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DEALING WITH RISK IN AGRICULTURE:
A CROP LEVEL ANALYSIS AND MANAGEMENT PROPOSAL FOR ITALIAN FARMS

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Abstract

Risk management plays a critical role in agriculture, which is particularly exposed to multiple and heterogeneous risk factors. In addition to the traditional basic risks that generally characterize any business venture, agriculture faces external factors, generally difficult to control and with a strong impact on farm profitability. These are firstly environmental (pests and diseases) and climatic conditions that affect the quantity and quality of agricultural production, but also the structural constraints of the agricultural market, which is characterised by a high degree of supply rigidity, price volatility and inelasticity of demand. This leads to the need to implement risk management tools, some of which aimed at income stabilization (already in place by many years in other countries, i.e. the USA and Canada) and requiring the active participation of the farmer on the one hand and of the institutional system on the other.

In order to suggest risk management solutions to Italian farmers, this thesis makes efforts in simulating the feasibility of a risk management tool introduced in the EU with Regulation (EU) No 2017/2393 but not yet implemented: the sector-specific Income Stabilization Tool.

This is based on a public-private partnership and is managed by a mutual fund steered by associated farmers. These latter pay an annual contribution to become eligible for receiving indemnities when experiencing a severe income drop. Unlike others that are limited to covering specific types of risk, this tool makes it possible to look at the farmer's entire income risk considering the correlation among several sources of risk (particularly between production level and prices).

This thesis provides first a theoretical background on risk analysis and risk management in agriculture (concepts, classification, literature and methodology). Second, the role of policies within the European Union framework and, Italy, in particular, has been viewed by analysing the normative framework and the reference context of insurance instruments in agriculture. Subsequently, since assessing farm profitability and economic risk is important to support farmers' decisions about investments and whether or not to join the insurance instruments, an explorative analysis on profitability and riskiness of a perennial crop in Italy, such as hazelnut, has been done. Finally, the implementation of a sector-specific

Income Stabilization Tool for the crop investigated has been suggested by following this structure:

- assessment of the profitability and risk of hazelnut production, in the four main production areas in Italy;
- assessment of the most important parameters generating risk;
- simulation of the feasibility of using an income risk management tool to make supply and demand able to interact and its impact on the level and riskiness of farm income;
- assessment of the geographical scale at which the Income Stabilization Tool scheme could be implemented.

Using data from the Italian Farm Accountancy Data Network on hazelnut producing farms, a downside risk analysis showed that riskiness is distributed in different ways on the entire country with sensitivity on yield risk affecting farmers' income level and economic risk. The simulation implemented in this study demonstrates the tool could reduce substantially the risk faced by hazelnut farmers in Italy. The additional public support is essential in case of joining the tool. In addition, in view of the differences within the Italian territory, the farmers' payments should be differentiated based on the requisites and the specific climatic and environmental characteristics of each region. Concurrently, recourse to a national mutual fund would make it possible to benefit from the principle of risk pooling.

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List of Abbreviation

ARMS	Agricultural Resource Management Study
CAP	Common Agricultural Policy
CDF	Cumulative Distribution Function
CMO	Common Market Organisations
COMAGRI	Commission for Agriculture and Rural Development (*Commissione Agricoltura e Sviluppo Rurale*)
EAFRD	European Agricultural Fund for Rural Development
ETL	Expected Tail Loss
EU	European Union
FADN	Farm Accountancy Data Network
FSN	National Solidarity Fund (*Fondo di Solidarietà Nazionale*)
GM	Gross Margin
ISMEA	*Istituto di Servizi per il Mercato Agricolo Alimentare*
IST	Income Stabilization Tool
MaxCont	Maximum Contribution Rate
MiPAAF	*Ministero delle Politiche Agricole, Alimentari e Forestali*
MF	Mutual Fund
MS	Member State
NRDP	National Rural Development Programme
PAAN	National Agricultural Insurance Plan (*Piano Assicurativo Agricolo Nazionale*)
PDF	Probability Density Function
RDP	Rural Development Programme
ROE	Return on equity
SCV	**S**emi-coefficient of variation
SEC	Securifies and Exchange Commission
SSD	Semi-standard deviation
USDA	United States Department of Agriculture
VaR	Value at Risk
WTO	World Trade Organization

Chapter 1

Introduction

1.1. General aspects

Currently, the extremely volatile nature of the business world requires farms to deal with a wide range of risks that pose threats to their organizations. The notion of *risk* can be said to be a very general term, albeit with several connotations. Johansen and Rausand (2014) have stated that "If you ask ten people what they mean by the word *risk*, you will most likely get ten different answers". Risk can be defined as: “imperfect knowledge where the probabilities of the possible outcomes are known, and uncertainty exists when these probabilities are not known” (Hardaker et al., 2015).

While risk is not exclusive to the economic activities related to agriculture, the agricultural sector usually faces a combination of risks, which is rarely found in other business sectors. For example, the local weather conditions might unexpectedly change, prices at harvest time might drastically decrease, the labour hired may not be available at the requisite time, animals may perish, and government policy and trade agreements may change. All these risks can affect farm profitability, and national or supranational governments have consequently adopted policies regarding the long-term support of the agricultural sector. Two of the major risks affecting agriculture are the climate and nature (pests and disease), and both can influence agricultural yields and market risks, in turn leading to important fluctuations in the prices paid to the farmer.

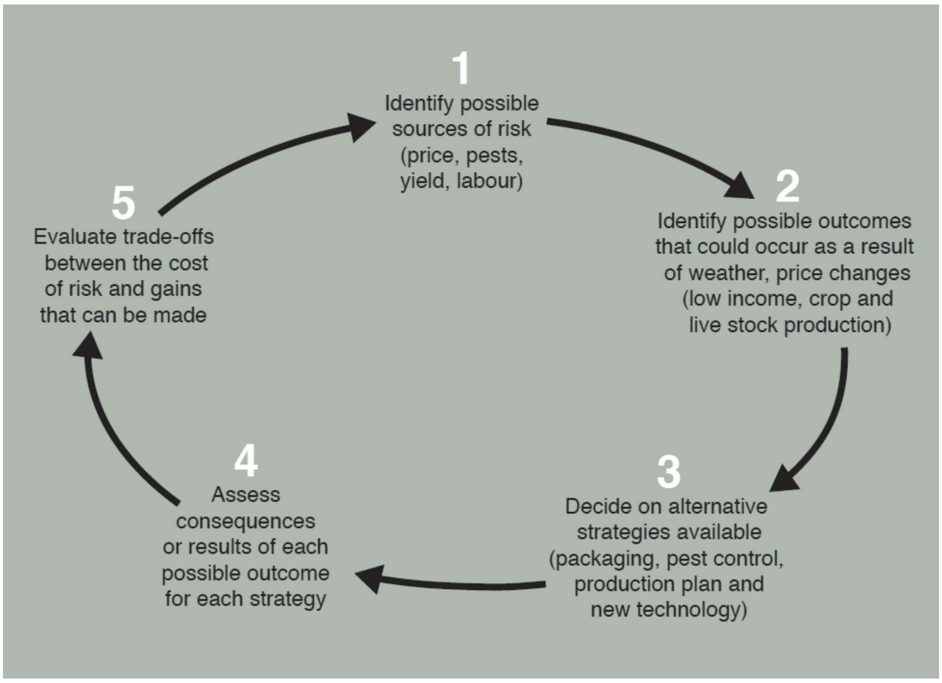
In this regard, it is useful to distinguish between production risks and market risks. The former refer to all factors that affect livestock and crop productivity and thus the farm profitability. Due to the high dependence of investments in agriculture on biological processes, external events such as drought, flooding, pests and diseases are major sources of production risk (Hollinger, 2004). Meagre precipitation or drought may lead to low yields and hail or heavy rain could damage or even eliminate crops; outbreaks of pests or diseases could also cause major losses in yield to crops and livestock.

Market risks are linked, for example, to cyclical and seasonal price fluctuations of agricultural commodities, to political intervention in commodity markets (i.e. changes in taxes, tariffs and quotas), or declining demand for the product (i.e. due to changes in consumer preferences, the advent of new product substitutes, etc.)

(Hollinger, 2004). Variations in prices, influenced by the supply and the demand for a product, are beyond the control of any individual farmer.

Farmers have always faced uncertainties and risks. However, the risk element in agriculture has increased over the long-term due to market liberalization and globalization, and small farmers have become particularly vulnerable (Kahan, 2008). Farmers generally have at least one basic set of goals and objectives, in the context of which the decision-making process occurs (Figure 1.1).

Figure 1.1. The decision-making cycle relating to farmers' risk management.



Source: Kahan, 2008.

Thus, farmers attempt to identify solutions for dealing with risk and to protect themselves from decisions in conditions of uncertainty. Furthermore, farmers differ in the degree to which they accept and estimate risk: some farmers are willing to accept more risk than others because they base their decisions on several factors. Since higher profits are typically linked to higher risks (Kahan, 2008), assessing farm profitability and economic risk is an important part of supporting farmers in their decision-making process.

The uncertainties inherent factors highlighted that affect farming can cause wide swings in farm income. Many options or a combination of strategies and tools are available to farmers for managing risks. Some strategies only deal with one type of risk while others address multiple risks. Indeed, the risk management policy not only regards natural disasters (e.g. adverse weather conditions, plant diseases or pest infestations, animal diseases, environmental incidents) but also price and production insurance. It follows that the income insurance scheme, in general, is important in the event that to distinguish between the previous ones is not possible (ISMEA, 2018).

Risk management involves choosing among available alternatives with the aim of reducing the financial effects of the uncertainties affecting the agricultural sector. This requires farmers to reformulate their agricultural practices and preferred business models in order to remain profitable in the market. Many actors in the field of agriculture believe that farmers need to acquire more professional skills regarding not only basic production but also farm business management (Kahan, 2008). Of these, there exist risk management skills in order to protect farm profitability and the economic sustainability of the investments made. Furthermore, the international market of agricultural products, characterised as it is by an elevated degree of supply rigidity and inelasticity of demand, in addition to price volatility, increasingly demands sustainable economic and environmental development. This necessitates a proactive attitude by the farmer on the one hand and the institutional system on the other. In this regard, the Common Agricultural Policy (CAP) 2014-2020 of the European Union (EU) has played an important role in providing both financial resources to environmental conservation and ecosystem services and risk management tools, with broader aims and larger budgets than was the case previously.

1.2. Research objectives

The broad aim of this thesis is to suggest risk management solutions to Italian farmers into a sector of a perennial crop after assessing the level of profitability and the income risk of their production activity.

The prerequisite to achieve this goal is, first, to investigate the concept of economic risk. Among several classifications concerning the origin of risk (i.e. market/price, production, financial and legal), the income risk affecting these farms was chosen.

In this direction, the objective is set to study how farmers can maintain their economic viability to have money to continue farming and to avoid bankruptcy in case of adverse/risky events.

Thus, it is necessary to identifying a suitable methodology to quantify the current risk conditions. In line with the objective mentioned at the beginning, it was needed to learn which legislation is currently in place and which tools are available to farmers with the aim to suggest risk management solutions able to stabilize the farm income.

Income risk is common to all farming systems although differences exist among farms by sector. Specifically, this thesis will propose a crop level analysis which focuses on hazelnut production in Italy, deploying data from the Farm Accountancy Data Network (FADN) relating to the 2008–2017 period.

Due to an increase in global demand, the areas of production dedicated to the cultivation of hazelnuts is ever-increasing and several competitors such as Spain, Georgia, Azerbaijan, Iran, Russia, the USA and Chile increase the competitiveness of the sector; many of these were hitherto unknown in this market (FAOstat, 2018). Italy is the second-largest producer on the international market after Turkey. Moreover, there is a notable industrial sector in Italy specializing in the production of spreads, which are similar to those used in confectionery, and chocolate-coated hazelnuts. Such is the popularity of these products that increasing volumes of hazelnuts have to be imported to meet consumers' demand. This national deficit in hazelnut production, mixed to the assessments of the political/economic outlook in major producer countries, have prompted the national confectionary companies to propose the conditions for obtaining supplies of raw materials at a domestic level.

On the one hand, these initiatives have been aimed at encouraging an increase in the surface area not only in the regions already traditionally employed in this sector (Lazio, Piedmont, Campania and Sicily) but also in other areas where hazelnut production has been hitherto marginal. The objective of these initiatives has also been to encourage the development of innovative techniques of cultivation, raising to marked interest in this crop by farmers and related trade associations. Public administrations have also been involved in these initiatives by including steps in the hazelnut production/processing chain within regional Rural Development

Programmes (RDPs) under the guise of identifying alternatives when traditional agricultural crops were characterised by increasingly lower economic margins.

The market for hazelnut production and processing is controlled by the price of the exported product from Turkey, and its international reference value can be identified over time. Thus, the importance of the relationship between fluctuations in prices and the profitability of production is evident. With reference to this study, the price paid to farmers for their hazelnuts varies according to the quality of the harvested product.

In this context, the profitability of the hazelnut sector has been estimated and then a risk analysis has been performed by applying a set of risk indicators (e.g. standard deviation, coefficient of variation, skewness and kurtosis) to the distribution of the income variable. The latter consists of the crop gross margin (GM) (€/ha), in addition to the difference between crop revenues and the specific variable crop costs of farms. In detail, this analysis will deploy the distribution centre for comparing profitability among the four main production areas (Piedmont, Lazio, Campania, Sicily). In order to obtain information on the left side of the distributions, a semi-standard deviation and a semi-coefficient of variation have also been computed and analysed (Monjardino et al., 2013; Mun, 2006) as they specifically focus on downside risk exposure. Commonly-used risk measures have also been used: the *break-even point* (P[GM]≥0, i.e. the probability of returning a profit), the *Value at Risk* (VaR) and *Expected Tail Loss (ETL)* (Dowd, 2007).

Furthermore, since identifying the role of parameters influencing farm results is a requisite of this study, a sensitivity analysis was performed by combining Monte Carlo simulations and stepwise regression techniques. It has identified the most important parameter generating risk among yields, price and a quality index for hazelnuts.

Farmers can make use of several tools for managing income risks (Meuwissen et al., 2013). Having previously observed existing cases of success in other countries (e.g. Canada and the US), in this study, the sector-specific Income Stabilization Tool (IST), introduced by the EU with Regulation (EU) No. 1305/2013 and modified by Regulation (EU) No. 2017/2393, has been simulated. Being based on a public-private partnership, it is managed by a MF and administered by associated farmers. The latter pay an annual contribution to become eligible to receive compensation on experiencing a drastic drop in income. Although the IST has already been approved by the EU, it has not yet been implemented in Italy and in most of the European countries. Therefore, there is significant uncertainty regarding the contribution which farmers should pay to the MF, notwithstanding the public contribution envisaged by Regulation (EU) No. 1305/2013.

The potential impact of the IST on farm income has been studied by means of a stochastic dominance analysis (Hardaker et al., 2015). In accordance with the expected utility analyses, the farmers' willingness to use the IST tool will also be evaluated. Finally, the financial sustainability of the MF will be assessed according to actuarial principles and accounting for loading costs and public support.

Moreover, geographical considerations in nature have been made in this study regarding compensation payments even if it is unclear if and how they would be differentiated.

In brief, the exploratory part of this study will analyse the following:

- assessment of the profitability and risks inherent in the hazelnut production of the four main areas of production in Italy (Piedmont, Lazio, Campania and Sicily);
- assessment of the most important parameters generating risk;
- simulation of the feasibility of using an income risk management tool to encourage the interaction of supply (MF) and demand (farmers) and its impact on the level and the degree of risk of farm income; and
- assessment of the geographical scale on which the IST scheme could be implemented.

1.3. Study structure

This thesis, comprising six chapters, explores the topic of agriculture risk and risk management relating to one sample of Italian farms producing hazelnut. The structure foresees two steps: an analysis of the economic and regulatory risk scenario; and research into a perennial crop in Italy.

Following a brief *Introduction* (Chapter 1), the study will outline a theoretical framework of risk (Chapter 2). This will focus on understanding the concept of risk specifically in the sphere of agriculture (classification of risk, risk analysis), the sources of risks (e.g. yield and price variability), relevant methodologies, and risk management strategies/policy and insurance. Thereafter will follow a review of risk management policies in Italy, dealing with the risk management tools currently available and the innovations of the Omnibus Regulation [Reg. (EU) No 2017/2393] (Chapter 3).

The study will include two exploratory research studies (Chapters 4 and 5), which are based on a quantitative technique methodology regarding the chosen FADN data sample of Italian hazelnut. The first study will concern profitability and risk analysis (Chapter 4). The second exploratory research study (Chapter 5) will assess the potential impact of the IST on farm income. Thereafter, there will follow *Concluding remarks.*

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Chapter 2

The risk in agriculture: a theoretical framework

2.1. Preface

The risk is an intrinsic element of the business activity since it is closely related to the expected income results. The concept of risk is generally associated with the possible deviation of the economic results from those expected, due to events of uncertain occurrence of internal or external origin to the farming system, not always foreseeable in the process of planning, production and sales.

Consider the risk into business activity is essential because it affects the well-being of farm families and/or reduces the ability to identify the best production and investment choices. Very negative economic outcomes can reduce the capability of farms to invest and, ultimately, to survive.

Because of the relevance of risk, it is important to manage it in a satisfactory way. However, before doing this, it is crucial to fully understand the risk considering several aspects.

The risk faced by farmers has a complex nature so that its analysis requires a systematization of the terms. The literature suggests considering three relevant dimensions that have been found useful to classify risk and, later on, to identify the best risk management strategies and tools. These dimensions are:

- frequency and intensity of the risk;
- sources of risk;
- idiosyncratic and systemic risks.

The greater the variety, frequency and intensity of the risk factors that the farm faces, the greater the complexity of risk management policies to be adopted in order to protect the farm profitability and the economic sustainability of the investments.

This Chapter first provides a definition of risk and its classification. Furthermore, it procures the background on the concepts and tools to assess the risk faced by farmers also introducing the concept of risk aversion. Then, it discusses the risk management strategies and tools used in agriculture. Finally, it describes the extent of the application of some risk management tools in the EU and the USA. Follow, an excursus on risk management strategies and tools.

Contextually, the Chapter provides the basis for developing the empirical analysis that focuses on the assessment of the income risk and its sources (Chapter 4) and of an innovative risk management tool (Chapter 5) using a specific case study and farm-level data.

2.2. The concept of risk in agriculture: definitions, sources of risk and classification

2.2.1. Definitions

Various authors have addressed the implications and definitions of risk in agriculture. For example, according to Robison and Barry (1987) "*Events are uncertain when their outcome is not known with certainty. Uncertain events are important when their outcomes alter a decision maker's material or social well-being. We define as risky those uncertain events whose outcomes alter the decision maker's wellbeing*". Robison and Barry (1987) observe that other definitions of risk consider variances, likelihoods of loss, and safe levels of income or specific requirements on probability distributions.

Newbery and Stiglitz (1981) argue that producers are concerned with income variability and how it affects consumption rather than risk factors such as price or yield. In their work, which primarily addresses price stabilization, they deem that price variability itself is not the appropriate metric to judge risk. At the same time, Newbery and Stiglitz (1981) make the distinction between systematic and non-systematic risks. The former is related to events that repeat over time with a probability model that can be analysed. On the contrary, non-systematic risks are characterized by very short or imperfect records of their occurrence. Consequently, difficulties might be in estimating an objective model of probability or distribution of results. This distinction is similar to the distinction between risk and uncertainty and it is not possible to draw a clear dividing line between these two types of risk.

Hardaker et al. (1997) define uncertainty as imperfect knowledge and risk as uncertain unfavourable consequences. They also define several primary causes of risk in agriculture. In particular, they identify production risk stemming from the unpredictable weather and uncertainty about the performance of crops or livestock due to pests and diseases. Moreover, they denote price or market risk due to farmers having to make decisions about input uses without knowing the price of inputs, or more importantly outputs. Then, they distinguish financial risk, which is related to the source and the methods of financing the farm operation.

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

Chavas (2004) defines risk as representing any situation where some events are not known with certainty. He suggests that risk and uncertainty are not equivalent but interchangeable.

2.2.2. Source of risk

Variability and risk are not the same things. While the former indicates a factor's attitude to manifest itself in different ways, risk tends to encompass the negative excesses of variability (cfr. downside risk afterward explained). Crop yields and prices might be two examples of risk. Yield risk is largely driven by weather-related factors such as rainfall and temperature, while price risk often arises due to the long production lags in agriculture that allows supply and demand forces affecting commodities prices to drive away from expected levels (OECD, 2009).

Crop yield risk is caused by many natural factors. These include diseases, pests, drought, excess moisture, hail, frost and floods. In general, weather risk also varies according to the geographical region. Weather conditions are typically perceived as the source of much of the risk of crop yields in agriculture (Ritter et al., 2014; Xu et al., 2010). The agricultural sector is usually exposed to a strong production basis risk because the functional relationship between crop yields and weather conditions are very complex and can not be captured by simple weather indices (Ritter et al., 2014). The literature studying the most relevant sources of meteorological risk has increased dramatically in recent years as it is highly correlated with loss of performance (Hansen et al., 2019; Luo et al., 2017; Nidumolu et al., 2016). For instance, Salk et al. (2007) report that 20 to 30 percent of French gross domestic product is affected by weather risk. They also state that French winegrowers identify frost and hail as the most serious weather problems. Cafiero et al. (2007) find that temperatures (minimum, average and maximum), humidity and rainfall account for more than 86% in causing the variation in grape and wheat yields in the Tuscany region. Richards et al. (2004), Van Asseldonk and Oude Lansink (2003), and Turvey (2001) focus on temperature risk. Other researches, such as Martin et al. (2001) focused on precipitation as a source of weather risk in American cotton. Migliore et al. (2019) demonstrate how an increase in temperature and reduction in precipitations in the future may results in a fall in income for farmers in the Mediterranean area (i.e. winegrape, olive, and citrus). Musshoff et al. (2006) analyse the risk of precipitation in German agriculture such as Stoppa and Hess (2003) for the study of meteorological derivatives for Morocco and Breustedt et al. (2008) in Kazakhstan. Thus, weather risks are immediately reflected in yield risks (e.g. Odening et al., 2008; Musshoff et al., 2011). Drought, excess moisture, and hail have been found to be the primary causes of yield risk for the major field crops – maize, cotton, soybeans, and wheat. Production inputs and their management strategies can be utilized to mitigate many of these sources of yield risk. For example, irrigation can reduce the impact of drought. For some crops, tiling fields can reduce the impact of excess moisture. Disease and pests can often be controlled somewhat by fungicide and pesticide applications. Genetically modified crops reduce the yield risk associated with pests from insects (OECD, 2008).

Regarding crop prices, a relatively large amount of research examined price volatility in input markets (Kamali et al., 2017; Gabriel et al., 2013; El Benni and Finger, 2013; Lehmann et al., 2013; Mary et al., 2013; van Winsen et al., 2011; Yonkers, 2011; OECD, 2009; Pretty et al., 2008; Leahy and Whited, 1996). Price risk is caused by various factors for a particular commodity and region. Many authors provided discussion and results, to reduce risk exposure, from the rational expectations in agricultural market estimating commodity price in supply and demand systems (Bonfatti, 2012; Kurosaki and Fafchamps, 2002; Deaton and Laroque, 1992; Shonkwiler and Maddala, 1985; Goodwin and Sheffrin, 1982).

In agriculture, output price and yield risk are the major risk factors associated with most crop production. As found by El Benni and Finger (2014) from net revenue variance decomposition results - for the main crops produced in Switzerland – yield

results the main source of variability in barley, corn and rapeseed, and price risk is the significant source in wheat. Neto et al. (2018), through a sensitivity and economic risk analysis, revealed that price received and productivity have the greatest interference on the profitability of organic tomato production in a protected environment. By means of the variance decomposition, El Benni and Finger (2013) assess how output prices and yields contributed to revenue risk. They demonstrate that, even if the importance of yield risk increased over time, prices were the main contributor to revenue risk. In addition, their study on dairy farming finds strong differences between regions as previously stated by Wolf et al., 2009. Vedenov (2008) analyses the relationship between individual farm yields and area yields.
Variability in prices and/or yields is the primary cause of instability in agriculture leading to income variability (Robinson, 1989). Fluctuations in farm income have important effects on agribusiness firms, creditors and communities serving farmers (Mishra and El-Osta, 2001). Being a rational agent, a farmer is interested in reducing fluctuations in household income. Income stability influences the ability of farm families to expand their operations and repay debts (Barry et al., 1988). In a large national survey conducted by the USDA's Economic Research Service and National Agricultural Statistics Service, Mishra and El-Osta (2001) examine how variability in farm operator household income is related to its components using the method of normalized variance decomposition and individual farm record from the Agricultural Resource Management Study (ARMS). The authors state that differences in farm income among farm operator households may arise due to variations in climate, the productivity of the land base, and the type and size of the operation. An important yet largely unanswered question is how these latter factors are distributed across farms with different business and structural characteristics. Purdy et al. (1984), for example, explore how specialization, size and other characteristics of Kansas farms have an effect on the level and variability of these farms' returns on equity (ROE). Their findings indicate that the variance of the ROE is not significantly influenced by total hectares utilized, but does respond significantly to various degrees of farm diversification. Similarly, Schrule and Tholstrup (1989) find that business risk (measured by the ratio of the variance of farm income to assets squared) is significantly related to farm size (measured as

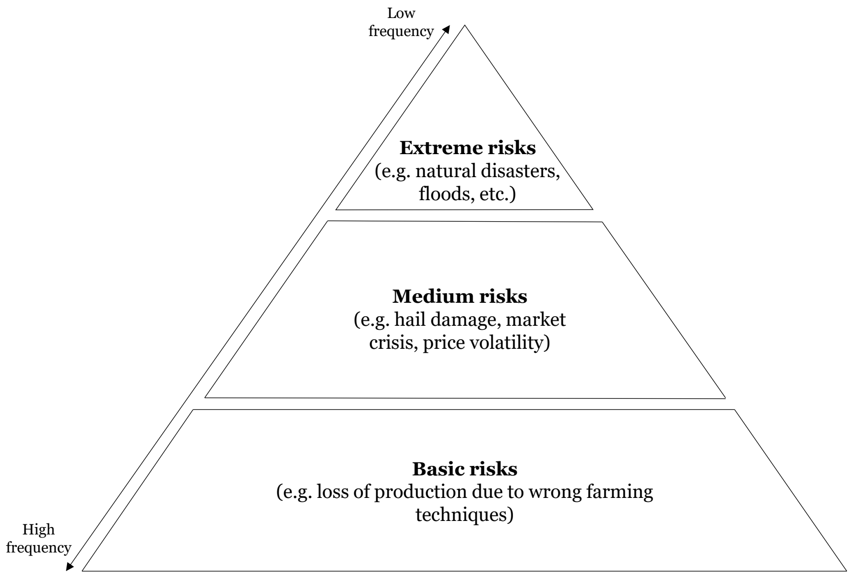
capital managed), age of operator, type of farm, location, and government payments. Cacho et al., 1999, assessing the production risk in the grazing model, demonstrate that it is important to account for variability in a dynamic management model. By means of a Monte Carlo simulation, they studied the effect of irrigation, stocking rate and lamb drafting weight on profit and on meat and wool production. Barry et al. (2001) demonstrate the relationship between economic risk and its determining factors, utilizing the mean-variance framework of portfolio theory (Machina et al., 2013; Elton and Gruber, 1998; Meyer, 1987; Robinson and Barry, 1987).

2.2.3. Classifications of risk

One possible classification of risk concerns the frequency and intensity of the occurrence of potential risk factors. In terms of lack/reduction of agricultural production, with respect to the frequency, and by the size of the economic damage that may result from, risks can be categorised as follows (Figure 2.1):

- *basic* risks, which occur frequently and can be addressed through direct management by farmers as part of normal production techniques and business strategies or with the help of other protective devices (e.g. frost protection systems);
- *medium* risks (e.g. hail damage, market crisis, price volatility) which can lead to significant economic losses and require to activate appropriate risk management tools such as traditional or innovative forms of insurance coverage, the use of futures and of associated forms of production and marketing;
- *extreme* risks, rare but wide-ranging (e.g. natural disasters, floods, etc.), which can affect large areas and a considerable number of producers. They require the intervention of the institutional system with appropriate protection instruments.

Figure 2.1 - Classification of risk based on its frequency - the pyramid of risk.



Source: adaptation from ISMEA (2018).

Risks could be also classified according to their origins. The literature on risk in agriculture has provided multiple risk classifications in this regard (Table 2.1):

Table 2.1 - Classification of risk based on its origin – a literature review.

Source	Classification
OECD (2000)	1. Common risks (family situation, health, personal accidents, and macroeconomic risks). 2. Agricultural risks: – 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, etc.); – regulatory or institutional risk (agriculture policies, food safety, and environmental regulations).
Hardaker et al. (2015)	1. Business 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, referring to the time when production decisions are taken; – Institutional risk is due to government actions and rules such as laws governing the disposal of animal manure or the use of pesticides, tax provisions, and payments; – Personal risk is due to uncertain life events such as death, divorce, or illness. 2. Financial risks result from different methods of financing the farm business.
Musser and Patrick (2001) following Baquet et al. (1997)	– Production risk: it concerns variations in crop yields and in livestock production due to weather conditions, diseases, and pests; – Marketing risk: it is related to the variations in commodity prices and quantities that can be marketed; – Financial risk: it relates to the ability to pay bills when due, to have money to continue farming and to avoid bankruptcy; – Legal and environmental risk: it concerns the possibility of lawsuits initiated by other businesses or individuals and changes in government regulation related to environment and farming practices; – Human resources risk: it concerns the possibility that family or employees will not be available to provide labour or management.
Moschini and Henessy (2001)	Distinguish among sources of uncertainty in agriculture: – Production uncertainty. The amount and quality of the output that will result from a given bundle of production decisions are not known with certainty. – 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 when the production decisions are taken. Inelastic demand is often cited as the 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, etc.) agriculture is typically characterised by an intricate system of government interventions, changes in which may create risk for agricultural investment.

Source: Author's elaboration.

According to the classification done by OECD (2009 and 2011), this thesis focus on the following four transversal macro-categories of risk resuming all the different possible catalogues (see the previous table) in this summary:

- price and market risks, including the risks associated with a fall in the selling prices, and those associated with an input prices increase or the inability of marketing the products;
- production risks, concerning all factors that may affect the availability of the products at the end of the cultivation or rearing cycle (e.g. adverse weather conditions or the spread of plant diseases and epizootic diseases);
- financial risks, related to capital availability, the congruence of the cycle of receipts and payments and the possibility of access to credit;
- Institutional and legislative risks, deriving from new regulations that influence the business, or condition it, with the introduction of new burdens or constraints.

These classifications of risk highlight that farmers may be facing very distinct risks at the same time, thus reflecting the variability of production (or rather yield since our focus is on crop farms mainly due to weather risks) and of prices (mainly due to market risks). In these conditions, the optimal strategy to deal with them requires to account for the correlations among them.

The decomposition of income risk indicates the significant contribution of output diversification and price-yield correlation to stabilise income. However, what is matters is the overall effect deriving from the interaction among the several components of risk.

A different dimension used to classify risks refers to how these affect the whole farm population.

Depending on the level at which risks occur and the intensity with which they materialize, the same types of risk can be taken on the form of specific risks (i.e. idiosyncratic) or widespread risks (i.e. systemic).

According to World Bank (2000a and 2000b) and Holzman and Jorgensen (2001) and referring to a sample of farmers, is essential to distinguish among micro or idiosyncratic risk that affects the individual; meso risk affecting the whole community of farmers and macro or systemic risk affecting a whole region or country.

Linking among the distributions of different risks is 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*[1].

In this context, it is important to recall that the risks can be classified according to more than one dimension at the same time. Moving from single farmer risks to entire regions or nations, and evaluating different risk factors actions, an analysis framework with the different criticism to face could be structured as in OECD (2009) using the last two dimensions previously described: source of risk and systemic/idiosyncratic nature of the risks (Table 2.2).

Table 2.2 - Types of risk in agriculture: from idiosyncratic to systemic risks.

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

Source: OECD (2009).

[1] Correlation can also occur over time (repetition of risk) or with other risks, and there can be positive and negative correlations.

In detail, idiosyncratic risk (such as personal hazards, such as the 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 (Holzmann and Jorgersen, 2001)[2]. Considering these aspects is relevant for the setting up of risk management strategies and tools.

2.3. Risk analysis in agriculture

Conceptual and empirical work related to risk analysis in agriculture has a long history focused on identifying sources of risk (El Benni and Finger, 2013; Anton and Kimura, 2009; Mishra and El-Osta, 2001; Goetz, 1993), measuring risk (Iyer et al., 2019; Kamali et al., 2017; Lien et al., 2007), identifying farmers' attitudes to risk and the effectiveness of various risk management practices (Rose et al., 2016; Hardaker et al., 2015; Monjardino et al., 2013; Harwood et al., 1999).

A large body of literature exists on risk in agricultural production (Cacho et al., 1999). Antle (1983) states that risk matters *"primarily because production is a dynamic phenomenon"*, thus *"production and price uncertainty affect expected productivity and expected income"*.

There are a number of different metrics that have been used to describe agricultural risk. To analysis the income risk, including the overall effect of the several risk components (production and market risks in detail[3]), appreciating more traditional risk measurement tools is useful to understand recent developments.

One common approach is the *gap analysis*, at first developed by financial institutions to give a simple idea of the exposure to interest rate risk (Sinkey, 1992). It starts with choosing an appropriate time horizon period to determine the amount of the portfolio of assets or liabilities that will be revalued in this period. Gap analysis is simple to be performed, although it has some limitations: it only applies to on-balance sheet interest-rate risk; it looks at the impact of interest rates on

[2] At that time, Mahul (2001) went further and proposed dividing individual risk into two components: idiosyncratic risk that can be mutualised through insurance, and systemic risk that can be covered through yield and weather-indexed insurance or catastrophic bonds and options.

[3] Forms of financial and institutional risk are difficult to analyse on the basis of the data that are object of our empirical analysis (FADN).

income, rather than on asset or liability values; and results can be sensitive to the choice of horizon period (Dowd, 2007).

Another method traditionally used by financial institutions for measuring interest-rate risks is *duration analysis*. It can be defined as the weighted average term to maturity of the bond's cash flows, where the weights are the present value of each cash flow relative to the present value of all cash flows. A third approach is the scenario analysis (or *'what if'* analysis), in which different scenarios are set out, and investigates what we stand to gain or lose under them. *Scenario analysis* tells nothing about the likelihood of different scenarios, then the assessment of the practical significance of the different scenarios needs for personal judgment. Results of scenario analyses are highly subjective and depend largely on the skill or otherwise of the analyst.

As stated by OECD (2009), considering two potential outcomes in the simplest risky scenario, probability can be diagrammed with a decision tree as expressed in terms of the probability that one will observe one possible outcome versus another. A decision tree context could be identified both for discrete possible outcomes - when risks are more complicated – and for a continuous set of outcomes.

In agriculture, many risks are observed where the set of outcomes is continuous rather than discrete. To give an example, prices or yields might be viewed as being continuous across a wide range with a probability distribution that can best be described graphically by a probability density function (PDF) or a cumulative distribution function (CDF). A PDF or a CDF provides a visual mathematical representation of risk without providing a simple metric that quantifies risk. Several numerical measures have been proposed and used over time in applied risk analysis. These are in line with the definition of Rothschild and Stiglitz (1970) who define risk in terms of a mean-preserving spread as moving probability away from the centre of a PDF to the tails while leaving the mean unchanged.

It is often argued that downside risk matters most. Considering the idea of "placement" of risk in a distribution, it is said to have more downside risk than another if the distribution has more dispersion below a specific target or if it is more skewed to the left. The general notion of a pure increase in risk involves the spreading of probability weight from the centre to the tails of a distribution, and conversely, a decrease in risk would result from a contraction of probability weight (Ang et al., 2006; Menezes et al., 1980). In fact, the 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., 2015). For instance, yields depend on several factors such as rainfall and temperature, however, large deviations from the central values of these variables in either direction have adverse effects. Hence, downside risk becomes particularly relevant. Nevertheless, the downside risk is part of the whole distribution of outcomes in a way that there is no downside risk without some associated upside risk (OECD, 2009). Indeed, various metrics in some fashion measure the probabilities of bad events. In literature, the probability of bankruptcy has been employed as a single quantifiable measure of bad events (Lien and Hardaker, 2001).

Focusing on downside risk has led to measures of risk based on downside outcomes such as the VaR which is widely used in decision-making processes, 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 often simplifies a more complex reality in which the whole distribution of probabilities and outcomes needs to be considered (OECD, 2009).

An increasing amount of literature uses VaR to identify some criterion level of risk based on a percentile, such as the 5^{th} to the 10^{th} percentile, of the CDF (Vedenov and Barnett, 2004; Giot, 2003; Manfredo and Leuthold, 1999 and 2001) giving a simple numerical metric by which one can judge the probability of bad outcomes.

In its most literal sense, VaR refers to a particular amount of money, the maximum amount we are likely to lose over some period, at a specific confidence level (Dowd, 2007).

Currently, VaR is considered the state of the art in measuring the risks associated with a portfolio of assets, specifically, derivative positions. In essence, VaR estimates seek to capture extreme events occurring in the lower part of the distribution of portfolio returns. The main advantage of VaR over more traditional risk measures is the focus on downward risk. Consequently, VaR is appreciated for being an intuitive measure of risk and for its ability to capture the risks of many different activities in one concise number.

The recent explosion in interest in VaR stems from its use in risk reporting and disclosure. In the wake of several well-publicised derivatives debacles, such as the bankruptcy of Barrings Bank, several regulators have recommended or requested the reporting of VaR estimates by companies (i.e. large commercial banks) that maintain positions in large derivatives to provide a clear measure of the company's downside risk potential. VaR was one of three quantitative risk reporting methods approved for the Securifies and Exchange Commission (SEC) (Linsmeier and Pearson, 1996). Similarly, futures exchanges use VaR to measure the probability of default of clearing members. Many see VaR as a more intuitive and easily understandable measure of risk for senior managers and external investors who may or may not be well trained in statistical methods. As a result of the interest in VaR, an entire industry dedicated to the implementation and use of VaR has evolved, in particular, designing software to calculate risk measurement.

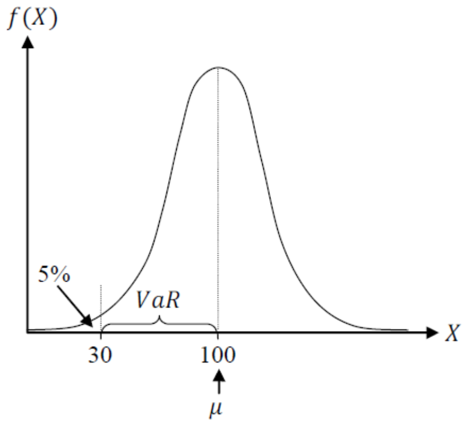
Despite the obvious uses for risk disclosure, VaR is also proposed for enterprise-wide risk management. VaR could be useful for making hedging decisions, managing cash flows, setting position limits, and selecting and allocating the overall portfolio.

Direct application of VaR in agriculture is often found in financial literature. A typical example is an agri-food company dealing with the supply and processing of agricultural commodities. In an effort to reduce the overall costs of the enterprise, the risk manager may incorporate forward contracts or forward positions and/or options in managing the risks associated with these input prices. The risk manager, who often is the same person as the farm owner or farm manager may maintain a trading portfolio containing several cash positions, forward contracts, futures and options. As a result, the risk manager may examine the VaR of this portfolio at a particular confidence level (e.g. 95%) over a given period, assessing the extent of a potentially large loss in value (Manfredo and Leuthold, 1999).

Techniques used to generate VaR measurements are not new. The calculation of VaR is synonymous with predicting the volatility of a portfolio over a given holding period, with particular attention to the lowest tail of the probability distribution.

Figure 2.2 is an example of how to calculate VaR on the distribution of outcome considering the left tail of the function [*f(X)*]. In fact, made 100 the average (μ) and considering the 5% of confidence level, where X assumes the value of 30 (quantile value), VaR is defined by the difference of the quantile value from the average one.

Figure 2.2 - Example of calculating VaR.



Source: materials distributed during the course of Risk analysis and risk management – Humboldt Universitat zu Berlin (2018).

There are many analytical models describing the fluctuation of financial instruments at the time. Two major classes of VaR estimation procedures received the most attention across time: parametric and full valuation procedures (non-parametric) (Table 2.3).

Table 2.3 - Comparison of Value at Risk methodologies.

	Parametric	**Full-valuation**	
	Variance/covariance	**Historical simulation**	**Monte Carlo Simulation**
Able to capture the risks of portfolios which include options?	No, except when computed using a short holding period for portfolios with limited or moderate options content.	Yes, regardless of the options content of the portfolio.	Yes, regardless of the option content of the portfolio.
Easy to implement?	Yes, for portfolios restricted to instruments and currencies covered by available off-the-shelf software. Otherwise reasonably easy to moderately difficult to implement, depending on the complexity of the instruments and availability of data.	Yes, for portfolios for which data on the past values of the market factors are available.	Yes, for portfolios restricted to instruments and currencies covered by available off-the-shelf software. Otherwise moderately to extremely difficult to implement.
Computations performed quickly?	Yes	Yes	No, except for relatively small portfolios.
Easy to explain to senior management?	No	Yes	No
Produces misleading value at risk estimates when the recent past is atypical?	Yes, unless alternative correlations or standard deviations may be used.	Yes	Yes, unless alternative estimates of parameters may be used.
Easy to perform "what if" analyses to examine the effect of alternative assumptions?	Easily able to examine alternative assumptions about correlations or standard deviations. Unable to examine alternative assumptions about the distribution of market factors, i.e., distributions other than normal.	No	Yes

Source: Dowd, 2007.

Parametric methods assume some particular distribution for the return of data. The core difference between them is mainly due to different approaches to the modelling of random noise (e.g. Normal distribution, t-Student distribution in parametric methods). Into non-parametric methods, there is no restriction resulting from the need for the assumption of normality or the estimation of some parameters (such as mean and standard deviation). Among these methods are the historical and the Monte Carlo simulation. Historical simulation method uses real data to estimate VaR reflecting the actual behaviour of the market based on the historical one. That requires collecting a large series of data because the higher the number, the more

accurate. Sometimes the use of the historical method is limited due to the inability to gather sufficient data. Since the historical simulation is also sensitive to extreme return rates included in the distribution, the size of VaR varies discretely. As a result, the size of the risk is often underestimated or overestimated (Mentel, 2013).
Turning into the second of the considered simulation methods, the Monte Carlo method is based on a hypothetical stochastic model that describes the evolution of the prices of the financial instrument. The essence of the stochastic processes is that it is not possible to predict the values of the process; one can only determine the probability with which a given value is reached. Determining the distribution quantile allows determining VaR in a direct way (Mentel, 2013).

The Monte Carlo method simply involves random sampling from certain probability distributions. This technique consists of repeating the experiment many times or use a sufficiently long simulation run to obtain many quantities of interest using different methods of statistical inference such as the Law of Large Numbers (Kroese et al., 2014).

Among the most interesting and consistent risk measures, there is the ETL. This measure often goes by various names in the literature including expected shortfall, *conditional*VaR, *tail*VaR, tail conditional expectation. The ETL is the expected value of losses, L, if a loss in excess of VaR occurs. The VaR informs about the most expected loss if a bad (i.e., tail) event does not occur, and the ETL tells what can be expected to lose if a tail event does occur. Concerning its estimation, the ETL is the probability-weighted average of tail losses, or losses exceeding VaR. It suggests that ETL can be estimated as an average of tail VaRs (Dowd, 2007).

2.4. Risk management strategies and tools in agriculture

In agriculture, which is particularly exposed to multiple and heterogeneous risk factors, risk management plays a critical role.

Agriculture faces external factors other than basic risks that generally characterize any business activity; they are difficult to control but have a strong impact on economic activity. These are firstly environmental (pests and diseases) and climatic conditions, which affect the quantity and quality of agricultural production, as well as the structural constraints of the agricultural market, characterized by a high degree of supply rigidity, inelastic demand and subsequent price volatility. This leads to the need to activate risk management tools, requiring the active participation of farmers along with the involvement of the institutional system.

Therefore, management measures are required at several levels: farm-level (individual farmers) or government-level (public institutions). Moreover, the type of measure to implement for adequate risk management, at both levels, could be different depending on the risk management strategy to be pursued.

Each class of risk can be faced with a different degree of intensity, selecting between actions aimed at reducing the risk or mitigating its effects and strategies for accepting the risk itself, with possible activation of compensatory ex-post interventions.

In fact, the policy options can be grouped into three categories (Table 2.4):

- risk reduction (e.g. adoption of active defence techniques, training and risk management training activities): to prevent and reduce the probability of an adverse event occurring;
- risk mitigation (e.g. insurance policies, futures contracts, etc.): to reduce the potential impact of an adverse event occurring;
- risk coping (e.g. ex-post compensatory measures, tax relief): to relieve the impact of the risky event once it has occurred.

Table 2.4 - Possible farm risk management instruments and strategies.

	Farm community	**Market**	**Government**
Risk reduction	Technological choice; production structures	Training on risk management	Macroeconomic policies (price support in supply management commodities); disaster prevention
Risk mitigation	Diversification in production; financial management	Futures and options; insurance; vertical integration; diversified financial investment; insurance	Tax system income smoothing; counter-cyclical payments;
Risk coping	Borrowing from neighbours/family intro-community charity	Selling financial assets; saving from banks	Disaster relief; social assistance; all agricultural support programs

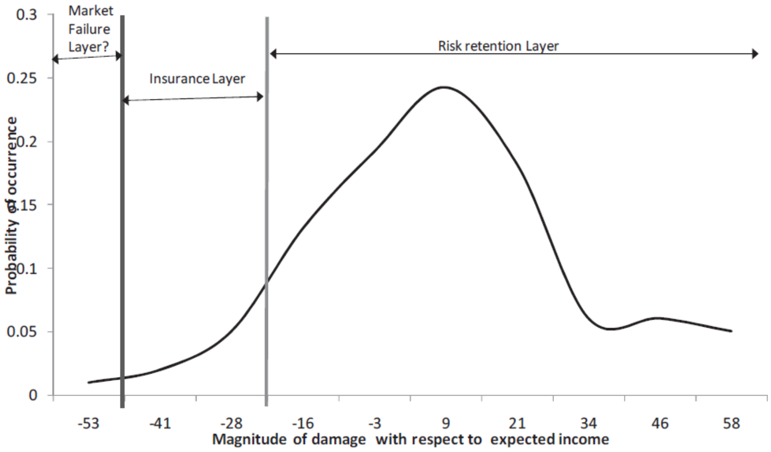
Source: OECD, 2009 and 2011.

So far, it is thus clear that risk management in agriculture must be considered as a "complex system", within which policy actions, market dynamics, effects produced by the variation of the different risk components and strategies implemented by the farmers themselves constitute a set of interconnected and interdependent variables. In order to be effective, risk management policies must, therefore, be activated primarily at the farm-level, but they must also be supported by specific interventions structured at the government level, according to policies that take into account the effects produced, at the systemic level, on other risk management measures (ISMEA, 2018).

In other words, in a complex and globalized agricultural system such as the modern one, approaching risk management following the old linear method is no longer coherent. It is necessary to move on to a holistic approach, in which the definition, the development, and the availability of each tool or strategy are determined on the basis of an overall vision that considers all the risk components: the degree of correlation between them, the strategic choices made by farmers, the public policies and the market dynamics (OECD, 2009).

As stated in the literature, markets are more likely to fail in the event of catastrophic risk (World Bank, 2005). A basic risk management technique of dividing risk into several layers permits to define risk in terms of probability of occurrence and size of losses and, consequently, the extent to which the risk is catastrophic (Figure 2.3). This segmentation would make it possible to match each set of risks with different risk management mechanisms.

Figure 2.3 - Risk layers in a Probability density function (layers at 1% and 10% probabilities)



Source: OECD, 2009.

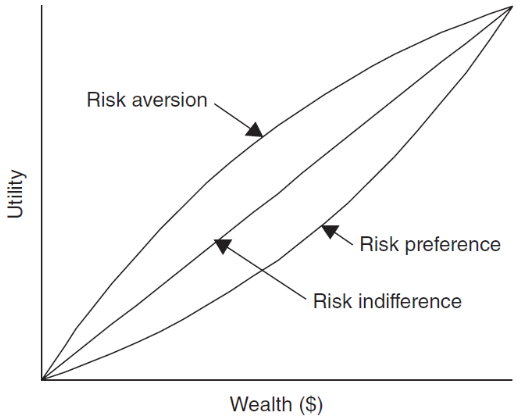
The first layer is characterized by "normal risk" and includes losses (or gains) that are part of the normal trading environment; they are very frequent but cause relatively small losses. Farmers should manage this type of risk with the tools and strategies available at the farm, family or community level, or through the policies of public administrations (i.e. financial assets management). The second layer corresponds to more expressly and less frequent risks, where farmers have the possibility to use additional specific market-based instruments, such as insurance or options specifically designed to address agricultural risks. This is the market insurance layer.

The third layer includes risks of a catastrophic nature as they generate very large losses, even if their frequency is low. However, many risks or combinations of risks lead to a distribution of impacts where the greatest losses are less likely.

2.4.1. Defining risk management strategy

Defining an appropriate risk management strategy requires knowledge of the decision-maker behaviour. There is a wide body of literature on risk in agricultural production focused on how to approach this issue: much of it with an economics orientation based on *expected utility* theory (Hardaker et al., 2015; Rae, 1994; Anderson et al., 1977). This theory assumes producers to choose among the risky alternatives they face so as to maximise their expected satisfaction or utility as measured by their personal utility function. The shape of the utility function and the attitude of implied risk play a central role in such analysis (Anderson et al., 1977). Generally, an attitude of risk aversion (rather than neutrality or preference) is assumed and the choice is dependent on the degree of risk aversion. The concepts of risk and risk aversion are important when modelling how to choose from or rank a set of random variables. A decision-maker is said to be risk-averse if that person, starting from a position of certainty, rejects the addition of any fair gamble to that certain starting position. All risk-averse persons prefer to receive the mean value of a gamble, rather than participate in the gamble itself (Machina et al., 2013). Risk aversion is represented by a utility function that showed decreasing marginal utility as the level of the payoff is increased (Figure 2.4) (Hardaker et al., 2015).

Figure 2.4 - Risk aversion and the shape of the utility function.



Source: Hardaker et al., 2015.

The theory of expected utility under risk received its first axiomatic characterization with the publication of von Neumann and Morgenstern's (1947). Building on and synthesizing their ideas, Savage (1954) proposed the first complete axiomatic subjective expected utility theory introducing a new analytical framework and providing necessary and sufficient conditions for the existence and joint uniqueness of utility and probability, as well as the characterization of individual choice in the face of uncertainty as expected utility-maximizing behaviour (Machina et al., 2013). In particular, it describes the necessary and sufficient conditions for the representation of a preference relation on risky alternatives by an expected utility function. Savage's (1954) subjective expected utility model postulates a preference structure that permits:

(a) the numerical expression of the decision maker's valuation of the consequences by a utility function;

(b) the numerical expression of the decision maker's degree of beliefs in the likelihoods of events by a finitely additive, probability measure; and

(c) the evaluation of acts by the mathematical expectations of the utility of their consequences with respect to the subjective probabilities of the events in which these consequences materialize.

In this model, the utility of the consequences is independent of the underlying events, and the probabilities of events are independent of the consequences assigned to these events by the acts.

2.4.2. Risk management systems

A risk management system can be seen as a set of complex relations among original sources of risk, available tools and strategies, and government measures. A standard solution typically used to manage risk and uncertainty regards developing insurance markets that facilitate the exchange of risk with other agents, realizing the potential gains from pooling or sharing the risk.

Risks in agriculture are managed in some countries by integrating risk management tools into agricultural policies. The EU, the U.S., Canada, Australia, and New Zealand all use risk management in their agricultural policy. Table 2.5 summarises each area's approach. The Percentage Producer Support Estimate (%) is an indicator of the amount of money that goes to farmers from consumers and taxpayers, arising from policy measures that support agriculture. The analysis of the data of the previously cited countries shows that agricultural support is the largest in the EU.

Table 2.5 - Support mechanisms for agriculture in a selection of countries.

Country	Guaranteed annual direct payment	Additional forms of support	Producer support estimate (%)
EU	Yes	Market tools/Direct Apyments/Pillar 2	18.9
U.S	No	Crop insurance policies/commodity programmes	9.4
Canada	No	Business risk management programmes	9.4
Australia	No	Taxation measures and disaster relief	1.3
New Zeland	No	Natural disaster relief	0.7

Source: Thomas, 2018.

Under the current EU CAP, farmers receive direct payments, which are guaranteed annual payments to farmers. They act as a form of risk management, by shielding farmers from strong fluctuations in markets.

In the U.S., farmers adopt either commodity programmes which support incomes when prices or revenue fall below reference levels or government-subsidised crop insurance schemes which can cover both yield and revenue losses.

The main focus of the farm act is now on market income and promoting the use of commodity and insurance programmes to address risk management. This means the government guarantees compensation for farmers for losses of crops or livestock if yields or revenue fall below a specific level. In total, the U.S. agricultural policy consists of around 60% insurance tools and no direct payments, whereas the CAP involves less than 1% insurance instruments and 60% income support through direct payments. The U.S. has the largest government subsidised agricultural insurance programme in the world. As a result, the share of U.S. cropland insured has increased from less than 30% in the early 1990s to nearly 90% in 2015.

The Canadian Government has developed various business risk management programmes to address different layers of public response to risk in agriculture: AgriInsurance, AgriStability, AgriRecovery, AgriInvest, AgriRisk Initiatives. The Canadian Agricultural Partnership gives producers access to a suite of business risk management programmes to help manage significant risks that could threaten farm viability. Risk management is a key priority area in the next policy framework of Canada, which aims to improve the anticipation, mitigation and response to risks. This has led to the development of different programmes to define different layers of public response to risk in agriculture. The programmes are not defined in terms of specific types of risk, meaning there can be overlap in terms of coverage and response (Thomas, 2018).

2.4.3. Demand for and supply of risk management tools

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. However, not all risks in agriculture have a corresponding insurance market because the insurance premium covering all the costs would be prohibitive. Therefore, it reduces or eliminates the demand from farmers at those prices (OECD, 2009).

In some countries (e.g. the United States and Canada), crop and livestock insurance is the main public policy mechanism for reducing farmers' exposure to yield and/or income risk (Mahul and Stutley, 2010).

Globally, the United States, followed by China, has the largest market for multi-period insurance (Barnett, 2014). The political importance of agricultural insurance in the EU landscape differs for several reasons. The cultural and political environment change among the Member States (MS) as well as the different types of risks to which they are exposed. In addition, the risk management of the CAP allows public support for many instruments, including insurance, MFs and income stabilization instruments (European Commission, 2016). Government attitudes towards disaster payments also vary among EU MS so much that they affect farmers' willingness to pay for insurance and, consequently, the development of (private) insurance schemes (European Commission, 2017).

The characteristics of specific agricultural insurances are different in the crop sector and in the livestock sector. In this latter, insurance covers mainly non-epidemic diseases and accidents. In the EU, crop insurance is much more widespread than livestock insurance. As far as harvest insurance covering climate risks is concerned, France, Spain, and Italy have the most important programs (Bardaji et al., 2016; Santeramo, 2018), while in Germany a single-risk hail insurance market for crops is more widespread (Reyes et al., 2017). Research by Cordier (2014) indicates that the respective weights of instruments in the EU policies are 1% insurance, 39% safety nets, 60% income support with direct payments. An important example of insurance based on drought indices is marketed in Austria (Url et al., 2018), while crop insurance covering plant health risks is not widely available in the EU. Some MSs have introduced plant health insurance which is offered as a complement to climate cover (for example Denmark, Germany, Germany, Hungary, Italy, the Netherlands and Spain) (European Commission, 2017a). A limited role in EU plays an insurance price risk (Meuwissen et al., 2018).

The literature on risk management is indeed rich. Meuwissen et al. (2018) suggest the need to assess *"willingness to pay for price, revenue, margin and income insurance"* (Schulte and Musshof, 2018; Url et al., 2018) and to analyse the degree to which various "indices" are an accurate measure of farm or sector risk (von Negenborn et al., 2018). They also recognize the need to assess the "impact of insurance on farm efficiency" (Zubor-Nemes et al., 2018).

The combination of agricultural policies and revenue and yield insurance has been studied in Bielza et al. (2004) as well as the failure of the crop insurance market (Miranda and Glauber, 1997). Even if crop insurance is an important risk coping mechanism in agriculture, its role of security has not been yet institutionalized in small farmers' culture (Farzaneh et al., 2017). Providing useful policy insights on the development of insurance as a financial face of a risk mitigation strategy, Farzaneh et al. (2017) find that a high percentage of their farmers' sample considers the low indemnity rate paid by insurance companies, as the main problem of insurance services, besides they are willing to pay for insurance only at indemnity reception.

For instance, an analysis of the causes of the loss of effectiveness of the Italian insurance system has been done by Capitanio and De Pin (2018) because of its inability to deal with the specific coverage demand from agriculture. Through the economic evaluation of convenience in adhering to the instruments offered by the insurance market to a sample of Italian winegrowers, they found that farmers are unlikely to accept policies that do not turn into an immediate income benefit.

Following the introduction of new insurance instruments into the CAP 2014-2020, much interest has been directed towards their impact on farm income stability.

Because guaranteeing farm income stability is an objective of the EU, the agricultural economic literature has been interested, over time, in studies on risk management tools for stabilizing income variability such as the new IST (Finger and El Benni, 2014; El Benni et al., 2016; Vera and Colmenero, 2017). Several studies have been performed on the IST (Liesivaara et al., 2012) generally starting from the investigation of factors affecting income loss and exploring its feasibility to implementation (Klimkowski, 2016; Trestini et al., 2017a and 2017b; Severini et al. 2019). In addition, the literature investigated several aspects linked to the setting-up of the MF by which the IST works (see chapter 3) (Severini et al., 2019; Cordier and Santeramo, 2019; Capitanio et al., 2016; Assefa et al., 2012).

2.5 Conclusions

The aim of this chapter was to frame the concept of risk analysis and risk management in order to lay the groundwork for the empirical analyses that will continue in the following chapters. The importance of assessing the extent and decomposition of the different sources of risk arises: although the literature has dealt a lot with downside risk linked to variations in yields and prices, it has placed limited emphasis on product quality. Considering all sources of risk and the correlation between them (particularly between production level and prices, and between revenues and costs also) sets the basis for a risk strategy that looks at the whole. Therefore, there is a need to focus on instruments that address income risk, which would go beyond the limits of instruments addressing individual sources of risk (e.g. yield insurance). In this regard, in an effort to simulate the feasibility of a risk management tool it is necessary to take into account the role of policies within the EU framework and, in particular, in Italy.

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Chapter 3

Insurance instruments in the Italian agricultural sector: regulatory framework and reference context

3.1. General aspects

The risk management policy in agriculture through public intervention began in Italy in 1970 with the Law No 364, which established the National Solidarity Fund (*Fondo di Solidarietà Nazionale*, FSN). As a result of the CAP reform path started in the 90s and aimed at reducing the measures to stabilize markets and prices, the Law No 364 was changed by the Legislative Decree No 102 of 29 March 2004 and by other laws (e.g. Article 127 Law No 388/2000). In subsequent years, risk management tools became an integral part of the CAP, for example in the Article 68 of Regulation (EC) No 73/2009.

For many years, the main objective of the CAP has been to secure farmers' incomes through market and price stabilization measures. Risk management was mainly in the form of ex-post interventions in those agricultural sectors affected by natural disasters, or of contributions to farmers taking out subsidised insurance authorised by the EU in the form of State aid. In 2005, the European Commission, through the Communication to the Council on risk and crisis management in agriculture (European Commission, 2006), sought to sensitise and urge the European Council to pay more attention to the issue of risk management. The document proposed and assessed three categories of new measures to help farmers manage risks and respond more effectively to crises: (1) insurance against natural disasters; (2) support to the MFs; and (3) provision of basic income coverage against income crises (Cafiero et al., 2006). The Commission's recommendations have to a large extent been taken on board in the successive CAP reforms, which have led to the provision of various instruments (Pontrandolfi and Nice, 2011):

- the reform of direct payments introduced by the CAP Health Check (Article 68, Regulation (EC) No 73/2009);
- the reform of the Common Market Organization (CMO) for fruit and vegetables (Regulation (EC) No 1182/2007), which came into force in 2008, confirmed in the Regulation (EU) No 1308/2013;
- the reform of the wine CMO (Regulation (EC) No 479/2008), which came into force in 2009, confirmed in the Regulation (EU) No 1308/2013;
- the CAP 2014-2020, which integrates risk management into rural development policy (Regulation (EU) No 1305/2013).

3.2. Risk management policies in the CAP 2014 – 2020

The CAP 2014-2020 has given an important role in risk management instruments, with broad aims and greater financial allocations than in the past. There are two new developments: the extension of instruments and financing under the second pillar of the CAP. Within this framework, support is granted to farmers for a larger number of events:

- adverse weather conditions;
- plant diseases or pest infestations;
- epizootic diseases;
- environmental emergencies;
- loss of income.

Thus, risk management deals not only with natural disasters but also with price and market insurance, and consequently with income insurance through enhanced support for insurance instruments (subsidised insurance) and MFs.

The allocation of resources for risk management is included in two CAP instruments:

- in market measures, in other words in the single CMO, namely in the wine and fruit and vegetable sector;
- in the second pillar of the CAP, thereby in the RDPs.

With the inclusion of risk management tools in the Second Pillar of the CAP, Regulation (EU) No 1305/2013 (art. 36) on support for rural development has provided for three specific measures that can be included by the MSs in their RDPs 2014-2020 (Table 3.1):

1. Crop, animal and plant insurance (Article 37);
2. MFs for adverse climatic events, animal and plant diseases, pest infestations and environmental incidents (Article 38);
3. Income stabilization tool (Article 39).

Table 3.1 - Risk management tools in the Second Pillar of the CAP.

Measure	Beneficiaries	Payments and maximum amount
Measure 17.1 - Crop, animal, and plant insurance premium	Farmers	- Financial contributions to crop, animal, and plant insurance contracts which cover for economic losses caused by adverse climatic events, animal or plant diseases, or pest infestations, or environmental incidents. - Insurance payment covers losses of more than 30% of the average annual production of the farmer. - Maximum public contribution: 65% of the insurance premium.
Measure 17.2 - Mutual funds for adverse climatic events, animal and plant diseases, pest infestations and environmental incidents	Farmers, mutual fund	- The mutual fund provides affiliated farmers with compensation payments in the event of economic losses caused by the outbreak of adverse climatic events, an animal or plant disease, a pest infestation, and environmental incidents. - Maximum public contribution: 65% of the administrative costs of setting up the mutual fund and 65% of the amounts paid by the mutual fund to farmers.
Measure 17.3 - Income stabilization tool	Farmers, mutual fund	- Compensation to farmers in case of loss of income greater than 30% of the average annual income of the individual farmer. - Compensation to farmers in case of loss of income greater than 30% of the average annual income of the individual farmer. - Maximum public contribution: 65% of the amounts paid by the mutual fund to farmers.

Source: Frascarelli, 2016.

3.2.1. Subsidised insurance contracts

The CAP 2014-2020 provides support for insurance contracts. The specific RDP 'Measure 17.1 - Crop, animal and plant insurance premium' provides for financial contributions to premiums for insurance contracts which cover for losses caused by adverse climatic events, animal or plant diseases, pest infestations or environmental incidents. The insurance contracts eligible to financial support cover losses exceeding 30% of the average annual production of the farmer in the preceding three-year period or a three-year average based on the preceding five-year period, excluding the highest and lowest production according to the Olympic average method. The maximum public contribution is 65% of the insurance premium.

3.2.2. Mutual funds

'Mutual fund' means a scheme recognised by the MSs, in accordance with its national law, which allows affiliated farmers to insure themselves and receive compensation payments in the event of economic losses caused by an adverse climatic event or by the outbreak of an animal or plant disease or an environmental incident or in the event of a sharp fall in income. MSs should define rules for the constitution and management of MFs, in particular for the granting of compensation payments and the eligibility of farmers in the event of a crisis, as well as for the administration and the monitoring of compliance with those rules. The MSs shall ensure that the funds provide for penalties in the event of negligence on the part of the farmer. No contribution by public funds shall be provided to initial capital stock. The contribution of the RDPs is a maximum of 65% of the eligible costs, which are:

- the administrative costs of setting up the MF spread over a maximum of three years in a digressive manner;
- the amounts paid by the MFs as financial compensation to farmers.

The financial contribution may also relate to interest on commercial loans taken out by the MF for the purpose of paying financial compensation to farmers in the event of a crisis. Public support shall be granted only to cover losses caused by the outbreak of adverse climatic events, animal or plant diseases, pest infestations or measures adopted to eradicate or contain a plant disease or pest or environmental incident which destroy more than 30% of the average annual production of the farmer in the preceding three-year period or an Olympic average on the preceding five-year period.

3.2.3. Income Stabilization Tool

Support under the IST consists of compensating farmers for losses greater than 30% of the average annual income of the individual farmer in the preceding three-year period or of the average annual income calculated on the basis of the Olympic average on the preceding five-year period. “Income” means the sum of the revenues the farmer receives from the market, including any form of public support, deducting input costs. The IST is based on the constitution of a MF, for which the considerations set out in the previous paragraph are applied. Payments by the MF to farmers compensate up to 70% of the income loss in the year the producer becomes eligible to receive this assistance.

The IST has been a real novelty both in the agricultural support policy in the EU and in the operations of the insurance world (insurance companies, farmers' associations).

3.3. The Omnibus Regulation [Regulation (EU) No 2017/2393]

The increased vulnerability of the agricultural production system to adverse climatic, health and market phenomena, characterised by greater impact and intensity than in the past, has raised the level of attention on risk management, whose centrality within both EU and national agricultural policy instruments is now unanimously recognised. The process started with the Health Check of the CAP [Regulation (EU) No 73/2009] - subsequently continued and strengthened with the rural development 2014-2020 programming [Regulation (EU) No 1305/2013] - made risk management measures plannable for the first time, providing them with a multiannual financial ceiling available until 2023. Such an important aspect gives greater stability and sustainability to the interventions, overcoming the limit of the funds previously allocated on an annual basis. The recent amendments adopted by Regulation (EU) No 2017/2393, also known as the Omnibus Regulation, taking into account the critical issues emerged in the first application phase, have introduced substantial changes, increasing the aid and promoting a greater efficiency of risk management tools as part of a broader process of modernization and simplification of the CAP.

Although the instruments made available by EU and national regulatory systems are multiple and structured, and therefore potentially suitable to pursue a holistic approach to risk management, the experience gained since the 2013 CAP reform has not produced the desired effects. The need to revise and improve the *toolkit* provided for in Regulation (EU) No 1305/2013, in fact, has emerged both with reference to the primary risk management tool -the support for insurance contracts provided for in Article 37 of the same Regulation, and with regard to the most

innovative tools (MFs and the IST).
With respect to subsidised insurance contracts, it should be noted that not only there were undoubted difficulties in pursuing the objective of increasing their spread at the EU level, but in some cases, such as that of Italy -today one of the countries with the strongest tradition in terms of risk management policies in agriculture- there was even a significant contraction in insured values.
With regard to the second element, MFs and IST, it should be noted that, despite the innovative scope of these instruments, their dissemination at the EU level is today still very limited. It is noteworthy to say that the relative measures have been transposed into the RDPs of very few MSs, with subsequent obvious start-up difficulties: the IST has been activated only by Italy, Spain (Castilla y León) and Hungary (the latter two on an experimental basis); the measure on MFs against climatic and health adversities has been activated only by France, Italy, and Romania. Moreover, to date, only France seems to have given concrete form to the measure within the framework of the Fonds national agricole de mutualisation sanitaire et environmental (FMSE), while the other countries have struggled to make operative EU instruments (ISMEA, 2018; Cordier and Santeramo, 2019).
In view of these considerations, given the importance of risk management measures, in a historical situation characterised by intense climatic variations affecting yields, and significant fluctuations in the prices of agricultural products and production factors threatening the profitability of farms, the Commission for Agriculture and Rural Development (*Commissione Agricoltura e Sviluppo Rurale*, COMAGRI) has taken the opportunity provided by the Omnibus Regulation to propose solutions for their improvement. In addition to the problems already mentioned and linked to the transfer of funds to the second pillar, the reflections conducted at EU level have led to the conclusion that the limited success of the risk management instruments promoted under the CAP was also to be found in the inevitable hostile effect caused by the slavish application of the rules by the World Trade Organization (WTO). These rules, by setting precise limits on the level of public contribution as well as on the thresholds of damage for access to compensation, have made the risk management instruments unattractive or too onerous for farmers. In particular, the IST needs to comply with WTO rules, which

impose a precise and accurate definition of the income subject to stabilization on the basis of economic-income items. These latter are difficult to be defined for an agricultural firm, which often is not required to draw up financial statements and subject to simplified regimes. Such a circumstance has in fact significantly hindered the dissemination of the instrument. Therefore, the whole of these issues has been extensively addressed in the Omnibus Regulation, which makes a number of substantial changes to the current structure of risk management measures under rural development with the aim of making insurance mechanisms more attractive to farmers and easier to implement.

A brief description of the new features introduced by the Omnibus Regulation follows.

- **Subsidised insurance contracts (Article 37 of Regulation (EU) No 1305/2013)**

The regulation provides for a reduction of the damage threshold for access to compensation from 30% to 20% of the average annual production. In addition, the public contribution rate is increased from 65% to 70% of the eligible expenditure (insurance premium). These amendments make possible, on the one hand, to increase the probability of the farmer to obtain compensation in the event of adverse climatic or health conditions affecting production and, on the other hand, to reduce the cost of taking out an insurance policy, in view of the higher public contribution that can be perceived.

- **Mutual funds for natural disasters (Article 38 of Regulation (EU) No 1305/2013)**

For MFs against adverse weather, health and environmental conditions, the regulation introduces the eligibility of public contribution into MFs and their initial capital stock. Even for this instrument, which is still not widespread, the support rate is raised to 70%. These actions should remove the obstacles related to the unavailability of financial resources for the establishment of MF and, at the same time, facilitate the ordinary activity of the MF, allowing for a more substantial and immediate recapitalization after adverse events involving the payment of compensations occur.

- **The Income stabilization tool (Article 39 of Regulation (EU) No 1305/2013)**

The IST is extensively revised and enhanced. Firstly, with the introduction of the new Article 39a, a sector-specific IST is introduced with the possibility to cover drops in farmer's income exceeding at least 20%. In addition, for both ISTs the regulation introduces extended possibilities to use economic indexes to calculate losses in order to overcome the aforementioned difficulties. Finally, similarly to what has been established for MFs, public contributions can supplement the annual payments into the MFs, as well as relate to their initial capital stock, and are increased on eligible expenses to 70% (Table 3.2).

Table 3.2 - Risk management measures - a summary of the innovations introduced by the Omnibus Regulation (Regulation (EU) No 2017/2393).

Instrument	Provisions	Regulation (EU) No 1305/2013	Omnibus Regulation
Crop, animal and plant insurance (Art. 37)	Aid intensity	Up to 65%	Up to 70%
	Damage threshold	30%	20%
Mutual funds (Art. 38)	Aid intensity	Up to 65%	Up to 70%
	Damage threshold	30%	30%
	Possibility to use public funds to supplement annual integration and initial capital stock	Not foreseen	Expected
Income stabilization tool (Art. 39)	Aid intensity	Up to 65%	Up to 70%
	Damage threshold	30%	30%
	Possibility to use public funds to supplement annual integration and initial capital stock	Not foreseen	Expected
	Possibilities to use indexes to measure losses	Not foreseen	Expected
Sector-specific IST (New Art. 39 a)	Aid intensity	Not foreseen	Up to 70%
	Damage threshold		20%
	Possibility to use public funds to supplement annual integration and initial capital stock		Expected
	Possibility to use indices for the measurement of losses		Expected
Risk management (Art. 36) - Ref. Amendment art. 9 Reg. (EU) n. 1307/2013	Active farmer	Application paragraph 2 Art. 9 Reg. (EU) No 1307/2013 (negative list)	Discretionary application paragraph 2 Article 9 Regulation (EU) No 1307/2013 (negative list)

Source: Regulation (EU) No 2017/2393 of the European Parliament and of the Council of 13 December 2017 and Regulation (EU) No 1305/2013.

3.4. Focus on risk management policies in Italy

3.4.1. The National Solidarity Fund

The FSN, established in 1970 by Law no. 364, aims to promote mainly preventive measures to deal with damage to agricultural and livestock production, farm structures and agricultural infrastructure in areas affected by natural disasters or exceptional events. Since its creation of the FSN, several measures have been adopted against specific disasters, introducing corrective measures and amendments (Legislative Decree No 102/2004 and Legislative Decree No 82/2008) which, in addition to compensatory contributions for damage caused by natural disasters, also provided for measures to contribute to the costs of insurance covering production against atmospheric damages. In compliance with EU legislation, Legislative Decree No 102/2004 provides for a contribution on insurance premiums paid by farmers, which may reach up to 80% of the cost of insurance premium when the contracts cover damage exceeding the minimum threshold of 30% of the insured value; the aid rate is reduced to 50% of the cost of the premium when the insurance contracts cover also damage below this threshold.

Legislative Decree No 102/2004 has also generated advantages for farmers by broadening insured risks: in the 1990s and until 2005, the insurance market's offer was limited to single-risk insurance contracts, especially for the coverage of hail damage. To remedy this situation, in implementation of Legislative Decree No 102/2004, the National Agricultural Insurance Plan (*Piano Assicurativo Agricolo Nazionale*, PAAN) since 2007 has opened the way to new guarantees and new types of insurance contracts: mono-risk, pluri-risk, and multi-risk contracts. More specifically, all adversities are insurable in all regions: hail, frost, ice, volcanic ash in Sicily, all plant productions, structures (greenhouses and hail nets, tree plants, etc.), and livestock production.

Today, the FSN continues to finance contributions both to insurance contracts against damage to farm structures and for the disposal of animal carcasses (ex-ante interventions), and to the costs incurred by farmers for production and farm premises losses and for restoring the infrastructures (compensatory or ex-post interventions) as a result of damage to production, structures, infrastructure and facilities, but not those caused by events foreseen by the PAAN. In 2017, FSN distributed contributions of more than 11 million euro (on just a little more than 25 million euro in premiums) for insurance contracts against damage to structures and, largely, for the disposal of carcasses (68%) (Table 3.3)

Table 3.3 - Agricultural insurance subsidised by the FSN (2014 and 2017) (€).

	2014	2017
Insured production value		
Structures	804,453,710	916,721,496
Animal husbandry - cost of disposal	167,357,401	377,036,516
Insurance premium		
Structures	6,658,057	7,600,264
Animal husbandry - cost of disposal	7,788,891	17,547,454
Public expenditure under FSN		
Structures	3,329,029	3,800,132
Animal husbandry - cost of disposal	3,894,445	7,896,354

Source: ISMEA on SIAN data and defence bodies

3.4.2. The agricultural risks reinsurance fund

Article 127 of Law No 388/2000 set up the Agricultural Risks Reinsurance Fund under the Istituto di Servizi per il Mercato Agricolo Alimentare (ISMEA) in order to promote the testing and dissemination of new insurance instruments. The Fund, whose operating procedures were defined by the decrees of the Minister of Agricultural, Food and Forestry Policies (*Ministero delle Politiche Agricole, Alimentari e Forestali*, MiPAAF) of November 7, 2002 (regulation) of February 7, 2003 (first reinsurance plan) and February 27, 2008 (second reinsurance plan), provides for the compensation of agricultural risks covered by pluri- and multi-risk insurance contracts, i.e. with a public contribution on a portion of premium cost. In general, the advantage of activating the reinsurance fund has been to provide farms with more innovative insurance cover instruments. Insurance companies would not be able to offer such instruments on the market without risk cover (second-degree insurance), except for very high premiums.

The reinsurance systems are actually two, called *stop-loss* (a technicality that sets a maximum loss for both the company and the reinsurer up to agreed limits) and *quota share* (the risk, in this case, is proportional to the share of premiums transferred from the insurer to the reinsurer).

In order to strengthen the effects of the Fund's activities in the perspective of public-private partnerships, in 2007 the Italian Co-reinsurance Consortium against natural disasters in agriculture was founded. In addition to the Fund, the Consortium is open to all Italian and foreign companies regularly authorised to insure or re-insure agricultural risks in Italy.

Since 2010 the Agricultural Risks Reinsurance Fund, which had achieved its objective of spreading and consolidating multi-risk insurance contracts on the market, has concentrated its activities on multi-risk insurance contracts, making use of the co- reinsurance consortium.

3.4.3. Innovative instruments: revenue and index insurance contracts

In Italy, with the aim of expanding the range of instruments available to farmers for the protection of production and income, through the PAAN 2017 two new categories of insurance contracts were introduced for the first time into the national agricultural insurance system: revenue insurances and *index-based* insurances (also called parametric or index insurance). With the subsequent Ministerial Decree No 10405 of March 23, 2017, MiPAAF integrated the PAAN by defining characteristics, requirements and operating methods for the implementation of the experimental insurances. In more detail:

- *revenue insurances* are insurance contracts that cover the loss of revenue from the insured production. This latter is determined as a combination of yield reduction (due to catastrophic events, frequent and incidental events) and market price reduction;
- *index insurances* are insurance contracts that cover the loss of production insured for damage in quantity and quality due to an adverse climatic event, identified by the positive or negative deviation from a biological (e.g. loss of biomass) and/or meteorological index.

The insured values are obtained from the product between insured quantity, determined on the basis of the three-year or five-year average of the holding (in accordance with the provisions of Regulation (EU) No 702/2014 and the Ministerial Decree n.162/2015), and insured price, the latter being equal to or lower than the maximum price established annually for each crop by a specific decree of the Ministry of Agricultural, Food and Forestry Policies.

The revenue insurances can currently be taken out exclusively with reference to the production of durum wheat and soft wheat, for income losses exceeding the threshold of 20% generated by reductions in the quantity produced due of catastrophic adversities (frost and hoarfrost, drought and flood), frequent (excessive snow and rain, hail, strong wind) and incidental events (sunstroke and warm wind, sudden temperature changes) and/or reductions in the market price. The public contribution that can be granted, within the limits of the available budget, is equal to a maximum of 65% of the eligible expenditure, represented by the cost of the insurance contracts net of the reparations made in compliance with the provisions of PAAN 2017 (application of the "contribution parameters") and in any case up to a maximum of 25% of the insured value. For this specific type of insurance contract, contributions are also paid in compliance with Regulation (EU) No 1408/2013 (*de minimis regime*), therefore up to a limit of € 15,000 over three financial years per individual beneficiary.

Subsidised index-based insurances can only be underwritten with reference to the production of cereals, fodder and oilseeds identified in Annex 1 of the PAAN 2017 against the risks of catastrophic, frequent and incidental adversities. Adverse climatic trends can be added, understood as alterations to parameters included in the meteorological index (e.g. rainfall and/or cumulative temperature during the cultivation period and for part of it), which determine significant deviations from the optimal curve for a given crop and produce negative effects on production, which can be measured with biological indexes.

Also for this type of innovative insurance contract, public contribution can be granted up to a maximum of 65% of the eligible expenditure, namely the cost of the insurance contract net of the parameters modification carried out in compliance with the provisions of PAAN 2017 (application of the "contribution parameters"), in any case, up to a maximum of 25% of the insured value and taking into account the budgetary availability.

Finally, it should be noted that the PAAN 2018 partially revised the requirements for the underwriting of index-based insurance contracts: the new text, in fact, provides for the possibility of activating coverage for damage caused by adverse weather conditions, regardless of whether or not multi-risk guarantees are taken out at the same time. This change represents a significant innovation: the scope of index insurance is broadened, thus reducing the regulatory limits for their eligibility for a contribution; it also exempts from the obligation to provide the necessary expert systems to verify the damage caused by catastrophic, frequent and incidental adversities. In such a manner, pursuing more effectively the objectives of reducing management costs is made possible.

In essence, index insurances differ from traditional indemnification insurances because the right to compensation is no longer related to the actual loss assessed in the field, but to a loss estimated ex-ante on the basis of specific parameters. This has led to a series of technical and legal issues about the compatibility of parametric insurance contracts with the provisions of Italian legal system, limiting their dissemination to date[4]. Another aspect concerns the application of the principle of indemnification of insurance. According to the general principles of national laws, the original requirement of the insurance contract is the existence of an indemnification vocation, namely the purely compensatory purpose of the contract, which cannot be justified by enrichment intentions.

In addition, in order to encourage the launch of these new insurance products by insurance companies, around €12 million has been allocated to the reinsurance of experimental guarantees under the Agricultural Risk Reinsurance Fund for the year 2017.

3.4.4. Measure 17 of National Rural Development Programme 2014-2020 and regional RDPs

As a result of the changes introduced by the Omnibus Regulation, the new Risk Management Plan for Agriculture (2019) has seen a strengthening of the set of risk management tools available to farmers for the protection of their production and income.

In fact, the insurance instruments have been proposed again in a widest configuration, by adding to the agricultural insurances (that can be financed under the measure 17.1 of the NRDP) the livestock insurance contracts and the insurances on the company structures, the index-based insurances (limited to the production of cereals, forage and oilseeds), and the revenue insurance on durum wheat and soft wheat, financed with national resources under the FSN (Legislative Decree No

[4] The principle of predetermination of damage which characterises parametric insurance contracts raises a question of the legal framework of the contract, which in the absence of certain characteristics could take the form of a "bet", i.e. a financial instrument, rather than an insurance contract.

102/2004 and subsequent amendments and additions) (Table 3.4).

Table 3.4 - Risk management in Italy: eligibility conditions and financial source - framework 2019.

Instrument	Damage threshold	Fund	Contribution
Crop, animal, and plant insurance premium	Damage threshold 20%: -crop production: - Animal husbandry (guarantee of loss of income; forced culling; loss of milk production due to hygrothermometric imbalances)	EAFRD[5] (NRDP) FSN	Max 70% of eligible costs
	Damage threshold 20%: - crop production (risk covers).	EAFRD (NRDP)	Max 65% of eligible costs
	No damage threshold: -Disposal of carcasses; - Farm structures.	FSN	Max 50% of eligible costs
Index-based insurance premiums (cereals, fodder, and oilseeds)	Damage threshold: 30%	FSN	Max 65% of eligible costs
Insurance premiums income contracts (durum wheat and soft wheat)	Damage threshold: 20%	FSN	Max 65% of eligible costs
Mutual funds for adverse climatic events, animal and plant diseases, pest infestations and environmental incidents	Damage threshold: 30%	EAFRD (NRDP)	Max 70% of eligible costs
Mutual funds for sectoral income losses	Income reduction threshold: 20%	EAFRD (NRDP)	Max 70% of eligible costs

Source: Elaboration on ISMEA (2019) data.

The measure 17 "Risk management" was activated at the national level with the NRDP 2014-2020 with the main aim of strengthening and modernising the instrument of facilitated insurance contracts (sub-measure 17.1) and encouraging their spread in those areas and sectors that were less involved. Although with less substantial financial resources, the NRDP has also provided for the activation of alternative or complementary risk management instruments to traditional insurance contracts (MFs relating to sub-measures 17.2 and 17.3), with the aim of expanding the range of instruments available and encouraging farmers to adhere to mutual risk

[5] European Agricultural Fund for Rural Development (EAFRD).

prevention schemes.

The financial allocation that the NRDP 2014-2020 reserves for Risk Management Measure 17 amounts to €1,535.5 million, for the entire programming period, €1,341.5 million of which are allocated to sub-measure 17.1 and the remaining €194.0 million are equally distributed between sub measures 17.2 and 17.3 (Table 3.5).

Table 3.5 - Measure 17: Planned public expenditure by sub-measure in Italy.

	Public expenditure (€)			Measure distribution (%)
Sub-measure description	**Total**	**EAFRD**	**National**	
17.1 Crop, animal, and plant insurance premium	1,341,534,479	603,690,516	737,843,963	87.4
17.2 – Mutual funds for adverse climatic events, animal and plant diseases, pest infestations and environmental incidents	97,000,000	43,650,000	53,350,000	6.3
17.3 - Income stabilization tool	97,000,000	43,650,000	53,350,000	6.3
Total Measure 17	**1,535,534,479**	**690,990,516**	**844,543,963**	100.0

Source: ISMEA progress report on public expenditure 2014-2020 - fourth trimester 2018.

It should be noted that the total amount allocated to risk management measures intercepts 72%[6] of the entire amount of financial resources allocated in the NRDP 2014-2020, amounting to €2,140 million[7].

Despite the changes introduced by the Omnibus Regulation and the consequent expansion of the risk management tools financed under the 2014-2020 NDRP, the budget for the National Programme has nevertheless remained unchanged in terms of financial planning and allocation of resources, since the sector-specific IST has not taken on the role of a new sub-measure, but has been activated under the already planned sub-measure 17.3.

On the other hand, there was a significant change in the progress of financial

[6] By design, the Italian government decided to use the NRDP to fund farm risk prevention and management, conservation of farm breeds and efficiency in the use of water resources. Therefore, it is obvious that the most of it goes to support risk management. However, the regional RDPs are the ones covering all the other priority axes and the amount of funds is higher. As a result, looking at the whole of the rural development funds (national and regionals) the percentage of RDP expenditures on measure 17 might fall below 15%.

[7] This amount also includes measures for the protection of ecosystems related to agriculture and forestry, for the efficient use of irrigation resources and for technical assistance activities

expenditure in 2018. Monitoring data show the percentage of progress towards achieving the planned public financial expenditure, which increased from 5.9% (in 15.10.2017) to 40.5% (in 31.12.2018) thanks to the acceleration in administrative procedures propaedeutic to payment (Table 3.6).

Table 3.6 - Public expenditure at 31.12.2018 (€).

	Planned public expenditure	**Programmed EAFRD**	**Realised public expenditure**	**Of which paid EAFRD**	**Realised expenditure (%)**
Measure 17 of the NRDP 2014 – 2020	*Public expenditure realised as at 15.10.2017*				
	1,535,534,479	690,990,516	90,143,450	40,564,552	5.90
	Public expenditure realised at 31.12.2018				
	1,535,534,479	690,990,516	621,164,271	2,795,234,922	40.50

Source: ISMEA progress report on public expenditure 2014-2020 - fourth quarter 2018.

3.5. Agricultural insurance in Italy: the budget for the 2018 marketing year

In 2018, the subsidised agricultural insurance market, analysed in its fundamental variables, confirmed the growth trend that had already emerged in the previous year, sanctioning the overcoming of the most critical phase of transition from the old to the new intervention regime (the two-year period 2015-2016) (Table 3.7). Overall, the market for agricultural insurance contracts is expected to grow by 5% in 2018, with an insured capital of €7.78 billion, the second-highest ever, lower than the peak reached in 2014 (€7.92 billion).

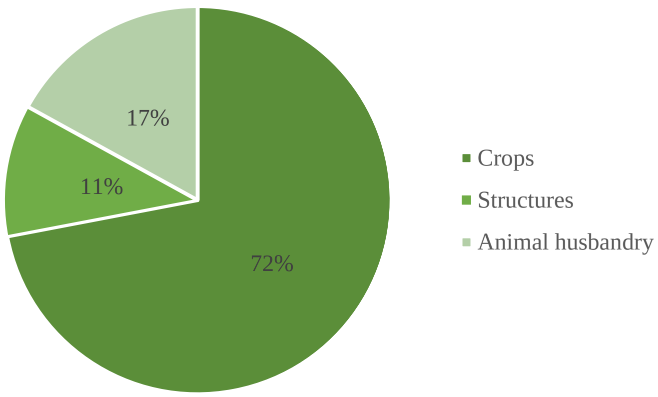
Table 3.7 - Trend in insured production values (€ million).

Year	**Crops**	**Structures**	**Animal husbandry**	**Total**
2010	4,805	520	541	5,866
2011	5,314	628	620	6,562
2012	5,454	696	672	6,822
2013	5,873	729	674	7,276
2014	6,422	804	698	7,924
2015	5,705	830	976	7,511
2016	5,103	804	970	6,877
2017	5,156	917	1,334	7,407
2018	5,605	851	1,323	7,779
Var. % 2018/2017	**8.7%**	**-7.2%**	**-0.8%**	**5.0%**

Source: Elaboration on ISMEA (2019) data.

The procedural simplifications adopted by the competent authorities to reduce bureaucracy for beneficiaries, but also the greater attention paid to risk prevention, after the exceptional crop losses caused by late frost and prolonged drought in the 2017 agricultural year, have given a considerable boost to crop insurance contracts, representing more than 70% of the entire subsidised market (Figure 3.1).

Figure 3.1 - Share of insured production values by insurance contract type in 2018 (%).



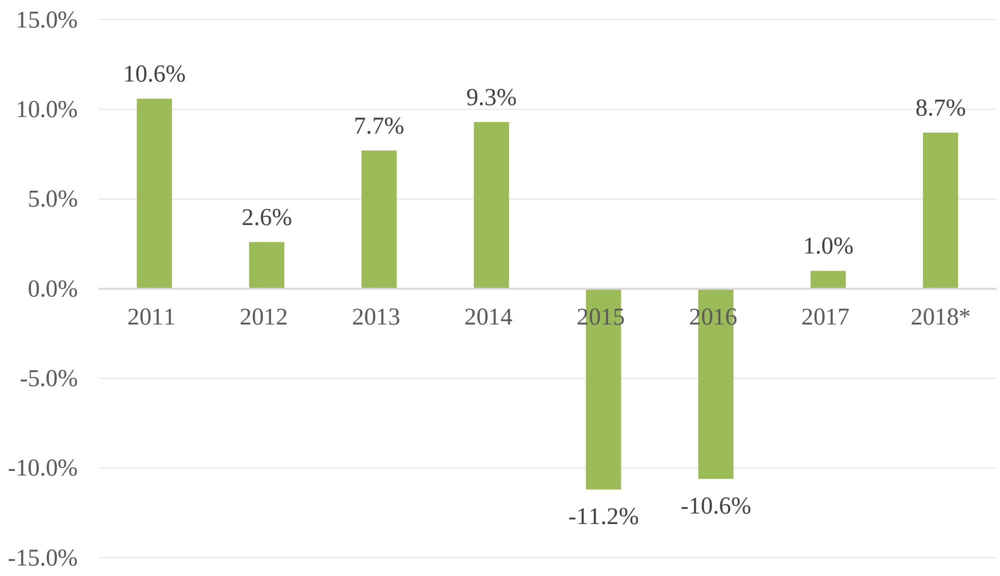
Source: Elaboration on ISMEA (2019) data.

According to ISMEA estimates (based on provisional data from insurance companies and defence consortia), the value insured in the crop sector (including wine grapes) was €5.6 billion in 2018, showing a growth of 8.7% on an annual basis, reinforcing the positive trend of the previous year and recording the best performance during the last 8 years after those of 2011 and 2014 (Figure 3.2).

On the contrary, after the strong increase in 2017, the livestock insurance market was reduced by about 1%, with a value of just over €1.3 billion. On the other hand, the decline in subsidised insurance contracts to cover corporate structures seemed more pronounced, with €851 million in insured capital and an annual contraction of 7.2%.

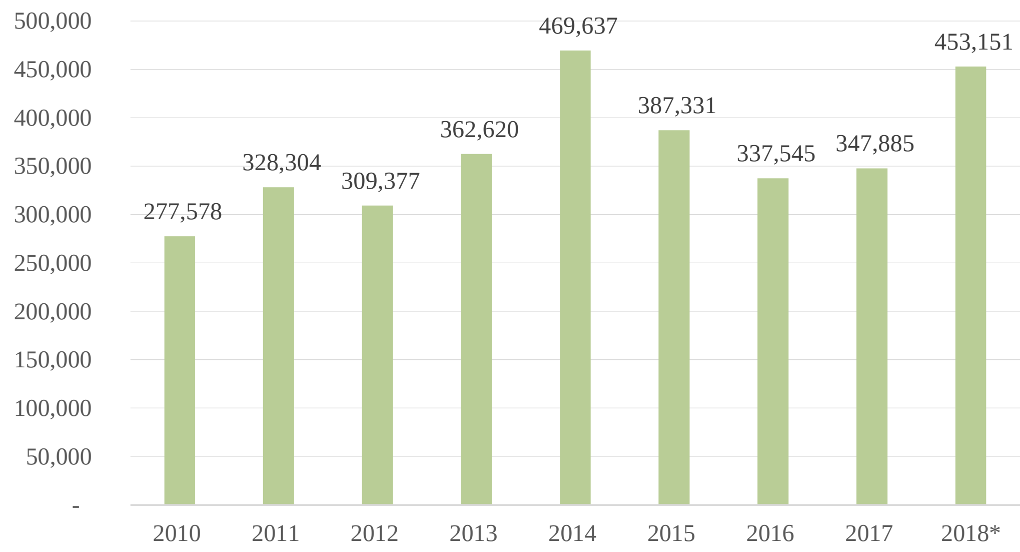
As well as insured values, the total amount of premiums in the crop segment increased, albeit by a much more significant 30% and ISMEA estimates those premiums amounted to over €453 million (Figure 3.3).

Figure 3.2 - Dynamics of insured production values - plant crops (annual variations %).



Source: Elaboration on ISMEA (2019) data.

Figure 3.3 - Evolution of premiums (,000 €) - vegetable crops.

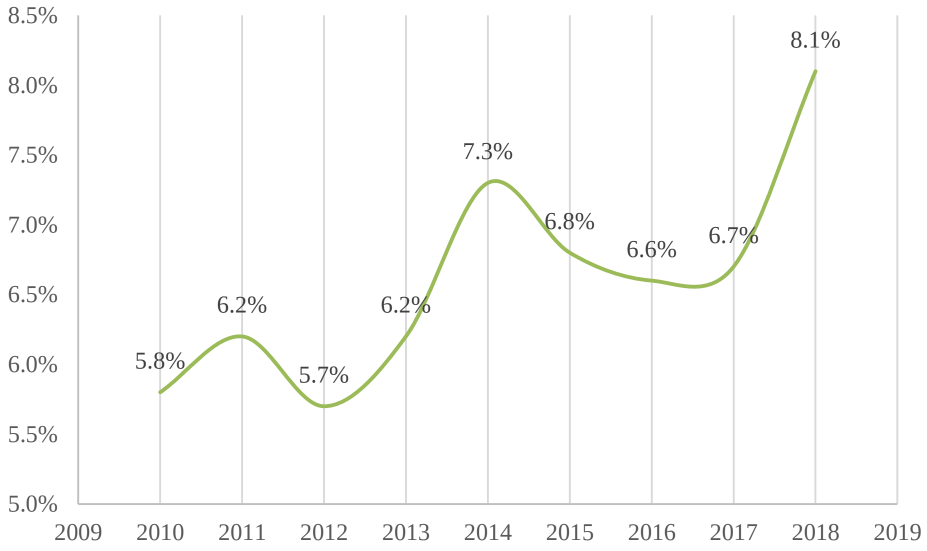


*Estimates

Source: Elaboration on ISMEA (2019) data.

The phenomenon observed in 2018 can be traced back to the sharp increases in insurance costs (on average the tariff, namely the ratio between premiums paid and insured values, rose from 6.7% to 8.1%). These increases were caused by an expense for compensation in 2017 increased by about 50% over a year as a result of the severe weather and climate conditions of the previous year (ISMEA estimates based on ANIA data) (Figure 3.4).

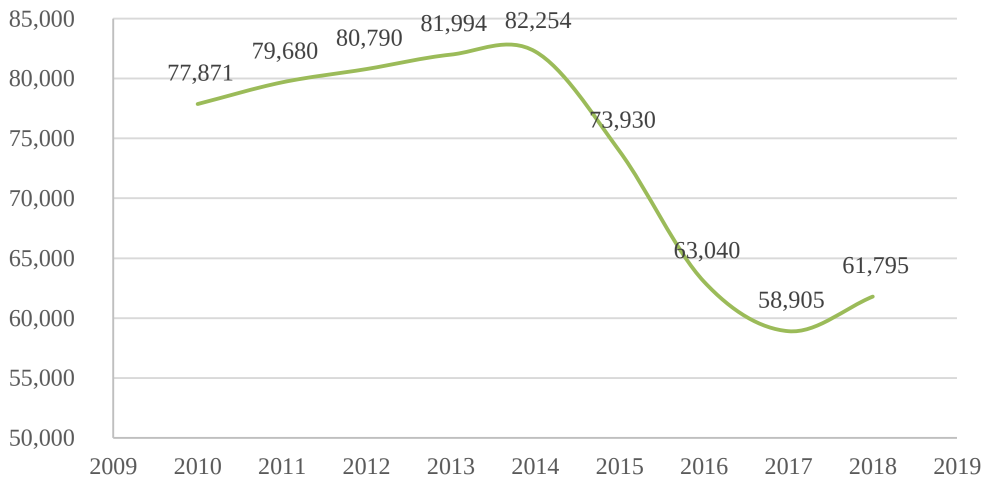
Figure 3.4 - Annual dynamics of average tariffs in Italy - vegetable crops.



Source: Elaboration on ISMEA (2019) data.

Another aspect to be highlighted is the growth of 4.9% in the number of insured farms, approximately 61,800 units in the 2018 marketing year in the crop sector (a similar increase was recorded for the number of contracts/certificates, amounting to almost 148,000) (Figure 3.5).

Figure 3.5 - Evolution of the number of insured farms - plant crops.



Source: Elaboration on ISMEA (2019) data.

Considering also livestock insurance contracts and contracts for the protection of farm structures, it can be estimated 77,000 farms involved in the subsidised circuit. Finally, the data for 2018 show significant growth in insured areas -more than 40% compared to 2017- which have exceeded the threshold of 1.4 million hectares at the national level.

The detailed data, available only for vegetable crops, show a generalised growth in insured values particularly in the South where the market for subsidised agricultural insurance contracts increased by more than 20% compared to the previous year. However, this area remains the one with the lowest insurance incidence in the agricultural sector, equal to only 7.7% of the total value (Table 3.8).

Table 3.8 - Insured values by macro-areas - plant crops.

	,000 €				%			
	Italy	**North**	**Centre**	**South**	**Italy**	**North**	**Centre**	**South**
2010	4,805,218	3,728,494	392,403	684,321	100	77.6	8.2	14.2
2011	5,313,911	4,161,613	458,941	693,357	100	78.3	8.6	13.1
2012	5,453,706	4,277,689	455,507	720,509	100	78.4	8.4	13.2
2013	5,872,818	4,619,260	481,707	771,852	100	78.7	8.2	13.1
2014	5,704,970	5,016,721	551,275	854,129	100	78.1	8.6	13.3
2015	5,704,971	4,611,746	516,186	577,039	100	80.8	9.1	10.1
2016	5,102,639	4,274,551	459,292	368,796	100	83.8	9.0	7.2
2017	5,155,597	4,298,883	497,026	359,689	100	83.4	9.6	7.0
2018*	5,605,450	4,650,418	522,692	432,340	100	83.0	9.3	7.7
Var. % 2018/2017	8.7	8.2	5.2	20.2		-	-	-

*Estimates

Source: Elaboration on ISMEA (2019) data.

In the central regions, where the market for subsidised insurance contracts grew by more than 5% on an annual basis, the share stood at 9.3%, but the gap with North Italy remains wide. In 2018, 83.0% of the insured values are concentrated in the northern area, corresponding to an amount of €4.6 billion of insured capital (+8% on an annual basis).

It should also be noted, with specific reference to insurance premiums, that the relative value, which increased in all the geographical macro-areas, showed the strongest growth rate in the northern regions, with an increase of 31.8% compared to 2017, a change which was accompanied by increases of 27.5% in the central regions and 17.3% in South Italy (Table 3.9).

Table 3.9 - Evolution of insured values, premiums and number of farms in the last three years - plant crops.

Insured values (€)					
Italian macro-area	**2016**	**2017**	**2018***	**Var. 17/16**	**Var. 18/17**
North	4,274,551,132	4,298,882,664	4,650,417,690	0.6%	8.2%
Centre	459,291,770	497,026,278	522,692,197	8.2%	5.2%
South	368,796,014	359,688,503	432,340,481	-2.5%	20.2%
ITALY	**5,102,638,915**	**5,155,597,444**	**5,605,450,367**	1.0%	8.7%
Premium (€)					
Italian macro-area	**2016**	**2017**	**2018***	**Var. 17/16**	**Var. 18/17**
North	284,641,962	294,713,665	388,286,351	3.5%	31.8%
Centre	23,947,161	24,593,260	31,350,157	2.7%	27.5%
South	28,956,338	28,578,560	33,514,230	-1.3%	17.3%
ITALY	**337,545,461**	**347,885,485**	**453,150,738**	3.1%	30.3%
Farms (No)					
Italian macro-area	**2016**	**2017**	**2018***	**Var. 17/16**	**Var. 18/17**
North	50,397	47,201	47,951	-6.3%	1.6%
Centre	4,914	4,936	4,978	0.4%	0.9%
South	7,755	6,768	8,866	-12.7%	31.0%
ITALY	**63,040**	**58,905**	**61,795**	-6.6%	4.9%

*Estimates

Source: Elaboration on ISMEA (2019) data.

The South is also the macro-area that recorded the largest increase in terms of number of insured farm in 2018, with 31% annual growth, a phenomenon mainly attributable to the introduction of two-risk insurance tools in the PAAN 2018, which covered only 6% of the total national value insured, but 23% in the South.

The growth in the number of insured farms is modest in the regions of Central Italy, with just 0.9% more than in 2017, while in the North, concentrating more than three-quarters of the entire number of insured farms, there was an increase of 1.6%.

Data by crop show an increase in premiums that appeared particularly significant for wine grapes and, in general, for fruit. These sectors suffered the most damage from frost and drought during 2017.

The price increases for rice insurance contracts were lower. Nonetheless, rice remains the third most assured product among vegetable crops, the first for areas, with decreasing insured values and the number of farms, respectively, by 12.5% and more than 3.0% on an annual basis.

Also for grain maize, the number of farms is decreasing (-3.1% compared to 2017), but values (+1.8%) and premiums (+19%) are growing. The same is for pears, with a 1% reduction in insured farms, but with values and premiums rising, respectively, 13.7% and over 35%. Generalised increases can be seen for industrial tomatoes, silage maize, actinidia and wheat, which show positive deviations, compared to the previous year, for all the variables considered (farms, certificates, values, and premiums). In the case of oil olives, on the other hand, there is a clear gap between the number of insured farms, which increased by more than 27%, and the insured values, which fell by almost 5% compared with the previous year, due to a reduction in both the insured quantities and the average prices. Based on the dataset of 2017, consolidated in SGR/SIAN, it is possible to analyse with a greater degree of detail some aspects characterising the agricultural insurance market in Italy. At the territorial level, still with reference to vegetable crops, Bolzano is confirmed as the province with the highest value, followed by Verona (almost equal merit), Ferrara, Trento, and Pavia. The same ranking on a regional basis sees Emilia-Romagna at the top, with nearly 20% of the market, followed by Veneto (18%) and Lombardy (about 16%). Considering also Trentino Alto-Adige and Piedmont, nearly 80% of the entire insured value comes from these five regions (Table 3.10).

The greater attention paid by farmers to multi-risk insurance contracts covering all insurable events seems to reflect the increased concerns about the prevention of weather and climate risks, associated with the particular negative experience of 2017. It is well known that if the hail event, the most insured in agriculture, occurs more frequently than others, the damage to crops caused by catastrophic adversities, such as frost or drought, is on average more intense, although less frequent. The "severity" of these events can be deduced from the compensation data for 2017, which led to a loss-ratio -namely the ratio between claims paid to farmers and premiums received by insurance companies- of 128%, a very high level and in strong growth compared to 88% in 2016 (Table. 3.11).

Table 3.10 - Insured values by region in 2017 - plant crops.

Region	,000 €	(%)
Emilia-Romagna	1,015,732	19.7
Veneto	928,830	18.0
Lombardy	820,787	15.9
Trentino Alto-Adige	657,540	12.8
Piedmont	615,512	11.9
Friuli-Venezia-Giulia	260,041	5.0
Tuscany	258,797	5.0
Apulia	130,795	2.5
Umbria	103,606	2.0
Lazio	78,451	1.5
Marche	56,173	1.1
Abruzzo	48,537	0.9
Sardinia	47,784	0.9
Sicily	46,166	0.9
Campania	33,259	0.6
Basilicata	29,956	0.6
Calabria	19,802	0.4
Molise	3,391	0.1
Liguria	441	0.0
Total	**5,155,597**	**100.0**

Source: Elaboration on ISMEA (2019) data.

Table 3.11 - Evolution of the main indicators of the facilitated insurance market in Italy.

Total plant crops	Unit of measurement	2013	2014	2015	2016	2017	2018
Farms	No	81,994	82,254	79,930	63	58,905	61,561
Contracts, of which:	No	203,891	194,012	169,695	145,891	140,891	147,820
- Multi-risk/Package A	%	8.3	24.7	10.7	10.6	12.9	-
-Pluririsck/Package B-C-D	%	91.7	75.3	89.3	89.4	87.1	-
Insured surface (farms)	hectares	1,254,111	1,323,832	1,189,611	1,045,669	1,027,394	1,450,316
Average farm size	hectares	15.3	16.1	16.1	16.6	17.4	23.6
Insured surface	%	10.1	10.7	9.6	8.4	8.3	-
Insured values	,000 €	5,872,818	6,422,124	5,704,970	5,102,639	5,155,597	5,604,067
Premiums	,000 €	362,620	469,637	387,331	337,545	347,885	453,077
Average rate	%	6.2	7.3	6.8	6.6	6.7	8.1
Reimbursed quantity	quintals	17,544,820	10,955,474	9,115,522	12,472,157	17,714,128	-
Compensated value	,000 €	430,964	268,955	206,574	298,105	445,122	-
Loss ratio	%	118.8	57.3	53.3	88.3	128.0	-
Average insured farm value	,000 €	71.6	78.1	77.2	80.9	87.5	91.0
Insured value/PBP*	%	20.0	23.9	19.8	18.7	18.7	-

*Production at basic prices (PBP)

Source: ISMEA (2019) estimates based on data from insurance companies.

3.5.1. The market for supplementary insurance contracts

Based on provisional data from insurance companies, in 2018 the number of supplementary insurance contracts (not subsidised) for plant crops amounted to 133,038. Almost all of them (99.6% of the cases) are so-called "sub-threshold" contracts, signed by farmers to extend the guarantee and be eligible to compensation even in the event of production losses at less than 20%, a share that remains outside the scope of subsidised insurance contracts.

On the supplementary circuit, the first six products in terms of insured value represent 59% of the market, while the remaining share is made up of 231 different crops (Table 3.12 and Figure 3.6).

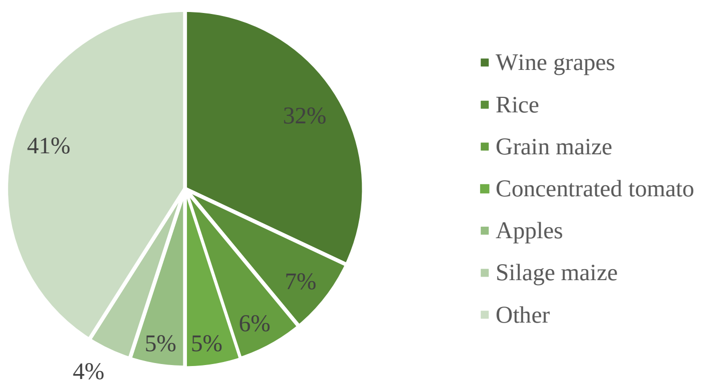
The highest insurance costs concern the fruit and vegetable sector, with average rates between 3% and 5%, while the average cost of other crops in most cases does not reach 2%.

Table 3.12 - The main indicators of supplementary insurance contracts – 2018.

Contracts (No)	**Insured farms (No)**	**Insured value (€)**	**Insured area (ha)**	**Total premium (€)**	**Average rate (%)**
133,038	53,412	4,891,188,171	1,451,398	109,032,845	2.23

Source: Elaboration on ISMEA (2019) data.

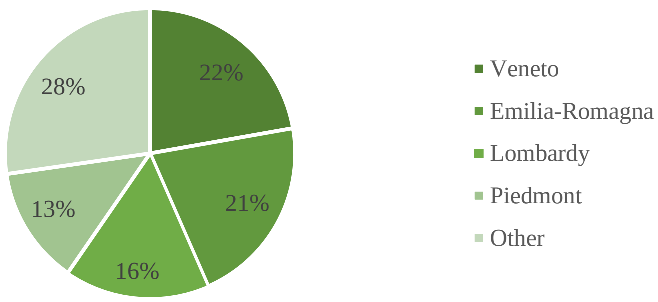
Figure 3.6 - Supplementary insurance contracts in 2018. Share of insured values by product.



Source: Elaboration on ISMEA (2019) data.

The first four regions, all in North Italy (Veneto, Emilia-Romagna, Lombardy, and Piedmont), cover more than 70% of the entire insured value (Figure 3.7). The first region, among the central ones, is Tuscany, with 4.4% of the supplementary market, while Puglia has the highest incidence, with 3.5% in the South.

Figure 3.7 - Supplementary insurance contracts in 2018. Share of insured assets by region.



Source: Elaboration on ISMEA (2019) data.

With particular reference to the hazelnut sector, in the five-year period 2014-2018 there was a more or less significant increase in the values of the main indicators of the insurance market with a simultaneous decrease in the ratio between paid premiums and insured values (Table 3.13).

Table 3.13 - The main indicators of the insurance market (2014 - 2018) - Hazelnut detail.

Items	Unit of measure	2014	2015	2016	2017	2018	Var. 17/16	Var. 18/17
Farms	No	98	112	115	606	691	427.0%	14.0%
Contracts	No	154	158	158	1,031	1,157	552.5%	12.2%
Insured values	,000 €	2,793	3,268	4,097	33,338	34,420	713.7%	3.2%
Premiums	,000 €	186	203	258	847	1,219	228.6%	44.0%
Average rate	%	6.7	6.2	6.3	2.5	3.5	-3.8%	1.0%

Source: ISMEA (2019) estimates based on data from insurance companies.

3.6. Conclusions

From the framework outlined on risk management policies and instruments in EU and Italy, the growing importance of insurance policies is witnessed by enrichment in terms of tools, objectives and funding. However, an examination of the financial data shows that there is a high degree of adherence by farmers to the traditional tools which have evolved from mono to multi-risk. Meanwhile, IST and MF applications are very limited in terms of planned funding and adhesions in comparison to the high level of application in some non-EU countries (e.g. the USA and Canada). Since they appear efficient tools for the stabilization of farms' income by taking into account different risk factors, it seems interesting to simulate their impacts and feasibility.

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Chapter 4

Economic performance and risk of farming systems specialized in perennial crops: an analysis of Italian hazelnut production

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Abstract

Assessing farm profitability and economic risk is important to support farmers' decisions. Several factors affect yields and product prices, in turn influencing farmers' income level and economic risk. However, the literature has often neglected to explicitly account for the role of product quality. This is particularly important for crops such as hazelnut because farmers' prices vary according to the quality of the harvested product. Furthermore, it seems fundamental to disentangle the role of parameters influencing farm results, noticeably yield, product price and quality. This is because farmers select their risk management tools to satisfy their needs, but these are often suitable for managing the risk of only one of these parameters.

Deploying a large sample of individual farm data over ten years, the profitability and risk of hazelnut production in the four main production areas in Italy are assessed. The analysis is performed by using a set of risk indicators, which are based on the distribution of the GM for hazelnuts. The results of this analysis suggest that Campania and Lazio are generally the most profitable regions while Sicily is the least profitable. Risk is quite high in all regions with Campania facing the lowest risk level. The sensitivity analysis, performed by combining Monte Carlo simulations and stepwise regression techniques, permits to establish that the most important parameter generating risk is yield, followed by product quality and, to a lesser extent, market price. These results suggest that hazelnut farmers could reduce their risk by using production insurances; there is also potential to develop tools suited to managing risks related to product quality.

4.1. Introduction

In economic terms farm resilience relates to the capacity of a farm business to survive various risks and shocks (Lien et al., 2007). This implies that the combined assessment of economic performance and risks are key in determining the resilience and sustainability of farming systems (Meuwissen et al., 2018; Reidsma et al., 2015). Assessing farm risk is particularly important when farms are specialized in producing perennial crops, where changing production patterns are seriously constrained by high costs and lengthy implementation time. Under these conditions, risk should be carefully managed by using available risk management strategies and tools. In recognizing this problem, agricultural policies have focused on supporting farmers to improve their management of farm-related risk. For example, the EU's CAP provides three different risk management measures, based on public-private partnerships within the framework of the EU RDP[8] (Bardají and Garrido, 2016). These are: farm insurance premium subsidies, MFs and the IST. The latter is aimed at levelling out the variability in farm income over the years and to account for price risk, even if this tool has not yet been implemented throughout the EU (Severini et al., 2018; Trestini et al., 2017 and 2018).

Assessing overall risk, as well as identifying and quantifying the type of risk facing a farming system (including the risk related to yield, product price and quality) is a preliminary requirement in deciding which strategy and tools are more suited to individual circumstances. Indeed, farmers are affected by several different types of risk: there exist production risk and market risks (Hardaker et al., 2015), with the former principally being caused by a sudden and unexpected drop in product prices. Risk management should, therefore, be tailored to coping with the most important risks and by selecting the most appropriate strategies and tools from those available. The latter are often suitable for managing only the risk arising from one of the aforementioned variables: for example, farm insurance[9] can be used to manage yield risks while future contracts can control price risk.

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[8] Regulation (EU) No. 1305/2013 of the European Parliament and the Council of 17 December 2013 (OJ L347, 20.12.2013, p.487).

[9] The current National RDP of Italy supports crop insurance which covers only combinations of negative events and not single-peril insurance (generally hail) (European Commission, 2019). Events are classified as *catastrophic weather risks* and other *weather-related risks*. The former are not very common but they do have a significant impact on crop production; they include flood,

Production risk is not only related to the amount of production but also to its quality. Negative climatic conditions and pests can have detrimental implications for the quality of the product which, in turn, might cause the price paid to farmers to decline below the expected level. Finally, the level and sources of risk, as well as farm profitability, can be expected to differ between different production areas, even when considering the same crop. Hence, it is important to explore these issues in different production areas and compare the results obtained to provide information which is specifically tailored to the producers operating in those areas.

The analysis outlined in this paper will focus on hazelnut production in Italy. Confirming Cristofori et al. (2008), interest in this crop has been increasing due to the growing demand from the processing industry (chocolate, confectionery and bakery products) (Dobhal et al., 2018; Liso et al., 2017; Cristofori et al., 2015). As tree-bearing nuts, the hazelnut (*Corylus avellana* L.) predominates in Italy (CREA, 2018). With its average annual production of nearly 106,000 tons of hazelnuts (in shell) for the 2007-2016 period, Italy is the second largest producer in the world (14.3%) after Turkey, which has always dominated the world market (in the same period, nearly 558,500 tons on average were produced, 75.0% of the world's hazelnut production) (FAOstat, 2018). Moreover, Italy plays a central role on the international market: if, on the one hand it is one of the main buyers of Turkish hazelnuts, on the other hand, it also re-exports part of this import as semi-finished products (Liso et al., 2017).

Italian hazelnut production is highly geographically concentrated and specialized due to its environmental and climatic conditions, the technical knowledge and human skills developed over time, and the expert selection of high-quality varieties (Piacentini et al., 2015). Approximately 90% of the Italian harvest is destined for the processing industry (USDA, 2014), which increasingly demands high-quality products (Cristofori et al., 2008). Accordingly, farmers receive a price for their produce and this is markedly influenced by quality parameters, such us: the size of

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drought and frost. The latter are more frequent and include, for example, excessive snow, excessive rain, hail and high winds. Crop insurance contracts can include approximately five different combinations of events. In the hazelnut sector a contract covering all catastrophic weather risks and hail has been made available to farmers in recent years. This has been channelled through various producers' organizations, which provide technical assistance to farmer members.

the shelled nut, the ratio of without/with shell nut weights, the quantity of defective nuts and the type of defect.

Several studies concerning profitability have been conducted on different crop systems with the aim of evaluating alternative production systems in vegetables (Halloran et al., 2005), small grains (Kolb et al., 2010and 2012), corn-soybean rotations (Cox et al., 1999; Davis et al., 2012; Caldwell et al., 2014) and perennial crops, like apples and cherries (Seavert et al., 2006). These studies have often utilized farm budgets to compare profitability but they did not explicitly analyse the risk of farming activities.

Risk analysis may also be used to identify systems with a degree of uncertain profitability (Brown et al., 2018). Several studies have been developed to analyse the risks faced by various farming systems. For example, Monjardino et al. (2013) have studied net return functions in order to observe the risk of low-rainfall cropping systems, in which farmers applied low rates of nitrogen. Osaki and Batalha (2014) have tested an optimization model of production factors to maximize the gross contribution margin in grain farms at risk. Luo et al. (2017) have examined the risk of GM variability, which was linked to the adaptation to climate change in the Australian cotton industry. Anton and Kimura (2009) have separated the roles of yield, price and costs in determining the final variability in the farm results of different field crops in different regions of Germany. This is an important suggestion for stakeholders to focus on the most important factors determining income risk.

The authors of this paper know of no study to date which has analysed profitability and risk relating to hazelnut production. However, there exists an extensive body of literature relating to Turkish hazelnut production, specifically: sustainability (Castro and Swart, 2017), economic efficiency (Kilik et al., 2009), the impacts of a policy change (Bayramoglu et al., 2010; Sisman, 2016), risk attitudes to organic and conventional producers (Demiryürek et al., 2012) and the profit level (Fidan and Sahinli, 2010).

Several methods have been proposed for identifying and quantifying risk in economic studies (Goetz, 1993, Gocsik et al., 2013; Hermann et al., 2014; Groen et al., 2014). Stochastic simulation is usually applied to study the impact of risk on a farm business (Antle, 1983). Of these, the most commonly used is the Monte Carlo (MC) simulation (Castañeda-Vera and Garrido, 2017; Kamali et al., 2017; Lien et al., 2007; Luo et al., 2017; Fariña et al. 2013; Monjardino et al., 2013; Ghasemi et al., 2012). This numerical, parametric technique combines information regarding the distribution of different stochastic input variables. By running multiple iterations, it can provide an insight into the range of possible outcomes and the likelihood or probability of these outcomes. Less used in the field of agricultural research is the use of MC to demonstrate the sensitivity of the outcomes to input variables (Ghasemi et al., 2012). In comparison with other applications (Lien et al., 2007), the analysis presented in this paper will focus on a single crop, instead of a whole-farm model. This is due to the fact that hazelnuts are often produced in specialized orchards in Italy; in some regions (e.g. Campania), farms may grow hazelnuts together with walnut, chestnuts and other crops.

Based on historical farm-level data, the aim of this study was to assess and compare the level and the risk of the profitability of hazelnut in the main areas of production in Italy. Stepwise regression analysis was also been used to combine the distribution of the most important variables affecting the profitability of the crop: yield, product quality and price. This enabled the quantification of the relative importance of these stochastic variables on the risk of hazelnut production. The specific objectives of the analysis were: (i) to assess the degree of profitability and risk in the main areas of production; (ii) to test whether profitability and risk differed among areas; (iii) to identify the key parameters making the greatest contribution to the risk involved with farm activities; (iv) and to verify whether there were differences in risk-generating parameters among the four regions.

It is expected that the results of this analysis will support farmers in the different production areas: in deciding whether it is worth changing their risk management strategies; in identifying the most relevant risk sources; and in selecting the most appropriate risk management tools. Furthermore, these results could also be useful in assessing whether there is potential for developing innovative risk management tools to mitigate risks for which tools are not currently available. Opportunities offered by the CAP could be put to work in this endeavour.

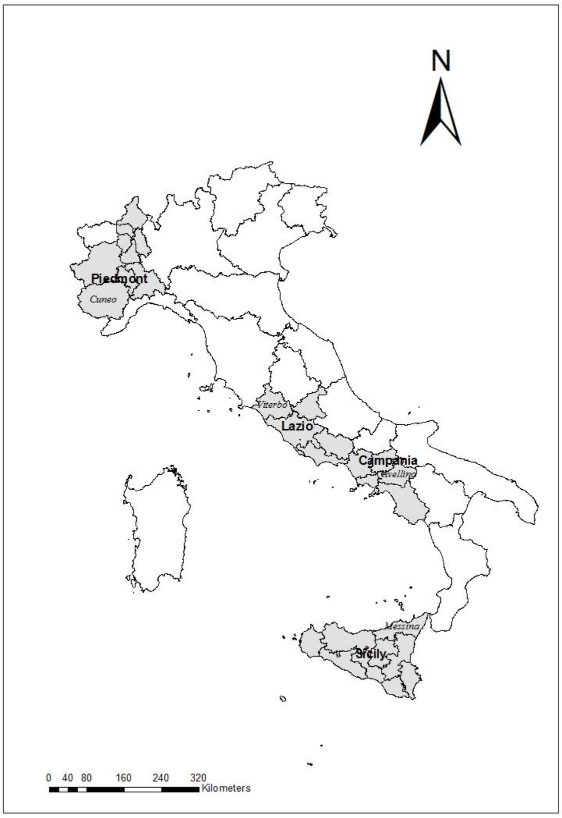
The paper is organized as follows: Section 2 will describe the study area, data and methods used; Section 3 will present the results of the analysis; and, lastly, Section 4 - the Discussion and Conclusion - will close the paper.

4.2. Material and methods

4.2.1. Study area

The key hazelnut production areas in Italy are located almost exclusively within four regions: for the period 2008-2017, Campania and Lazio jointly accounted for approximately two thirds of national production (34% and 33% respectively), with the remaining production located in Piedmont (20%), Sicily (11%), and other regions (2%) (Istat, 2017) (Figure 4.1).

Figure 4.1 - Study locations map - Main hazelnut production regions in Italy.

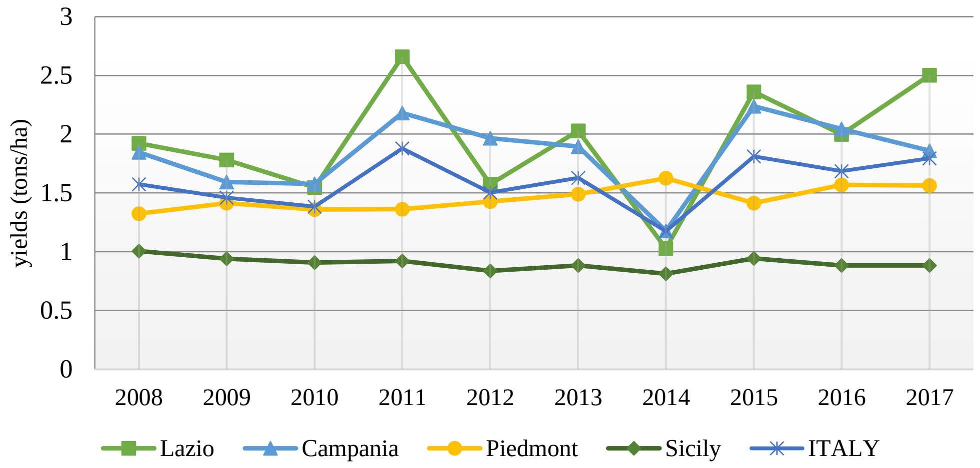


Hazelnut production in these four regions plays a crucial role in the local economy as well as an environmental safeguard (Anania and Aiello, 1999). The relevance of these areas is linked to the geographical spread of hazelnut production and the phenomenon of socio-economic development, which integrates technology, commerce and social relations (Franco et al., 2014, Piacentini et al., 2015). Furthermore, the spatial polarization of hazelnut production is the key element to boosting the local production system towards becoming a specialized agro-industrial district (Franco et al., 2014).

There is a growing interest in organic hazelnut production (Pancino and Franco, 2009); it represented a very small share of production in Italy until 2013 after which the surface area of land dedicated to organic hazelnut production increased (FADN database). Due to the lack of a long enough time series, it was not possible to include an analysis relating to organic hazelnut production. However, according to Franco and Pancino (2009), the GMs of organic hazelnut management can be higher or lower than that of conventional hazelnut management, in accordance with the intensity of the cropping technique. It is not, therefore, possible to conclude that there is a significant difference between these management forms. This study will, therefore, present a joint analysis.

Albeit with a degree of fluctuation, Italian hazelnut production has grown constantly during the period 2008-2017. This increase originated from the Piedmont and Lazio regions, both of which more than compensated for the declining production in Sicily (Istat, 2017). Whilst the four regions (Piedmont, Lazio, Sicily and Campania) under consideration possess ideal soil and climate conditions for hazelnut production (growing the local cultivars), crop production at the farm level is affected by variability over time due to climatic factors and pests (Piacentini et al., 2015). The yield data show a slight increase in Piedmont, Lazio and Campania and a slight reduction in Sicily for the period 2008-2017 (Figure 4.2); this has resulted in slow growth at the national level.

Figure 4.2 - Development of hazelnut yields in the main four Italian regions (tons/ha) – year 2008-2017.



Source: Istat, 2017.

Average yields levels differ among the four aforementioned regions: they are higher than the national average (1.59 tons/ha) in Lazio and Campania (1.95 and 1.86 tons/ha respectively), lower in Piedmont and even lower in Sicily (Istat, 2017).

4.2.2. Data

The data used in this study was obtained from the Italian FADN sample and it refers to the period 2008-2016 (CREA, 2018). An original sample of 1,756 observations (obs.) was extracted and then filtered in order to account for two factors. First, observations referring to the installation period of the crop were excluded because, for the first 6 years after plantation, there is no production or it is negligible (Frascarelli, 2017). 129 observations were, therefore, excluded. Second, only observations of farms with at least 1 hectare (ha) under hazelnut production were taken into account to avoid the inclusion of hazelnuts, which had not been grown for commercial purposes; consequently, additional 435 observations were excluded. These steps resulted in a final sample of 1,192 observations regarding Piedmont, Lazio, Sicily and Campania (Table 4.1).

Table 4.1 - Sample size by region and year.

Regions	2008	2009	2010	2011	2012	2013	2014	2015	2016	Obs. (2008-2016)
Piedmont	62	73	73	64	68	67	75	72	55	609
Lazio	13	16	29	39	45	52	99	30	40	363
Campania	13	15	23	22	14	15	19	26	28	175
Sicily	3	4	5	6	4	5	7	6	5	45
TOTAL	91	108	130	131	131	139	200	134	128	1,192

Source: Authors' elaborations on Italian FADN data.

The sample size would appear to be sufficiently large for performing the analysis by region even if the results for Sicily should be considered with caution due to the relatively small sample size. The key variables of interest are: crop GM, yield, product quality and the standard- quality price of hazelnuts without shells, as well as specific variable costs. All values refer to a single hectare of land to make comparable observations and production areas. Monetary values were deflated using annual coefficients (Istat, 2018) to permit comparability over time.

4.2.3. Profitability and variability analysis

Profitability was assessed by using the crop GM (€/ha), that is, the difference between crop revenues and the specific variable crop costs of farms (Castaneda-Vera and Garrido, 2017; Luo et al., 2017):

$$\mathrm{GM}_{i,t} = R_{i,t} - Cv_{i,t} \quad (4.1)$$

where GM is the unitary gross margin, R are revenues and Cv are specific variable costs associated to the crop in the i-th farm in the t-th year.

Although different profitability indexes could also have been used to account for general and fixed costs, the GM was preferred because farms can differ markedly in terms of the source of production factors, such as labour and machinery. Some farms rely totally on family (often unpaid) labour and purchased machinery while others make great use of hired labour and rented machinery. Thus, GM seems to be the most suitable index with which to compare crop profitability.

The PDFs of GM, as well as yield, price and quality index, were described by using four moments, including mean (μ), standard deviation (σ), skewness and kurtosis.

The centre of the distribution (μ) was used to compare the profitability among the different areas. Variability was evaluated in absolute (σ) and relative terms, with respect to the mean values (Coefficient of Variation, CV), in observing potential outcomes.

To enhance the role played by the non-symmetric nature of the distributions, the degree of skewness and kurtosis were observed to reveal insights regarding the probability of negative results and extreme events respectively.

4.2.4. Risk analysis

All the farms in this study in each of the four regions were assumed to face the same risk. The available data do not permit a single-farm analysis due to the relatively limited number of farms which were observed for more than three years. However, each region is relatively small in surface area and homogeneous regarding climatic and soil characteristics. Therefore, the assumption of an analysis of single farms per region seems reasonable. Economic results are strongly affected by the development of product prices. However, all farms in all regions operate in the same market (that is, the international market) and they, therefore, face the same price risk.

The risk associated with producing the hazelnut crop was assessed by calculating several risk indexes, starting from the PDF of the unitary GM. As stated in Luo et al. (2017), the CV is a simplified measure of risk because it measures the width or spread of a distribution. The riskier condition has a wider range of potential outcomes, thus wider distributions are associated with greater risk. However, the standard deviation or other measures of spread around the distribution mean are insufficient measures of risk when used alone (Kandulu et al., 2012; Monjardino et al., 2013). Therefore, economic risk measures were presented as a combination of different indicators to quantify the expected GM at different confidence levels for each area.

In order to obtain information on the left side of the distributions, a semi-standard deviation[10] (SSD) and a semi-coefficient of variation (SCV) were also computed

[10] The semi-standard deviation was calculated using the *RiskSemiStdDev* function in @Risk. This is the standard deviation of the values in the distribution below the mean.

and analysed (Mun, 2006; Monjardino et al., 2013) - because they specifically focus on the downside risk exposure. Commonly used risk measures were also used: the break-even point (P[GM]≥0, i.e. the probability of returning a profit), the VaR and ETL. According to Dowd (2007), VaR is the maximum loss which may be expected over a given horizon period at a given confidence level. It was calculated as follows:

$$VaR = E(GM) - V^{*} \tag{4.2}$$

where E(GM) is the expected mean of GM and V^{*} is the expected value of GM at a confidence level of 95%. That is, how much of the expected GM could be lost if a tail event (i.e. negative but unlikely) occurs. The VaR is contingent on the choice of confidence level: it will generally change when the confidence level changes. VaR only states the maximum loss if a tail event (i.e. exceeding 95% c.l.) does not occur. It refers to a chosen probability level (e.g., 95%) but reveals nothing about that which could be lost after that level (i.e. the remaining 5% of cases). However, if a tail event occurs, it can be expected to lose more than the VaR; the VaR figure itself gives no indication of how much that might be (Dowd, 2007). To overcome this drawback, the ETL index was also calculated; this refers to the expected value of losses if extreme events occur. The latter are defined as those in which the losses (L) exceed the VaR (Dowd, 2007):

$$ETL = E[L|L > VaR] \tag{4.3}$$

ETL was calculated using the approach proposed by Dowd (2007). This consists of: slicing the left-tail into 10 slices, each of which has the same probability mass (95.0%, 95.5%, 96.0%, until 99.5%); estimating the VaR associated with each slice; and taking the ETL as the average of these VaRs. The results of VaR and *ETL* were also compared with the values of expected GM at 95% c.l. ($E[GM]^{95\%}$) and an average of the expected GMs in the last 5% of c.l. on the left tail of the curve ($E[GM]^{>95\%}$) respectively. VaR and ETL can also be expressed as relative values (VaR% and ETL%) (i.e. using the average GM as a denominator).

4.2.5. Monte Carlo analysis

Similar to the work by Luo et al. (2017), an MC analysis was performed. The MC sampling framework (Hardaker et al., 2015) was used to iteratively draw hazelnut yields, prices and quality indicators from the PDF, to model input data and to simulate their impact on GM. Accounting for the stochastic nature of the GM, it is possible to consider GM as:

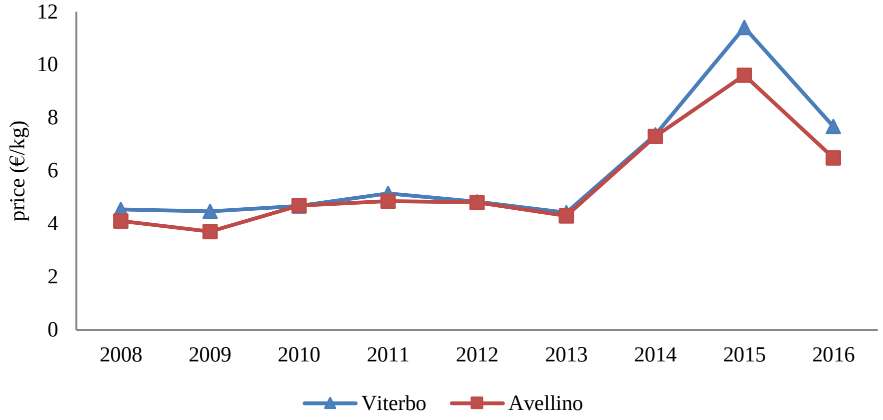
$$\widetilde{\mathrm{GM}_{i,t}} = \widetilde{R_{i,t}} - Cv_i \tag{4.4}$$

where the tildes identify what is assumed to be a stochastic variable. $\widetilde{R_{i,t}}$ is derived through the product of simulated crop yields ($\tilde{y}$), price of hazelnut without shell ($\tilde{p}$) and a quality index ($\tilde{q}$):

$$\widetilde{R_{i,t}} = \tilde{y}_{i,t} \cdot \tilde{p}_t \cdot \tilde{q}_{i,t} \tag{4.5}$$

Yields were calculated as the ratio of produced quantity to cultivated area in each farm (i) in every year (t). The FADN does not provide price data but only the total value of production. By dividing this figure by the produced quantity, it is possible to identify a proxy of the average received price. The level of this indicator is strongly affected by two main factors: the development of market price (i.e. expressed in terms of standard-quality hazelnuts without shells) and the average quality of the product obtained on the farm. The average annual market prices were obtained from the Chamber of Commerce, Industry, Crafts, and Agriculture (CCICA). The price series relating to the Viterbo CCICA and Avellino CCICA were used for the Piedmont-Lazio and Campania-Sicily areas respectively, after they had been deflated. A positive price trend was observed during the analysis due to the relatively high prices observed in the 2014-2016 period (Figure 4.3). Price levels did not differ very much in the two markets, Viterbo and Avellino respectively. The two series were highly correlated with a peak in 2015 in both series.

Figure 4.3 - The development in the deflated price of hazelnuts (without shells) in Viterbo and Avellino (€/kg) – Years 2008 - 2016.



Source: CCICA of Viterbo and Avellino.

The presence of such a positive trend could lead to incorrect estimates of the price risk, which is faced by farmers. Assessing the spread around the mean of the series in these circumstances overestimates the price risk faced by farmers, for which the ignoring of such a trend cannot be assumed. As is standard practice in the literature relating to risk analysis, the price series has been detrended to only assess the spread around the estimated trend in order to refer to uncertain developments in price (Miranda and Glauber, 1997; Lien et al., 2007).

The resulting prices were applied to each farm located in a region, assuming that all farms within a region faced the same price in a given year. Inter-farm price heterogeneity was used as a proxy for product quality index. Indeed, farmers sell products in shell which are heterogeneous in quality, a fact which depends on two main parameters: the technical conversion rate from product in shell to product without shell (usually approximately 45%), and the technical characteristics of the product. The latter refer to the relative occurrence of empty (due to hazelnut weevil), aborted nuts (due to bugs) and kernels which have been damaged by insects, causing an unpleasant taste and odour, both of which render the nuts unsuitable for processing production. These technical parameters strongly affect the net price obtained, and they could vary over time, according to climatic conditions and farm specific management practices. In order to account for quality-related aspects, an overall and concise quality index was calculated as follows:

$$\tilde{q}_{i,t} = \left(\tilde{P}_{i,t}/\tilde{p}_t\right) \quad (4.6)$$

where P is the average revenue obtained for each produced quantity of hazelnut in shell. This was obtained as the ratio between total gross production value (TGP) to produced quantity (Q), using FADN data from each farm and for each year:

$$P_{i,t} = (TGP/Q)_{i,t} \quad (4.7)$$

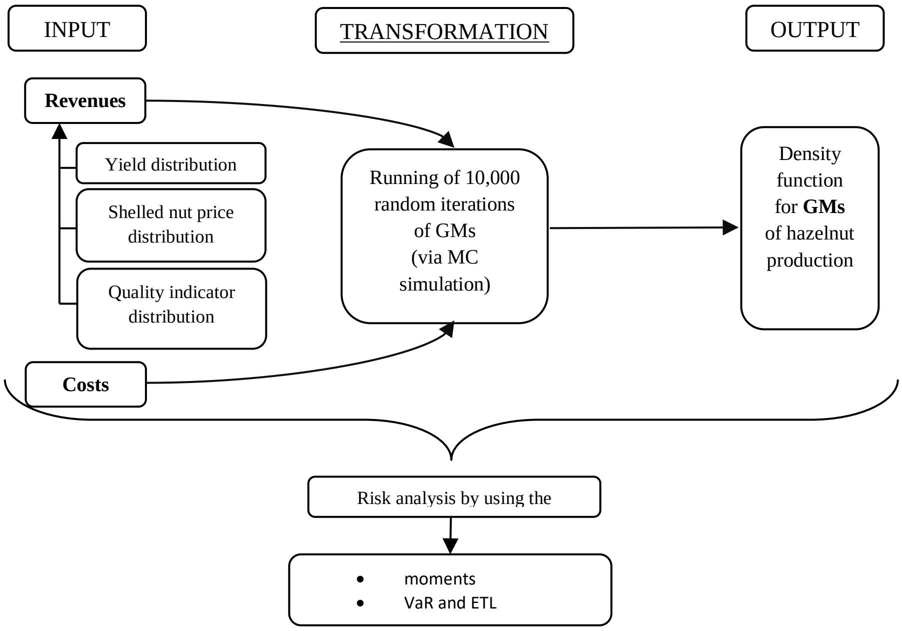
The quality index (4.6) is low when the product quality is low and *vice versa* so that it positively correlates with the crop GM.

As stated by Fariña et al. (2013), all crop specific costs (including direct costs, reuses and other costs), as reported in the FADN database, were not considered as stochastic, using the average variable cost for each region. This seems a reasonable assumption given that most of these costs are planned and incurred in the early stages of crop activity; therefore, the degree of uncertainty related to costs is low.

The stochastic MC simulations, developed using the Version 7.5.2 @Risk™ software (Palisade Corporation, Newfield, New York)[11], are described as in Figure 4.4.

[11] Available at: https://www.palisade.com/risk/default.asp

Figure 4.4 - Diagram of the MC simulations.



The random components, referring to hazelnut yields, price and quality are the key input variables which were used in the simulation to produce a PDF for GM. This reflects the uncertainty of farm business profitability (the key output variable) for the four production areas under consideration. Combining a very large number of different possible input parameters, 10,000 random iterations were used to define the simulated range of farm business profitability. Correlations between the three key input variables were verified by using Spearman Rank correlation coefficients. If significant, such correlation coefficients would be considered in the MC simulations, using the related software features.

4.2.6. Probability distributions functions of key variables

The PDFs for yield, price and quality index were fitted considering a range of suitable PDFs, including Normal, Weibull, InvGauss, Logistic, Pearson5, Uniform and Beta distributions. These distributions were ranked according to the goodness-of-fit tests, which provides a measure of how closely the fitted distribution matched the data distribution. Unlike Monjardino et al. 2013, who used the Anderson-Darling statistics test to observe cereal yields variability, the Akaike Information Criteria (AIC) statistics test was chosen to measure the goodness-of-fit of each input variable in this paper. This criterion defines the best density function from the log-likelihood function, taking into account the number of parameters of the fitted distribution. It is based on the following expression:

$$AIC = 2k - 2\ln L \tag{4.8}$$

where L is the likelihood function and k is the number of parameters estimated for the fit. This test was chosen because its informative prior distributions and hierarchical structures tend to reduce the amount of overfitting, compared to what would happen under simple least squares or maximum likelihood estimation (Gelman et al, 2014; Burnham and Anderson, 2004; Bozdogan, 1987).

The PDFs of the key input variables were selected, using the *BestFit* in @Risk software, and they were compared with the fits from all distributions, for which valid fits were generated. The selected PDFs were used in the MC simulation of GM. Hazelnut prices were found to be logistically distributed, as in the case of wheat by Monjardino et al. (2013), being the PDFs typified by *leptocurticity* and positive skewness. Different fits were observed for yields and quality index distribution data, as shown in tables 4.2 and 4.3.

Table 4.2 - Hazelnut yield distribution parameters in the risk model.

Regions	Probability distribution function	Min.	Max.	μ	Median	σ	*Skewness*	*Kurtosis*
Piedmont	Normal	0.000	59.962	19.264	19.286	9.037	0.199	3.520
Lazio	Logistic	0.000	48.193	21.150	21.560	8.665	0.203	3.794
Campania	Weibull	3.871	60.000	23.011	23.316	10.389	0.705	3.792
Sicily	Extvalue	0.661	32.000	14.557	15.000	7.356	0.504	3.055

Source: Authors' elaborations on Italian FADN data.

Table 4.3 - Hazelnut quality index distribution parameters in the risk model.

Regions	Probability distribution function	Min.	Max.	μ	Median	σ	*Skewness*	*Kurtosis*
Piedmont	BetaGeneral	0.000	0.798	0.450	0.420	0.176	-0.106	2.718
Lazio	Gamma	0.113	0.974	0.500	0.471	0.164	0.381	2.717
Campania	Extvalue	0.193	0.963	0.522	0.483	0.159	0.480	2.760
Sicily	Extvalue	0.100	0.757	0.370	0.352	0.127	0.757	4.012

Source: Authors' elaborations on Italian FADN data.

The distributions of the key input variables were observed with the aim of deleting outliers, which would have biased the simulation. In particular, observations reporting yields higher than 6 tons/ha and a quality index higher than 0.8 were eliminated. The latter was performed by using the *RiskTruncate* functions during the simulation. Boundaries were chosen on the basis of collected data and interviews with experts in hazelnut production.

In order to verify whether the distributions of the variables under consideration (yield, price, quality index and GM) were significantly different among the regions, the Wilcoxon–Mann–Whitney test was applied given the results of the Shapiro test[12] (Wilcoxon, 1945; Mann and Whitney, 1947; Fay and Proschan, 2010) (Table A1 in the Appendix). Being nonparametric in nature, this test does not require normally distributed data. The Wilcoxon-Mann-Whitney test compares two treatments (e.g. the yield distribution for variables relating to two regions), using scores (ranks) which replace numerical data in order to validate or not the statistical hypothesis that the samples are not significantly different (Wilcoxon, 1945).

4.2.7. Sensitivity analysis

A sensitivity analysis was performed to identify those input variables which impact GM outcomes and the degree of this impact. First, a multivariate regression between GM and the key input variables was estimated (Saltelli et al., 2008). Subsequently, following Ghasemi et al. (2012) and Kamali et al. (2017), a multivariate stepwise regression analysis was performed. It consisted of varying the level of one input parameter across the possible range while other input parameters were kept constant at their mean values. This provided a quantification of the effect of each factor on the dependent variable of interest. The dependent variable used in the model was the GM output, and the independent variables were each a random function, defined for each stochastic input variable of the model (i.e. yield, price and quality index).

[12] The results of the Shapiro test permit the rejection of the hypothesis of normality of the distribution in all but one case. Such tests were carried out by using the Rstudio software (Crawley, 2012).

Since the variables are measured in different units of measurement, a Regression-Mapped Values approach was used. These mapped values are the beta coefficients produced from a regression which uses standardized variables (Kamali, 2017; Ghasemi, 2012). The results of this approach are shown by means of tornado graphs. The length of the bar shows the change in output due to a unitary standard deviation change in the input.

4.3. Results

4.3.1. Expected profitability

In order to assess the profitability in hazelnut production, the average unitary GM (€/ha) was considered. Campania and Lazio were the most profitable regions for hazelnut production with the Piedmont region attaining third position with the region of Sicily trailing significantly (Table 4.4).

Table 4.4 - Descriptive statistics of the gross margin.

Regions	GM PDF	μ (€/ha)	σ (€/ha)	CV (%)	SSD (€/ha)	SCV (%)	Skewness	Kurtosis
Piedmont	Log-Logistic	4,754	3,009	63	1,787	38	1.54	9.71
Lazio	Log-Logistic	5,032	2,760	55	1,764	35	0.88	6.02
Campania	Pearson5	5,690	3,047	54	1,705	30	1.75	9.23
Sicily	Weibull	2,786	1,816	65	1,108	40	0.94	4.00

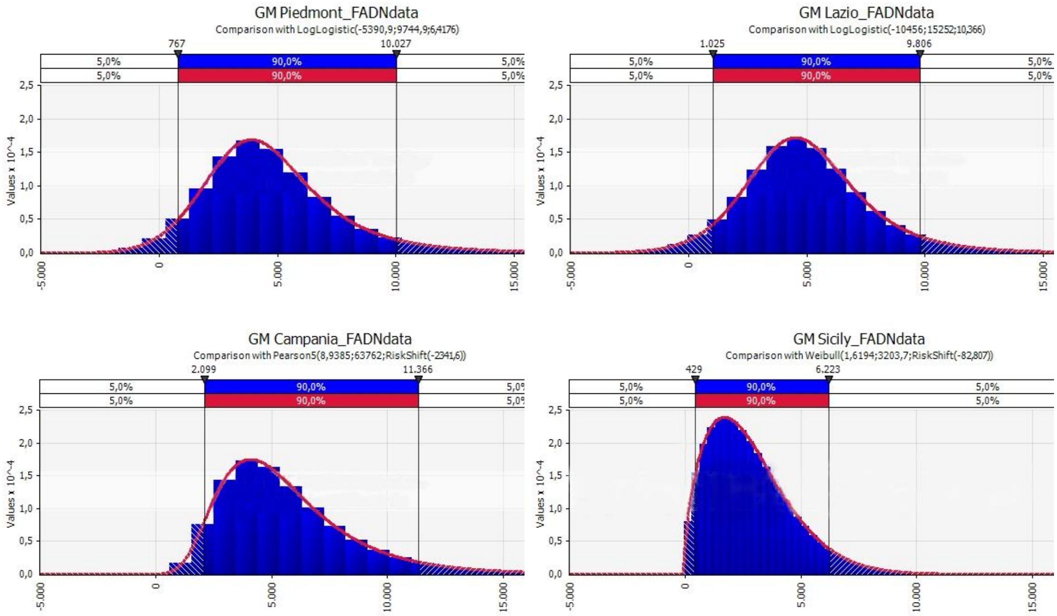
Source: Authors' elaborations on Italian FADN data.

Although Campania is the most profitable region (5,690 €/ha), followed by Lazio (5,032 €/ha), the Wilcoxon-Mann-Whitney test revealed that the difference between these two regions is not statistically significant (see the Appendix). The low profitability of Sicily is due to the specific structural characteristics of Sicilian farms, which are often located in mountain areas with steep slopes and limited field size, thereby minimising the use of machinery.

4.3.2. Economic-risk performance

As suggested by the width dispersion of the GM level around the mean (i.e. large levels of CV) (Table 4.4), hazelnut production was found to be quite risky. However, differences exist between regions: it is higher in Piedmont and Sicily than in the other regions. The GM distributions in the four regions are not symmetric (Figure 4.5).

Figure 4.5 - Probability density functions of the unitary GM of hazelnut (€/ha).



Source: Authors' elaborations on Italian FADN data.

Hence it is important to focus on the left-side tails of the distributions (i.e. the worst outcomes). The SSD and the SCV confirm that Campania is exposed to a lower risk than is the case with the other regions.

The PDFs of GM are positive or right skewed for all four regions and this is particularly the case with Piedmont and Campania. Contemporaneously, a high kurtosis provides information regarding the probabilities of extreme and catastrophic events (potential large losses) and these are relatively higher in Piedmont and Campania. Here skewness values are higher than 1, demonstrating that these regions face a high frequency of low GM levels. Further insights can be obtained by observing the VaR and ETL, both of which are also specifically focused on the left tail of the PDFs. The VaR study was performed by comparing the absolute and relative terms of VaR with the value of the expected GM at a confidence level of 95% (Table 4.5).

Table 4.5 - Economic risk measures.

Regions	μ (€/ha)	*E[GM]* $^{95\%*}$	*VaR (€)*	*VaR %**	*ETL (€)*	*ETL %**	*E[GM]* $^{>95\%*}$	*P[GM]≥0 **
Piedmont	4,754	767	3,987	83.9	4,691	98.7	63	97.8%
Lazio	5,032	1,025	4,007	79.6	4,854	96.5	178	98.0%
Campania	5,690	2,099	3,591	63.1	3,981	69.9	171	100.0%
Sicily	2,786	429	2,358	84.6	2,531	90.8	255	99.7%

* - E[GM] $^{95\%}$ measures the expected GM at a c.l. of 95%;
- VaR% is a relative measure of VaR, referring to the mean;
- E[GM]$^{>95\%}$ measures an average of the expected GMs in the last 5% of c.l. on the left tail of the curve;
- ETL% is a relative measure of ETL referring to the mean;
- P[GM]≥0 is the Probability of Break-even

Source: Authors' elaborations on Italian FADN data.

Despite the highest absolute values of VaR being recorded in Piedmont and Lazio, VaR% suggested that the highest relative risk was to be located in Sicily and Piedmont. Indeed, the VaR% was lower in Campania where, at the 95% confidence level, farmers could lose 63% of the regional average GM. Even if this were to happen, farmers would still gain € 2,099/ha (E[GM]$^{95\%}$), that is, the highest expected value at that confidence level of the four regions. The VaR% index was also high in Lazio but less than in Piedmont and Sicily. All these results imply that Sicily is the riskiest region for hazelnut production, followed by Piedmont and Lazio, and finally Campania.

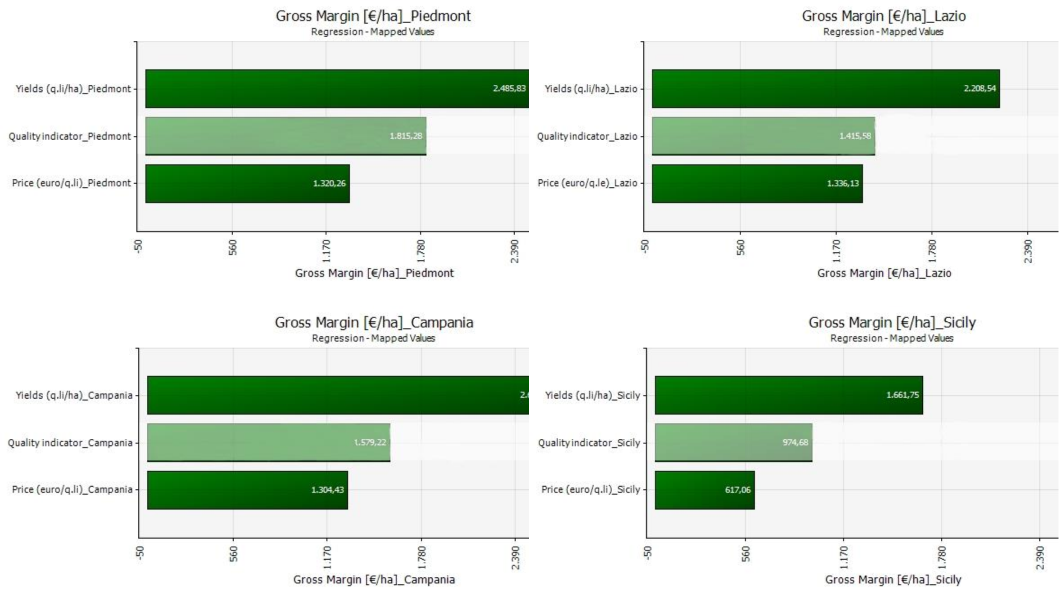
The risk profile for each region was further defined by an interpretation of the P[GM]≥0: the probability of breaking even was greater than 90% for all regions under investigation. Moreover, it seems important to analyse the possible economic results which may occur if catastrophic events (i.e. events referring to 5% of the distributions) should occur (ETL). The absolute and relative values of the ETL was analysed, as well as the average GM in the 5% of the left-side tail of the function (i.e. the average outcome from the conditions referring to 5% of such cases). The ETL% results suggested that the most limited impact of such events is found in Campania, followed by Sicily with joint place being held by Lazio and Piedmont.

In cases of the aforementioned negative events, farmers in Campania could still obtain an outcome (E[GM]$^{95\%}$), which is definitely higher than in other regions. Under these circumstances, farmers in Campania would be expected to lose 70% of their expected GM whilst still obtaining an average of €1,709/ha. Significantly more negative results would occur in the other regions: given such circumstances, farmers would be expected to forgo more than the 90% of their E[GM] and to gain not more than €255/ha (Sicily) and even less in Piedmont (€63/ha). All these results suggested that hazelnut production, especially in Piedmont and Lazio, is affected by high risks and that, under very negative (even if not probable) conditions, the economic results could drop markedly below the level of expected GM. These results also suggested that the four Italian regions differ not only in terms of expected profitability but also in terms of the risk of their activity. And regarding some of these regions, the degree of risk is such that it could well affect the behaviour and well-being of risk-averse farmers.

4.3.3. Factors affecting the risk of the activity – sensitivity analysis

The results of the sensitivity analysis have been used to quantifying the relative importance of yield, quality and price in generating the overall risk of hazelnut production in four Italian regions. As previously explained, these results are shown by means of tornado graphs, one for each region (Figure 4.6).

Figure 4.6 - Tornado graphs showing the results of the Regression-Mapped value analysis.



Source: Authors’ elaborations on Italian FADN data.

Yield is the factor generating the greatest GM variability at the farm level in all regions. The second factor is product quality, while market price has a minimal effect on GM variability. These results suggested that farmers should focus their attention more on yield variability than on the other two factors and, consequently, look for efficient tools to cope with this yield risk. The lack of importance shown by the prices in the sensitivity analysis is probably linked to the use of annual average data which tends to reduce intra-annual variability. Evidently, there are differences among regions. Yields are of greater importance in Campania and Sicily than in the other two regions.

Product quality also plays an important role in determining the extent of the risk, especially in Piedmont. Finally, the price has a very limited role in determining the GM variability in Piedmont and, even more so, in Sicily. These results highlighted that the regions under consideration also differ in terms of the sources of risk (i.e. the relative importance of the three considered factors). Hence, farmers in the four regions may wish to make use of different risk management strategies and tools. For example, it does not seem useful to have production contracts at pre-determined price levels whilst it would seem provident to deal with production risk by, for example, underwriting production insurance. While crop yield is the key parameter in stabilizing GM, it also seems important to consider how to manage fluctuations in product quality.

4.4. Discussion and conclusion

This study has performed a comparative analysis of the profitability and risk profile of hazelnut production, upon which farmers in the four Italian regions rely heavily. This analysis seems timely, given the growing interest in this crop, which is expanding in terms of area under cultivation. This expansion is further assisted by the high price levels observed for the period 2014-2016. The predicted increases in prices and yields, although very gradual, are expected to have a positive impact on the profitability of the crop in the future. An additional factor, which will probably play an important role in crop profitability, regards the quality of the product as the confectionery industry demands high quality hazelnuts (Cristofori et al., 2008). Finally, given the perennial nature of the hazelnut crop, its high establishment costs and a production variability in quality and prices, it is important to pay great attention to risk management and the individual components affecting it, that is, price, yield and product quality.

This analysis has permitted the attaining of specific research objectives: (i) to assess the extent of profitability and risk in the four production areas; (ii) to test whether these two factors differ among regions; (iii) to identify the key parameters making the largest contribution to farming-related risk; (iv) and to verify whether there are differences in risk-producing parameters between the four regions.

The study areas under investigation differ from each other in several aspects. Campania and Lazio have the most profitable hazelnut production on average while Sicily is the least profitable. Unlike the central-northern regions (where hazelnut production has been adapted to modern and intensive management techniques), Sicily suffers from steep-sloped and small fields which make hazelnut cultivation difficult to mechanise. Moreover, the GM risk in Sicily is relatively high, thereby suggesting the requirement to skilfully manage it. This factor differs among the four regions discussed in this research: cultivation in Campania is less risky than in Sicily, Piedmont and Lazio.

The sensitivity analysis has provided clear indications that the most important source of risk for all four regions is yield, followed by product quality and, to a lesser extent, market price for hazelnuts without shell. While this is the general pattern in all four areas, the relative magnitude of these sources of risk differs: for example, product quality in Piedmont plays a not indifferent role in determining the overall risk of this crop.

The results of this study are in line with those obtained for Italy by the European Commission (2007). Comparing the GM of nut production throughout the EU MSs, the Italian GM was found to be the most profitable, followed by the production from Greece, France, Spain and Portugal (European Commission, 2007).

Despite the importance of the instability of farm economic results, there is currently a lack of up-to-date empirical evidence regarding this topic. However, various analyses relating to farms specialized in permanent crops are available in the literature. For example, the European Commission (2009) has assessed the extent of EU farms facing a degree of income instability: it was observed that farms specialized in permanent crops (other than vines for wine-making) face a higher income risk than dairy farms and specialized field crop farms. Comparing different farm types for the period 1980-2007, Trestini et al. 2017 confirmed that the farms with a higher probability of a severe income reduction were those specialized in horticulture, permanent crops (other than viticulture) and livestock, with the exception of dairy farms. Severini et al. (2016) also noted that farms specialized in permanent crops face an intermediate level of economic risk (Severini et al., 2016). There are very few analyses relating to single crops: El Benni and Finger (2014) have investigated the riskiness of various Swiss crops, observing that canola and potato produce greater variable net revenues than other crops (such as sugar beet) and, even more so, wheat and barley. Alexander and Moran (2013) have analysed the decision to invest in perennial energy crops and they established that taking into account the variability of crop income affects risk-averse farmers in crop selection. These results could assist farmers in the decision-making of whether to intensify their risk management strategies and which tool to use.

The findings outlined in this paper suggest that hazelnut farmers should focus their attention on tools which enable them reduce production risk. The latter include, for example, production insurance which can be used to mitigate the effects of adverse climatic conditions. Less attention should be paid to managing market risk because price volatility has been found as the least important factor affecting the economic performance of hazelnut production. Hence, this suggests that there may be limited interest in developing new tools, such as supply chain contracts, which ensure farmers with constant price levels in this specific sector. Finally, the results outlined in this paper also suggest that there is scope for developing risk management tools to improve farmers' capacity to cope with risks related to the quality of their product. Thus, it could be of benefit to farmers to explore the opportunities offered by more comprehensive risk management instruments such as the IST, which is currently supported by the CAP.

Two additional points are worth mentioning. First, while the empirical analysis provides different quantitative indicators, the graphical presentation of the results (by means of the PDFs and tornado graphs) also seem useful in communicating results to stakeholders. This is perceived as important because these stakeholders have to decide in accordance with their subjective preferences and local conditions.

If additional information regarding the relative preferences of the farmers in the four regions was currently available, it would be possible to extend the analysis by using approaches such as the stochastic efficiency with respect to a function (Hardaker et al., 2004). Unfortunately, no data is currently available to guide the analysis in choosing the form of utility function and the degree of risk aversion of the agents, as required by similar approaches[13]. Second, the results regarding the expected profitability and risk of the activity could be important to agents who are interested in investing in this sector by expanding hazelnut cultivation. Such information could greatly assist investment analyses by developing, for example, net present value analyses accounting for the uncertain nature of economic results, or analyses which account for the dynamic nature of investment decisions, such as those described in Lien et al. (2007). No doubt, further research will pave the way for enhancing the farm risk management of farming systems, those specializing in perennial crops, and thus the resilience and contribution to the local economies of such farms.

[13] Given that farmers can be expected to have different risk preferences (see e.g. Iyer et al., 2019), it seems inappropriate to apply the same level of risk aversion to all farmers.

4.5. Appendix

Table A1 -Wilcoxon-Mann-Whitney test results relating to gross margin, yields, quality indicator and prices

Gross margin

	Piedmont	Lazio	Campania	Sicily
Piedmont	1	-	-	-
Lazio	0.00008376	1	-	-
Campania	2.2e-16	0.8084	1	-
Sicily	0.0001318	0.000002586	0.000003416	1

Yields

	Piedmont	Lazio	Campania	Sicily
Piedmont	1	-	-	-
Lazio	0.0006961	1	-	-
Campania	0.0001428	0.1186	1	-
Sicily	0.0002387	0.00006432	0.0006702	1

Quality indicator

	Piedmont	Lazio	Campania	Sicily
Piedmont	1	-	-	-
Lazio	0.0001522	1	-	-
Campania	0.003971	0.1275	1	-
Sicily	0.0003637	0.000000219	0.000005052	1

Price

	Viterbo CC	Avellino CC
Viterbo CC	1	-
Avellino CC	0.4363	1

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Chapter 5

Can mutual fund-based insurances increase farm economic sustainability? An application to hazelnut production in Italy

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Abstract

Income risk is pervasive in all farming systems, although there are differences among farms by sector. Farmers can use several instruments to cope with income risks. The IST, introduced in the EU, is based on a public-private partnership and is managed by a MF steered by associated farmers. These latter pay an annual contribution to become eligible for receiving indemnities when experiencing a severe income drop.

The aim of this study is to assess the impact of the IST on the level and riskiness of farm income. It also evaluates the feasibility of this tool to make supply and demand interact. Finally, the study assesses the geographical scale at which the IST scheme could be implemented.

The implementation of the IST scheme on hazelnut farms located in the four main production areas of Italy was simulated based on the FADNdata referring to the period 2008–2017. The potential impact of the IST on farm income was assessed through a profitability and riskiness analysis. Subsequently, stochastic dominance and expected utility analyses were performed to evaluate the farmers' willingness to join in using the tool. Finally, the financial sustainability of the MF was assessed according to actuarial principles and accounting for loading costs and the public support.

The results of the analysis showed that the IST reduces strongly the riskiness of the income of hazelnut farmers in all Italian production regions. Moreover, supply can interact with farmers' demand, making a sector-specific IST potentially feasible. Additionally, the presence of public support increases strongly the opportunities for farmers to join in using this risk management tool. Lastly, farmers' contribution should be differentiated among regions, while it is advisable to take advantage of the risk-pooling principle by opting for a nationwide MF.

This study provides insights into and suggestions for supporting stakeholders in deciding whether to implement IST in specialized farming systems and how to design its scheme in an efficient way. This seems important, given that this new tool has not been yet implemented in the EU.

5.1. Introduction

The resilience and sustainability of farms are influenced strongly by their capacity to survive various risks and shocks that affect their income (Lien et al., 2007; Dahms, 2010; Mitchell and Harris, 2012; Meuwissen et al., 2018; Reidsma et al., 2015). For example, in the EU, a relatively large amount of farmers face severe income drops: every year during the period 1998–2006, approximately a quarter of farms in the EU incurred in severe losses (i.e. income drops greater than 30% of their average income) each year (European Commission, 2009). The relative share of these farms changes by sector and by economic size class. For example, because of the high variation of both pig and poultry prices, "granivore" farms experienced the greatest income variability, whereas the dairy sector showed rather limited variability. Similarly, small farms are more exposed to large (relative) income variability than are big farms (European Commission, 2009). According to Trestini et al. (2017), farms that specialize in horticulture and in permanent crops (other than viticulture) have a relatively high probability of severe losses.

Risk management may ensure that a farm remains in or returns swiftly to the *status quo* when facing potentially disruptive challenges (Meuwissen et al., 2019). A stable flow of income is a prerequisite for allowing farms to also adapt and transform in response to evolving conditions. In particular, higher uncertainty reduces the responsiveness of investment to demand shocks, making firms more cautious when either investing or disinvesting [see, for example, Bloom et al., (2007)].

Farmers can use several instruments to cope with risks (Bielza Diaz-Caneja et al., 2008; Meuwissen et al., 2013). However, there is an interesting and innovative way to do so. Whole-farm income insurance schemes have attracted the interest of agricultural policy-makers world-wide, and the EU RDP has introduced the IST [Article 39 of Regulation (EU) No 1305/2013]. The IST is based on a public–private partnership that provides compensation (i.e., indemnities) to farmers who experience a severe income drop (Bardaji and Garrido, 2016). The IST is managed by a MF steered by associated farmers who pay an annual contribution to the MF to become eligible for receiving indemnities when their incomes either decrease by over 30% from the expected income or, in the case of sector-specific IST, decrease by over 20% their average historical level [Regulation (EU) No 2017/2393]. After the first three years of the setting-up of the MF, the financial contributions provided by the RDP cover the amounts paid by the MF as indemnification to farmers. These indemnifications may also relate to interests on commercial loans taken out for the purpose of compensate farmers in case of crisis. The public support is expected to foster the development of MF and farmers' participation to the IST (Cordier and Santeramo, 2019).The IST has several desirable features. First, it refers to the farm income as a whole and considers the complex nature of farm risk (i.e., not just production risk like farm insurance) as weel as the correlation between prices and yields and across the profits from different farm activities (Meuwissen et al., 2003; Severini et al., 2016). Second, the IST has the potential to cover also systemic risks (specifically price risk) that are not covered by purely commercial insurances hampering the principles of risk pooling (Meuwissen et al., 2003). Third, it moves away from a mainstream market-based approach (e.g., insurances) because, in contrast with traditional insurance products that are offered by insurance companies, it is based on MFs managed by groups of farmers (Cordier and Santeramo, 2019). Fourth, it can be supported by agricultural policies being in agreement with World Trade Organization green-box requirements (e.g., Mary et al., 2013).

This paper investigates the potential implications of introducing a sector specific IST considering the case of hazelnut producers located in the four main production areas of Italy as a case study. Italy is the second-largest producer of hazelnuts in the world (14.3%) after Turkey (CREA, 2018; FAOstat, 2018). Moreover, Italy plays a central role in the international market, being one of the main buyers in the international market for hazelnuts and one of the main exporters of processed products (Liso et al., 2017).

The IST could reduce income risk, increase farmers' wellbeing, and reduce the risk of default. This is relevant in the hazelnut sector as it is fast developing in response to an ever growing demand for products derived from hazelnuts (Cristofori et al., 2008; Cristofori et al., 2015; Liso et al., 2017, Dobhal et al., 2018). This is pushing toward a high level of production specialization and, in turn, a high level of income risk (Zinnanti et al., 2019). The level of risk faced by hazelnut farmers in Italy has been assessed by Zinnanti et al. (2019). However, no previous analyses have explored ways to manage risks and demonstrate their potential impact into the hazelnut sector. In contrast, supporting hazelnut farmers in managing income risk is particularly important because they rely on a perennial crop, where changing production patterns is constrained strongly by high costs and lengthy implementation time.

The role of IST has been seen by some authors as potentially very positive, whereas others have suggested that there are many issues to address before making it applicable (see Cordier and Santeramo, 2019, for a recent review). There is now a large amount of research on the effects of IST. For example, Finger and El Benni (2014a) and El Benni et al. (2016) found that this tool stabilizes farm-incomes, but it increases the income inequality within the farm population, because the benefits from such a tool might be highly heterogeneous across farm types. Other studies have focused on actuarial evaluations of potential income insurance, its governmental costs, potential beneficiaries within the farm population, and conceptual investigation of problems of adverse selection and moral hazard with such whole-farm income insurance tools (Dell'Aquila and Cimino, 2012; Liesivaara et al., 2012; Liesivaara and Myyrä, 2016; Pigeon et al., 2014; Mary et al., 2013; El Benni et al. 2016; Finger and El Benni, 2014a and 2014b). This paper adds to the literature, because very few analyses have assessed the potential impact of the IST when applied at a sector-specific level (Trestini et al., 2018), and none have addressed the hazelnut sector specifically. More importantly, the mandatory participation commonly assumed by previous analyses was not considered in this study (El Benni et al., 2016; European Commission, 2009; Finger and El Benni, 2014a; 2014b; Severini et al., 2018). Furthermore, the current analysis also explores the feasibility of the system by assessing whether there is scope for developing IST (i.e., supply and demand interact) under plausible hypotheses regarding the levels of contribution to the MF, policy support, and farmers' risk aversion.

In particular, the paper answers the following three research questions. First, what could be the impact of the IST on the level of income-related risks at farm levels? Second, is the IST feasible, given that there is scope for supply and demand to interact? In answer this crucial question, the maximum level of contribution to which farmers are willing to participate in the IST and the minimum contribution that makes the MF managing the IST financially viable were both assessed. Third, which geographical scale should be adopted when implementing IST (i.e., either national or regional)?

The results of the analysis provide insights that can support stakeholders in deciding whether to implement this innovative tool and how to design it. This seems important given that this tool has not been yet implemented throughout the EU (Severini et al., 2018; Trestini et al., 2017 and 2018). Hence there is scope to assess whether the introduction of the IST will be successful in specific regions and types of farming, to decide the level of contribution the MF should charge participating farms. Furthermore, this kind of analyses could provide two types of policy recommendations: (1) the advisability of managing IST at national or regional level and (2) the financial risk of fluctuations in the overall amount of payments paid by the MF to farmers over the years.

The chapter is organized as follows. Section 5.2 describes the data and the methods used in this analysis, including a description of the functioning of the IST. Section 5.3 presents the results of the analysis regarding the potential impact of the IST on level and riskiness of farm income, the feasibility of the IST, and the appropriate geographical scale on which design the IST. Section 5.4 closes the paper, providing a discussion of the results.

5.2. Material and method

5.2.1. Data and study area

Italian hazelnut production is highly geographically concentrated and specialized (Piacentini et al., 2015). Most of the hazelnut production in Italy comes from four regions: Campania, Lazio, Piedmont, and Sicily, accounting for approximately 34%, 33%, 20% and 11% of the national production areas in the period 2008–2017 (Istat, 2018). Because of this, this analysis focuses on hazelnut production in these four regions. Data used in this study were obtained from the Italian FADN referring to the period 2008-2017[14].

[14] We wish to thank the CREA-PB of Rome for letting us use the individual farm data.

The preliminary sample consisted of 1,973 observations of the crop unitary GM (€ per hectare, €/ha). This is a commonly used activity-based indicator of economic performances of crops given by the difference between crop revenues and crop-specific explicit costs for purchased inputs (such as fertilizers, crop protection products, other specific crop costs excluding overheads and labor cost) (European Commission, 2018; Castañeda-Vera and Garrido, 2017).

Data have subsequently been filtered taking into consideration three aspects. First, observations referring to a utilized agricultural area under hazelnut production lower than 1 ha have been deleted to avoid the inclusion of non-commercial hazelnut production. Second, only observations referring to plantations older than 7 years were included, because there is either no or negligible production in this period, which can be considered as being the crop establishment period. Third, farms with a number of observations of fewer than three years within the considered period have been eliminated, because these observations were considered too limited to provide a reliable representation of inter-year variability of economic results. The resulting sample consists of 1,207[15] observations distributed among regions and years (Table 5.1).

Table 5.1 - Farm sample (number of observations).

Year	**Campania**	**Lazio**	**Piedmont**	**Sicily**	**Total**
2008	13	10	63	4	90
2009	15	11	81	4	111
2010	20	18	82	4	124
2011	19	30	82	5	136
2012	13	29	84	4	130
2013	14	31	81	5	131
2014	17	24	86	5	132
2015	20	23	84	5	132
2016	17	22	82	5	126
2017	14	22	54	5	95
Total	**162**	**220**	**779**	**46**	**1,207**

Source: Author's elaboration on Italian FADN data.

5.2.2. Methods

5.2.2.1. Implementation of the IST

[15] In order to have at least three observations for each farm, the sample considered in this part of the thesis is a subsample of the sample used in the analysis described in the previous chapter.

The analysis assumes farm deflated unitary GM (€/ha) as the income indicator used to apply the IST[16]. This choice is close to that in Trestini et al. (2018), who use the farm Value Added. These indicators have the desirable property of allowing comparison of farms with different levels of involvement of family labor. Furthermore, this choice is in line with the decisions of the Italian Ministry of Agriculture (ISMEA, 2015; MIPAAF, 2017).

Following the Regulation (EU) No 1305/2013, later modified by the Regulation (EU) No 2017/2393, the IST is going to be managed by an MF. In the case of the sector-specific IST, farmers are indemnified if their income drops by more than 20% of the expected income level.

Several approaches could be used to identify the expected income. Two of these were foreseen by the EU Regulation in the case of the IST: these are either the average of the three previous years or the Olympic average of the previous 5 years (i.e., the average over the period excluding the lowest and highest levels) (see Finger and El Benni, 2014b for discussions). In this study, because there are not long enough series and because the need to discriminate between the regions studied as they are affected by different risk profile (Zinnanti et al., 2019), we therefore estimate the expected income as an average of the whole period considered (2008–2017)[17].

Given these assumptions, for each individual farm hypothetically participating in the IST scheme:

$x_{i,t}$ is the deflated value of the unitary GM of the i_{th} farm at the t_{th} year; and

$\bar{x}_i$ is the average of the $x_{i,t}$ realized in the period considered (2008–2017) in the i_{th} farm.

To allow better comparability of the variability of economic results among farms, GM has been standardized by dividing each GM observation by the farm-specific

[16] EU regulations do not provide specific indications regarding whether the income distributions should be deflated or not. This is probably going to be defined by future implementation rules. The choice of using deflated series seems coherent with the standard practice used within the risk analysis literature (e.g. Hardaker et al., 2015).

[17] Considering the previous three-year period only, might yields different results. Hence, when additional data will be available, it will be interesting to assess how much this choice affects the result of the analysis.

mean of GM. In this way, each regional GM distribution is centred to unity. Formally:

$xs_{i,t}$ is the standardized value of the unitary GM of the i_{th} farm at the t_{th} year, obtained as $xs_{i,t} = \frac{x_{i,t}}{\bar{x}_i}$.

The relative reference income that triggers the indemnification in the t_{th} year is a and it is fixed at 80% by assuming that the minimum trigger allowed by the EU Reg. (EU) no. 2017/2393 is used (i.e. 20%). This simply means that farmers experiencing a drop of GM less than 20% of their average GM are not going to receive any indemnification. Furthermore, farmers who experience a severe drop in income will receive a compensation equal to only a share of the occurred loss. Formally, the indemnification the MF pays to the i_{th} farm in the t_{th} year is:

$$y_{i,t} = \begin{pmatrix} 0 & \text{if } xs_{i,t} \geq a \\ (\bar{x}_i - x_{i,t}) \cdot b & \text{if } xs_{i,t} < a \end{pmatrix} \quad (5.1)$$

where the parameter b is set at 0.7 that is the maximum relative level of indemnification of the losses allowed by the EU Regulation. This partial compensation is supposed to reduce the effects of moral hazard in the case of the IST. In other words, because they will be only partially compensated, farmers are expected not to change their behavior in the case they subscribe an IST. To participate in the IST scheme, farmers must pay an annual contribution to the MF managing the IST that is conceptually similar to the premium paid in the case of the insurances. This analysis assumes that farmers pay contributions that are proportional to their expected income[18] (Severini et al., 2018). Hence, large farms pay larger absolute contributions than small farms.

After having been deflated and standardized, the observed distributions of GM (now called "baseline") have been analysed and compared with those derived from the application of the IST. However, because the contribution rates have not been defined yet, the following three scenarios of application of the IST have been

[18] The application of a flat per-farm contribution could change the results of the analysis. However, given the large heterogeneity of farms about size, the use of a flat contribution seems very unlikely in practice.

considered: no contribution ($IST_{0\%}$); contribution rate at 5% ($IST_{5\%}$); and contribution rate at 10% ($IST_{10\%}$). The first scenario is a hypothetical scenario, because it is assumed that farmers do not pay any contribution to the MF. This scenario is used as a benchmark to assess the impact of the contribution rate. The other two scenarios refer to situations in which farmers pay contributions that are set, respectively, at 5% and 10% of the farm GM mean.

Because each region is relatively small in surface area and homogeneous regarding climatic and soil characteristics, it is assumed that all farms in a region face the same relative income risk. This means that the farms within a region face the same distribution of the standardized GM ($xs_{i,t}$). However, we retain the idea that, as observed in reality, the absolute average GM levels differ among farmers also within the same region. This allows accounting for the existence of farm-specific individual effects that explain such absolute differences in average values.

5.2.2.2. Assessing the potential impacts of the IST

The potential impact of introducing the IST was assessed, considering the average profitability and the income-related risk. The analysis assumes that farmers in each region face the same distribution of standardized incomes.[19] The level of profitability of hazelnut production was analysed by considering the first moment of the distributions (μ) of GM both without and with the IST in place. Apart from the data for each region, the average, weighted according to the area cultivated with hazelnut of each region, is provided.

To assess the riskiness of the activity, the distributions of the standardized GM both without and with the IST have been estimated for each region. From discrete distributions of data, the PDFs by region were estimated by using the *BestFit* tool provided by Version 7.6 of the @Risk™ software (Palisade Corporation, Newfield, New York). The estimations were developed by comparing the goodness-of-fit of each distribution to several functions: the Akaike Information Criterion statistics test was chosen to rank the PDFs. This test provides a measure of how closely the fitted distribution matches the data distribution, defining the best density function

[19] The lack of long enough individual farm income series does not permit to explore farm heterogeneity within the region but only differences between regions. Future research could explore further this issue by considering farm heterogeneity also within each region.

from the log-likelihood function and taking into account the number of parameters of the fitted distribution. The risk analysis, by studying the VaR, was calculated based on the estimated PDF of the unitary GM. According to Dowd (2007), VaR is the maximum loss that may be expected over a given horizon period at a given confidence level. It was calculated as follows:

$$VaR = \bar{x}_i - V^* \quad (5.2)$$

where $\bar{x}_i$ is the average GM and V^* is the value of GM at a confidence level of 95%. This indicator is calculated using the standardized GM and then converted in absolute values. Large values of VaR suggest high risk because this index focuses on the worst outcomes only. Any risk-reducing strategy reduces the level of VaR so that the effectiveness of different risk management strategies can be analysed through assessing by how much they reduce the VaR they generate. Because the average level of GM differs between the regions considered, the relative VaR (Var%) is reported also: this is given by the ratio between VaR and the average GM. This index facilitates comparison of the riskiness of the activity in the regions considered, indicating how much below the average it is possible to lose in relative terms.

5.2.2.3. Comparing farmers' wellbeing with and without IST

The likely impact of introducing the IST on farmers' wellbeing has been assessed assuming that farmers are rational, that all agents have full information[20] and ruling-out moral hazard (Hardaker et al., 2015). This latter assumption may not be verified – resulting in higher indemnifications to farmers- because insured farmers could undertake riskier activities than not-insured farmers could (see for example Horowitz and Lichtenberg (1993) for an empirical assessment of the effect of insurance subscription on farmers behavior). However, in the considered case, the extent of moral hazard should not be large because of two main reasons. First, farmers receive indemnities that only partially compensate for the faced losses (i.e.

[20] Further developments could relax such assumptions and take stake of the literature based on the prospect theory (Kahneman and Tversky, 1979).

a maximum of 70% of the losses). Second, the perennial nature of the crop and the high specialization of the considered farms reduces the chance of changes in production practices (e.g. pest control).

The likely impact of introducing the IST has been first analysed using the stochastic dominance (SD) theory that is applied widely to compare risky alternatives (Hardaker et al., 2015). SD is a form of non-parametric stochastic ordering that enables ranking one probability distribution of outcomes as being superior to another distribution (Mishra et al., 2019). Being a criterion of decision rule that provides a partial ordering of risky alternatives, this approach has the desirable property that it does not require normally distributed outcomes (Hardaker et al., 2004; Hildebrandt and Knoke, 2011). Based on Hardaker et al. (2004), the risky alternatives to be compared were assumed to have uncertain outcomes. In this study, values of GM are assumed to be stochastic, and the risky alternatives correspond to non-participation in the IST (i.e., baseline) and participation in the IST considering increasing contribution rates (e.g., $IST_{0\%}$, $IST_{5\%}$, and $IST_{10\%}$).

More in general, given $f_1(w), f_2(w), \ldots, f_n(w)$ the PDF describing the outcomes for n risky alternatives, the corresponding CDF, denoted by $F_1(w), F_2(w), \ldots, F_n(w)$, were used to define the SD. As explained by Levy (1998), different methods of SD do exist, including first-degree stochastic dominance (FSD) and second-degree stochastic dominance (SSD). FSD occurs when it is possible to order alternatives for decision-makers who prefer more money rather than less money, no matter how risk-averse they are. By graphically comparing the CDFs of two risky alternatives it is generally possible to state that one dominates the other, in the sense of the FSD, if the CDF of the first considered alternative (i.e. $F_A(x)$) is either equal to or less than the second one [i.e. $F_B(x)$] for every possible outcome (Hildebrandt and Knoke, 2011, Hardaker et al., 2015):

$$F_A(x) \leq F_B(x), \text{ for all } x \tag{5.3}$$

Ordering alternatives in this manner allows differentiation among efficient (undominated) and inefficient (dominated) choices (Hildebrandt and Knoke, 2011).

Nevertheless, in some cases, the CDFs of two risky alternatives intersect, making it not possible to rank alternatives by means of the FSD principle. In this case, it is desirable to use SSD, which requires an assumption: decision-makers must be risk-averse for all values of x. This means he/she must have a utility function with decreasing slope (i.e., $U'(x) > 0$ and $U''(x) < 0$) (Hardaker et al., 2015).

The SSD principle states that alternative A is preferred to alternative B for a risk-averse agent if the cumulative area under the CDF for the dominant alternative [i.e. $F_A(x)$] lies everywhere below and to the right of the corresponding curve for the dominated alternative [i.e. $F_B(x)$] (Hardaker et al., 2015). More formally:

$$\int_{-\infty}^{x^*} F_A(x)dx \leq \int_{-\infty}^{x^*} F_B(x)dx \quad for\ all\ values\ of\ x^* \tag{5.4}$$

Sometimes, the SSD also does not allow discrimination between risky alternatives. Under these conditions, the result depends strongly on the level of risk aversion of the agent considered. Indeed, for a very risk-averse person, the less risky alternative may be still be preferred even if the SSD principle fails to identify whether one alternative dominates the other. In fact, such a risk-averse agent weighs negative outcomes more heavily than positive outcomes. This may clearly be the case in our empirical analysis, especially when the contribution rate is relatively high.

Because of these considerations, it is more convenient to compare risky alternatives using the expected utility (*E(U)*) approach (Hildebrandt and Knoke, 2011). This approach is based on the assumption that agent behavior is based on the maximization of the expected utility deriving from the stochastic outcomes. Following Masten and Saussier (2002), it is possible to formalize the farmer's decision to either accept or reject the IST scheme (y^*) as a discrete decision-making problem:

$$y^* = \begin{cases} y = 0 & if\ \ U(V^0) \geq U(V^1) \\ y = 1 & if\ \ U(V^0) < U(V^1) \end{cases} \tag{5.5}$$

where, in this study, V^o and V^1 represent the net benefits associated with not participating and participating in the IST scheme, respectively.

To implement this approach in practice, it is required, first, to assume a specific functional form for the utility function and, second, to set reference levels of risk aversion. Despite this imposes some restrictions on farmers' behavior, empirical analyses often use the negative exponential form (Hardaker et al., 2015):

$$U = 1 - exp(-cw)\,, c > 0 \tag{5.6}$$

where w are the levels of the economic variable of interest that, in this application, is the hazelnut GM, and c denotes the measure of risk aversion that is constant and has the following specification:

$$r_a(w) = -U^{"}(w)/U^{'}(w) \tag{5.7}$$

where $U''(w)$ and $U'(w)$ represent the second and first derivatives of the utility functions, respectively (Hardaker et al., 2015). This functional form assumes a constant absolute risk aversion function (CARA).

Love and Buccola (1991), using CARA, revealed that production decisions are affected significantly by revenue uncertainty and/or output price for risk-averse producers. As assumed by Iyer et al. (2019), it is reasonable to assume that farmers are risk-averse, although risk aversion is necessarily a relative concept. In this analysis, three absolute risk aversion coefficients ($r_a(w)$) have been chosen to identify possible alternative risk aversion levels:

- 0.01 risk neutral;
- 0.3 low risk aversion;
- 0.6 high risk aversion.

The choice of these values of risk aversion coefficients is arbitrary and further analyses based on experimental studies may provide context specific insights to refine further the analysis. However, the chosen intervals are supported by other scholars who investigated farmers' risk attitudes in Europe (Cerroni, 2019; Kumbhakar and Tveterås, 2003; Groom et al., 2008; Serra et al., 2008; Piet and Bougherara, 2016; Castaneda-Vera and Garrido, 2017; Iyer et al., 2019).

Participation in the IST depends critically on the level of the contribution requested by the MF. The willingness of farmers to participate in the IST was calculated as the maximum contribution rate (MaxCont) that makes farmers indifferent about whether to participate in the scheme. In particular, the willingness to participate in the IST is the contribution (in %) that makes the farmers' expected utility (adhering to the IST) equal to that obtained in the baseline conditions: $E(U)_{BL} = E(U)_{IST}$.

5.2.2.4. Assessing the financial sustainability of the MF

On the supply side, it is important to assess which contribution rate will make the IST scheme sustainable from the point of view of the MF managing the scheme. The basics of insurance pricing refer to a fair insurance premium (Bowers et al., 1989). From an insurer point of view, the premium should be such that expected losses (E(X)) do not exceed collected premiums. While various premium principles can be derived (see Embrechts, 1996, for a review), the simplest and most widely used is the expectation principle:

$$\Theta = E(X) + \delta E(X) \quad (5.8)$$

where Θ refers to collected premiums, and δ should be positive and large enough to have sufficiently protective solvency margins that can be derived from ruin estimates of the underlying risk process (Embrechts, 1996). In the field of the insurances, one often considers the loss ratio index: this is the ratio between losses and collected premium. In the case of IST, this is the ratio between paid indemnities and the collected contributions.

The basic consideration that drives insurance pricing is that the price (i.e., the contribution rate in the case of IST) should be both high enough to bring forth sellers and low enough to induce buyers to enroll (Finn and Lane, 1997). Despite this, the literature on insurances and actuarial science generally assumes the number of insured as being constant regardless of the premium charged, a limitation that is very often caused by a lack of factual data on insured behavior. In this paper, it has been considered that MF will also face loading costs and that the RDP will cover a share of the costs faced. Based on the average loss ratio experienced in the period

2010–2015 by the subsidized farm insurance schemes in Italy (ISMEA, 2018), a benchmark loss ratio of 0.65 is assumed. The level is assumed to be lower than one because MFs are expecting administrative and other loading costs and to have a margin to constitute a fund to be used in the years in which the volume of indemnity is large because of unfavorable economic farm results. Hence, a loss ratio higher than 0.65 may indicate a negative result for the MF because not all costs are covered by farmers' contributions.

Furthermore, it has been assumed that the public support is set on 70% of the costs faced, as stated by the Regulation (EU) 2017/2393. Because it is still not very clear which costs are the basis for establishing the extent of such support, two scenarios have been considered. The first one assumes that public support is calculated over all costs: this results in charging farmers for 30% of the whole costs. The second assumes public support calculated on indemnities costs only: this results in charging farmers for 54% of the whole costs.

5.3. Results

5.3.1. Potential impact of IST on level and riskiness of gross margin

The average GM value of the baseline is 4,800 €/ha, but values differ considerably at regional level, varying from 2,569 €/ha (Sicily) to 5,876 €/ha (Campania). The introduction of the IST would greatly increase the average GM values in the hypothetical case that farmers did not have to pay contributions (scenario $IST_{0\%}$) (Table 5.2).

Table 5.2 - Average GM levels by region (€/ha). Baseline conditions and simulated implementation of the IST.

	Baseline	IST with contribution rates set at:		
		0%	5%	10%
Piedmont	4,999	5,600	5,350	5,100
Campania	5,876	6,176	5,883	5,589
Lazio	5,012	5,435	5,184	4,934
Sicily	2,569	2,843	2,715	2,586
Weighted average	4,800	5,214	4,974	4,734

Source: Author's elaboration on Italian FADN data.

Clearly, these levels fall as the contribution rate increases (Table 5.2). The average GM of $IST_{5\%}$ is still favorable in the four regions, although to a lesser extent for Campania and Lazio, in comparison with the baseline conditions. Lastly, the implementation of a 10% contribution rate ($IST_{10\%}$) allows farmers to reach an average GM that is similar to that of the baseline, even if it drops below this level in Campania and Lazio (Table 5.2). Hence, the IST could enhance farm GM unless contributions rates are set at approximately 10% or more.

To assess the impact of the IST on the riskiness of farm income, results of the $VaR_{\%}$ and the $GM^{5\%}$ were observed. $GM^{5\%}$ is the GM level that marks the 95^{th} percentile: at this point, there is a 5% probability of obtaining a value below this GM level. As expected, the riskiness of the activity drops strongly when the IST is implemented: indeed, $VaR_{\%}$ decreases radically moving from the baseline to the implementation of the IST regardless of the contribution rate level, because of the positive role of the indemnifications it provides to farmers experiencing relevant drops in their GM (Table 5.3).

Table 5.3 - Risk indicators by region in the baseline and with the IST.

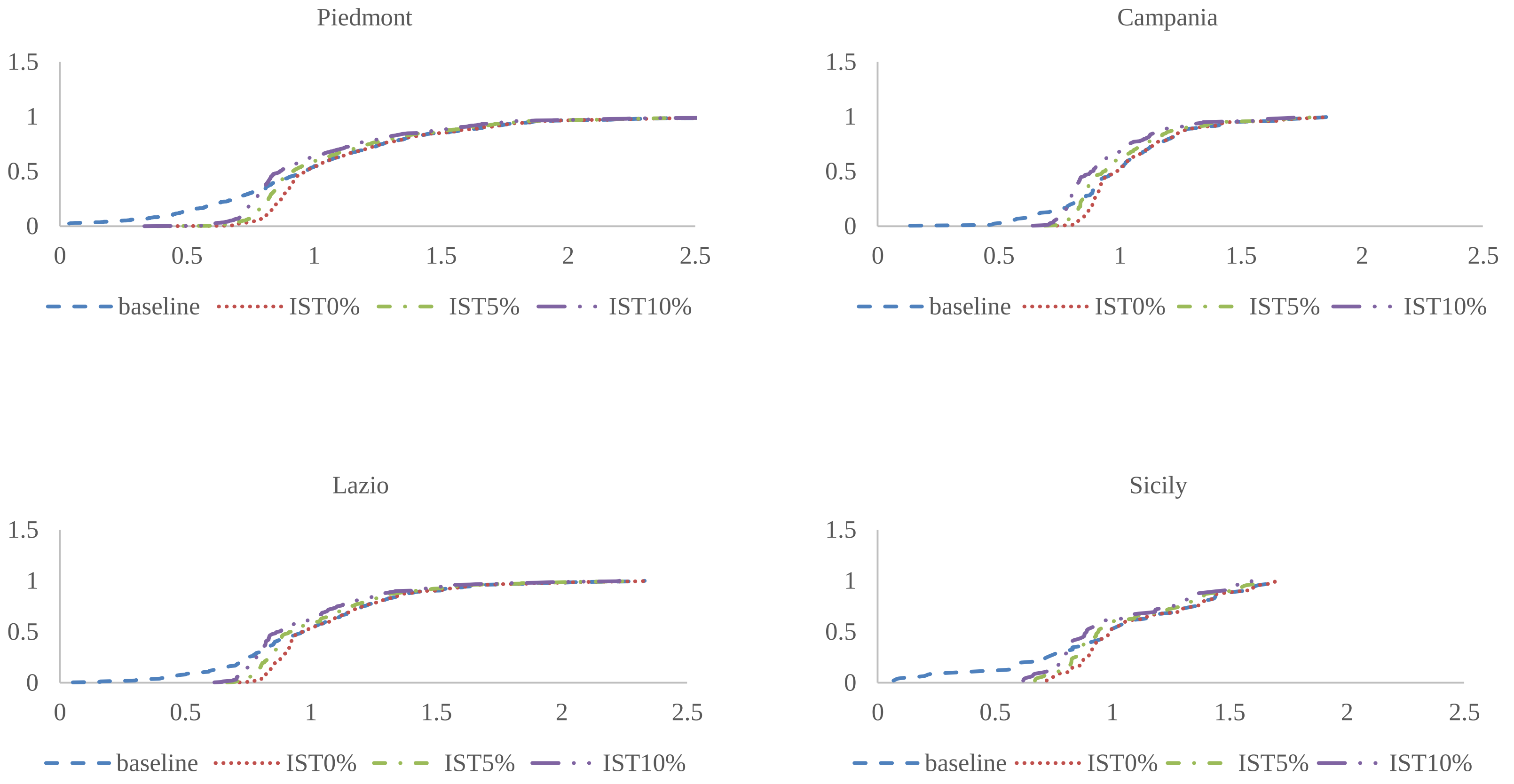
	Baseline		IST with contribution rates at:					
			0%		5%		10%	
	$GM^{5\%}$ (€/ha)	VaR	$GM^{5\%}$ (€/ha)	VaR	$GM^{5\%}$ (€/ha)	VaR	$GM^{5\%}$ (€/ha)	VaR
Piedmont	1,140	77%	3,840	31%	3,590	33%	3,340	35%
Campania	3,279	44%	4,895	21%	4,601	22%	4,307	23%
Lazio	2,100	58%	4,040	26%	3,789	27%	3,538	28%
Sicily	504	80%	1,950	31%	1,822	33%	1,693	35%

Source: Author's elaboration on Italian FADN data.

Risk increases as the contribution payment increases (from $IST_{0\%}$ to $IST_{10\%}$). Both options (with and without IST), the Campania and Lazio regions may lose less than the other regions do in relative terms.

The impact of IST is appreciated when shown graphically: the left tail of the CDFs of GM in each region is shifted totally to the right (Figure 5.1).

Figure 5.1 - Cumulative Distribution Functions (CDFs) of standardized GMs in the four regions. Baseline and implementation of the IST with contribution rates at: 0%, 5%, and 10%.



Source: Author's elaboration on Italian FADN data.

The results suggest that the IST could greatly reduce the risk faced by farmers but, in the case of very high contribution rates, it also supports farmers' income levels.

5.3.2. Farmers' willingness to participate in the IST

Following the SD approach, in all four regions, the scenario $IST_{0\%}$ clearly dominates the baseline conditions, suggesting that farmers would be willing to participate under this favorable but implausible condition. The CDFs referring to the scenario $IST_{0\%}$ never lie above that of the baseline: this shows that this scenario dominates the baseline according to the FSD principle and, because of this, it represents an improvement in comparison with the current situation without IST (Figure 5.1). However, as farmers are charged a contribution, it is not possible to easily assess visually that the IST dominates even according to the SSD principle. Using the *E(U)* approach, it is possible to identify the MaxCont at which farmers are willing to participate in the IST (i.e., $E(U)_{BL} = E(U)_{IST}$) (Table 5.4).

Table 5.4 - Contribution rates making farmers indifferent to participating in the IST under three different hypotheses of risk aversion (MaxCont).

	Risk neutral	Low risk-averse	High risk-averse
Campania	5.5%	7.5%	9.5%
Lazio	8.5%	12.5%	17.5%
Piedmont	10.5%	19.5%	25.5%
Sicily	9.5%	13.5%	18.5%
Weighted average	8.3%	13.0%	17.4%

Source: Author's elaboration on Italian FADN data.

As foreseen, the MaxCont increases as risk aversion increases. The average rate moves from 8.3%, when farmers are assumed to be risk-neutral, but it increases up to 17.4% assuming a high level of risk aversion. These results suggest that, under the conditions considered, there is a relatively high willingness to participate in the IST, even for moderate levels of risk aversion.

However, the level of willingness to participate in the IST, expressed in terms of MaxCont, differs among regions: in Piedmont and Campania farmers are willing to participate with higher and lower rates, respectively, than are farmers in other regions. The farmers in Lazio and Sicily are in between.

5.3.3. Contribution rates making the MF economically sustainable

From the MF point of view, the minimum contribution rates required to make management of the IST financially sustainable are shown in table 5.5.

Table 5.5 - Minimum contribution rate required by the MF to make the scheme economically sustainable both without and with public support.

	no public support	with public support	
		on indemnities costs only (0.54)	*on all costs (0.30)*
Campania	7.5%	4.1%	2.3%
Lazio	12.5%	6.8%	3.8%
Piedmont	16.5%	8.9%	5.0%
Sicily	14.5%	7.8%	4.4%
Weighted average	12.4%	6.7%	3.7%

Source: Author's elaboration on Italian FADN data.

Without public support for farmers, the average contribution rate that satisfies the MF to obtain a loss ratio of 0.65 is 12.4%. If the public support covers 70% of the compensation costs (not including all fund management costs but on indemnities only), the minimum contribution rate required by MF reaches to 6.7%, on average. Clearly, the minimum contribution rate decreases if the public support covers all costs reaching 3.7% (Table 5.5).

Therefore, without public support, interaction between farmers and MFs is possible assuming farmers with medium-high risk aversion only: the minimum contribution rate that an MF could receive is less than the farmers' willingness to participate in the IST at 0.6 risk aversion coefficient (compare tables 5.4 and 5.5). In the presence of public support, the percentage of contribution rate requested by MF is lower than in the previous case, so that interaction between farmers and MFs is always possible: even risk-neutral farmers could accept.

However, such a minimum contribution rate varies across regions: higher values are found in Piedmont and Sicily (Table 5.5). These results suggest that carefully consideration should be given to differentiating the contribution levels among regions. Indeed, differences among regions exist in terms of the relative number of indemnified observations (Table 5.6).

Table 5.6 - Number of cases of indemnification by region and year.

	Absolute values (n. obs.)					*Relative values (%)*				
Year	Campania	Lazio	Piedmont	Sicily	Total	Campania	Lazio	Piedmont	Sicily	Total
2008	1	3	25	2	31	8	30	40	50	34
2009	1	3	31	2	37	7	27	38	50	33
2010	8	5	54	1	68	40	28	66	25	55
2011	6	6	33	2	47	32	20	40	40	35
2012	3	14	35	1	53	23	48	42	25	41
2013	7	13	23	0	43	50	42	28	0	33
2014	3	4	7	2	16	18	17	8	40	12
2015	1	3	12	0	16	5	13	14	0	12
2016	1	3	28	1	33	6	14	34	20	26
2017	1	12	18	3	34	7	55	33	60	36
Total	32	66	266	14	378	20	30	34	30	31

Source: Author's elaboration on Italian FADN data.

On average, 31% of the farms are indemnified in the whole sample and the whole period considered; a slightly larger share of farms is indemnified in Piedmont, while, in Campania, the share of indemnified farms drops more than 10% points below the national average (Table 5.6).

5.3.4. Comparing the riskiness of a national vs. regional MFs

An additional aspect affecting the economic sustainability of the scheme lies in the fact that MF may face high volumes of indemnities paid to farmers in specific years, thereby increasing the level of the loss ratios. When a large number of farms are indeed indemnified, the financial resources available to the MF may be not adequate, making the financial management of the MF untenable unless adequate risk management strategies are pursued actively by the MF. Nonetheless, these strategies come at a cost that, in the end, results in higher contribution rates being charged to participating farmers.

The percentage of indemnified farms at the national level varies over time, from a minimum of 12% (in 2014 and 2015) to 55% (in 2010). Within regions, the variability is even more significant with values between 0% (Sicily) and 66% (Piedmont). This clearly increases of the variability of the amount of indemnities paid by the MF to farmers over the years and this can make the financial management of the MF non-sustainable. If MF were established for individual regions, the percentage of indemnifications could be higher than the national average. This allows adjusting the riskiness for each region, but linking the four regions in a national MF allows risk pooling: the risk to be borne at the level of each region can be distributed at the national level. Hence, in a specific year, the low GM levels experienced by a specific region may be compensated by a high GM level in another region.

Looking also at the level of indemnifications among regions, the total percentage seems to moderate differences among regions (Table 5.7).

Table 5.7 - Unitary indemnification levels in the regions considered for the indemnified farms. Average over the considered period (€/ha).

	Campania	Lazio	Piedmont	Sicily	Total
Indemnifications *(a)*	1,494	1,344	1,608	793	1,522
Average GM *(b)*	4,999	5,876	5,012	2,569	4,800
a/b	30%	23%	32%	31%	32%

Source: Author’s elaboration on Italian FADN data.

To further investigate the riskiness of a unique national MF management instead of separate regional MFs, the evolution of the loss ratios over time was analysed. It varies strongly among years: in many cases, it exceeds 0.65 (that has been set as the break-even reference level) reaching a maximum of 1.24 in the case of the total sample (Table 5.8). Here, the variability, assessed as standard deviation, is 0.30. In all the regions considered, such variability is higher than is the one observed in the total sample: in particular, the standard deviation is very high in Campania and Sicily (Table 5.8).

Table 5.8 - Loss Ratio (Indemnities/Contributions) by region and year.

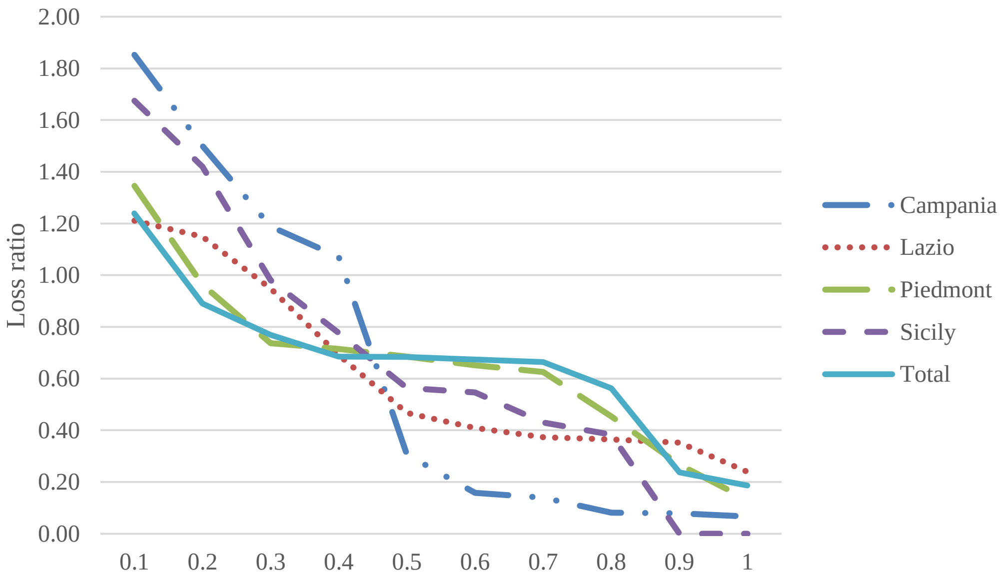
	Campania	Lazio	Piedmont	Sicily	Total
2008	0.14	0.69	0.96	1.67	0.89
2009	0.08	0.37	0.72	1.42	0.66
2010	1.50	0.47	1.35	0.56	1.24
2011	1.07	0.35	0.74	0.78	0.68
2012	1.19	0.95	0.69	0.55	0.77
2013	1.85	1.15	0.45	0.00	0.67
2014	0.31	0.36	0.13	0.43	0.19
2015	0.07	0.24	0.27	0.00	0.24
2016	0.08	0.41	0.65	0.38	0.56
2017	0.16	1.21	0.63	0.98	0.69
Weighted average	0.65	0.65	0.65	0.65	0.65
Max	1.85	1.21	1.35	1.67	1.24
Standard deviation (sd)	0.69	0.36	0.34	0.55	0.30
Mean	0.64	0.62	0.66	0.68	0.66
Min	0.07	0.24	0.13	0.00	0.19
Semi Stand. Dev (right side)	0.81	0.40	0.32	0.67	0.25

Source: Author's elaboration on Italian FADN data.

The differences existing among regions are also confirmed by the values of the semi-standard deviation that accounts only for the loss ratios that are higher than the average (i.e., right side semi-standard deviation). This indicator shows clearly that Campania is the riskiest region, having the highest value of this index. It is followed by Sicily and Lazio, while the Piedmont region has the lowest level of risk, indeed it is very similar to that potentially faced by a national MF (Figure 5.2).[21]

[21] This graph is derived directly from data in table 8 by ordering the data for each region from the highest to the lowest loss ratios.

Figure 5.2 - Comparison of Loss Ratio levels by region (Campania, Lazio, Piedmont, and Sicily) and in the case of a national MF (Total) in the ten years considered.



Source: Author’s elaboration on Italian FADN data.

These results suggest that managing a national MF is less risky than is managing regional MFs separately. In the latter, the loss ratios can become very high, putting the financial sustainability of the regional MFs under pressure. In contrast, the national MF can more effectively use the risk pooling principle (Trestini and Giampietri, 2018).

5.4. Discussion and conclusion

The results of the analysis allow the three research questions described in the introduction of the paper to be answered. This research has shown that the IST could reduce substantially the risk faced by hazelnut farmers in all four production regions of Italy considered: hence, the IST could potentially be very effective in stabilizing their incomes. Furthermore, given the public support provided to the IST, this tool can also enhance farm income. Clearly, this occurs up to a given level of the contribution rate the MF is going to charge associated farmers.

The overall impact will depend critically on the level of farmers’ participation in this tool. This paper assessed the conditions ensuring the development of the MF and farmers’ participation. The results of the analysis suggest that a sector-specific

IST for hazelnut farming in Italy could be, in principle, very feasible, because supply can interact easily with farmers' demand. Indeed, in three out of four cases, the maximum extent to which even limitedly risk-averse farmers are willing to participate in the IST exceeds the minimum contribution that makes the MF managing the IST financially viable. Hence, there are also opportunities for interactions between the supply and the demand for the IST without sizeable policy support. Clearly, the presence of public support strongly increases the opportunities for developing this new risk management tool. However, it is important to recall that relevant implementation issues not considered in this analysis, including the lack of certified financial statements reporting farm income figures, can hinder the implementation of the IST (Cordier and Santeramo, 2019).

In addition, the analysis provides two pieces of information that are potentially useful for the design of the IST. On the one hand, farmers' contributions should be differentiated among regions because they face different income risk levels. On the other hand, to ensure the financial viability of the MF, it seems important to have a limited fluctuation of indemnities over the years. If this goal is perceived as important, it is advisable to take advantage of the risk pooling principle and opt for a national-wide MF, rather than for single regional MFs. Indeed, regional MFs could face years in which the amount of indemnities paid strongly exceeds the amount of the contributions received. If a regional MF has to be developed, it should manage such adverse financial conditions by collecting larger funds, negotiating the opening of credit lines, or underwriting reinsurance contracts (Pigeon et al., 2014). However, these strategies may be costly and cause an increase in the level of farmers' contributions. This, in turn, is expected to reduce the level of farmers' participation.

In the end, it is important to mention three limitations that affect the present empirical application. First, due to the limited number of sampled farms and the willingness to compare regions where both income levels and risk differ, the analysis refers to the average income calculated over the whole period considered. This is not fully in line with what the EU Regulation that requires the calculation of indemnities based on data from the three previous years. However, the lack of continuous and reliable data, that could effectively hinder the implementation of a sector-specific IST, has forced us to use this approach. Second, it is assumed that all farms in a region face the same relative risk by referring to standardized GMs. If additional data become available, it could be possible to develop an analysis that will overcome these two limitations. Third, the analysis assumes rational behavior, full information and is based on specific assumptions regarding the functional form of the utility function and risk aversion levels. This leads to possible future extension of the analysis toward the use of experimental data to better specify the nature of farmers behavior. Despite these limitations affecting the developed empirical application, it seems that the proposed methodology may be used to assess the implication and feasibility of the IST also in other EU countries, regions, and sectors to yield more widespread results. This is perceived as useful because the results of this kind of analysis can feed the debate at the EU level on this new and interesting risk management tool, which is not yet implemented in the EU.

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Chapter 6

Conclusion

In agriculture, as in other business types, risk typifies decision-makers' choices. Dealing with risk systematically is arduous for farmers and researchers due to different views as to the nature of risk and its assessment.

Measuring the impact of risk on the well-being of farms, in general, requires careful analysis of the sources of risk. Climate change, natural disasters and the related yield risk, greater price volatility for inputs and outputs, international trade restrictions, new food safety standards and quality, and changes in EU agricultural policy are all factors that tend to affect farm income and their medium-to-long term economic performance.

The aim of this Ph.D. thesis, therefore, was to suggest a possible tool to manage risk exploring inside the profitability and riskiness of an Italian agri-food sector production such as hazelnut.

The Italian hazelnut crop sample was selected for several reasons, one of which is the high probability of the income loss of a crop characterised with a certain degree of specialisation. Besides, perennial crops are characterized by high costs involved in production and lengthy periods of non-productivity after planting. Therefore, the decision to replace the crop with others, following adverse climatic and phytosanitary conditions, for example, is not easy. The growing interest in quality production demanded by the national and international market, combined with rising prices and the lack of relevant studies in literature, can only serve to compound this situation and are further reasons that led to the choice of this crop as a case study.

The results of our analysis show that, within the same country, different geographical areas show different levels of risk in losing income. These differences reflect the existing variety among regions in terms of geoclimatic characteristics, the suitability of the area, and therefore, the quality of the product. The sensitivity analysis made it possible to separate the various income components capable of generating risk. Although yield was found to be the most important parameter generating risk in all the areas analysed, product quality plays a crucial role. Risk-taking can, therefore, be said to be inevitable, and thus income stability and risk balancing are crucial issues in hazelnut production and in agriculture in general.

The agricultural sector, however, has had public financial incentives over time in relation to the specificity of productive activities that have lower incomes than other economic sectors and environmental and social functions not remunerated by the market at the same time. In this sense, by virtue of the CAP programming, risk management policy has played an increasingly important role in recent government policies. Hence, risk management deals not only with natural disasters but also with price and production risks and, consequently, income through enhanced support for insurance tools (subsidised insurance contracts) and MFs.

Considering only a few risk factors affecting the downside risk could be limiting. Here the need (in this thesis) to search and simulate tools able to consider for an over-all risk was felt.

It is interesting to note that over the years risk management policies in the UE have been enriched in terms of objectives and funding. In spite of the growing importance of insurance policy in other contexts (see for example the USA and Canada), the current application of the IST and MF is very limited in Italy. In contrast with agricultural insurances covering only production risk, the IST also considers price risk. The very desirable characteristic of the IST is that it considers at the same time all sources of risk accounting for possible interactions among these. In particular, yield and price can be correlated. If such a correlation is negative, this provides scope for natural hedge. Hence, the overall risk cannot be simply assessed considering the effect of both parameters in isolation.

Looking at international experiences on which ISTs as part of a comprehensive risk management policy has been applied in advance, the IST has been applied to our case study. The IST has proved to be capable of markedly reducing the riskiness of the income of hazelnut farmers in all Italian production regions. Moreover, supply (identified as MF) can interact with the farmers' demand for an insurance tool covering ensuring them from risk, thereby rendering a sector-specific IST potentially feasible. In addition, public support decisively increases the opportunities for farmers to deploy this risk management tool. Lastly, the farmers' contribution should be differentiated among regions, and it is advisable to take advantage of the risk-pooling principle by opting for a nationwide MF.

Generally, the research objective satisfied by this Ph.D. thesis would appear to be relevant, given that, to the best of author's knowledge, no profitability and risk analysis have been performed on hazelnut crops or on other perennial crops. Although few studies exist regarding the implementation of the IST, no risk management analysis has been performed with the admixture of methodological techniques used in this study, which were "in series but integrated" among themselves. The limitations found in this thesis are closely related to the availability of accounting data: this has been supported by a careful examination of the FADN database for single crops. Despite the positive results demonstrated by the potential use of the instrument, widespread criticism regarding the application of the regulation to a sectoral IST exists. The lack of timely and continuous data relating to the same crop on a national and regional detail, whilst some farms make modest use of accountancy practices, suggests that some gaps need to be resolved by policy-makers prior to the implementation of the tool. It is, therefore, necessary to adapt the instruments currently working to the actual needs of the farm by reducing the administrative costs of risk management and facilitating the access of farmers to new forms of insurance cover.

The implications of this thesis can be said to be twofold: on the one hand, farmers could deploy a functioning framework describing the profitability, the riskiness of the crop and the sources of variability to leverage in the management of their income risks. On the other hand, this study can be said to provide insights into and suggestions for supporting stakeholders in deciding whether to implement an IST in specialized farming systems and how to design such a scheme in an efficient way. Further developments of this analysis could ascertain the application of methodological techniques to other production contexts (such as other crops). It would also be of interest to compare the results of this research with those from the implementation of other risk management tools such as production risk insurance, in order to assess the suitability of one tool vis-à-vis another.

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