Direct payments, crop insurance and the volatility of farm income. Some evidence in France and in Italy

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Abstract

Volatility in farm income represents a major challenge for farm management and for the design of public policies. This paper measures the extent to which risk management tools, especially direct payments and crop insurance, can significantly reduce crop income volatility in France and in Italy. We use an original dataset of 9,555 farms for the period 2003-2007 drawn up from the Farm Accountancy Data Network (FADN) and three different econometric models to explain the volatility of crop income. The results are contrasted between the specialization of the farms and the two countries. Italian farms use management tools (European payments, crop insurance and inputs) to improve their income and reduce its volatility. French farms use the same tools to raise incomes and their volatility and tend to substitute European payments with production. These results question the efficiency of structural policies aimed at stabilizing farmers' incomes.

Keywords: *volatility, farm income, farm management, insurance, France, Italy, FADN.*

Résumé

La volatilité du revenu agricole représente un défi majeur pour la gestion des exploitations et pour la mise au point des politiques publiques. L'objectif de ce travail est d'évaluer dans quelle mesure les instruments de gestion des risques, en particulier les paiements directs et l'assurance agricole, peuvent réduire la volatilité du revenu agricole en France et en Italie. Les données retenues concernent 9555 exploitations et se réfèrent à la période 2003-2007. Elles ont été obtenues à partir du Réseau d'Information Comptable Agricole (RICA) et de trois différents modèles économétriques, élaborés pour expliquer la volatilité du revenu agricole. Les résultats diffèrent considérablement selon le type de spécialisation des exploitations et entre les deux pays. Les exploitations italiennes utilisent des instruments de gestion (paiements européens, assurance agricole et intrants) pour améliorer leur revenu et en réduire la volatilité. Les exploitations françaises utilisent les mêmes instruments pour accroître leur revenu et la volatilité du revenu et tendent à remplacer les paiements européens par la production. Ces résultats amènent à remettre en cause les politiques structurelles visant à stabiliser le revenu des agriculteurs.

Mots-clés: volatilité, revenu agricole, gestion de l'exploitation agricole, assurance, France, Italie, RICA.

1. Introduction

As a result of the biological nature of agricultural production processes and their strong dependency on natural and climatic conditions, forms of public intervention aimed at reducing income variability, with no parallels in other sectors of the economy, have been in place in developed countries for several decades. Without neglecting the peculiarities of the production conditions in agriculture, farming in developed countries has indubitably reached high levels of complexity. Both the origins of income variability and its impact on the viability of farms have radically changed (Meuwissen *et al.*, 2008).

The organization of agricultural production, its integration in the agro-food chain, increased use of credit, professional technical assistance, finance and insurance services by farmers, the regulatory system within which it operates and the diversification of income are all factors that make the risk faced by a farmer in a developed economy in 2012 very different and more complex than that faced by his father on the same farm only few decades ago.

In this scenario, we need to take into account the impact on the sector of greater future volatility in food markets. Climatic instability will translate into high crop yield variability, heightening tensions in the markets. As a result, the frequency of price shocks may well increase, thereby raising farmers' exposure to income risk and leading to farm closures (Capitanio, 2010). This eventuality is not only bound to squeeze farm yield potentials, but also to favour conditions for a withdrawal of environmental and social conservation functions from huge acreages of rural and agricultural land world-wide. The remarkable variations observed in agricultural commodity prices over the last few years is the demonstration that we are heading towards a scenario of greater uncertainties, which are inevitably reflected in market trends (Trostle, 2008).

Since market stabilization was one of the founding objectives of the Common Agricultural Policy (CAP), it may be argued that the increased market price volatility could affect farmers' revenues both in terms of level and stability. Therefore, public intervention in supporting risk management policies in agriculture, aimed at protecting farmers' crop revenues both from price volatility and falling yields, would become a desirable policy objective. Two main instruments usually contribute to risk management: European payments and

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crop insurance. As a result, they must be considered jointly in order to study their specific effect on income returns and volatility (Hauser *et al.*, 2004; Vedenov and Power, 2008; Capitanio *et al.*, 2011).

Farm income stabilization has traditionally been a great concern for European agricultural policy makers. Since the setting up of the CAP, income stabilization has been achieved mostly indirectly, through various price support mechanisms included in almost all Common Market Organizations (C-MOs). With the gradual abandonment of price support that has followed the CAP reform process from Agenda 2000, the responsibility for smoothing any income fluctuations is being transferred more and more to the farmers or to Member States' policies, although the introduction of the Single Payment Scheme (since 2007), by providing farmers with a fixed amount, could partly contribute to stabilizing total farm incomes (Cafiero *et al.*, 2007).

At the European level, the review of risk management tools has proceeded in parallel with that of the path of reform of the CAP, and, in particular, with the new structure of direct payments launched under the 2003 Medium-Term Reform. An initial analysis of the risk management tools in this regard was conducted in 2001 (European Commission, 2001), the reform itself being accompanied by an exhortation to examine the role attributed to specific measures of risk coverage together with a Communication from the Commission "on risk and crisis management" (European Commission, 2005).

The first concrete initiative arrives, however, only with the 2008 Health Check which allowed the Member States a financial contribution from the EU towards the premiums on insurance taken out against economic losses caused by adverse climatic events and animal or plant diseases or pest infestation and to promote farmers' membership of mutual funds with the same aims.

Today, in a scenario in which the theme of volatility in agricultural markets is newly centre-stage on the political agenda and on the eve of a new CAP reform, a review of risk management tools is assuming greater relevance. The proposed regulations covering rural development for the period 2014-2020 confirm the possibility for Member States to co-finance premiums for insurance policies and to promote participation in mutual funds, with the added possibility of activating income stabilization tools to be pursued through the use of mutual funds.

In parallel with European payments, insurance offers a way to protect the farmer against large yield variations. The contracts basically offer coverage if the yield falls below a threshold defined in the contract. Crop insurance is likely to have been providing significant income stabilization over the years (Bielza *et al.*, 2009). However, it cannot be expected to provide effective protection against income fluctuations due to price instability. Income or revenue insurance offers a real opportunity to manage risk at the farm scale (Mahul, 2003; Mishra and Goodwin, 2003; Shnitckey *et al.*, 2003). Yet, such products are not well developed in Europe despite many efforts in this direction (Meuwissen *et al.*, 2003).

Despite the importance of crop insurance capacity and European payments to reduce income volatility, few studies have been carried out on this topic until now (Vedenov and Power, 2008). Both mechanisms provide a sort of certainty for farmers which should encourage them to continue their activity. The aim of this paper is therefore to measure the extent to which crop insurance and CAP payments significantly reduce volatility in farmers' crop revenues. Moreover, our analysis also considers other risk management tools that can contribute to facing up the challenge of income volatility, while allowing for the definition of a methodology of risk-management tools in agriculture according to their effect on income return and volatility and the timing of their use.

To address this research topic, we focused our analysis on crop income instead of farm revenue for one main reason. Since both crop insurance schemes and European payments are based on farmers' past physical production, we argued that analysing the overall farm revenue could mislead the explanation of the empirical results. This point is one of the most salient specificities of our paper as all articles cited above refer to overall farm income. Examining crop income allows us to precisely study a level of revenue that is independent from European payments or insurance indemnities. It corresponds to the income exclusively linked to production. In doing so, we do not underestimate that in many cases there is a range of different revenue-generating activities on the farms in question, (e.g. work outside the farm), which, among other things, negatively affect the farmers crop insurance demand (Jetté-Nantel *et al.*, 2010; Mishra and Goodwin, 1997; Poon and Weersink, 2011).

Our empirical model for farmers is located in France and in Italy. These two European countries present similarities and specificities that make the comparison relevant. Firstly, France and Italy benefit from the same system of European payments, which are decoupled and depend on the area under cultivation and the type of production. Secondly, both in France and in Italy, the insurance system has essentially been private since 2005 while it used to take the form of a public fund in the years prior to that. Starting from this institutional framework, Italian and French farms present different structures both in terms of their cultivated area, being smaller for the Italian ones, and in terms of production, because Italian farms are more intensive than their French counterparts. In other words, these two countries are somewhat comparable but have specificities: that is the reason why we have to perform separate analyses for each of them.

We use survey data drawn up from the Farm Accountancy Data Network (FADN), selecting only farmers that had continuously belonged to the sample from 2003 to 2007. The sample included 2,998 farmers for France and 6,557 for Italy, representing a total of 47,775 observations. To our knowledge, this is the first empirical analysis in this strand of literature in Europe that makes use of such a large data set. To carry out our analysis, we used three econometric models specifically aimed at capturing farmers' income returns for both countries, using 1) balanced panel data, 2) increases or decreases in crop income using a logistic model, and 3) overall volatility in farmers' crop revenue by using Ordinary Least Squares (OLS).

The structure of the paper is as follows. The next section provides a debate of the typologies of the tools that are mainly used by farmers to manage their volatility. Section 3 introduces the empirical analysis, providing full details on the sample characteristics in terms of the variables used together with the descriptive statistics and the econometric models that we implemented. Section 4 presents the results and section 5 offers some concluding remarks.

2. A typology of risk management tools employed in agriculture

Over the years, many tools have been used for the management of risks in agriculture: starting from a diversification of activities to the development of financial tools. The aim of this section is to propose a typology that takes two dimensions into account: the use of risk management tools on returns and volatility in farmers' incomes as well as the timing of their use. This typology provides a framework for the choice of factors affecting returns and volatility. More precisely, we specifically consider crop income, that is to say the income only resulting from production and therefore independent of any receipt of European payments and insurance claims. This is a key point since it puts the role of European payments and decisions regarding insurance on the resulting production into perspective. Crop income is suited because we can measure the direct impact of factors affecting its level and its volatility.

2.1. Returns and volatility effects of risk management tools

Following the usual distinction in finance theory, a farmer's yield is a random variable that can be described according to its return and its volatility. In fact, risk management aims both at securing and stabilizing the expected return. As a result, we shall separate tools that play a direct influence on yield levels from those which are aimed at reducing its volatility.

As indicated in the introduction to this section, a well-known way to reduce volatility is to diversify activities. To do so, the farmer can use a three-stage plan (Wu, 1999), firstly choosing the repartition of his working time between the farm and external activities (Jetté-Nantel *et al.*, 2010; Mishra and Goodwin, 1997; Poon and Weersink, 2011). Secondly, within the farm, he chooses his specialization: for instance breeding animals, crops or a mix. Thirdly, and finally, within the cropping, he defines his crop planning, i.e. the number and variety of the crops, taking into account his capacity to irrigate some of them. In this way, the farmer has diversified before the season begins, reducing volatility in yields.

In addition, the farmer can complement the management of revenue volatility using insurance policies, the aim of which is to compensate physical losses due to natural disasters. In essence, the insurance policy compensates crop yield deficits by providing the payment of an indemnity over a certain threshold of losses. Multi-peril crop insurance is now available in many developed countries, including France and Italy (Enjolras *et al.*, 2012). Alternatively, crop-revenue insurance protects from deviations in the farmer's revenue. This type of contract is well developed in the United States whereas it is not as widespread in Europe (Bielza *et al.*, 2009).

Some financial policies also contribute to decreasing yield volatility. Futures contracts allow the farmer to hedge price risk before the season (Mahul, 2003; Garcia and Leuthold, 2004). Recently, there has been a huge growth of trading volumes in securities based on agricultural commodities, with the number of futures and options increasing five-fold between 2000 and 2010 (Piot-Lepetit and M'Barek, 2011).

Some alternatives to financial markets exist that can help reduce volatility. Membership in a group of farms (a legal form) provides better market power for purchasing and selling commodities (Kyriakopoulos, 1997). Forward contracting guarantees the farmer to sell his crops at a price that is less dependent on market fluctuations (Velandia *et al.*, 2009). Finally, the farmer can use inputs such as pesticides to protect his yields against diseases and external attacks.

European payments are a way to substantially increase farm returns, providing a sort of certainty equivalent. Most of them are decoupled from production and linked to crop rotation and cropping area. As a result, they represent a guarantee in all circumstances. The farmer can also increase his return using inputs such as fertilizers that stimulate the development of the plants.

2.2. The timing of risk management tools

The timing of the use of each kind of tool is essential as it determines the strategy used by each farmer at the start of the season and the monitoring of this strategy during the course of the farming year. Firstly, the farmer determines the basic structure of the production he will put into effect. Simultaneously, he chooses how or whether to insure his future production (Wu, 1999). He can also anticipate the amount of EU payments he will receive. A part of the structure of the farm is predetermined when one takes into account the situation over previous seasons such as past investments and past payments.

During the season, the farmer is constrained by most of his initial choices but he can adapt his strategy, taking into account external factors such as the climate or commodity markets (Serra *et al.*, 2005). Weather influences the use of inputs including pesticides which maintain yields in the face of pests and diseases while fertilizers contribute to increasing crop yields (Babcock and Blackmer, 1994; Hall and Norgaard, 1974). The farmer can also decide to spread the sales of its production according to the prices on the markets (Velandia *et al.*, 2009). This adaptive management contributes to providing the farmer with some flexibility. An insured farmer also receives indemnities if his production is severely compromised.

As a result, the farmer takes decisions sequentially, at a specific moment. Therefore, most of the choices are not simultaneous. This has many implications, especially in terms of econometric modeling. For instance, the use of si-

Table 1 - *Typology of risk management tools in agriculture.*

		Timing	
		Strategy ***(Before the season)***	**Monitoring** ***(During the season)***
Direct influence on	**Return** ***(Security)***	EU payments	Fertilizers Insurance profitability
	Volatility ***(Stabilization)***	Specialization of activities (ETO) Crop diversification Irrigation Crop insurance Financial policies Forward contracting Legal form	Pesticides Spread selling

multaneous equations is inappropriate and endogeneity can be corrected using the timing of the risk management decisions.

Table 1 shows the typology of risk management tools considering only the direct effects of the strategy and monitoring of the farmer's yields. It provides a dynamic overview of the farmer's capacities to manage his risk. Indirect effects, such as an additional wealth resulting from insurance claims, are random. As a result, they can only be taken into account at the end of the season.

3. Empirical framework

3.1. The data

Within Europe, France and Italy are two major agricultural countries. Both have benefited from the CAP and have also encouraged the development of crop insurance, beginning with (public) solidarity funds, the systems later being changed to private and subsidized insurance for most crops. As a result, French and Italian farms are fairly equal with regard to their institutional frameworks. In this context, a direct comparison of the behaviours might be possible, taking into account the structures and productions of the respective farms.

We use a survey of farmers in France and Italy belonging to the Farm Accountancy Data Network (FADN-RICA). This sample offers a reliable way to access the structural and financial characteristics of professional farms, providing useful information on their balance sheets. It is then possible to identify strategies farmers use to cope with risk (Phimister *et al.*, 2004).

Within the original databases, we selected only farms that had continuously belonged to the sample between 2003 and 2007. Our sample finally included 9,555 farms for each year, of which 2,998 are French and 6,557 Italian, providing a total of 47,775 sets of farm data over the 5-year period in question.

3.2. The variables

In the following subsections, we present the main variables that enter into the analysis. The details are given in Table 2. We focus specifically on the ways to measure volatility and on the tools used to hedge that volatility.

3.2.1. Measure of farm income volatility

As stated before, the reference used for the computations is that of income from crop production (y_i) as it provides the return specifically linked to this activity whilst avoiding considering diversification resulting from activities outside the farm.

Following the literature and public reports (Cordier *et al.*, 2008; Dunn *et al.*, 2000; OECD, 2000), we can consider two measures for volatility:

1. The growth rate (Δ_y) between each year, with $\Delta_y = (y_N - y_{N-1})/y_{N-1}$
2. The standard deviation (σ_y) over the period 2003-2007.

3.2.2. Risk management tools

Our models include many risk management tools used by French and Italian farmers. The farmer first makes some structural choices and can choose the rotation. In doing so, he diversifies his activities and reduces variance in his income (Purdy *et al.*, 1997). As far as his crop selection is concerned, he can plan the irrigation of part of his land in order to protect his crops in the case of drought (Dalton *et al.*, 2004).

Farmers can also take into consideration the sum of the European payments they receive, the amount corresponding to a direct wealth effect (Hennessy, 1998; Sckokai and Moro, 2006). The effect of these payments may be ambivalent. On the one hand, the farmer can use them to invest and increase his productive capacity. Thus, he might increase his income and the risk he takes. On the other hand, the farmer can use this additional money as a substitute for his activity. In that case, crop income and risk may decrease.

Insurance is another key indicator. We take into account the farmer's decision to insure or not, i.e. to take out policies sold by private insurance companies. Insurance decisions may prove costly, depending on the size of any premiums (Enjolras and Sentis, 2011). In addition to this crite-

Table 2 - *List of variables and summary statistics.*

			France		Italy	
		Classes	N	%	N	%
ETO	Economic and Technical Orientation 1 = Field-scale crops, 2 = Wine-growing, 3 = Market gardening, 4 = Herbivorous, 5 = Other	1	3,982	33.2%	6,387	24.4%
		2	798	6.7%	2,466	9.4%
		3	163	1.4%	1,998	7.6%
		4	3,682	30.7%	5,759	22.0%
		5	3,364	28.1%	9,576	36.6%
LFA	Less Favoured Area = 1 if farm is located in a less-favoured area, 0 otherwise	1	4,748	39.6%	10,156	38.8%
		0	7,241	60.4%	16,030	61.2%
Education	Education of the farm manager (3 categories: higher, secondary and other)	1	3,976	33.2%	8,828	33.7%
		2	6,351	53.0%	13,758	52.5%
		3	1,662	13.9%	3,600	13.7%
Legal form	Legal Form = 1 if farm is an individual farm, 0 otherwise	1	5,697	47.5%	12,374	47.3%
		0	6,292	52.5%	13,812	52.7%
Insured	Insured during the year (yes / no)	1	5,950	49.6%	3,247	12.4%
		0	6,039	50.4%	22,939	87.6%
Growth rate (dichotomous)	Δ =1 if growth rate of crop income is positive, 0 otherwise	1	6,467	53.9%	13,470	51.4%
		0	5,522	46.1%	12,716	48.6%

Table 2 - *List of variables and summary statistics (continued).*

			France		Italy	
Number of observations per year			2 998		6 557	
Number of observations (total)			11989		26 186	
Dependent variables			**France**		**Italy**	
		Unit	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Crop income	Level of crop income	€/ha	1,498.06	5,533.83	3,540.60	12,474.84
Δ of Crop income	Growth rate of crop income	%	53.75	5 288.68	10.74	91.47
σ of Crop income	Standard deviation of crop income		20,390.03	30,485.78	7,399.51	37,774.99
Explanatory variables			**France**		**Italy**	
		Unit	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
EU payments	European payments	€/ha	292.54	416.64	411.99	979.02
Δ of EU payments	Growth rate of EU payments	%	20.30	171.71	20.29	387.49
σ of EU payments	Standard deviation of EU payments		74.07	380.96	192.33	784.60
Insurance profitability	Total claims - Total premiums	€/ha	-1.55	132.51	-25.37	256.52
Δ of Insurance profitability	Growth rate of insurance profitability	%	-11.38	4,726.61	-183.87	10,881.24
σ of Insurance profitability	Standard deviation of insurance profitability		33.66	123.54	19.93	149.36
Pesticides	Total pesticide costs	€/ha	147.00	250.02	251.45	725.45
Fertilisers	Total fertiliser costs	€/ha	136.37	313.81	285.75	1,237.64
Inputs	Total input costs	€/ha	283.37	464.20	537.20	1 778.45
Crop diversification	Number of cultivated crops	Nb/ha	0.11	0.13	0.51	1.03
Total area	Total area of the farm	ha	111.06	77.90	36.72	79.84
Turnover	Annual turnover of the farm	€	225 264.00	168,467.00	138,215.00	425,963.80
Financial leverage	Indebtedness of the farm		0.54	7.11	0.61	3.98
Average temperature	Average temperature observed over one year	°C	11.98	1.43	14.86	1.78
Temperature deviation	Deviation between the average temperature observed over one year and its average (absolute value)	°C	0.52	0.18	0.62	0.20
Aggregate precipitations	Aggregate volume of precipitations over one year	mm	724.20	189.79	684.12	390.66
Precipitations deviation	Deviation between the precipitations observed over one year and their average (absolute value)	mm	9.09	3.88	10.32	3.88
Age	Age of the farm manager	year	47.58	8.36	54.70	13.72

rion, we measure insurance profitability, this being the difference between claims and premiums. A positive sum should be correlated to lower volatility (Coble and Knight, 2002).

The farmer can also use inputs, such as pesticides and fertilizers for the protection and/or growth of his crops (Horowitz and Lichtenberg, 1994). Pesticides should reduce income volatility while fertilizers should increase the returns.

The FADN-RICA database does not provide access to some strategies used by farmers such as forward and future contracting or spread selling. This represents one of the limitations of the database.

3.2.3. Structural and financial characteristics of the farm

The size of the farm, either measured by its total area or the area under cultivation, plays a direct role in the determination of the return. One can also expect that larger farms are more able to diversify their crops than the smaller ones (Penrose, 1959).

Even if some farms cultivate many crops, most of them are specialized. We can therefore identify some differences between the various farm outputs while considering their Economic and Technical Orientation (ETO). We differentiate 5 main ETOs: field-scale crops, vineyards and wine production, market-gardening, herbivore breeding and other farm outputs so as to identify different behaviours among the sectors (Cordier *et al.*, 2008).

Farms can join together to form a group to be able to make economies of scale and increase their bargaining power (Marcus and Frederick, 1994). This strategy should lead to better returns and lower volatility.

Finally, we examine an essential parameter of the farm's financial situation, its level of debt measured by the financial leverage or debt-to-assets ratio. Leveraged farms are exposed to a higher probability of default. As a result, they may adopt a more cautious strategy (Purdy *et al.*, 1997).

3.2.4. Control variables

Weather plays a direct role in crop income volatility (Chmielewski and Kohn, 1999). Annual temperature and precipitations are measured for each year and analysed at a locality level. We then take into account the original values observed each year and their absolute deviations from the mean to measure their impact on returns and volatility.

Some farms are located in less-favoured areas, corresponding to high altitudes, steep terrain or economically-depressed regions. As a result of these constraints, their returns are likely to be lower and their volatility higher.

We have chosen to introduce a dummy for each year. These indicators should reveal a systematic component of yield variation among farmers. Finally, we take into account the farmer's age. We use two measures: age and age-squared so as to control for an experience effect of the farmer.

3.2.5. Standardization of data

As the size of the farm may influence the level of return and volatility (σ or Δ), it would appear necessary to control its influence on the other variables, most of those employed in the models being standardized, by dividing them by the total farm area.

Not all of the variables identified above could be considered in the models because of endogeneity. We can identify a strategic behaviour when considering irrigated area, specialization, crop diversification and insurance which are chosen simultaneously by the farmer to reduce risk before the growing season begins. This behaviour has an impact both on these variables and crop incomes, the latter being our dependent variable. Because of the interaction between exogenous variables, we decided to consider only the variable related to insurance as it is chosen at the beginning of the season while crop income is observed at the end.

3.3. The models

Using our dataset, we develop three kinds of model that aim to measure the influence of farm structure on crop income returns, on its volatility and the growth of farm returns over the period. All analyses have been performed for the two countries, France and Italy, to highlight their specificities.

We group our main variables into items regarding their influence on crop return: (1) risk management tools (EU payments and insurance), (2) structural and financial characteristics of the farm, and (3) control variables. The measure of the variables considered for each of these items may differ between models (original values, growth rate or standard deviation). This point will be discussed while presenting the models and the dependent variables.

3.3.1. Relationship between income returns and risk management tools

To measure the impact of management factors on crop income returns, we have considered the whole period, from 2003 to 2007. More precisely, we performed a panel analysis with random effect, on balanced panel data, to consider both the individual and the temporal effect. In fact, because our sample is not exhaustive, we chose to perform a random effect model (Nerlove, 2003;Trognon, 2003). Moreover, the size of the sample and the existence of a location effect confirm this choice. We carried out heteroscedasticity and autocorrelation tests (Wooldridge, 2002).

As the model explains the level of crop income per hectare[1], some exogenous variables are considered in their raw form, i.e. without undergoing any transformation. The model considered is the following:

$$(1) \quad y_{it} = \alpha + \beta' R_{it} + \gamma' S_{it} + \delta' C_{it} + \varepsilon_{it}$$

Where: y_{it} is crop income per hectare, α is the constant, R_{it} is the matrix of risk management tools, S_{it} is the matrix of structural and financial characteristics of the farm, C_{it} are control variables and ε_{it} are error terms.

3.3.2. Relationship between income variability and risk management tools

The second model is a discrete regression model. The aim is to understand factors that lead to a positive growth rate of crop income. We distinguish positive and negative growth rates that are calculated as the variability of crop income observed for each farm between 2 years (Δ). Because of the dichotomous format of the dependent variable, we performed a logit model. The reason is the closer approximation between the logistic distribution and the standard normal distribution (Amemiya, 1981; Maddala, 1989).

The latent variable Δy_i is continuous. The estimated model measuring the impact of factors that bring about an increase in income between 2004 and 2007 is the following:

$$(2) \quad \Delta y_i = \alpha + \beta' \Delta R_i + \gamma' S_i + \delta' C_i + \varepsilon_i$$

Where: Δy_i denotes a growth in crop income per hectare, α is the constant, ΔR_i is the matrix of the variability of risk management tools, S_i is the matrix of structural and financial characteristics of the farm, C_i are control variables and ε_i are error terms.

3.3.3. Relationship between income volatility and risk management tools

The third model considers the volatility of crop income. Variables identified for item 1 and item 2 are now considered in terms of volatility over the period 2003-2007 (σ). More precisely, we defined the logarithm of this volatility for the dependent variable. In fact, we observed that the variance of the income increases with the income. The log-transformation is then used to stabilize the variance (Heij *et al.*, 2004).

$$(3) \quad \mathrm{Log}(\sigma_{yi}) = \alpha + \beta' \sigma_{Ri} + \gamma' S_i + \delta' C_i + \varepsilon_i$$

Where σ_{yi} denotes the volatility of crop income per hectare, α is the constant, σ_{Ri} is the matrix of the volatility of risk management tools, S_i is the matrix of structural and financial characteristics of the farm, C_i are control variables and ε_i are error terms.

4. The results

In this section, we interpret the results of the models detailed above for French and Italian farms.

4.1. Summary statistics

Summary statistics are given in Table 2. Farms present rather different characteristics depending on their country. In Italy, their size is smaller than in France both in terms of total area and turnover[2]. They make more use of risk management tools (crop diversification, EU payments, pesticides and fertilizers). This leads to a larger crop income compared to France, which is also less volatile over the period 2003-2007. It may signify that risk management is successful in Italy.

Conversely, French farms are larger but they benefit from a less favourable crop income per hectare, probably as a result of a decreasing marginal productivity. In line with a lower use of management tools, they exhibit a higher volatility in their returns. This having been said, they have benefitted from a significant growth rate in income. Thus, taking risk appears to be a winning strategy over the period.

One should also note that indebtedness is similar between the two countries while insurance is not profitable, especially for Italian farms.

[1] 1 hectare (denoted ha) is equal to 2.47 acres.

[2] Farms are considered as professional if their gross standard margin is higher than €4,800 in Italy and €9,600 in France.

Table 3 - *Panel data regressions explaining crop income return.*

	France	Italy
European payments	-1.066***	0.339***
Insured	56.320	146.364
Insurance profitability	0.557***	0.044
Fertilisers	3.037***	0.799***
Pesticides	7.791***	1.307***
Total area	-23.195***	-12.967***
Total area²	0.044***	0.010***
Financial leverage	-2.554	-54.381
Legal form	-232.968	-533.330*
Age	-34.546	36.600
Age²	0.499	-0.428*
Education	218.404*	166.982
Temperature	-280.004***	1.954
Temperature deviation	15.863	-2,234.240 ***
Precipitations	-0.122	-0.121
Precipitations deviation	9.851	207.698***
Wine-growing	1,618.799***	102.811
Market gardening	-1,146.932**	7,390.410***
Herbivorous	-251.714	-65.354
Other ETO	231.727	90.396
Less-favoured areas	-143.303	-1,476.297***
2004	190.840**	274.001***
2005	-121.531*	101.780
2006	286.269***	392.533***
Intercept	5,424.537***	1,504.996
R^2 overall	0.535	0.303
Number of cases	11,989	26,186

Legend: * p<0.05, ** p<0.01, *** p<0.001
Source: own elaboration, FADN 2003-2007.

4.2. Relationship between income return and risk management tools

The panel-data analysis explains the level of crop income per hectare through the main factors we identified in the previous section. The results are summarized in Table 3.

We observed that EU payments benefit Italian farms as they are considered as an additional income, whereas French farmers seem to substitute subsidies with production.

The same relationship exists with insurance, leading to a higher crop income per hectare in Italy. This could be explained by a strategic behaviour aimed at securing production. However, insurance profitability (i.e. the difference between claims and premiums) only has a significant and positive impact on crop income for French producers.

As far as inputs are concerned, the model highlights a positive impact on crop income for both France and Italy. In theory fertilizers should increase crop income while pesticides should reduce its volatility. Results show that both fertilizers and pesticides lead to increased crop income.

A farm's structure plays a role in the level of crop income in both countries. Total area and crop income are negatively linked but there is a threshold above which the effect is the opposite. This refers to decreasing returns.

Climatic constraints do not seem to affect Italian crop incomes while French farms appear to be more sensitive in terms both of precipitation and temperature changes in which a higher temperature leads to a lower crop income per hectare.

Beyond these effects, the model highlights specific features of some types of farming. In France, wine-growing is associated with a higher crop income while the contrary is the case for market garden production[3], while in Italy, the results show that market garden production is associated with a higher level of crop income.

The final difference between French and Italian farms is that of the time effect. In Italy, it would appear that farmers maintain the same crop income per hectare over the years, while the factor seems to be more volatile in France.

4.3. Relationship between income variability and risk management tools

While the previous model explains the level of crop income per hectare, this second one attempts to identify and evaluate

Table 4 - *Logistic regressions explaining a positive growth rate in crop income.*

	France	Italy
European payments	0.001	- 0.001
Δ of European payments	- 0.006	0.001*
Insured	0.327 ***	- 0.072
Δ of Insurance profitability	- 0.001	- 0.001
Fertilisers	0.001	0.001
Pesticides	- 0.001	- 0.001
Crop diversification	0.005	- 0.037
Total area	0.006 ***	- 0.001 **
Total area²	- 0.001 ***	0.001
Turnover	0.001	0.001 **
Financial leverage	- 0.004	- 0.020
Legal form	0.113	0.011
Age	0.047	- 0.007
Age²	- 0.001	0.001
Education	- 0.035	0.020
Temperature	- 0.042	0.022
Temperature deviation	1.177 ***	- 0.134
Precipitations	0.001	0.001
Precipitations deviation	- 0.012	- 0.010
Wine-growing	- 0.128	0.026
Market gardening	- 0.758 *	- 0.184
Herbivorous	- 0.779 ***	- 0.248
Other ETO	0.050	- 0.243 *
Less-favoured area	- 0.417 ***	- 0.119
2004	1.245 ***	- 0.553 ***
2005	- 1.017 ***	0.302
2006	0.002	0.952 ***
Intercept	- 1.265	0.287
Correctly classified	0.691	0.620
Number of cases	6 776	2 296

Legend: * p<0.05, ** p<0.01, *** p<0.001
Source: own elaboration, FADN 2003-2007.

[3] Site of the French Agricultural Ministry: http://agreste.agriculture.gouv.fr/definitions/otex-mbs/

factors leading to a positive growth rate for crop income. The growth rate (Δ) is computed for each farm and between each period. We then classify the farms according to its sign. The results are summarized in Table 4.

The results show that the turnover has a positive effect on the probability of having a positive growth rate of crop income for Italian farmers while it has no effect for their French counterparts. In Italy, we observe that an increase in the growth rate for EU payments per hectare has a positive effect on the probability considered; it seems to go hand in hand with the results observed in the first model that highlighted the positive relationship between the amount per hectare of EU payments and the level of crop income. EU payments again appear to stimulate crop production in Italy.

With regard to insurance, the first model indicates that insured French farmers did not benefit from a higher return. However, the second model proves they have a higher probability of increasing their crop income over time. The situation is the opposite in Italy where insured farmers benefit from a higher income but the growth in this income is as stable as that for non-insured farmers.

Use of inputs does not significantly influence the probability of increasing crop income, either for pesticides or fertilizers.

The model also emphasizes the sensitivity of French farmers to deviations in climate. There also exist some specificities with regard to the type of farm. For instance, market gardeners have a lower probability of obtaining a positive growth rate in crop income if they are operating in France.

Being located in a less-favoured area leads to a lower probability of income growth in France whereas it does not negatively affect crop income whereas in Italy, such a location does not seem to play a role either in the level of crop income or on the probability of obtaining higher growth.

4.4. Relationship between income volatility and risk management tools

The third model brings a viewpoint that is complementary to the first two, focusing on the volatility of crop income, explained as the standard deviation of its return (σ) over the period 2003-2007. The results are summarized in Table 5.

Table 5 - *Linear regressions explaining the volatility of crop income.*

	France	Italy
European payments	-0.001	0.001**
σ of European payments	0.001**	0.001***
European payments * LFA	0.001***	0.001
Insured	0.096***	0.318***
σ of Insurance profitability	0.001**	0.001*
Fertilisers	0.001**	0.001*
Pesticides	0.001***	0.001*
Total area	0.006***	0.012***
Total area^2	-0.001***	-0.001***
Turnover	0.001***	0.001***
Financial leverage	-0.001	-0.006
Legal form	-0.087***	-0.161***
Age	-0.010	-0.002
Age^2	0.001	-0.001
Education	0.002	0.026*
Temperature	0.055***	0.022**
Temperature deviation	0.134**	-0.940***
Precipitations	-0.001**	0.001***
Precipitations deviation	-0.001	0.051***
Wine-growing	-1.550***	-0.030
Market gardening	0.790***	0.045
Herbivorous	-1.207***	0.221***
Other ETO	-0.539***	0.017
Less-favoured area (LFA)	-0.244***	-0.956***
2004	-0.106***	0.010
2005	-0.003	-0.006
2006	-0.082***	0.033
Intercept	8.479***	6.559***
R^2	0.602	0.219
Number of cases	2998	6557

Legend: * p<0.05, ** p<0.01, *** p<0.001
Source: own elaboration, FADN 2003-2007.

The results demonstrate similarities between France and Italy. More volatile EU payments lead to increased crop income volatility. This emphasizes the close link between changes in EU support and the risk associated to the farmer's income.

Being insured increases the volatility of crop income in both countries, suggesting a moral hazard effect. We also note that the volatility of insurance profitability has a positive effect on French crop income volatility while the opposite effect is observed in Italy. This means that insurance is not a stabilizing tool in France while it reduces income risk in Italy.

Considering inputs, we observe that both pesticides and fertilizers contribute to increasing crop income volatility over the period. This reinforces the results of the first model, inputs being used to boost the production rather than to reduce risk.

Some structural aspects are common to French and Italian farms; belonging to a group of farms (a legal form) permits a reduction in the volatility of crop income. Farm size plays an ambivalent role: for small farms, the larger the size, the higher the volatility while for larger farms, the greater their size, the lower the level of volatility we encountered. Volatility in crop income also depends on location. Both in France and in Italy, farms located in less-favoured areas have less volatile returns than those elsewhere.

Weather conditions are a natural source of crop income volatility. In both France and Italy higher temperatures lead to higher volatility. In France, we also noted that higher rainfall leads to lower volatility while the opposite effect was noted in Italy.

Finally, we observed a time effect in France. The type of production also leads to variable effects that depend upon the farm ETO. Wine growing is less volatile than either market gardening or field-scale crops in France. We do not find such effects in Italy.

5. Conclusion

Despite the relevance and topicality of agricultural income volatility in the European Union, a few studies have been drawn to measure the consequences of the use of risk management tools until now. This paper is also intended to understand which factors might explain crop income volatility and its variation. More specifically, the principal aim of this paper was to measure the extent to which direct payments and crop insurance could significantly reduce crop income volatility in two major countries of the EU, France and Italy.

To address these research topics, we set up a typology of risk management tools taking into account their objective in terms of return and volatility and the dynamics of these tools. We then used an original dataset drawn up from the Farm Accountancy Data Network (FADN) for farmers in France and Italy from 2003 to 2007, representing 47,775 observations. To carry out our analysis, we estimated several econometric models in order to assess the main dimensions and the dynamics of crop income volatility.

Our analysis clearly questions the efficiency of structural policies aimed at securing and stabilizing farmers' incomes. Despite similar institutional systems, the results between the two countries are contrasting. This reflects differences in exposure to volatility and risk management practices. Italian farms are smaller than the French ones and therefore more exposed to changes in their income. As a result, they use a larger range of tools to increase their income (EU payments, crop insurance) and reduce its volatility (crop insurance, inputs). Despite some differences depending on the specialization of the farms in question, it appears that these tools manage to stabilize crop income over the years.

French farms exhibit a different behaviour. As the mean size of their farms is larger than their Italian counterparts', they are able to substitute EU payments with production. However, this decision is counterbalanced by farmers, who, at the same time, use other risk management instruments such as inputs (fertilizers and pesticides) and take out crop insurance. This combination of tools appears beneficial for the farmer as it eventually results in increased income. Yet this strategy tends to enhance risk: income volatility is much higher for French farms than for the Italian ones.

Variables related to the farm manager (age, education) and to the financial situation of the farm (leverage) are not significant, revealing that volatility mainly depends on the production conditions found on the farm. In addition to EU payments and insurance, climate and specialization play a significant role in crop income volatility. For instance, wine growing incurs less volatility than other crops in France.

These contrasted results reveal that risk management tools can clearly be counterproductive. EU payments, insurance or input use may, in certain circumstances, be risk-enhancing tools. In terms of public policies, there is a powerful need to target each instrument to the location of the farm in question and to its production in order to verify its appropriate use. This question is even more problematic when one considers the CAP reform which plans to promote a global stabilization tool at the farm scale (Meuwissen*et al.*, 2011).

Therefore, it would be of interest to confirm the validity of our results over a longer timescale. Taking into account annual data also restricts the scope of the analysis to the balance sheet of the farm. An access to additional variables such as the details covering production (prices and quantities) might offer a more precise analysis of crop income volatility. An alternative would be to develop models designed for each farm ETO. Further research should address these issues in the light of the current CAP reform.

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