in locations such as the U.S. where adoption has occurred rapidly over the past decade. This is confounded by the rapid development of second and third-generations biotech crops. Most public yield trials are for only a few years and do not provide sufficient yield series for yield risk comparisons or examination of susceptibility or resistance to disease. A significant literature has arisen examining the consumer acceptance of these crops, suggesting consumers in many countries view biotechnology enhanced crops less favourably than U.S. consumers (Lusk *et al.2004*), but information on environmental risk appears limited.

Livestock production risk tends to differ from crop production risk. Increased using of confinement production systems appears to have reduced production risk in livestock agriculture dramatically. We do note that many producers are still using less intensive production system such as in grazed beef production which remains subject to significant weather risk. It appears that output price risk remains the major concern of livestock producers. With low probability, but catastrophic implications, disease epidemics are also a major risk factor. Increasingly these events may not only affect output, but also cause catastrophic demand shifts. Finally in many livestock systems, the output price risk of crop agriculture translates into an input price risk for the livestock sector.

Cause of variability in agriculture

Major underlying cause of risk

Crop production

Crop yield risk is caused by many natural factors. While major causes of yield loss vary by species, some are common across many crop species. Among these are drought, excess moisture, disease, pests, hail, freeze, and flooding. In general, weather risk also varies by geographical region as weather patterns differ. For many crops there are areas with near ideal weather and then other production regions where economic incentives (including government programs) induce production at the extensive margin for the crop.

Weather

Weather is generally perceived as the source of much of the crop yield risk in crop agriculture. The literature investigating the most relevant sources of weather risk has increased dramatically in recent years as many have investigated various forms of weather derivatives. Because a weather derivative needs to be highly correlated with yield loss to be an effective risk management tool these studies have tended to sift through the various weather risk to identify the most important. For example, Salk *et al.* (2007) report that 20 to 30% of French GDP is affected by weather risk. They also report that French wine growers identify frost and hail as the most serious weather concerns.

Cafiero *et al.* (2007a) find that temperatures (minimum, mean and maximum, humidity and rainfall explain more than 86% of the variation of grape and wheat yield in the Tuscany region of Italy. Richards, Manfredo, and Sanders (2004), Turvey (2001), and van Asseldonk and Oude Lansink (2003) all focus on temperature risk. Other papers, such as Martin, Barnett, and Coble (2001) focused on rainfall as a source of weather risk in U.S. cotton. Musshoff, Odening, and Xu (2006) focus on precipitation risk in German agriculture as did Stoppa and Hess (2003) when investigating weather derivatives for Morocco and Breustedt, Bokusheva, and Heidelbach (2007) in Kazakhstan.

Other models such as that of Vedenov and Barnett (2004) for Southern and Midwestern regions of the United States, Xu, Odening, and Musshoff (2006) for Germany, and Tannura *et al.* (2008) for Illinois create indexes using both temperature and rainfall because tests of statistical significance show that those factors drive yield risk.

The U.S. federal crop insurance program reports the cause of loss for each indemnified insurance policy. Analyzing these data over a long period of time (1980-2001) reveals the primary causes of yield risk for major U.S. crops. Drought, excess moisture, and hail are the primary causes of yield risk for the major field crops: maize, cotton, soybeans, and wheat. Excessive moisture and freeze are the primary sources of yield risk for sugar beets. Excessive moisture, excessive heat, drought, and freeze are the primary sources of yield risk for potatoes. Drought, excess moisture, freeze, hurricanes, and excessive heat are important causes of yield risk for tomatoes and other vegetables. Freeze is the primary source of yield risk for citrus fruit. For other tree and vine fruit such as apples, grapes, pears, peaches, nectarines, and cherries, the primary sources of yield risk are frost, freeze, hail, and excessive moisture.

Production inputs and associated management strategies can be utilized to mitigate many of these sources of yield risk. Irrigation can reduce the impact of drought. For some crops, tiling fields can reduce the impact of excess moisture. Disease and pests can often be controlled somewhat by fungicide and pesticide applications. Genetically modified crops reduce the yield risk associated with certain insect pests. Some genetically modified crops target pests that feed on the roots of the plant. The result is a stronger and more developed root system that makes the plant more drought-tolerant. Effective mitigation strategies are less common for other perils (*e.g.* hail).

Other disasters and disease

Oerke and Dehne (2004) report estimates of crop losses for wheat, rice, maize, barley, potatoes, soybeans, sugar beet and cotton for the period 1996–1998 on a regional basis for 17 regions. Actual crop losses are estimated at 26–30% for sugar beet, barley, soybean, wheat and cotton, and 35%, 39% and 40% for maize, potatoes and rice, respectively. They also report weeds had the highest loss potential (32%) but also have a relatively high mitigation efficacy. Animal pests and pathogens are less important (18% and 15%, respectively). Finally, they report that although viruses cause serious problems in potatoes and sugar beets in some areas, worldwide losses due to viruses averaged 6-7% on these crops and less than 1-3% in other crops.

Crop prices

Supply shocks in crop input markets

The relatively small amount of research examining price shocks in input markets has focused almost exclusively on fuel and fertilizer prices. Evidence is provided above on the magnitude of the price variability of these inputs. That these two inputs are deemed significant risks is in part due to the fact that both tend to be relatively large components of input cost and that both fuel and many major fertilizer components are commodities themselves and subject to similar market forces as are crop output prices. Furthermore, there is a strong link between nitrogen fertilizer prices and fuel prices indirectly due to ammonia-based nitrogen often being produced from natural gas which also moves with crude oil prices. Groover (2005) reports a correlation of 0.79 between natural gas and nitrogen fertilizer prices.

Fuel costs have received significant attention of late due to increases in gas and diesel prices. Intuitively, these input prices are not commodity specific and may easily impact all enterprises on the farm simultaneously. Further, because OECD countries often import significant portions of their fuel needs, shocks in exchange rates and world agricultural and more importantly non-agricultural demand for fuel may cause fluctuations in the cost of agricultural fuels.

Demand shocks in crop output markets

Price risk for a particular commodity and region is caused by various factors. Deaton and Laroque (1992) provide a seminal discussion of the functioning of storable commodity markets with rational expectations. Earlier models had typically assumed a backward looking cobweb or distributed lag forms. In such markets, storage is an endogenous choice which is fundamental to the price variability of many agricultural commodities.

Goodwin and Sheffrin (1982) provide an early test of the rational expectations hypothesis in an agricultural market, concluding that a model of producer behaviour incorporating rational expectations outperforms models based on adaptive expectations. Shonkwiler and Maddala (1985) develop a detailed model for incorporating rational expectations into the estimation of supply and demand systems in the presence of specific commodity price supports for the U.S. maize market. Holt and Johnson (1989) also provide support for the rational expectation models. These findings are relevant to risk analysis as they imply subjective probability distributions of price and yield determine market equilibriums.

In these models, supply is typically composed of known inventories and expected production while demand is often decomposed into various demand sources. For example, grain market demand can be decomposed into feed, food, ethanol, and export use. Conceptually, these markets may have differing elasticities and bring separate price shocks to the market. For many crop markets models have identified the following major demand components:

- Export demand may be affected by yield shortfalls in other supplying countries or by demand shifts resulting from foreign market demand or policy shock.
- Feed and food use has been shown to depend on the market for livestock while food use may be shocked by sudden changes in consumer preferences. In many cases food safety scares create negative demand shocks in these markets.

- In some markets such as maize, bio-fuel production has created a new and dramatic component to demand.

Less storable crops, such as fruits and vegetables tend to function somewhat differently than major storable commodities. First, in many cases storability is less likely except in a processed form. This tends to accentuate price risk as temporal arbitrage is not possible [Henneberry *et al.* (1999) and You, Epperson, and Huang (1996)]. Fresh market crops tend to be higher valued then crops used in processing, but often both supply and demand may be quite seasonal. Fruits and vegetables also tend to be market segmented by variance in quality. A final distinction of non-commodity crops relative to commodity crops is that for non-commodity crops, markets are often geographically distinct which leads to less opportunity for geographical arbitrage which also would dampen price variability.

Livestock production

Hall *et al.* (2003) surveyed beef cattle producers in Texas and Nebraska regarding their perceptions of risk sources. Respondents were asked to rate sources of risk "in terms of their potential to affect your ranch/farm income" on a scale from one to five (with five being the highest). Severe drought (average score of 4.4) and cattle price variability (average score of 4.3) were reported to be the most significant sources of risk. The next cluster of scores (between 3.0 and 2.5) included in descending order of importance: variation in non-feed input prices; changes in government environmental programs; extremely cold weather; changes in government farm programs; hay price variability; and disease.

Hog producers in Indiana and Nebraska were surveyed about sources of risk by Patrick *et al.* (2007). In that study producers rated price risk highest on a five point scale. Following price risk were environmental and disease risk. However, independent producers (those whose production was not forward contracted to an integrator) were significantly more likely to rate disease risk higher than environmental risks. This study also highlights the differing risk environment of contract producers versus independent producers. The independent producers were significantly more concerned about input costs and market access than contracted producers.

Disease

It is interesting that survey respondents did not list disease as one of the most important sources of risk. However one must be careful in interpreting this finding. Animal diseases generally do not cause large-scale production losses in OECD countries, though governments sometimes order depopulation efforts to control highly contagious livestock diseases. Instead, the impact of livestock diseases is most often reflected in lower market prices (Shaik *et al.*, 2006). Following an outbreak of a highly contagious livestock disease, export demand often plummets as trading partners implement import restrictions to protect domestic herds. Depending on whether the disease can be transmitted to humans, domestic consumption may decrease significantly as well. As a result, all domestic producers are impacted by contagious disease outbreaks, not just those with infected animals. As an example, consider the December 2003 case of Bovine Spongiform Encephalopathy (BSE) in the United States. The disease was found in only one herd of cattle so production losses due to depopulation were miniscule. However the resulting fall in cattle prices cost U.S. cattle producers an estimated one-half billion dollars in lost market value in just the first quarter of 2004 (Gramig *et al.*, 2006). When such an event occurs, market losses will continue until producers are able to regain the confidence of trade partners and domestic consumers.

Unlike major crop perils such as drought, excessive moisture, or hail, diligent management can have a significant impact on animal disease risk. Particularly with confinement animal production, using best management sanitary practices can reduce the frequency and severity of many contagious livestock diseases. For this reason, Gramig *et al.* (2006) describe a country's disease-free status as a non-exclusive common property resource. All producers benefit from the disease-free status but maintaining the common property resource is highly dependent on the sanitary practices of individual livestock producers.

Weather risk

Confined animal operations appear to be subject to weather risk in a much different fashion that grazing agriculture. Confined dairy hog and poultry operations tend not to be subject to many risks such as drought in the same manner as grazing agriculture. However, extreme temperature and rainfall can create risks in these operations. For example, Deng *et al.* (2007) examined the effect of derivatives to mitigate the risk of milk production declines to due to high temperatures. For meat animals, growth rates decline in extreme cold or hot situations. Confinement facilities typically reduce these extremes, but at times will do so at significant cost such as required to cool poultry facilities.

In less intensive grazing agricultural, weather risk can result in significant reductions in available forage. In particular, drought can cause reduced rate of gain or in extreme cases require liquidation of herds (Stockton and Wilson, 2007). An analysis of Palmer Drought Severity Index (PDSI) values for the period from 1895 to 1995 indicates that most of the U.S. West experiences severe to extreme drought more than 10% of the time and a significant portion of the region more than 15% of the time. (Wilhite, 1997)

Livestock prices

Supply shocks in input markets

In the livestock sector, especially confinement feeding operations, feed ingredients represent a major portion of input cost. Thus, the output price risk observed in the grain crops is the primary input risk for the livestock producers. As discussed earlier a number of factors may influence the price of feed grains. These include fluctuation in export demand, yield shortfalls, and acreage shifts. Also, recent policy decision in several counties to produce bio-fuels has added to the demand for grain crops and thus driven up the price of feed used in the livestock sector. Similarly, shocks in fuel and fertilizer also affect livestock grazing profitability as was the case for crops.

Demand shocks in output markets

The output price risks of livestock markets reflect several characteristics similar to crop price risk. Foremost is the general lack of product distinction that leads beef, pork, sheep meat, and poultry products to behave as a commodity. However, a salient feature of many livestock production processes is that there are significant biological lags; and Rucker *et al.*, 1984). Further, Aradhyula and Holt (1990) as well as Chavas, Kliebenstein, and Crenshaw (1985) address modern confinement production which has not eliminated biological lags, but has created a dynamic flow of output. As with crops, trade shocks may arise through export markets and trade intervention.

Some of the most researched demand shocks are associated with health scares. We examine the results from several different events and countries. Lloyd *et al.* (2001) found that beef consumption temporarily fell forty percent in the U.K and some other European countries.

However, beef prices at the retail, wholesale and producer levels in the United Kingdom fell by 1.7, 2.25, and 3.0 pence respectively per kilogram in the long-run after the British government in 1996 announced a possible link between BSE and Creutzfeldt–Jacob disease. Burton and Young (1996), using a dynamic almost ideal demand system, found that BSE had significant negative impacts on British domestic beef demand. Leeming and Turner (2004) found a negative effect of the BSE crisis on beef price but a positive effect on lamb price in the United Kingdom.

As mentioned earlier, Gramig *et al.* (2006) found that the 2003 BSE discovery in the United States cost U.S. cattle producers nearly one-half billion dollars in lost value during the first quarter of 2004. Pritchet, Thilmany, and Johnson (2005) argue that the 2003 U.S. BSE discovery led to a 14% decrease in the choice boxed beef price and a 20% decrease in the fed cattle price between 22 December 2003 and 8 January 2004. Saghaian (2007) found that the same event caused a 6% reduction in retail prices, a 16% reduction in wholesale prices and a 21% reduction in feedlot prices. Schlenker and Villas-Boas (2006) found that futures prices on cattle and grocery store beef prices had comparable price decreases in response to the 2003 U.S. BSE event. Conversely, Piggot and Marsh (2004) find a minimal impact of food safety information on U.S. meat demand when one considers how quickly the effects dissipate. In another study examining hog and live cattle futures, Lusk and Schroeder (2002) find that beef and pork recalls tend to play out quickly.

Peterson and Chen (2005) find that following the BSE discovery in Japan in September 2001 there was a structural change in the Japanese meat market in September followed by a two-month transition. McCluskey *et al.* (2005) find that the consumption of domestic and imported beef in Japan drastically dropped by 70% in November 2001 two months after the Japanese BSE discovery.

In a recent study of Korean data, Park, Jin, and Bessler (2008) conclude that the 2000 domestic foot and mouth disease outbreak induced a structural change in the Korean meat price system. In contrast they find the domestic avian influenza and the U.S. BSE events in 2003 did not lead to any significant meat market structure. They go on to conclude that animal disease outbreaks caused temporary price shocks but the adverse impacts of the 2000 FMD outbreak dissipated and partly recovered over 6 months, and over the next 13 months for the AI/BSE incidents. However, a longer effect was seen in farm pork prices resulting from the 2000 FMD outbreak.

Niemie and Lehtonen (2008) is one of the most recent papers to examine the price risk associated with the outbreak of an epidemic disease. This study considered the case of Finnish pig producers. Results suggested that losses to pig producers can increase considerably when the risk of a prolonged export ban increases. Consumers can gain from a trade ban, because options to adjust supply in the short run are limited.

New concerns

Biotechnology

Agricultural crop yields for many crops have been increasing at a rapid rate. However the driving factors have varied. The causal factors have included hybrid seed for crops like maize, improved equipment, and new chemical herbicides to name a few. In recent years, significant attention has been directed toward how biotechnological change impacts the distribution of crop yields. While much of the research has focused on average yields, some literature has also addressed the implications for yield variability.

Kim and Chavas (2003) investigated the linkages between technological change and production risk, using data from Wisconsin maize experiment station plots. The empirical results indicate that technological progress contributes to reducing downside risk in maize production, although this effect varies across sites.

Carew and Smith (2006) examined Canadian canola yields using a Just-Pope production function. They observed yield heteroscedasticity in the data (*i.e.* increasing variability over time). They also found that hybrid and herbicide tolerant varieties experienced an increase in mean yield over time but did not have higher yield variability. In a similar study, Hurley, Mitchell and Rice (2004) examined Bt maize in the U.S. and found Bt maize can be marginally risk increasing or decreasing and can either increase or decrease maize acreage. Also, depending on the price, Bt maize can provide a risk benefit to farmers, even when Bt maize is risk increasing.

Crost and Shankar (2008) examine the adoption of Bt cotton in India and South Africa. Interestingly they note adoption bias in the data suggesting better farmers are earlier adopters of this technology. Controlling for this effect, they find Bt technology risk reducing in India but not in South Africa.

Snow *et al.* note the potential positive production effects of GMOs in developed and developing countries However, they also identify five primary environmental risks: (1) creating new or more vigorous pests and pathogens; (2) exacerbating the effects of existing pests through hybridization with related transgenic organisms; (3) harm to nontarget species, such as soil organisms, non-pest insects, birds, and other animals; (4) disruption of biotic communities, including agro-ecosystems; and (5) irreparable loss or changes in species diversity or genetic diversity within species.

Aslaksen, Natvig, and Nordal argue that GMOs demand new approaches to risk assessment, risk management and risk communication. In particular they advocate applying the precautionary principle to GMO risk. Moreover, they discuss Bayesian analysis in the context of improving the informational basis for decision-making under uncertainty. They argue that more myopic risk analysis may seriously mischaracterize the economic consequences of environmental uncertainties.

Clapp (2008) addresses the direct legal liability for producers that has arisen in a number of cases of “accidental” or “unintentional” releases of genetically modified organisms (GMOs) that were not approved for human consumption or for commercial planting. Clapp noted that the agricultural input industry has instituted Corporate Social Responsibility reporting and some are participants in the UN's Global Compact. However she goes on to argue that these measures have proven weak and that external, state-based regulation which places liability on firms is more likely to prevent illegal releases.

Climate change

The topic of climate change has attracted significant attention in a relatively short period of time. We found several studies addressing climate change but the lack of historical and experimental data has lead to an emphasis on the use of simulation and other modelling techniques.

The potential impact of climate change on crop production in the Netherlands using a whole farm portfolio analysis approach was examined by van Asseledonk and Langeveld (2007). Projected joint crop yield distributions were derived from crop growth models so that projected impacts of weather conditions could be compared with historic data. The results for a representative Dutch farm with potatoes, sugar beets and winter wheat show projected crop yields and ultimately farm income increased due to more favourable climate conditions, even when the risk of poor performance of a particular crop due to extreme weather conditions increases. Increased risk of crop failure and income loss due to climate change was not confirmed. The authors suggest this is, in part, due to the fact that poor yields often have positive effects on farm income due to increased crop prices in times of relative commodity shortages.

Quiggin and Horowitz (2003) argue that the costs of climate change are primarily adjustment costs. They conclude that climate change will reduce welfare whenever it occurs more rapidly than the rate at which capital stocks (interpreted broadly to include natural resource stocks) would naturally adjust through market processes. They do note that costs of climate change can be large even when lands are close to their climatic optimum, or evenly distributed both above and below that optimum.

Fuhrer *et al.* (2006) report a study on climate risk impacts on agriculture and forests in Switzerland. Their models project more frequent heavy precipitation during winter which increases the risk of large-scale flooding and loss of topsoil due to erosion. In contrast, they find that constraints in agricultural practice due to waterlogged soils may become less in a warmer climate. Fuhrer *et al.* also find a decrease in the frequency of wet summer days, and shorter return times of heat waves and droughts.

Torriani *et al.* (2007) also examine the effect of climate change on crops in Switzerland. They conclude that climate change is expected to affect both the average level and the variability of crop yields. Climate change effects on the mean yield of maize and canola were consistently negative, but they found a positive impact on the mean yield of winter wheat for elevated CO2 concentrations. The yield CV increased for maize and canola, but decreased for wheat.

Xiong *et al.* (2007) assessed China's potential maize production given alternative climate change scenarios using the PRECIS Regional Climate Model. Without the CO2 fertilization effect, China's maize production was predicted to suffer a negative effect under most scenarios with the largest production decreases occurring in today's major maize planting areas. When the CO2 fertilization effect is taken into account, production was predicted to increase for rain-fed maize but decrease for irrigated maize.

Howden *et al.* (2007) examined the adaptations of agriculture to climate change. They note that there are many potential adaptation options available for marginal changes to existing agricultural systems, often variations of existing risk management techniques. However, they go on to conclude that there are limits to the effectiveness of these strategies under more severe climate changes.

John, Pannell, and Kingwell (2005) investigated how changes in climate would affect agricultural profitability and management systems in Australia. Using a whole-farm linear programming model, with discrete stochastic programming to represent climate risk, they find that climate change may reduce farm profitability in the study region by 50% or more compared to historical climate conditions. In their model this leads to a decline in crop acreage due to greater probability of poor seasons and lower probability of very good seasons.

Chang (2002) modelled the potential impact of climate change on Taiwan's agricultural sector. Yield response regression models were used to investigate the impact of climate change on 60 crops. Results suggest that both warming and climate variations have a significant but non-monotonic impact on crop yields. Society as a whole would not suffer from warming, but the study does conclude a precipitation increase may be devastating to farmers.

A synthesis of the climate change literature which provides clear measures of climate change implication for crop yield variability is reported in Table 4.10. Most models rely on some form of crop growth simulation models. The time periods examined are generally for at least thirty years in the future. Results are quite varied across studies. There appears to be a more cases where mean yields increase than decline, especially if CO^2 fertilization is considered. The effect of climate change on yield risk is much less clear from the relatively few studies that provide quantified results (many studies focus solely on the first moment effects of climate change. Further, these studies seldom address the speed of climate change onset; however it appears that the time spans evaluated suggest gradual increases in climate change relative to the time-span of most risk management tools in use.

Table 4.10. Comparison of climate change studies addressing crop variability

Author and date	Study area	Analytical method	Time period	Mean effect	Variability effect
Chang (2002)	Taiwan 60 crops	Regression and math programming	Not reported	Mostly positive	Mostly negative
Fingers and Schmidt	Switzerland				
	Maize			+	-
	Wheat			+	-
Fuhrer *et al.* (2006)	Switzerland Mixed crops	Simulation	2058-2108	-	-
Harle *et al.* (2007)	Australia	Simulation	2030		
	Wool			-	-
Isik and Devadoss (2006)	U.S. Idaho	Just-Pope Production function	2025-2034		
	Wheat			+	-
	Barley			-	-
	Potatoes			+	+
	Sugar beets			-	+
Lobell *et al.* (2006)	U.S. California perennial crops	Simulation	2050	-	+
Richter and Semenov (2005)	England Wheat	Simulation	2020-2050	+	-
Toriani *et al.* (2007)	Switzerland	Simulation	2071-2100		
	Maize			-	+
	Canola			-	+
	Wheat			+	-
Van Asseldonk *et al.*	Netherlands	2050			
	Potato			+	+
	Sugar beet			+	+
	Winter wheat			+	+
Xiong *et al.* (2007)	China Maize	Plant growth simulation		Mixed (conditional on CO^2 Assumptions	None

Policy reform

WTO compliance and risk management

Historically, governments in OECD countries have used various combinations of four general mechanisms to provide direct benefits to producers of agricultural commodities. The first of these are price or income supports that are tied directly to agricultural production and prices.[4] These supports provide opportunities for farmers to receive effective prices for their agricultural commodities that are higher than prevailing market prices. In exchange for receiving higher effective prices, farmers may be required to "set-aside" (not plant) some of their land. A second general mechanism includes various types of border protection such as import quotas and tariffs. Border protections tend to maintain domestic prices that are higher than world market prices. When price or income support programs are in place, border protections are often necessary to support domestic market prices and thus reduce the cost to the government of the price or income support program. The third general mechanism is "decoupled" transfer payments to farmers that are not tied to production of any particular commodity or to market prices. The fourth mechanism is various types of disaster payment or subsidized agricultural insurance programs that compensate farmers for production or revenue shortfalls.

In recent years, many OECD countries have shifted much of their agricultural support from price or income supports to decoupled payments. There has also been a general tendency toward reducing border protections for agricultural commodities through various bilateral trade agreements. Widespread multilateral reduction of border protections is likely contingent on a successful resolution to current World Trade Organization (WTO) negotiations. Disaster payment and subsidized agricultural insurance programs are utilized extensively in some OECD countries.

As the European Union and the United States have moved more of their agricultural supports to fixed decoupled payments questions have been raised about the risk effect of these transitions. Simple non-dynamic analysis of risk suggests that a shift from a price responsive program to a non-stochastic program would decrease risk protection afforded producers. However, this ignores the potential for producers to save and borrow across time. Thus, fixed payments could be used to smoothing income if the producer chose to use the funds in that manner.

It also merits attention that many government risk management programs are redundant with private risk management tools. A clear example, is price support programs such as U.S. marketing loan programs and revenue insurance program that strongly compete with private risk management instruments such as futures contracts and forward pricing contracts (Coble, Miller, Zuniga, and Heifner, 2004).

Macro-economic shocks

In OECD countries, exchange rate variability affects farmers primarily through its impact of export and import markets and thus, domestic prices (Cho, Sheldon, and McCorriston, 2002; Pick and Vollrath, 1994; Pick, 1990). Changes in real interest rates (nominal interest rates minus the rate of inflation) affect both production costs (through the cost of credit) and asset values. Barnett (2000) describes how the U.S. farm financial crisis of the early 1980s was caused by significant monetary policy changes implemented in 1979.

Sawada (2007) provides a detailed overview of the impacts that manmade or natural catastrophe have on household welfare. Catastrophes considered included natural disasters and wide-scale economic down turns. Importantly they assess ex ante and *ex post* risk management strategies. Sawada also makes an important distinction between diversifiable risk and non-diversifiable risk. Sawada shows that ex ante insurance and insurance-like mechanisms are likely to perform poorly for rare unforeseen events. Ultimately, Sawada argues that credit availability is likely an essential risk-coping strategy which is particularly relevant during the recent credit crisis of 2008.

Blancard *et al.* (2006) find empirical evidence of credit and investment constraints among French farmers. They conclude that financially unconstrained farmers are larger, are financial more sound and make more productive choices. Bessant (2007) argue that financial crisis and similar terms are usually not meaningful as used by political leaders. Bessant goes on to identify four main criteria for an "agricultural crisis": 1) farm financial difficulties (low or unstable incomes, indebtedness, and increasing reliance on nonfarm revenue), 2) structural changes in agriculture (increasing scale, concentration, and consolidation), 3) dwindling communities, institutions, and services, and 4) international factors such as market fluctuations, trade regulations, and disputes.

Shane and Liefert (2000) argue that exchange rates, consumer income and interest rates are the key macro-economic variables likely to affect agricultural producers. All these factors influence agricultural trade. Consumer income declines reduce the demand for agricultural goods and interest rates affect both consumers and the producer's cost of borrowing.

Breustedt and Glauben (2007) use regional data for 110 regions in Western Europe to indicate that exits from farming are strongly influenced by farm characteristics and policy conditions. They conclude that "exit rates are higher in regions with smaller farms and are closely related to production structures. Exit rates are lower in regions with more part-time farming, high subsidy payments and high relative price increases for agricultural outputs." They conclude that off-farm income and government intervention have slowed down structural change in European agriculture.

Subservie (2008) analyses the effect of world price instability on agricultural supply from developing countries and addresses the extent that the price instability effect is dependent on macroeconomics. She concludes that producers from agricultural exporting countries are particularly vulnerable to the fluctuations of world prices. Importantly the ability to cope with price instability is found to be conditional upon macroeconomic factors such as infrastructure and inflation. Using panel data for 25 countries between 1961 and 2002, Subservie finds the expected negative effect of world price instability on supply. In addition, the macroeconomic factors of high inflation, weak infrastructure and a poorly developed financial system exacerbate the problem.

The literature on changes in government macroeconomic policy suggest that these can also be a major source of risk for agricultural producers. Macroeconomic policies affect exchange rates, interest rates, and the rate of inflation, all of which directly affect many agricultural producers. Our assessment is that the literature on these topics has been fairly sporadic in response to the economic context of the time.

Policy and trade shocks

While various government policies can be used to reduce farmers' exposure to risk, the potential for changes in government policies is itself a major source of risk. As indicated above, government agricultural support programs change over time. The European Union's CAP was changed in 1999 and 2003. U.S. agricultural policy changes approximately every five years when a new "farm bill" is adopted. Modest changes occur even more frequently in response to changing market conditions, government budget constraints, or trade negotiations. Increased variability in farm wealth is likely the most important impact of changes in government agricultural policies. Gardner (2001) provides a comprehensive discussion of the risk implications of changing government agricultural policies.

Obviously, farm policy changes cause variability in farm revenues. However, since farm revenues (including government program benefits) are capitalized into the value of farmland and other specialized agricultural assets, these changes also cause variability in the value of farm assets and hence, wealth (Duffy *et al.*, 1994; Barnard *et al.*, 1997; Beach, Boyd, and Uri, 1997; Weersink *et al.*, 1999; Oltmer and Florax, 2001; Roberts, Kirwan, and Hopkins, 2003; Shaik, Helmers, and Atwood, 2005; Lagerkvist, 2005; OECD, 2008).

As this is being written, the World Trade Organization (WTO) is engaged in a round of trade negotiations focused on reducing agricultural subsidies. Should this round of negotiations result in an agreement that significantly reduces agricultural subsidies, this will certainly have an impact on cotton, sugar, cereals and oilseeds farmers (the commodities that receive the largest share of agricultural subsidies). Reduced subsidies would not only affect farm revenues but also the value of farm assets that were purchased with an expectation of continued government support. However, if a WTO agreement also reduces global border protections for agricultural commodities, farmers in many OECD countries would benefit from increased export opportunities. Regardless, the uncertainty associated with multilateral trade agreements is another important source of risk for agricultural producers.

Recent efforts to move from non-renewable to renewable fuels has created new and significant demand for maize in the United States, sugarcane in Brazil, and soybeans in Europe. Government subsidies for biofuel production have contributed to significantly higher prices for some agricultural commodities. Farmers are currently faced with tremendous uncertainty regarding the longevity of these high commodity prices as policy-makers in both the U.S. and Europe reconsider government subsidies for biofuels.

Animal diseases

While difficult to analyze, livestock producers appear to have a concern regarding the possibility of new and unknown diseases that have never occurred at least in their region. Recent attention to the potential for high pathogen avian influenza illustrates this point. The perceived risk magnitude and the economic consequences of such a risk are quite difficult for even professionals to assess. Much of the literature in this area tends to be conditioned upon an outbreak. For example, Ekboir (1999) estimated that potential losses due to a hypothetical FMD outbreak in California would amount to USD 13.5 billion. Similarly, Schoenbaum and Disney (2003) estimated that net changes in consumers' and producers' surplus due to a hypothetical FMD outbreak in the United States would amount to USD 789.9 million annually.

Much of the recent research in this area has focused on sub-optimal behaviour of producers given that many diseases spread from herd to herd and that bio-security and disease mitigation efforts represent an unvalued positive externality to adjoining farms. Gramig, Horan, and Wolf (2005) address the potential moral hazard problem of validating incentives to encourage risk mitigation. Bicknell, Wilen, and Howitt (1999); Ott (2006); Shaik *et al.* (2006); and Hennessy, Roosen and Jensen (2005) all have addressed the policy incentives to induce greater risk mitigation of these low probability events. In a related paper, von Asseldonk *et al.* (2005) examine the potential for a public/private partnership to protect against livestock diseases.

Huirne *et al.* (2005) provide an overview of a variety of animal disease control issues in the European Union and point out the economic consequences of various diseases often vary dramatically from one farm to another. Nielen *et al. (*1999) conducted a financial analysis of Classical Swine Fever outbreaks in the Netherlands. There results include an assessment of the financial consequences for governments, farms, and related industries. They conclude the costs of the 1997/1998 outbreak are USD 2.3 billion. Losses for farmers and related industries are USD 423 million and USD 596 million respectively. In a related study Meuwissen *et al.* (1999) address the significant cost increase incurred by the Dutch poultry industry to manage the financial risk of poultry epidemics. The potential for High-Pathogenicity Avian Influenza (HPAI) epidemics has contributed to insurance costs incurred by the industry (Meuwissen *et al.*, 2006).

An assessment of primary risk factors and changes occurring over time

A synthesis of the literature on crop risk clearly identifies crop yield, output price and to a lesser extent input prices as the major risks confronting crop producers. Clearly, weather dominates the body of literature addressing cause of crop yield risk (Deng, Barnett, and Vedenov, 2007). While, irrigation and other modern production practices may mitigate some weather risk, these practices are not cost effective in many production systems. Further as competition arises for water resources in many locations, widespread increases in irrigation are unlikely.

It is useful to note the specific aspects of weather that induce losses. Once one reaches this degree of detail, rainfall and temperature tend to dominate the research findings. With both rainfall and temperatures, extreme high and low values are usually detrimental to crop growth. The recent explosion of weather derivative research has led to significantly broader knowledge of the specific relations between weather factors and yields. It appears that functional forms and parameterizations of the yield-weather relationship are not robust in the sense that effective models need to be re-estimated as one moves across crops and regions.

Price risks affect crop producers in both the input and output markets. Clearly the literature examining output prices dominates input price risk literature by a wide margin. Further, producer surveys asking for a ranking of risks suggests output price is generally of greater concern to producers (Coble *et al.* 1999). Of the input risks that have been studied two stand out: fuel and fertilizer prices. The data we observe suggest that fertilizer and fuel tend to be commodities and subject to price fluctuations much like all other commodities. An interesting side note is that futures markets exist for fertilizer and fuel but are seldom used by producers in part because contract sizes are too large to be practical for all except the largest of farms. Further it appears that fertilizer and fuel price risk is equal to or greater than output price risk for most major commodities. The causes of fertilizer and fuel risk appear to be linked somewhat as nitrogen fertilizer is often produced from energy sources and in some instances due to significant fertilizer transportation cost (Dhuyvetter, Dean, and Parcell, 2003). However, price fluctuations in fuel prices are clearly driven by non-agricultural demand and supply issues. Perhaps the recent price shocks in both fertilizer and fuel markets will encourage researchers to augment the very limited amount of research available on input price risk.

Output price risk in crop commodities has been addressed widely for different crops and for many locations (Shonkwiler and Maddala, 1985). The literature describing the causes of price risk clearly identifies production shocks from major production regions as a source of variability. Thus, weather events such as droughts and flood in major production regions tend to matter. It is also important to distinguish storable commodities from non-storable commodities as stock-holding can reduce intertemporal price volatility. Various shocks may also arise from the demand side of the market. For crops traded in international markets, policy changes and exchange rate changes are both potential market shocks. Several crop commodities have multiple uses creating a composite demand that may be shocked by various factors. Many major crops such as maize and wheat have both feed and food uses which may diversify demand somewhat. We would also note that recent efforts to produce bio-fuels have added a new dimension to some crop markets. In effect, this ties the demand for maize and sugarcane-based ethanol and soybean-based bio-diesel to the price of oil, various government policies related to energy markets, and trade policies affecting these emerging markets.

Our review of the literature also suggests that markets for non-storable products such as some fruits and vegetables function somewhat differently than markets for storable commodities (Henneberry, Piewthongngam, and Qiang, 1999). Often there is variation in quality and grades which add to the complexity of the market and perishability tightens the supply and demand window. In many cases these markets are more geographically limited which reduces spatial arbitrage opportunities. This suggests greater price risk in these markets.

A synthesis of livestock production risk depends critically on whether modern confinement production systems are used (Aradhyula and Holt, 1990). If so, many production risks may be reduced although disease risk may be concentrated. Some livestock production systems continue to rely heavily on grazing which does leave the livestock producer subject to much of the same temperature and rainfall risk faced by crop producers. Livestock price risk also occurs in the input and output markets. Clearly, grain-based feeds are a major input cost which makes output price risk for crops like maize a major input price risk for many livestock enterprises. The aforementioned fertilizer and fuel price risk can also apply to grazing operations.

Output price risk in livestock generally reflects limited storability of slaughter-ready livestock and cyclical behaviour due to relatively long biological lags. Another dimension of these industries is the advent of strong vertical integration in livestock agriculture. For example, many U.S. poultry producers do not own the animals and thus do not confront price risk in the typical fashion. Recent disease events such as BSE have created significant shocks in livestock markets across several countries. These events have been widely studied. Some studies suggest that many disease-related price shocks have sharp, but relatively short-term, price impacts. Other studies find long-term effects.

Finally, we address some of the looming trends likely to alter the agricultural risk environment in coming years. First, the advent of bio-technology based traits appears to alter not only mean yields but the variability of yields as well. Recent claims of reduced yield risk for bio-tech crops have been validated in some studies. The genetic improvement, however, appears to be proceeding much faster than risk research can validate with long time-series data. It is interesting to note that the U.S. federal crop insurance program recently approved a rate reduction for a particular bio-technology enhanced seed variety based on evidence of reduced yield risk. As biotechnology moves forward, the risk profile of crop agriculture may evolve rapidly.

Recent attention to climate change issues has resulted in a rapidly expanding body of literature on the effect of climate change on production agriculture. It appears several important agricultural risk issues are obvious. First, alteration of rainfall and temperature patterns would cause shifts in the feasible production area and weather risks confronting producers. These changes may cause shifts in the value of agricultural assets at a specific location. It does appear that the rapidity of climate change is also a crucial issue. If climate change occurs gradually, producers may have sufficient time to adapt to the changes without significant losses. Thus, the real risk implications of global climate are related to changes in the second and higher moments of the yield distribution and how accurately that can be assessed.

Policy risk remains relevant as unanticipated government action may alter expectations of agricultural enterprises with fairly fixed assets. Among the shock affecting agriculture are exchange rates and fiscal policies. Looming uncertainties include bio-fuel production policy and continued evolution of trade policy.

Producer risk perceptions and preferences

Risk perceptions

In this section we review the empirical literature that addresses producer subjective risk perceptions. First, we address general rankings of major agricultural risks. Then we review literature that compares elicited subjective probabilities to objective estimates of the same risk.

Identification of primary risks

Coble *et al.* (1999) surveyed U.S. crop farmers regarding their risk perceptions. The responses indicated that price risk and yield risk were the farmers' primary concerns. Patrick *et al.* (2007) surveyed U.S. hog producers and asked them to rate, on a scale of 1 (low) to 5 (high), a number of sources of risk in terms of their potential to affect the operation's income from hogs. Hog price variability was rated the highest source of income variability at 4.28 and was followed by changes in environmental regulations (3.92) and disease in hogs (3.90). Similarly, Hall *et al.* (2003) asked beef producers to rate the risks that they faced. Drought and price variability were rated the highest (4.4) and (4.3). The third highest rated risk was non-feed input price variation. Meuwissen *et al.* (2001) also identified the primary risks observed among Dutch livestock farmer. Output price received the highest score with disease a clear second. Flaten *et al.* (2005) conducted a similar study of Norwegian organic and conventional dairy farmers' perceptions of risk and risk management. Organic farmers appeared the least risk averse of the two groups. Further, institutional and production risks were perceived as primary sources of risk, with concerns about reductions in farm support payments at the top of the list. Compared to their conventional producers, 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.

Table 4.11 provides a summary of the ranks various studies have provided. The top five risks as ranked by average Likert scale scores for the surveyed producers are identified by study. One can observe price risk being ranked as either top or second place for all five studies. The concern for other categories is less clear. Production risk is either first or second in three studies that do not include confinement livestock production. Disease and input price risk also are noted in four of six studies. Disease ranked high in specialty crops and confinement livestock operations. Input price risk is not highly rated as a risk in specialty crops and Dutch livestock farms.[5]

Table 4.11. Comparison of studies identifying farmers' primary risk concerns

Authors Producer group	Coble *et al.* (2005) US row crop producers	Blank, Carter, McDonald California specialty crops	Patrick *et al.* (2005) Independent US hog producers	Hall *et al.* (2005) US beef cattle producers	Flaten *et al.* (2005) Norwegian dairy farmers	Meuwessen *et al.* (1999) Dutch livestock farmers
	Ranking of top five perceived risks					
Production risk	2	2		1		
Disease		4	2		5	2
Freeze (extreme cold)		3		5		
Input price	3		5	3	4	
Output price	1	1	1	2	2	1
Pests		5				
Environmental regulations	5		3	4		
Market access			4	n.a.		
Farm program uncertainty	4				1	
Animal welfare policy					3	
Illness or death of operator					5	3

Perceived risk magnitude

Eales *et al.* (1990) compared producer subjective price distributions to objective futures-based price expectations and volatility of price. Notably they find that producer subjective price expectation is quite accurate. However, producers' subjective variances are found to generally be less than those implied by the options market.

Pease (1992) compared subjective and historical (objective) probability distributions for crop producers from Kentucky. In many cases there were wide discrepancies between the two estimators. This was true in both the estimated mean and the variance of yields.

Egelkraut *et al.* (2006) used survey data from Illinois maize farmers to investigate the relationship between subjective and objective yield measures. They found that farmers viewed themselves as having better than average yields and lower than average variance of yields. They also found that over and under confidence influence farmers' crop insurance purchasing decisions. The effects are not symmetric in that overconfidence is primarily reflected in a farmer's belief that his/her yields are higher than average while under-confidence emerges mainly from a belief that his/her yields exhibit higher variability than average.

Blank, Carter, and MacDonald also elicited producer risk concerns from California crop producers in 1992. This survey included producers of several specialty crops such as grapes, lettuce, and processing tomatoes. Their study asked for a ranking of various risk sources. Output price risk was most often ranked first with drought second. Two more production risks, freeze and disease, were the third and fourth most common risks reported.

Risk preferences

Are producers risk averse?

Decision maker preferences about risk are fundamental to understanding behaviour in the presence of risk. It also follows that understanding farm risk preferences is essential to evaluating agricultural policy intended to assist producers in the management of agricultural risk. By far the most widely accepted model for understanding choices between risky outcomes is expected utility theory as formalized by John von Neumann and Oskar Morgenstern (1947). Their axiomatic representation of risk preferences allow for risk aversion, risk seeking behaviour and risk neutral behaviour. Pratt (1964) built upon their work by defining a risk aversion coefficient defined in terms of the curvature of the utility function. The Arrow-Pratt absolute risk aversion (ARA) measure may be written:

$$ARA = -\frac{U''(W)}{U'(W)}$$

where U is the producer utility function defined over ending wealth. Also, U' and U" denote the first and second derivative of utility respectively. Given the standard assumption that producers prefer more wealth than less, the first derivative is positive. The second derivative determines whether the producer is risk averse, neutral or risk loving. Risk aversion results from U" < 0. As noted in OECD (2004), it is common to consider subclasses of risk aversion including constant absolute risk aversion (CARA) and decreasing absolute risk aversion (DARA).

The related measure relative risk aversion (RRA) scales risk aversion by ending wealth such that

$$RRA = -\frac{U''(W)}{U'(W)}W$$

Again, there are common subclasses of RRA, most notable is constant relative risk aversion (CRRA). CRRA implies that the level of ending wealth does not affect preferences.

Since these seminal studies, expected utility theory has dominated the conceptualization of how decision makers evaluate risk. This holds generally, but in agriculture as well. It merits note that several more restrictive non-expected utility models of risk preferences have been widely used in agriculture. For example mean-variance models (Freund, 1956), but we would argue largely because of tractability rather than conceptual validity. Another vein of agricultural risk literature — stochastic dominance — is conceptually based in expected utility, but avoids having to know the degree of risk aversion for the decision maker. The limit of these studies is that they shed little light on producer preferences.

In this section, we focus on the literature that specifically has attempted to characterize the risk preferences of agricultural producers. Nearly all this literature is based on the expected utility model. However, one needs to recognize that numerous studies finding behavioural anomalies have been observed that conflict with the expected utility assumptions and variant models have been introduced, *e.g.* see Starmer (2000) and Fredrick, Loewenstein, and O'Donoghue (2002) for reviews. We would suggest that alternative models such as prospect theory (Kahneman and Tversky, 1979) have not been widely adopted to evaluate agricultural producer risk due to complexity and other limits on empirical application.

Quantifying risk preferences

Various studies have attempted to estimate the risk preference of producers. Given the importance of risk analysis in agriculture, these studies have important implications. However, that empirical data required in most cases is quite difficult to obtain. OECD (2004) followed Young's (1979) categorization of risk preference estimation into three groups: first, direct elicitation of utility functions which typically has involved posing hypothetical choice games to the producer. The second approach is categorized as experimental methods. This approach has gained increasing favour over the years among economist and involves placing farmers in a controlled context and observing choices among real monetary payoffs. However these payoffs typically are of small value and often have been criticized for potentially being subject to a scale effect. Finally, the third approach and most often used in the literature is observed economic behaviour. This approach uses *ex post* behavioural data in some real-world economic decision such as acreage allocation and then estimates risk preference parameters from these choices. Typically, econometric techniques are used, but some studies such as Brinks and McCarl (1978) calibrated a programming model instead. As noted in OECD (2004) comparison of absolute risk aversion estimates are difficult because the risk aversion estimate is dependent on prices, quantities or income. Relative risk aversion measures, on the other hand, can be compared because they are independent of ending wealth. However comparisons across countries are always tenuous due to different institutional frameworks.

We begin with a quick summary of risk aversion estimates estimated in a fashion that precludes comparison. For the most part these are studies estimated under the assumption of constant absolute risk aversion. A related study by Bard and Barry (2001) used Illinois crop farmer data to examine risk attitudes using a non-parametric "closing-in" procedure and also developed a multi-attribute scale. Interestingly, Bard and Barry conclude, "The responding farmers, on average, self-assessed their risk attitudes as slightly risk-seeking. However, their responses to utilization of risk management tools and the "closing-in" method indicated mild degrees of risk aversion." More recently, Gardebroek (2006) estimated risk aversion among organic versus non-organic producers in the Netherlands. Using a Bayesian version of Antle's (1987) approach, Gardebroek found that organic farmers were on average significantly less risk averse than non-organic producers. This paper also notes what several papers also found: significant heterogeneity of preferences across individuals is typically found when the procedure allows for heterogeneity to be addressed.

Several other papers have attempted to identify the risk preferences of agricultural producers. To facilitate a summary of the findings Table 4.12 categorizes the results into two categories the first group finds some evidence of risk loving behaviour. The second group finds a preponderance of risk averse preferences. The study by Pennings and Garcia (2001) using data from hog farmers in the Netherlands finds evidence of risk seeking behaviour among producers. However, their more general conclusion is that risk preferences are more complex than can be represented by a single dimension. Ultimately this result appears to be an outlier among papers that generally find that risk aversion is well supported in at least a significant percentage of producers.

Table 4.12. Summary of papers examining agricultural risk preferences

Some risk neutral or risk loving preferences	Risk aversion in most or all cases
Collins, A., W.N. Musser, and R. Mason, (1991) – 30-32 risk loving King, R.P., and G.E. Oamek (1983) – 70% Mixed Lin, W., G. Dean, and C. Moore (1974) – 17% mixed Tauer, L.W. (1986) 26% risk loving Thomas, A.C. (1987) 13% Risk loving Pennings and Garcia (2001) – Mostly risk loving Wilson, P.N., and V.R. Eidman (1983) – 22% Risk loving	Brink, L., and B. McCarl (1978) Chavas, J.-P., and M.T. Holt (1990) Chavas, J.-P., and M.T. Holt (1996) Gardebroek (2006) Gómez-Limón, J.A., L. Riesgo and M. Arriaza (2002) Hennessy, D.A. (1998) Hildreth, C., and G.J. Knowles. (1982) Lansink (1999) Lien (2002) Love, H.A., and S.T. Buccola (1991) Pope R.D. and R.E. Just, (1991) Ramaratnam, S.S., M.E. Rister, D.A. Bessler and J. Novak (1986) Saha, A. (1997) Saha, A., C.R. Shumway, and H. Talpaz (1994) Schurle, B., and W.I. Tierney, Jr. (1990)

Because our purpose in this chapter is to compare risk aversion across farms and regions, the literature couched in terms of CRRA is more useful. Thus, we concentrate on a summary of studies reporting CRRA estimates. These parameter estimates are reported in Table 4.13. This table builds upon the tables reported in OECD (2004) and the paper by Gardebroek (2006)

Table 4.13. CRRA parameter estimates

Authors	Farm Type	Country	Minimum	Mean	Maximum
Antle (1987)	Crop farmers	India	-0.1	0.82	1.4
Bar Shira *et al.* (1997)	Crop farmers	Israel		0.611	
Brink and McCarl (1978)	Crop farmers	United States	0	~0.22	> 1.25
Bontems and Thomas (2000)	Crop farmers	United States		3.7174	
Chavas and Holt (1996)	Maize and soybean farmers	United States	1.41		7.62
Kumbhakar (2002)	Salmon producers	Norway		0.051	
Lence (2000)	All farms	United States	1.136	1.136	1.136
Lien (2002)	Crop farmers	Norway	0.1	2.2	10.8
Love and Buccola (1991)	Crop farmers	United States	2.4	10.6	18.8
Oude Lansink (1999)	Crop farmers	Netherlands	0.2		0.31
Saha, Shumway, and Talpaz (1994)	Wheat farmers	United States	3.8	4.6	5.4

Antle (1987) econometrically estimated producer risk preferences from data derived from south-central Indian rice farmers. He found these farmers to be both Arrow-Pratt and downside risk averse but quite heterogeneous in their risk preferences which ranged from nearly risk neutral to risk averse with a risk premium as high as 25% of expected income. The CRRA coefficients from this study ranged from -0.1 to 1.4. Brinks and McCarl (1978) used a programming approach which precluded risk loving behaviour. Thus, the minimum CRRA was found to be 0 in their study. There results were reported in ranges with an average of approximately 0.22. This is suggestive of near-risk neutrality. Bontems and Thomas (2000) estimated an average CRRA of 3.717 using U.S. data. Saha, Shumway, and Talpaz (1994) followed Antle's (1987) study with another econometric study which suggested a more flexible functional form for the utility function. Using data from Kansas wheat farmers they also found farmers to be risk averse with relative large values ranging from 3.8 to 5.4. Chavas and Holt (1996) used aggregate U.S. data to find CRRA ranging from 1.41 to 7.6 while Lence (2000) also used U.S. data and found a relative risk aversion coefficient of 1.136; and Bar-Shira *et al.* (1997) studying crop farmers from Israel found an average CRRA parameter of 0.611. Kumbhakar's (2002) study of Norwegian salmon producers concluded that the subjects examined fell into the lower end of typical risk aversion ranges with an average CRRA value of 0.051. Lien (2002) used Norwegian crop data to estimate CRRA parameters that varied between 0.1 and 10.8. Love and Buccola (1991) used U.S. crop farm data to estimate CRRA parameters that are well above those of any other study compared in Table 4.13. Love and Buccola found a minimum CRRA of 2.4 and a maximum of 18.8 which is more than double the next highest estimate. Finally, Oude Lansink (1999) estimated CRRA using data collected from crop farmers in the Netherlands. This study found CRRA values that were relatively low compared to other studies. The range was from 0.21 to 0.31

In summary, a synthesis of these studies suggests several conclusions regarding risk aversion across farmers and regions. First, only two of eleven studies suggest either risk neutrality or risk loving behaviour. In several studies the minimum CRRA was well above zero. Thus, it seems clear that a great deal of evidence supports the risk aversion assumption. While, producers in several countries were subjects of these studies, US data dominated. Our review of the literature suggests the variation across studies likely has much more to do with differences in estimation procedures than with the region or agricultural product produced. In the end, it seems that this summary is fairly Consistent with the characterization of Anderson and Dillon (1992) who provide a general guideline shown in Table 4.14.

Table 4.14. Anderson and Dillon risk aversion categories

Relative risk aversion coefficient	Anderson and Dillon characterization
0.5	Hardly risk averse
1.0	Somewhat risk averse (normal)
2.0	Rather risk averse
3.0	Very risk averse
4.0	Extremely risk averse

The primary discrepancy between the empirical estimates and the Anderson and Dillon classification is that there is some empirical evidence of CRRA values beyond 4. OECD (2004) chose a range of zero to five which appears a reasonable generalization of the Anderson and Dillon rule of thumb.

Extension of expected utility

A limited set of papers have empirically investigated relaxing the expected utility assumption. In all these cases it appears there is a clear ramification for risk management. Thus we add a summary of this literature to our assessment.

Two studies have investigated the interaction of risk and time preferences. Typically risk analysis in agriculture that involves significant time lags can be modelled by simply discounting the expected utility with a market-based discount factor. Howitt *et al.* (2005) and Lence (2000) both investigated models of the Kreps-Porteus family that allow for an intertemporal elasticity of substitution that differs from the degree of risk aversion. Howett *et al.* rejected time-additive separability, with or without risk aversion, such as the standard constant relative risk aversion utility model. The improvement in model fit when recursive preferences are used is notable. Lence fit a generalized expected utility model to U.S. farm data to estimate farm operator's time preferences and risk attitudes. He found the forward-looking expected utility model is soundly rejected in favour of the generalized expected utility paradigm. Importantly, the generalized expected utility model was also found to fit the data better than the discounted expected utility model typically used to study agricultural production under risk.

Lessons learned on the magnitude and causal factors of agricultural risks

The purpose of this chapter is to synthesize the evidence provided by existing scientific literature regarding the magnitude and casual factors underlying the risks faced by agricultural producers. Further, we examined the existing scientific evidence regarding the risk preferences of agricultural producers. We first note that the scientific evidence in many respects is thin at best and in many cases appears to be non-existent. The authors have consciously attempted to avoid allowing U.S. research to dominate our discussion, but in many instances it appears the literature is simply deeper there than in other locations. Further, we must acknowledge that the literature is not robust across commodities. Not surprisingly, the research on major crops and livestock enterprise dominate the literature cited in this paper. It is also noted that much of the existing literature fails to examine farm household income or consumption as theory would suggest. In effect, studies that focus on a single risk such as price risk or a single output are inherently myopic and may over-estimate the value of risk management tools. We conclude that greater attention should be devoted to obtaining farm-level time-series data so that more realistic measures of risk reduction can be made. This is particularly true when farms are well diversified across enterprises.

Magnitude of agricultural risk

We easily conclude that in crop agriculture, output price and yield risk are the major risk factors associated with most crop production. Yield risk is largely driven by weather-related factors such as rainfall and temperature, while price risk often arises due to the long production lags in agriculture which allow supply and demand forces affecting commodities prices to drive price away from expected levels. The empirical measurement of objective data would also indicate the output price and yields are relatively variable as compared to several other risks (Deaton and Laroque (1992), Ray *et al.* (1998), Poor and Hegedusne Baranyai (2007), Hubbard, Lingard, and Webster (2000), Hazell, Shields, and Shields (2005), Subervie (2007)). Also, we also take the efforts to develop insurance and futures markets as *prima facie* evidence that price and yield risk are major concerns for crop producers.

What is less clear in our review of the literature is the importance of input price risk in production agriculture. Objective measurements of those data indicate fertilizer and fuel CVs equal to or greater than those for price and yield risk [Oehmke, Sparling and Martin (2008)]. Dhuyvetter, Albright and Parcell (2003) estimated a CV of 0.187 for diesel, 0.489 for natural gas, and 0.270 for anhydrous ammonia. However, producer surveys have tended to not rank input price risk particularly high in comparison to other risks. This is likely due to the fact that the inputs most often considered risky typically reflect only a portion of total cost and contribute relatively less to net revenue risk than do either yield or output price risk. It is quite clear, however, that the literature related to input price risk is quite limited and appears an area in need of further research to better understand these risks.

A consistent theme in the literature is that commodity prices are right skewed (Goodwin, Roberts, Coble). Annualized price coefficients of variation typically range from 0.15 to 0.25 for both commodity crops and livestock. Somewhat higher values appear typical for more perishable crops. Certainly, market volatility spikes beyond these levels at times. Input price variation appears to be of a similar magnitude or slightly higher than that observed for commodity output prices.

Yield risk is much more difficult to assess from the literature than price risk (Just and Weninger. Yields measured in the aggregate simply provide a quite biased estimate of farm-level yield variability. This limits the literature to those few instances where a time-series of farm yields is available. An examination of the literature that does use farm-level data suggests a great deal of heterogeneity in the shape of the probability distribution and the coefficient of variation (Just and Weninger (1999), Allen and Lueck (2002), Hart, Hayes, and Babcock (2006)). In general, it appears that the magnitude of farm-level yield risk tends to exceed that of price risk, but many exceptions will exist. Knight *et al.*(2008) and Marra and Schurle (1994) show that larger farms are less risky. Likewise certain production practises such as irrigation also profoundly affect yield risk. For livestock, production risk appears dramatically lower in modern confinement operations versus more extensive production systems such as pasture-based cattle production in arid regions.

Correlation of random variables

When one considers that risk preferences are generally defined in terms of wealth or consumption, then the risk context of a farm often results from the summation or product of random variables. Thus, correlation among these random variables matters. Recent literature has focused increasing attention on price-yield correlation and in many studies negative correlation is found in major production regions or in more localized markets (Coble and Dismukes (2008); Weisensel and Schoney (1989); Bielza and Sumpsi (2007); Hart, Hayes, and Babcock). This tends to dampen revenue risk. However, for many commodity-location combinations, price and yield independence appears in the historical data. Positive correlations between the prices of similar crops and between yields on the same farm tend to profoundly affect the revenue variability of a farm. Ultimately, it also creates the risk mitigating value of enterprise diversification. For example, combining crops and livestock has been a longstanding risk mitigation strategy. However, it appears that movement to larger and vertically integrated livestock production systems for the sake of cost efficiency has reduced the opportunity for many farms to diversify in that manner.

Off-farm income

Off-farm income and investments are well documented in the literature with most research focused on the choice of how much off-farm labour to supply. Studies from the U.S. tend to assume a risk reducing effect and generally do not report a correlation between farm and no-farm income. El-Osta, Mishra, and Morehart (2008) found expected government payments decreased the likelihood of off-farm work strategies. Lien *et al.* (2006) conclude full-time and part-time farmers' goals, risk perceptions, and risk management strategies differ significantly. Mishra and Godwin (1997) find riskier farms choose to work more in off-farm employment. Mishra and Sandettro (2002) find a negative covariance between farm and off-farm income suggestive of the risk reduction created by off-farm income. It appears in other literature that there is a strong presumption that off-farm investments and labour returns are uncorrelated (or weakly correlated) with farm revenue unless the non-farm employment (investment) is in a closely related agricultural industry. Nartea and Webster (2008) note that investment in other industries can have a risk reducing effect for the farm family. Painter (2000) concluded that investments in farmland are negatively correlated with returns with other equity markets.

Causes of agricultural risk

A synthesis of the literature on crop risk identifies crop yield, output price and to a lesser extent input prices as the major risks confronting crop producers. Clearly, weather dominates the body of literature addressing cause of crop yield risk. While, irrigation and other modern production practices may mitigate some weather risks, these practices are not cost effective in many production systems. It is useful to note the specific aspects of weather that induce losses. Once one reaches this degree of detail, rainfall and temperature tend to dominate the research findings. Cafiero *et al.* (2007a) find that temperatures and rainfall explain more than 86 percent of the variation of grape and wheat yield in the Tuscany region of Italy. Richards, Manfredo, and Sanders (2004), Turvey (2001), and van Asseldonk and Oude Lansink (2003) all focus on temperature risk. Martin, Barnett, and Coble (2001) in U.S. cotton and Musshoff, Odening, and Xu (2006) and Stoppa and Hess (2003) all identify precipitation risk. Another set of studies find both temperature and rainfall affect yields (Vedenov and Barnett (2004); Xu, Odening, and Musshoff (2006) and Tannura *et al.* (2008). With both rainfall and temperatures, extreme high and low values are usually detrimental to crop growth. The recent explosion of weather derivative research has led to significantly broader knowledge of the specific relations between weather factors and yields. It appears that functional forms and parameterizations of the yield-weather relationship are not robust in the sense that effective models need to be reestimated as one moves across crops and regions.

Price risks affect crop producers in both the input and output markets. Clearly the literature examining output prices is much larger than the input price risk literature by a wide margin Hazell, Shields, and Shields (2005). Further, producer surveys asking for a ranking of risks suggest that output price risk is generally of greater concern to producers. Of the input price risks that have been studied, two stand out – fuel and fertilizer. The data we observe suggest that fertilizer and fuel tend to be commodities and subject to price fluctuations much like all other commodities (Dhuyvetter, Dean and Parcell, 2003). The causes of fertilizer and fuel price risk appear to be linked somewhat as nitrogen fertilizer is often produced from energy sources and in some instances due to significant fertilizer transportation cost.

Output price risk in crop commodities has been addressed widely for different crops and for many locations (Henneberry *et al.* 1999). The literature describing the causes of price risk clearly identifies production shocks from major production regions as a source of variability (Deaton and Laroque (1992), Coble (1999). Thus, weather events such as droughts and flood in major production regions tend to matter. It is also important to distinguish storable commodities from non-storable commodities as stock-holding can reduce intertemporal price volatility. Various shocks may also arise from the demand side of the market. For crops traded in international markets, policy changes and exchange rate changes are both potential market shocks. Several crop commodities have multiple uses creating a composite demand that may be shocked by various factors. Many major crops such as maize and wheat have both feed and food uses which may diversify demand somewhat. We would also note that recent efforts to produce bio-fuels have added a new dimension to some crop markets. In effect this ties the demand for maize and sugarcane-based ethanol and soybean-based bio-diesel to the price of oil, various government policies related to energy markets, and trade policies affecting these emerging markets.

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Output price risk in livestock generally reflects limited storability of slaughter-ready livestock and cyclical behaviour due to relatively long biological lags. Another dimension of these industries is the advent of strong vertical integration in livestock agriculture. For example, many U.S. poultry producers do not own the animals and thus do not confront price risk in the typical fashion. Recent disease events such as BSE have created significant shock in livestock markets across several countries. These events have been widely studied Lloyd *et al.* (2001). Some studies suggest that many disease-related price shocks have sharp, but relatively short-term, price impacts. Other studies find long-term effects.

Looming developments in agricultural risk

Looming issues that appear to have the potential to alter the risk context for farmers are varied. We identify four potentially important issues which may alter the risk environment for producers: 1) climate change, 2) genetically modified crops, 3) potential disease epidemics in livestock, and 4) unexpected policy shocks. The current concern about climate change has already sparked a surprising number of studies which are, however, somewhat inconclusive with regard to the impact on production risk and appear region specific (van Asseledonk and Langeveld (2007); Quiggin and Horowitz (2003); Fuhrer *et al.* (2006); Toriani *et al.* (2007); Xiong *et al.* (2007); Howden *et al.* (2007); John, Pannell, and Kingwell (2005)). It does appear that a distinction can be made between changes in mean levels of temperature and rainfall versus the variability of temperature and rainfall. Gradual onset of climate change would have dramatically different implications than if rapid onset occurred. Several models do not address the speed at which climate change is expected to occur, but the literature appears to implicitly assume the onset will be gradual enough to allow some agricultural adjustment. Biotechnology appears to increase mean yields and studies also suggest this technology is risk decreasing. However, this is difficult to assess as adoption and technological advances are occurring so rapidly we do not have long time series of data to assess the issue. Furthermore, the literature suggests concerns related to the environmental risks of biotechnology as well. Disease epidemics are also a looming risk factor (Gramig, Horan, and Wolf (2005); Bicknell, Wilen, and Howitt (1999); Ott (2006); Shaik *et al.* (2006); Hennessy, Roosen and Jensen (2005); von

Asseldonk *et al.* (2005)). Increasingly these events may not only affect output, but also cause catastrophic demand shifts. Meuwissen *et al.* (1999) illustrated the large costs resulting from prevention efforts and losses due to livestock disease epidemics. Policy risk remains relevant as unanticipated government action may alter expectations of agricultural enterprises with fairly fixed assets. Often the most profound shocks to agriculture may arise from macro-oriented policies rather than agricultural policies themselves. For example exchange rates and fiscal policies may provide dramatic shocks to the agricultural sector. Looming agriculturally-oriented issues appear to include bio-fuel production policy and continued evolution of trade policy.

Risk perceptions and risk preferences

The surveys that have asked producers to identify major risk categories are quite confirming of the emphasis placed on yield and output price risk (Coble *et al.* (1999); Patrick *et al.* (2007); Hall *et al.* (2003) Flaten *et al.* (2005)). We do note that a fairly limited literature suggests that subjective risk perceptions of risk magnitude are not always consistent Eales *et al.* (1990); Pease (1992); Egelkraut *et al.* (2006). Input price risk tends to be identified as of lesser importance in recent surveys, but might rate higher in the current environment. The literature on agricultural producer risk preferences lacks the geographical diversity that one would desire.

While the expected utility hypothesis has been criticized in the literature, it remains the dominant assumption in agricultural risk modelling. Many papers simply impose risk aversion in simulation studies which indicate researcher acceptance of risk aversion but do not scientifically confirm it. A much smaller literature estimates risk aversion parameters (Saha, Shumway, and Talpaz (1994); Antle's (1987); Bar-Shira *et al.* (1997); Kumbhakar (2002); Lien (2002); Love and Buccola (1991)). A synthesis of the studies that have been reported clearly support the assumption of risk aversion (OECD, 2004 Gardebroek (2006)). However some common functional forms such as CARA do not allow comparisons across individuals with differing contexts. Where the CRRA model is used comparisons can be made. Only two of eleven studies suggest either risk neutrality or risk loving behaviour. In most of these papers the minimum CRRA parameter is well above zero. It appears that variation across studies has more to do with individual differences rather than the region or agricultural product produced. This makes cross-country-comparisons of risk aversion somewhat tenuous.

Research and data needs

This summary of scientific literature has already noted various omissions in the research and knowledge. There appears to be a fairly strong consensus that researchers have conceptualized the agricultural producer's risk management problem but data constraints have precluded fully empiricizing models and thus more completely understanding producer decisions or the implications of risk management tools provided by either markets or governments. Our assessment of productive research directions would include the following: identify a population of producers to follow across time to create panels; and survey to obtain farm-level risk preferences, income, consumption, saving/borrowing, and off-farm labour choices. Also, we suggest collecting enterprise-level cash prices and yields and risk management decisions.

Notes

1. Prices tend to exhibit high spatial covariance so they are far less susceptible to aggregation bias.
2. A recent study suggests that under certain conditions (highly inelastic demand that generates prices with “chaotic motion” time paths) liberalization may actually increase world price variability (Boussard *et al.,* 2006).
3. Readers are again cautioned about the difficulty in making meaningful comparisons of domestic price coefficients of variation across countries when countries impose different types and magnitudes of market interventions.
4. Price support programs ensure that the commodity will not be sold at prices lower than the price support. Income support programs do not support prices but instead compensate producers for the difference between the target price and the market price whenever the market price is less than the target price.
5. Likert scale questions are survey question that allows the user to choose the response that best represents his or her opinion relative to a scale reflecting varying strength of opinion.

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Managing Risk in Agriculture

A HOLISTIC APPROACH

The sources of risk in agriculture are numerous and diverse, ranging from events related to climate and weather conditions to animal diseases; from changes in agriculture commodities prices to changes in fertilizer and other input prices; and from financial uncertainties to policy and regulatory risks. Recent turbulence in the world commodity markets, together with increasing concerns about the impact of climate change, have given risk management a central role in the agricultural policy debate.

Agricultural risks are not independent, but rather are linked both to each other and as part of a system that includes all available instruments, strategies and policies designed to manage risk. A holistic approach is thus necessary. Indeed, analysing a single risk or policy measure in isolation generally leads to wrong conclusions. Governments have a role in facilitating the availability of a variety of instruments while at the same time empowering farmers to design their own business strategy. Risk policies should thus be targeted to well-identified efficiency or equity concerns, avoid the displacement of market or on-farm solutions and take into account all agricultural support policies because most have implications for risk management.

What are the current magnitude and characteristics of risk-related policies? What is known about the quantitative size of agricultural risks? What on-farm, off-farm or market instruments are available to manage agricultural risk? How does the holistic approach help to understand the role of governments? These are some of the questions addressed in this publication, the first piece of an ongoing OECD project on risk management in agriculture.

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