



# **MANAGING RISK IN AGRICULTURE: A HOLISTIC APPROACH**

***HIGHLIGHTS***





## *Foreword*

The study *Risk Management In Agriculture, A Holistic Approach* is the first building block of a project on risk management in agriculture undertaken by OECD. 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 will be used to further analyze agricultural risk management systems in specific countries as well as 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](http://www.oecd.org/agriculture/policies/risk).

Jesús Antón of the OECD Secretariat leads the risk management project and coordinated the studies for this publication. The contents of this booklet are extracted from *Managing Risk in Agriculture: A Holistic Approach* (OECD, 2009).

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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 an 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<sup>1</sup> 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](http://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.<sup>1</sup> 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.

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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).

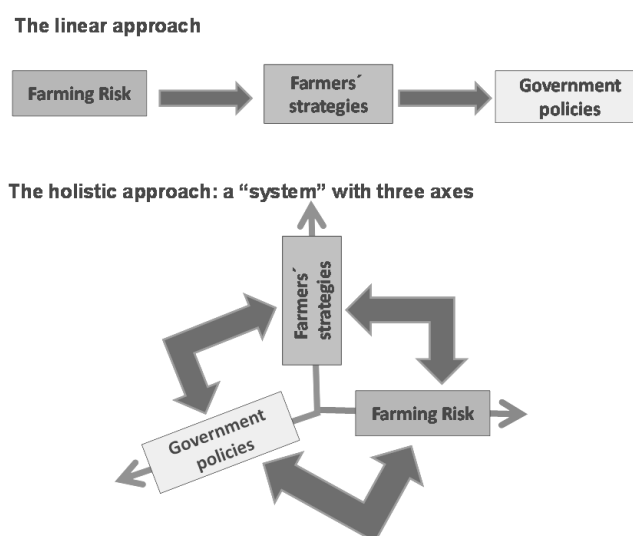
There is a growing literature that tackles risk related issues from a governance angle. It is mainly focused on risks with significant consequences for a society or an economy, that go well beyond consequences for an individual. These “systemic risks” can also be relevant in agriculture. In this literature 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 Barnett, 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.<sup>1</sup> This focus on down side risk has led 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
<b>Market/prices</b>		Changes in price of land, new requirements from food industry	Changes in input/output prices due to shocks, trade policy, new markets, endogenous variability ...
<b>Production</b>	Hail, frost, non-contagious diseases, personal hazards (illness, death) assets risks	Rainfall, landslides, pollution,	Floods, droughts, pests, contagious diseases, technology
<b>Financial</b>	Changes in income from other sources (non-farm)		Changes in interest rates/value of financial assets/access to credit
<b>Institutional/legal</b>	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 Hardwood *et al.* (1999) and Holzmann and Jorgensen, 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 Jorgensen, 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.

### 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 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...).

### *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.

$$\pi_i = \sum p_i * \bar{q}_i - C_0 - \sum \bar{C}_j + \sum \bar{O}_k$$

$$Var(\pi_i) = Var(P) + Var(C_0) - 2Cov(P, C_0)$$

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.

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.

#### 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  $\underline{W}$  implies bearing a variance that is a quarter of  $V(\underline{W})$ , 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.<sup>1</sup>

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

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.

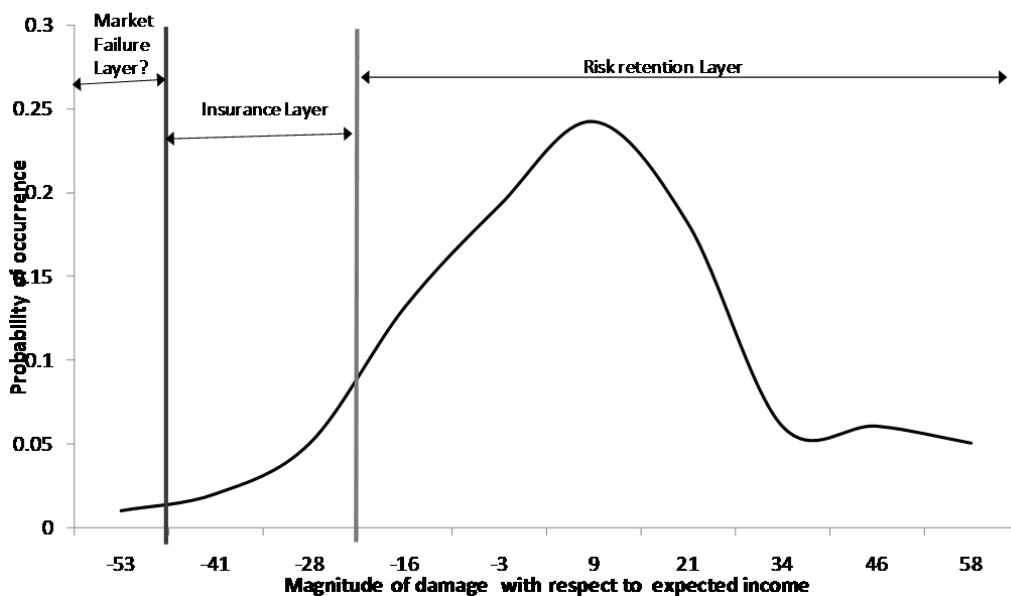
There is hardly any agricultural risk that complies with these strict requirements of insurability. Emphasis has often been posed on the symmetric information condition (Chambers, 1989). Miranda and Glauber (1997) emphasise the need for risk to be independent among the insured, arguing that due to correlations 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*<sup>1</sup>.
- 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*.

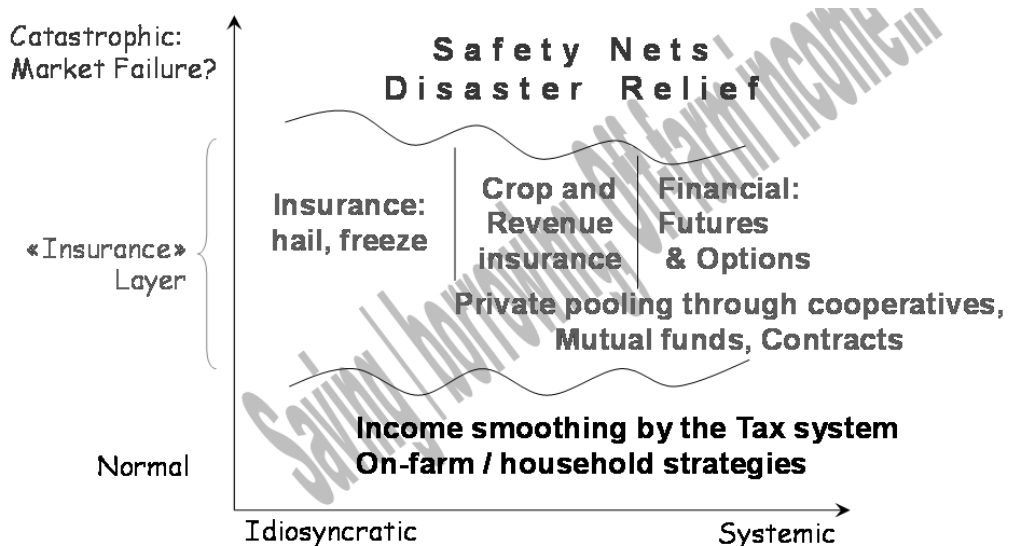
The distinction of risks with respect to two different criteria, their frequency of occurrence and magnitude of losses, could be contradictory if big losses were not associated with low probabilities. But many risks or combination of risks lead to a distribution of impacts where larger losses have lower 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 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 an 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<sup>2</sup> 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<sup>3</sup>. 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 Collé 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<sup>4</sup> (Newbery, 1989, and Newbery and Stiglitz, 1981), except under very restrictive conditions<sup>5</sup>. 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<sup>6</sup>. 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<sup>7</sup>: 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)
<i>Ex ante</i>	<ul style="list-style-type: none"> <li>Stable macroeconomic policies and business environment</li> <li>Risk management training and information to farmers</li> <li>Facilitating the production and sharing of information on risks</li> <li>Increase competition in the insurance market</li> <li>Law and institutions for futures and options markets</li> <li>Defining the limits of government and farmers responsibility in risk management</li> <li>Private / public partnerships</li> </ul>	<ul style="list-style-type: none"> <li>Subsidies to insurance</li> <li>Subsidies to reinsurance</li> <li>Subsidies on futures contracts</li> <li>Participation in mutual funds</li> <li>Incentives on saving accounts</li> <li>Facilitate access to credit</li> <li>Output Market interventions</li> <li>Regulations (price stabilization)</li> <li>Border measures (tariffs...)</li> </ul>	<ul style="list-style-type: none"> <li>Disaster prevention (flood control...)</li> <li>Prevention of animal diseases (domestic and border measures)</li> <li>Legal form of farms</li> <li>Research and Development of new varieties or breeds</li> </ul>	
<i>Ex post</i>			<ul style="list-style-type: none"> <li>All agricultural support programs</li> <li>Countercyclical programs</li> <li>Tax system for income smoothing</li> <li>Border and other measures in case of contagious disease outbreak</li> <li>Ad hoc payments for quick economic recovery</li> </ul>	<ul style="list-style-type: none"> <li>All agricultural support programs</li> <li>Social assistance</li> <li>Disaster relief (payments, subsidised credit...)</li> <li>Other Ad hoc ex post payments</li> </ul>
- triggered ex post				
- decided ex post				

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 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.<sup>8</sup>

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<sup>9</sup>. 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.

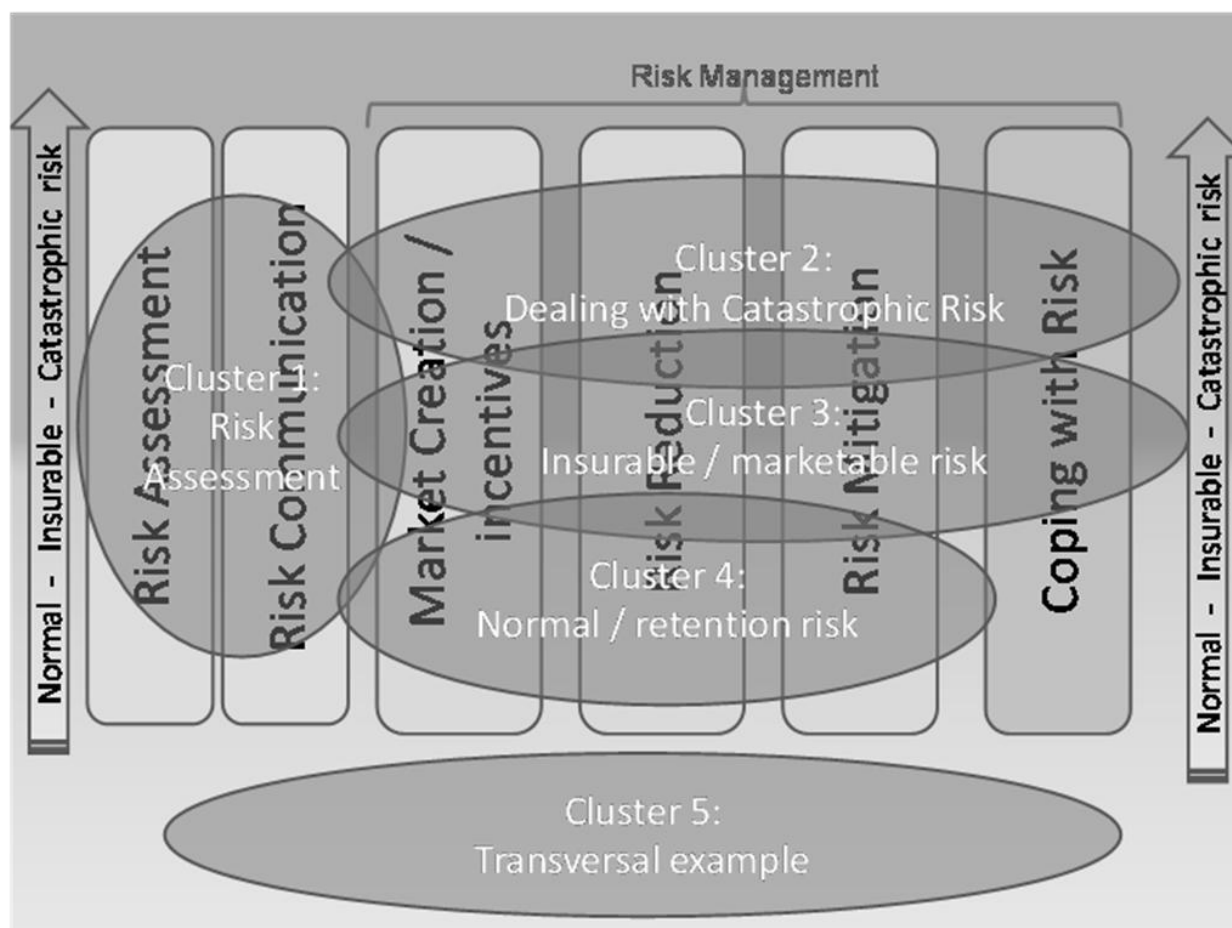
Using this holistic approach, different types of analysis can be carried out. Two types are suggested here. First, a thematic review of risk management in agriculture that would apply the same holistic template to a set of countries, in order to learn about how complex interactions work in different 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 Collé (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 consequence, 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 agrochemicals 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 Jørgensen (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 farmers’ 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<sup>1</sup>. 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<sup>2</sup> 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<sup>3</sup>.

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”<sup>4</sup>. Empirical studies find that farmers are risk averse ( $R>0$ ), and in most cases the estimated coefficients are larger than one<sup>5</sup> (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)<sup>6</sup>. 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  $\underline{W}$  is defined as the certain level of wealth that would make the farmer indifferent between the two:  $EU(\underline{W})=U[CE(\underline{W})]$ . 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:  $RP(\underline{W})=E(\underline{W})-CE(\underline{W})$ . 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:  $CE(\underline{W}) \approx E(\underline{W}) - 0.5 \cdot A \cdot V(\underline{W})$ . This gives an approximate risk premium equal to half of the absolute risk aversion times the variance across the different possible wealth outcomes<sup>7</sup>: 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.<sup>8</sup> It is then said that this later stochastically dominates the former.

### ***Economic analysis of decisions under uncertainty***

The existence of 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 rise 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<sup>9</sup>, 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 from the scientific literature is presented.
7. The risk premium is:  $RP(W)\approx 0.5*A*V(W)$ . A proportional risk premium is sometimes calculated by dividing the risk premium by the expected value of wealth (Hardaker, 2000; Newbery, 1989):  $PRP\approx 0.5*R*CV^2(W)$ . 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 of 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 (MasCollé, 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

	<b>MPS</b>	<b>Border prices</b>
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<sup>1</sup>. 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):

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

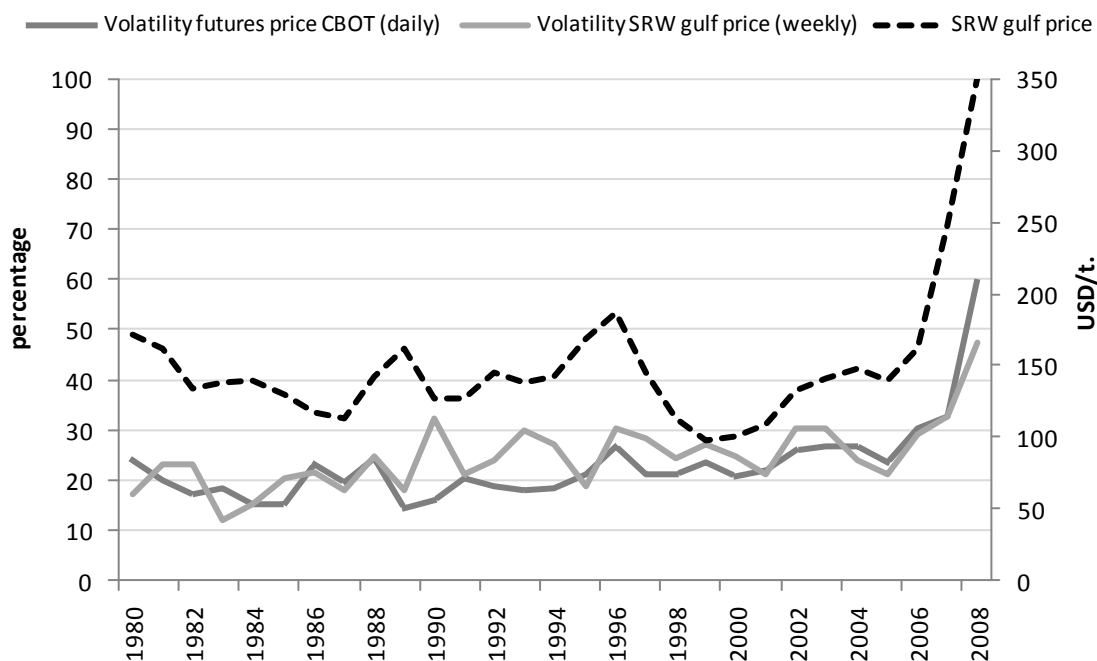
Historical volatility is calculated applying this formula to past data. The periods "t" are typically days, weeks or months. The variance is calculated over a historical set of consecutive periods, e.g. a month of daily data. In order to compare volatility calculated with data based on different periods, 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<sup>2</sup>. 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.

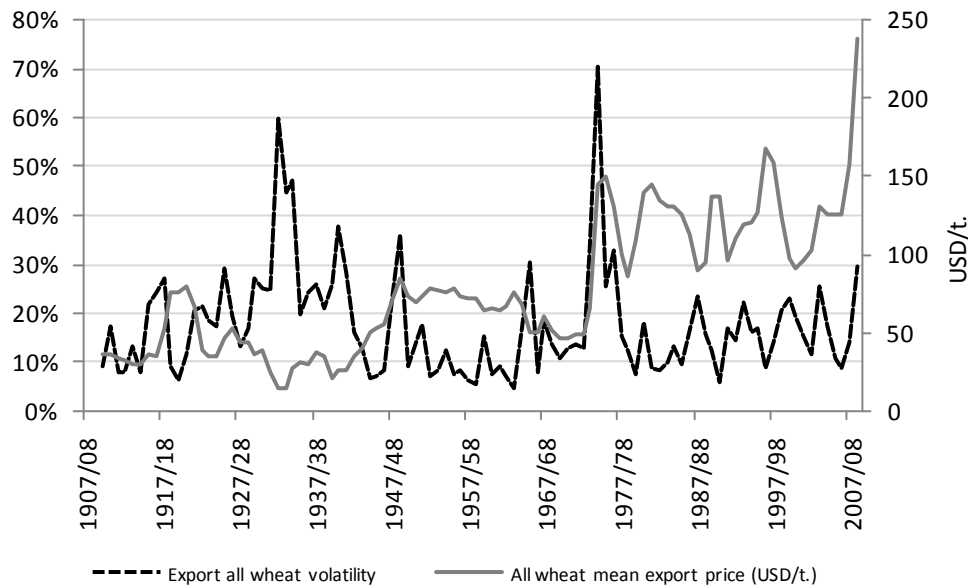
FAO (2008) revisited its analysis of volatility showing a significant jump in historical volatility of wheat and rice in the first months of 2008, but reductions in dairy products and hardly any change in oilseeds and meats. Implied volatility doubled in the first months of 2008 for wheat, maize and 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

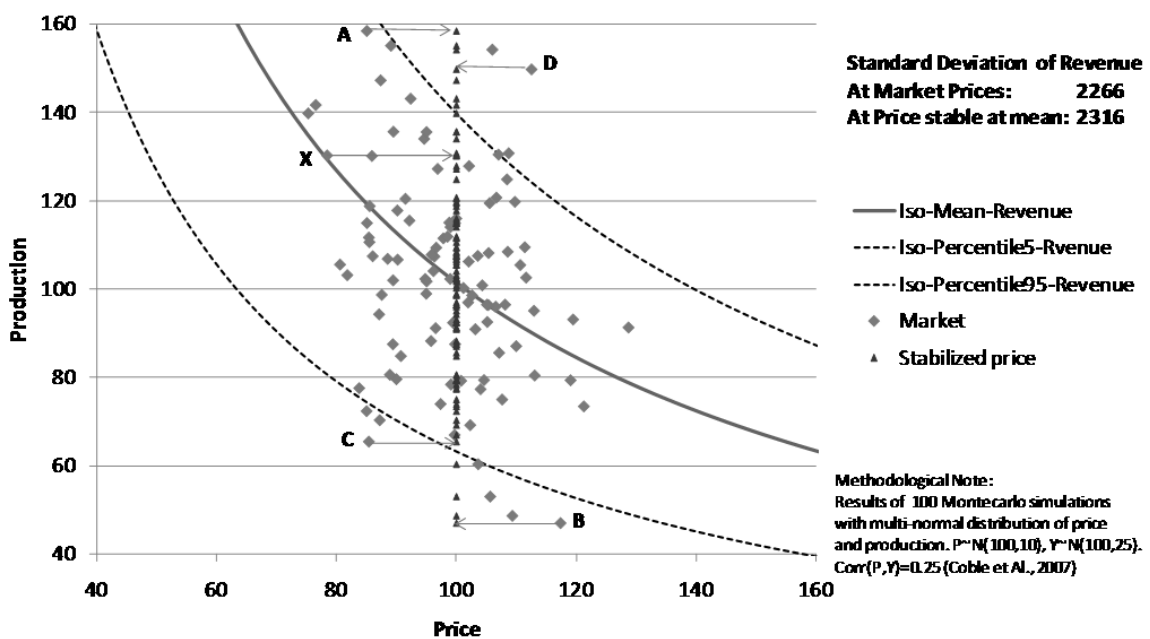
requires analytical and empirical investigation. The existence of basis risk not associated with the stabilized price may further reduce this capacity.

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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