ADOPTION OF RISK MANAGEMENT STRATEGIES IN EUROPEAN AGRICULTURE

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16 December 2016

Public

D5.2A

SEVENTH FRAMEWORK PROGRAMME

agriXchange is funded by the European Commission's 7th

ABOUT THE FLINT PROJECT

FLINT will provide an updated data-infrastructure needed by the agro-food sector and policy makers to provide up to date information on farm level indicators on sustainability and other new relevant issues. Better decision making will be facilitated by taking into account the sustainability performance of farms on a wide range of relevant topics, such as (1) market stabilization; (2) income support; (3) environmental sustainability; (4) climate change adaptation and mitigation; (5) innovation; and (6) resource efficiency. The approach will explicitly consider the heterogeneity of the farming sector in the EU and its member states. Together with the farming and agro-food sector the feasibility of these indicators will be determined.

FLINT will take into account the increasing needs for sustainability information by national and international retail and agro-food sectors. The FLINT approach is supported by the Sustainable Agriculture Initiative Platform and the Sustainability Consortium in which the agro-food sector actively participates. FLINT will establish a pilot network of approximately 1000 farms (representative of farm diversity at EU level, including the different administrative environments in the different MS) that is well suited for the gathering of these data.

The lessons learned and recommendations from the empirical research conducted in 9 purposefully chosen MS will be used for estimating and discussing effects in all 28 MS. This will be very useful if the European Commission should decide to upgrade the pilot network to an operational EU-wide system.

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LIST OF ACRONYMS

CAP	Common Agricultural Policy
EU	European Union
ESU	European Size Unit
FADN	Farm Accountancy Data Network
FLINT	Farm Level Indicators for New Topics
RMT	Risk Management Tool

EXECUTIVE SUMMARY

Current European Union's (EU) agricultural statistics, through the Farm Accountancy Data Network (FADN), capture limited indicators to access farmers' risk management strategies adopted. Complementing one year of FADN data with data collected in the FLINT (Farm Level Indicators for New Topics in Policy Evaluation) project have made it feasible to assess the adoption of different risk management strategies and the determinants of farmers' choice for complementary or substitute instruments in the EU. Adoption rates of risk management instruments such as insurance contracts, price contracts, off-farm income, other risk reduction measures and other gainful activities vary significantly across EU Member States and farming types. Econometric analysis indicates that larger farms adopted more often crop insurance, occupational accident insurance, price contracts and diversification but were less likely to adopt credit avoidance and off-farm employment (at a significance level of 1%).

Given the increased attention to risk management in the Common Agricultural Policy (CAP), it is important to monitor and evaluate the adoption rates and their determinants over time. For policy analyses these indicators are a step forward for the determination of the net impacts and establishment of counterfactuals on the long run with FADN (i.e., time series encompassing adverse years) for measuring the impact of the CAP at farm level.

1 INTRODUCTION

Farming is a heterogeneous sector in a complex and multi-faceted environment facing a variety of risk sources beyond the control of farmers (McElwee and Bosworth, 2010). In recent years, farm income has been subject to a wide range of environmental, technological and economic perturbations, as well as structural changes in policy and institutions. These multifaceted dynamics and conflicting demands generate unexpected outcomes with volatile income streams for the whole agricultural value chain (Darnhofer et al., 2016). Within this context, farmers need to apply risk management strategies to balance their income and risks and to achieve income stability.

The reduction of income risks through years will affect farmers' well-being, competitiveness and ability to expand their operations through innovation and the appropriate investment decisions (European Parliament, 2014). Risk management at farm level is crucial in coping with income volatility and prevent bankruptcy. A major task for farmers is thus to use proper strategies and instruments to manage their risk exposure (Hardaker et al., 2004). Farmers can for example follow risk-sharing strategies (marketing contracts, production contracts, hedging on future markets, participation in mutual funds and insurance) or on-farm measures (selection of products, diversification, off-farm activities, vertical integration, self-insurance, farm financial management and savings/credit) (Meuwissen et al., 1999).

There has been extensive theoretical and empirical research attempting to understand the issue of risk and to develop instruments to support farmers (see for example OECD, 2009; Kimura et al., 2010). Nowadays, at the European level, there is an increasing discussion about risk management tools and policies. More specifically, agricultural insurance is one of the tools, which has been included in the risk management toolkit of the recently reformed Common Agricultural Policy (CAP) (European Commission, 2013). It has a long history and plays a significant role in the compensation of crop damages (hail, drought), livestock diseases outbreaks, farm assets and disability of farmers (Hardaker et al., 2004). Insurance tools have been developed to mitigate the risks associated mainly with adverse natural events, such as weather risks and climatic impacts, sometimes with the assistance of governments (Mahul and Stutley, 2010). Therefore, insurance is an effective financial instrument that can help farmers to reduce income variability and stabilize it, to develop responsibility, to maintain their living standards and promote the economic development not only of their farm but also of the countryside (Burgaz, 2000).

In European agriculture, the available tools to manage agricultural risk through insurance are highly diverse and not common for all Member States. There are mainly single-risk insurances tools (such as hail insurance, frost) while some Member States also have multi-peril risk insurance schemes (e.g. France, Italy, Spain), securing against different kind of weather risks while yield and revenue insurances are far less developed (Bielza et al., 2008). In contrast, in other non-European countries more sophisticated tools are available (Mahul and Stutley, 2010). The spectrum of agricultural insurance ranges from Member States in which the public sector provides no support (private non-subsidized insurance schemes), Member States in which governments heavily subsidize agricultural insurance, up to Member States, like Greece and Cyprus, where the system is public and mandatory (Bielza et al., 2008). In practice, however, agricultural insurance has been a costly way of transferring the risk from farmers to governments and other insurers (Nelson and Loehman, 1987). In the European Union (EU), there is a discussion on the role of policy measures and the development of the corresponding market. Furthermore, farmers' preferences, the perception of risks, farm and farmer characteristics are factors that influence the demand for agricultural insurance.

On the other hand, one of the most common strategies that farmers follow to reduce income variability is to transfer risk along the food chain with the use of contracts, either marketing or production. A

marketing contract is an agreement between a farmer and a buyer to sell a commodity at a specified price before the commodity is ready to be marketed (Goodhue and Hoffmann, 2006). The risk shifting characteristics of the received contract depend mainly on its terms (e.g., variable benchmark price versus fixed price). The farmer keeps full responsibility for all production management decisions while he/she loses the opportunity of achieving a higher price on the open market. Regarding the effect of contracts on the risk of farmers, it may reduce price variability, but at the same time lower the average price farmers receive, and there is little information available about the risk transfer throughout the value chain (OECD, 2000). A large body of empirical literature highlights main determinants of choosing marketing channels like locational and geographical disparities, temporal specificities, and transaction costs in combination with farm and farmer characteristics.

Production contracts typically give the contractor control over the production process. This kind of contracts specifies the quality and the quantity of the product, the price to be paid to the farmer and the inputs to be used. For example, uptake of price contracts is a common practice applied on Dutch arable farms. Approximately 50% of the Dutch arable farmers have some kind of potato price contract of which the pool contracts and fixed price contracts are the most common ones (Van Asseldonk et al., 2016). Farmers shift the price risk to the processor but depend on only one buyer. In the USA, researchers have found that production contracts reduce income risk to a large extent, increase specialization on farms, help create lower costs and improve efficiency (Harwood et al., 1999). However, production contracts have been criticized because they limit farmers' entrepreneurial capacity, reduce farmers' autonomy, and may increase other types of risks such as quality, investment and contractual risks (OECD, 2000).

Furthermore, diversification is one of the basic approaches widely used in agriculture to deal with multiple sources of risk. Through diversification, farmers will use resources more efficiently and enhance sustainability. Certain characteristics are associated with diversification, for example young farmers with a university degree and large farms are more likely to follow diversification strategies. In the literature a great variety of diversification actions have been mentioned (Hardaker et al., 2004; Vik and EcElwee, 2011; Dries et al., 2012; Bowman and Zilberman, 2013; Ullah and Shivakoti, 2014; Barnes et al., 2015). Farmers use a form of agricultural diversification through various farm planning models to cope with risk at the farm level. Farmers' cropping choices, the degree of diversification, and allocation of resources amongst sectors will have direct impact on mitigating risks and supporting income stability. Moreover, structural diversification, which will include activities like direct sales, on-farm processing, agro-tourism and labelling of products (with added value) is a way to comply with various risks. Farmers also follow strategies to improve income diversification with the option of finding either off-farm employment or off-farm activities from non-agricultural sources (McNamara and Weiss, 2005). Finally, public payments for ecosystem services are crucial drivers that farmers use to reduce risk, for example payments for land management and preservation of biodiversity.

Today, European farmers may choose from a diversity of tools to ensure the sustainability of their farm. The objective of this paper is to examine the adoption rates and determinants of farmers' choice of risk management strategies. More specifically, we focus on five mainstream strategies, namely insurance contracts, price contracts, off-farm income, other risk reduction measures, and other gainful activities. Our analysis is conducted using farm level data for farms located in eight EU Member States. Before presenting results and conclusions, we first describe the methodology and data used in the next section. In concluding the paper, we also discuss methodological and data issues in studying the adoption of risk management strategies and their impacts.

2 METHODOLOGY, SAMPLING AND DATA

2.1 Econometric model

For farmers, adoption of a specific risk management tool is often a continuous choice decision (e.g., to adopt more or less on-farm diversification or rely more or less on off-farm income). Also the decision to insure or hedge follows a (binary) adoption decision and a (continuous) conditional decision about the amount (e.g. proportion of production insured or hedged). In the current approach, however, the adoption of a specific risk management tool is modelled as a discrete choice decision on whether or not to adopt a specific tool (and continues variables are recoded into binary values). Binary specifications are often used for the evaluation of actual or hypothetical decisions about insurance purchase with numerous explanatory variables (i.e. Ganderton et al., 2000; Sherrick et al., 2004).

Given the hierarchical classification of farms into farming types for all Member States in the EU, farm data are naturally nested in farming types and Member States. This hierarchical structure gives rise to multi-level mixed-effects modelling by incorporating random-effects at the level of Member States and at the level of farming types (Andrews et al., 2006). In this paper, three-level mixed-effects logistic models were used to determine which factors influence the choice to adopt insurance or other risk management strategies. The demand will likely differ substantially between the relevant farming types as a result of numerous distinct factors such as tilling season, susceptibility of crops and livestock, and possibilities to adopt preventive measures. Moreover, Member States differ in supply conditions (e.g., availability of premium subsidies, price contracts and disaster relief programmes) and differences in demand (e.g., cultural differences). Formally, the econometric model for the probability of adoption is described as follows:

$$Pr(y_{ijk} = 1|\boldsymbol{x}_{ijk}, w_j, z_{jk}) = H(\boldsymbol{x}_{ijk}\beta + w_j + z_{jk} + \varepsilon_{ijk}) \quad (1)$$

where $Pr(y_{ijk} = 1|\boldsymbol{x}_{ijk}, w_j, z_{jk})$ denotes the conditional probability of $y_{ijk} = 1$ given a set of variables $\boldsymbol{x}_{ijk}$, w_j and z_{jk}, y_{ijk} is a binary indicator of a specific risk management tool adoption decision on farm in 2015 (value 1 for adopters and 0 for non-adopters) taken by farmer i in farming system k in Member State j, $\boldsymbol{x}_{ijk}$ is a vector of explanatory variables related to demand factors. In equation (1), $\mathrm{H}(\cdot)$ is the logistic cumulative distribution function ($H(\theta) = \frac{\exp(\theta)}{1+\exp(\theta)}$), which maps the linear predictor to the probability of adoption ($y_{ijk} = 1$). In this model, the linear combination $\boldsymbol{x}_{ijk}\beta$ represents the fixed effects of the explanatory variables on the likelihood of adoption, with β being the parameters to be estimated. The terms w_j and z_{jk} represent random effects at the level of Member States and farming types, respectively. The last term, ε_{ijk}, represents the random error term at farm level. The model is estimated using the melogit procedure of Stata® (14.0).

The adoption of one strategy can affect (substitute or complement) the adoption of another strategy (e.g., impact and thus need for a price contract is less for a well-diversified farm in comparison to a mono-cropping farm). Therefore, regression models for each risk management strategy are estimated in which the explanatory variables comprise the simultaneously adoption decision of other risk

management strategies. Similar three-level logistic models are applied as presented in Equation 1 to estimate odd's ratios.

2.2 Data

Current EU agricultural statistics, through the Farm Accountancy Data Network (FADN), capture limited indicators to access farmers' risk management strategies adopted. Complementing one year of FADN data with data collected in the FLINT (Farm Level Indicators for New Topics in Policy Evaluation) project have made it feasible to assess the adoption of different risk management strategies and the determinants of farmers' choice for complementary or substitute instruments in the EU. In the FLINT selection plan the heterogeneity of the farming sector was explicitly considered. In designing the selection plan the same stratification was used as in FADN (EC, 2015) which is based on types of farming and economic size classes. The theory of stratified sampling shows that the optimal allocation of the sample size across strata depends on the number of units (farms) in the strata and the homogeneity of farms in a stratum (Cochran, 1977). The outcome of this step (the optimal sample design) was further restricted to fit the purpose of the project. Given the pilot nature of the FLINT project, the objective was not to be representative for the whole country, but to test the feasibility and added value of collecting this type of data. Firstly, at least 25 observations per farming type were required for meaningful statistical analysis. Secondly, at least two Member States were selected for each main farming type to enable cross-country comparison. Therefore, the sample was limited to the most important farm types in each Member State.

The FLINT data collection was organised in different ways in each of the participating countries (Vrolijk et al., 2016). There were differences in who collected the data (students, data collectors, bookkeepers) and how the data was collected (self-reported, face to face interview or use of external documents). This approach was in line with the regular FADN data collection, to fit the data collection as much as possible to the local circumstances and possibilities. Data collection processes and strategies were designed and data collectors were trained to ensure uniform data gathering with respect to the additional risk management indicators. Data collection was finalised in the spring of 2016 on the calendar year 2015. The risk management data (and other additional indicators collected in FLINT) were merged with the FADN database for the 2015 accountancy year (2014 in Germany). The analysis in this paper is based on data from 821 farmers collected in eight Member States.

2.3 Adoption variables

The adoption models focused on the actual participation decision. This information was elicited during the FLINT project. Three complementing or substitute mainstream categories of risk management strategies were identified, namely, insurances, contracts, and alternative methods (such as diversification and off-farm income).

Four sub-categories of insurance coverage were included: crop insurance, livestock insurance, property insurance and occupational accident insurance. Insured perils were elicited as well (multiple selections were allowed) for crop insurance and property insurance allowing to distinct hail, storm, excessive rainfall, drought, frost and other perils (e.g. fire). Moreover, a distinction was made between a coverage reimbursing only the direct losses of replacing the damaged goods or a coverage also reimbursing consequential losses due to lost business revenues.

The category of price contracts focussed on the most important formal contracts in terms of sales values of a farm. A maximum of four contracts for the main agricultural outputs were considered. Contracts only focused on the marketing of agricultural or horticultural outputs, consequently manure contracts

and energy supply contracts were excluded. Six characteristics per contract were derived: contracted output (i.e., 18 classes of crops or livestock); price type of contract (i.e., market price, pool price, minimum price or fixed price); contracted amount (i.e., fixed quantity or supply obligation); duration (one year or less versus multiple years); contracted turnover (i.e., <20%, [20%,50%), [50%,79%), [80%,99%), and 100%); and other contract characteristics (e.g., fixed or flexible delivery date, specified quality standards).

The alternative risk mitigation or adaptation strategies included a set of other measures that contribute to risk reduction and a set of other gainful activities. Measures that could contribute to risk reduction included diversification, off-farm employment, off-farm investment, avoiding use of credit, hedging (futures and options), and holding financial reserves. Multiple other gainful activities were included, ranging from farm tourism, processing of agricultural products, child / health care, nature management, production of renewable energy and contract work for others.

2.4 Explanatory variables

The demand for risk management strategies is often hypothesized to be influenced by numerous explanatory variables (see for example Goodwin, 1993). Expected utility maximization is the usual framework in which the determinants of demand are examined. In the multi-variate regression analysis explanatory variables available in the FADN are also included. These are variables describing farm structure, farm income and performance, farm financing and personal characteristics.

Farm structure is expected to influence the adoption of risk management instruments. Two main components with respect to farm structure, namely farm type and farm size were distinguished. Risks and the rationale of adopting specific risk management strategies differ for obvious reasons between agricultural produces (e.g. losses as a result of adverse weather affecting farms with field crops and the adoption of crop insurance). Therefore the major segmentation variable used in this research is type of farming. In this research, the general types of farming based on Eurostat's farm typology are applied (FADN code GENERAL). In total eight farming types are listed as dummy variables in the analysis, segmenting farms with mainly field crops, horticulture, wine, other permanent crops, milk, other grazing livestock, granivores or mixed (i.e., crops and livestock). It should be noted that the classification of farms according to type is based on the (relative) mix of their output. Furthermore, the absolute size of a possible loss is positively correlated with the total size of a farm. Economic size of farm is included as a linear variable and expressed in standard output units (FADN code SE005).

Two variables were included as indicators for farm income and performance, namely farm net income (FADN code SE420) and total subsidies received (FADN code SE605). Farm net income is the remuneration to the unpaid factors of farm production (i.e., work, land and capital) and a reward for taking risks. The need to adopt more risk management strategies may be less on farms with larger farm income because of opportunities for self-financing adverse losses. The reverse situation could be hypothesized for farmers with deprived income. The total amount of subsidies received on current operations included EU-financed and co-financed decoupled and coupled payments. In the EU, farm incomes are supported by mean of direct payments that represent around 30% of farm income (but differs between farming types). It has been claimed that such payments play an income stabilising role (Cafiero et al., 2007; OECD, 2009) and the somewhat scant empirical evidence available supports this hypothesis (Agrosynergie 2011; El Benni et al. 2012). The stabilising role of such payments results from the fact that direct payments are fixed, thereby inducing a decrease in the variability of income and creating what is called a “wealth effect”. This additional stream of income, therefore, enters into the set of farmers’ risk management strategies; particularly for decoupled programs that are more transfer efficient. For this reason, it is not easy to disentangle the risk management component from the support component of many measures (OECD, 2009).

Also the financial structure of the farm is often tested in explaining adoption of risk management strategies. Farmers with larger amounts of debt (total liabilities, FADN code SE485) would be expected to adopt more often risk management strategies. The reverse situation would be hypothesized for farmers with larger net worth (total assets, FADN code SE501). Ultimately, the capacity to bear the risk will affect the demand for risk management strategies. Therefore the holding's capacity for saving and self-financing in terms of receipts minus expenditure for the accounting year, not taking into account operations on capital and on debts and loans, could affect demand (cash flow, FADN code SE526). The previous described FADN indicators for financial structure are all included as explanatory variables.

Other explanatory variables included were age and training of the farmer. Both personal characteristics are often used in demand studies but the direction of the effect is difficult to predict and are often non-significant. From the FLINT data, the use of advisory services in terms of total number of times of personal contact with an advisor was included as an indicator for training.

3 RESULTS

3.1 Adoption of risk management strategies

3.1.1 Adoption of insurance

All farm types under study cultivated land and hence crop insurance adoption was estimated for all farms surveyed. Adoption of livestock insurance was analysed for the relevant farming types (i.e., grazing livestock, granivores, mixed livestock holdings, and mixed crops – livestock holdings). Although elicited separately, it is questionable whether respondents were aware of the distinction between direct and indirect coverages for crop and livestock insurance. Enumerators did not in all cases cross check policy documents (to confirm either direct, indirect or both). Therefore adoption rates were aggregated and adopters were those who have subscribed to at least one coverage. Adoption rates for building insurance and occupational accident insurance were aggregated for all farming types in the survey (Table 1).

Crop insurance adoption varies across Member States, which can be partially explained in the light of availability of public support. In Ireland, subsidised crop insurance is not available, which may have hampered demand for insurance. In Finland the existing Crop Damage Compensation (CDC) scheme was abolished in 2015 as a result of inherent deficiencies in the CDC system (Myyrä and Jauhiainen, 2012). Most other analysed Member States with higher adoption rates have opted for public support to promote demand with the exception of Germany. This could be the risk management toolkit under articles 37-39 (e.g., The Netherlands). Also, other Member States have chosen not to make use of the toolkit despite the possibility of co-financing under rural development (and previously under direct payments). Instead, most Member States continue their national subsidised insurance schemes under the State aid rules (e.g., Spain) or deploy other policy instruments to increase uptake.

Germany has a long tradition of private based crop insurance with high adoption rates of predominately hail insurance (to a lesser extent this also holds for The Netherlands but the public-private multi-peril crop insurance scheme is gaining momentum and out crowds private-based hail insurance). Both Member States have also high adoption rates of private-based livestock insurance. In Germany the majority of insurance policies sold are the standard epidemic livestock coverage, while in The Netherlands farmers take out cover protecting their livestock against accidents such as ventilation breakdowns and fire. Livestock insurance uptake is highest in Spain, Greece and Finland (note that in Spain livestock insurance is subsidised and in Greece livestock insurance is mandatory).

Uptake of building insurance and occupational accident insurance is on average high across all Member States with the exception of building insurance in Greece and occupational accident insurance in Hungary.

Table 1: Insurance adoption in terms of the share of farms (%), and total number of observations (n) per Member State (i.e., coverage for crop, livestock, building and occupational accident)

Member State	Crop insurance		Livestock insurance		Building insurance		Occupational accident insurance	
	Adoption (%)	n	Adoption (%)	n	Adoption (%)	n	Adoption (%)	n
Finland	0	50	90	49	100	50	96	50
Germany	61	52	51	35	88	52	77	52
Greece	90	124	93	30	0	124	100	124
Hungary	34	102	11	64	39	102	13	102
Ireland	0	64	11	64	86	50	56	64
Netherlands	35	155	56	82	95	155	55	155
Poland	41	146	9	87	97	146	82	146
Spain	50	128	95	69	54	128	64	128

Source: the authors

Premiums paid and indemnities received were not collected in the FLINT project since they are registered in FADN. Agricultural insurance premiums relate to agricultural production income or any of its components (prices, yields, costs), and include for example insurance against damage to crops and death of livestock (some targeted by CAP). Other farm insurance premiums include cost of insurance of non-agricultural production or services (other gainful activities) of the farm. It thus covers other farm risks, such as the holder's third-party liability, losses to buildings, and accidental breakdown of machinery. The holder's and employer's (including partners) personal social security charges and insurance premiums (for example occupational accident insurance) and those of unpaid labour are not regarded as farm costs. The amounts received by unpaid workers (for example indemnities from job-related accidents) do not appear in the farm return either.

3.1.2 Adoption of contracts

The level of price protection depends on the type of price contract and contracted turnover. Descriptive statistics provided in Table 2 show distinct adoption rates of market price, pool price, minimum price or fixed price contracts. Contracted amount was in the majority of cases below 50% of the total turnover. Price contracts are less frequently applied in Ireland and Greece. However, also the adoption rate is low in Finland if market price contracts are excluded from the analysis. In a market price contract the price a farmer receives only depends on the market price (i.e., benchmark) at the moment of delivery, which provides no protection and can be seen as a delivery contract. Yet in a pool contract a farmer receives the average market value of a commodity over a specified period and thus smoothens price volatility to a certain extent. Protection increases if the contract guarantees a minimum price. If the market price at the moment of delivery is higher than the specified minimum price, the farmer will benefit from this higher price. Given a fixed price the contract specifies a pre-determined price for which the product is delivered. If the market price is higher than the fixed price the farmer will not benefit from this higher price. Member States with the highest adoption of price contracts (pool, minimum or fixed) are The Netherlands and Germany with adoption rates of respectively 60% and 38%. Activities contracted mainly comprised cereals, industrial crops, potatoes and milk. In three quarters of the contracts duration was 1 year or less and quality standards were specified in 50% of the contracts.

Table 2: Adoption of contracts in terms of the share of farms (%), and total number of observations (n) per Member State (type of contracts)

Member State	No price contract (%)	Market price contract (%)	Pool price contract (%)	Minimum price contract (%)	Fixed price contract (%)	n
Finland	34	56	0	0	10	50
Germany	35	27	2	0	37	52
Greece	70	19	2	0	9	124
Hungary	35	36	0	0	28	102
Ireland	100	0	0	0	0	64
Netherlands	28	12	29	9	22	155
Poland	49	29	6	5	12	146
Spain	16	59	9	1	15	128

Source: the authors

3.1.3 Adoption of other risk management tools or other gainful activities

The adoption rates of other risk management strategies or adopting other gainful activities to substitute or complement insurance and price contracts also greatly differ across Member States (Table 3). Highest overall adoption rates reported included the avoidance of credit use to minimizing external dependency, diversification to reduce the variability of farm income, holding financial reserves to ride out adverse times and off-farm employment to diversify streams of income. Hedging by using futures and options to limit or offset the probability of loss from fluctuations in agricultural commodity prices was least preferred in almost all Member States. Substantial differences were also observed between farming types partially because of how the typology of farms was defined (e.g., mixed farming systems apply by definition diversification) and inherent characteristics of a farming system (e.g. field crop farms and more specifically arable farms widely apply diversification not only as a risk management tool but also because of agronomic constraints).

Table 3: Adoption of other risk management strategies in terms of share of farms (%), and number of observations (n) per Member State

Member State	Diversi-fication (%)	On-farm processing / sales (%)	Off-farm investment (%)	Credit avoidance (%)	Hedging (%)	Financial reserves (%)	Off-farm employment (%)	Other gainful activities (%)	n
Finland	40	18	26	66	4	36	44	32	50
Germany	54	17	19	46	0	64	60	64	52
Greece	90	18	2	69	0	68	23	13	124
Hungary	38	8	6	40	4	38	43	16	102
Ireland	30	0	14	53	3	50	53	2	64
Netherlands	33	10	8	16	2	14	51	46	155
Poland	62	7	2	45	3	40	26	14	146
Spain	28	13	2	59	0	9	23	12	128

Source: the authors

The aforementioned binary elicited FLINT indicators of adoption are subjective indicators expressing the importance from a farmer's viewpoint, while some can also be objectively quantified with FADN data directly. The amount of financial reserves and credit avoidance correspond respectively with total farm savings and the opposite of a farm's total liabilities, or a relative measure such as solvency rate. Moreover, quantifying the heterogeneity of diversification can be straightforwardly measured with an index on the basis of the revenue stemming from each activity jointly determining total output.

3.2 Determinants of adoption

The determinants of adoption of 12 distinct risk management strategies were estimated. A hedging demand model was not estimated because generating robust estimates given the limited number of uptake was not feasible. The three-level model with two random-effects equations comprises 39 farming type levels from eight Member States levels in the upper two levels. Estimated fixed effects of the explanatory variables and the random effects at the level of Member States and farming types are presented in Table 4. Likelihood-ratio tests comparing each model to its ordinary logistic regression approach revealed that all were highly significant for these data. Reversing the order of the upper two levels did not affect the main findings.

The results reveal that larger farms adopted more often crop insurance, occupational accident insurance, contracts and diversification but were less likely to adopt credit avoidance and off-farm employment (at a significance level of 1%). Although the latter risk management strategies are considered very effective, they may affect the efficiency of scale (and thus limits prospects of higher average incomes). Note that the perceived adoption of applying financial strategies (i.e., credit avoidance or holding financial reserves) was indeed objectively confirmed by lower liabilities and higher assets as recorded in FADN. With respect to random effects it can be concluded that the adoption of risk management strategies was significant affected by farm type while Member State effect was not significant.

The relationship between adoptions of different risk management strategies was also analysed with a three-level mixed effects logistic regression model with the help of odds ratios (OR), to determine whether they are substitutes (OR<1) or complements (OR>1) (Table 5). Main findings are described within and between the three mainstream categories of risk management strategies (i.e.., insurances, contracts, and alternative methods). OR within the category of insurance revealed that uptake is positively associated (OR>1). For example, adopters of occupational health insurance were statistically significantly two or three times more likely to adopt other insurance coverages as well. Significant OR within the category of alternative risk management strategies revealed that most strategies complemented each other. For example, farmers opting for credit avoidance were three times more likely to hold also financial reserves too. Between the categories of alternative risk management strategies, significant results on complementing or substituting choices are more mixed. For example, farmers opting for crop insurance were 2.5 times more likely to use price contracts as well, while half as likely to have off-farm employment.

Table 4: Estimates of the adoption models (parameters are odds ratios) and standard errors in parentheses for insurance and other risk management strategies [1]

Variables	Crop insurance	Livestock insurance	Building insurance	Occupational accident insurance	Price contract	Diversifi-cation	On-farm processing/ sales	Off-farm investment	Credit avoidance	Financial reserves	Off-farm employment	Other gainful activities
Fixed effects												
Economic size class	1.548***	1.289	0.973	1.388***	1.737***	1.470***	0.995	1.057	0.779***	1.081	0.712***	0.910
	(0.160)	(0.202)	(0.121)	(0.114)	(0.192)	(0.133)	(0.116)	(0.145)	(0.0594)	(0.0868)	(0.0493)	(0.0801)
Total farm output[2]	0.992	1.010	0.992	1.003	0.983**	0.986**	0.992	0.997	1.010	0.999	1.006	0.996
	(0.00716)	(0.00920)	(0.00997)	(0.00504)	(0.00712)	(0.00719)	(0.0102)	(0.00819)	(0.00609)	(0.00681)	(0.00429)	(0.00466)
Farm net income[2]	1.003	0.997	0.995	0.984	0.981	0.994	1.001	1.005	0.992	0.987	0.994	1.017
	(0.0178)	(0.0247)	(0.0302)	(0.0143)	(0.0182)	(0.0175)	(0.0272)	(0.0264)	(0.0164)	(0.0165)	(0.0132)	(0.0147)
Total subsidies[2]	0.944	1.104	1.035	0.943	0.925	1.007	1.061*	1.061*	0.952	0.996	1.025	1.056*
	(0.0389)	(0.0669)	(0.0684)	(0.0342)	(0.0438)	(0.0321)	(0.0362)	(0.0354)	(0.0312)	(0.0312)	(0.0282)	(0.0319)
Total liabilities[2]	1.000	1.000	1.004	1.001	0.994*	0.995	0.999	1.000	0.988***	0.992**	0.999	0.999
	(0.00278)	(0.00303)	(0.00637)	(0.00189)	(0.00319)	(0.00330)	(0.00431)	(0.00347)	(0.00372)	(0.00339)	(0.00189)	(0.00252)
Total assets[2]	1.001	0.999	1.003	0.999	1.005***	1.002	1.000	1.002	1.002*	1.002**	1.001	1.002**
	(0.00134)	(0.00119)	(0.00271)	(0.000837)	(0.00180)	(0.00135)	(0.00155)	(0.00118)	(0.00105)	(0.00110)	(0.000774)	(0.00111)
Cash flow[2]	1.009	0.988	1.008	1.000	1.017**	1.009	0.997	0.992	0.994	1.004	0.998	1.007
	(0.00685)	(0.00983)	(0.00982)	(0.00461)	(0.00734)	(0.00682)	(0.00982)	(0.00940)	(0.00593)	(0.00604)	(0.00406)	(0.00471)
Age	1.002	0.984	0.988	0.985	0.999	0.990	0.996	1.011	1.004	0.991	0.963***	0.975***
	(0.0107)	(0.0140)	(0.0128)	(0.00950)	(0.0107)	(0.00887)	(0.0119)	(0.0144)	(0.00803)	(0.00845)	(0.00777)	(0.00934)
Advisory	1.008	1.023	0.996	0.986	0.990	1.025*	0.965*	1.022	0.995	0.994	1.003	0.986
	(0.0125)	(0.0211)	(0.0188)	(0.0128)	(0.0133)	(0.0134)	(0.0200)	(0.0205)	(0.0104)	(0.0114)	(0.0109)	(0.0144)
Constant	0.0268***	0.00829***	6.179	1.012	0.00563***	0.123**	0.179*	0.0167***	5.074**	0.510	40.93***	1.230
	(0.0339)	(0.0128)	(10.11)	(1.170)	(0.00579)	(0.115)	(0.178)	(0.0221)	(3.555)	(0.415)	(29.74)	(1.065)
Random effects												
Member State	189.1	1.000	251,882	414.0	1.623	6.470	1	2.015	1.464	2.905	2.102*	3.501
	(717.2)	(0.0493)	(2.193e+06)	(1,529)	(1.350)	(8.404)	(0)	(1.201)	(0.466)	(1.973)	(0.903)	(2.701)
Farm type	30.45**	1.565e+06**	3.034**	1.190	14.93**	4.958**	2.453**	1.512	1.408**	1.795*	1.065	1.016
	(41.09)	(1.087e+07)	(1.612)	(0.173)	(16.37)	(3.194)	(1.046)	(0.672)	(0.228)	(0.537)	(0.101)	(0.107)
Observations	782	782	782	782	782	782	782	782	782	782	782	782
Number of groups	8	8	8	8	8	8	8	8	8	8	8	8

[1] *** p<0.01, ** p<0.05, * p<0.1

[2] Per 10,000 euros.

Table 5: Estimates of the adoption models (parameters are odds ratios) and standard errors in parentheses between risk management strategies [1]

Variables	Crop insurance	Livestock insurance	Building insurance	Occupational accident insurance	Price contract	Diversifi -cation	On-farm processing/ sales	Off-farm investment	Credit avoidance	Financial reserves	Off-farm employment	Other gainful activities
Fixed effects												
Crop insurance		1.596	1.314	2.223***	2.572***	1.577*	0.599*	1.517	0.685*	0.908	0.526***	1.926***
		(0.586)	(0.493)	(0.571)	(0.671)	(0.385)	(0.183)	(0.581)	(0.152)	(0.216)	(0.106)	(0.430)
Livestock insurance	1.326		6.679***	2.772***	1.365	1.919**	1.523	0.664	0.667	0.751	0.835	1.001
	(0.491)		(3.734)	(0.784)	(0.445)	(0.629)	(0.553)	(0.287)	(0.182)	(0.226)	(0.191)	(0.248)
Building insurance	1.673	4.904***		1.823**	1.727	0.860	0.924	1.097	1.546	1.145	1.032	1.650
	(0.656)	(2.620)		(0.551)	(0.606)	(0.257)	(0.359)	(0.584)	(0.436)	(0.360)	(0.249)	(0.547)
Occupational accident insurance	2.361***	2.572***	1.636		1.489	1.420	0.655	1.172	1.020	1.560*	1.197	0.752
	(0.696)	(0.817)	(0.511)		(0.399)	(0.330)	(0.206)	(0.447)	(0.217)	(0.379)	(0.235)	(0.178)
Price contract	2.530***	1.612	1.999**	1.410		1.640**	1.206	0.616	1.310	1.083	1.016	1.262
	(0.665)	(0.556)	(0.704)	(0.357)		(0.405)	(0.358)	(0.264)	(0.291)	(0.276)	(0.206)	(0.280)
Diversification	1.495	2.425**	0.879	1.333	1.644**		2.891***	1.272	1.248	1.813***	0.874	1.185
	(0.377)	(0.866)	(0.267)	(0.299)	(0.416)		(0.888)	(0.426)	(0.241)	(0.369)	(0.157)	(0.260)
On-farm processing/ sales	0.547*	1.008	1.769	0.633	1.074	3.155***		1.309	1.417	0.879	0.762	3.529***
	(0.194)	(0.437)	(0.892)	(0.207)	(0.338)	(1.040)		(0.585)	(0.379)	(0.272)	(0.203)	(0.976)
Off-farm investment	1.680	0.414*	0.810	1.246	0.507	1.430	1.178		1.128	3.301***	2.275***	2.964***
	(0.720)	(0.202)	(0.419)	(0.479)	(0.235)	(0.499)	(0.540)		(0.375)	(1.144)	(0.701)	(1.024)
Credit avoidance	0.662*	0.658	1.602	0.957	1.427	1.195	1.463	1.098		3.237***	0.964	0.755
	(0.155)	(0.203)	(0.473)	(0.204)	(0.327)	(0.235)	(0.385)	(0.363)		(0.628)	(0.167)	(0.164)
Financial reserves	0.850	0.968	1.341	1.592*	0.978	1.875***	0.923	3.356***	3.164***		1.001	1.187
	(0.215)	(0.334)	(0.437)	(0.389)	(0.260)	(0.393)	(0.277)	(1.163)	(0.606)		(0.186)	(0.282)
Off-farm employment	0.468***	0.897	0.846	1.208	0.939	0.838	0.772	2.102**	0.973	0.984		1.627**
	(0.110)	(0.251)	(0.238)	(0.243)	(0.209)	(0.161)	(0.212)	(0.663)	(0.174)	(0.191)		(0.327)
Other gainful activities	1.843**	1.049	1.638	0.751	1.165	1.188	3.639***	3.325***	0.788	1.129	1.754***	
	(0.487)	(0.343)	(0.626)	(0.185)	(0.296)	(0.286)	(1.027)	(1.163)	(0.178)	(0.277)	(0.353)	
Constant	0.259	0.00832***	0.884	0.920	0.0404***	0.392**	0.0517***	0.0126***	0.502	0.144***	0.664	0.0875***
	(0.232)	(0.00768)	(1.199)	(0.713)	(0.0276)	(0.185)	(0.0235)	(0.00842)	(0.216)	(0.0708)	(0.191)	(0.0422)
Random effects												
Member State	63.72	2.202	1.890e+06	41.62	5.549	1.801	1	2.279	1.978	2.311	1.155	2.474
	(208.1)	(3.822)	(1.885e+07)	(99.85)	(7.855)	(1.088)	(0)	(1.643)	(0.923)	(1.322)	(0.142)	(1.422)
Farm type	38.87***	14,617**	1.625	1.258	8.240**	4.257**	1.890*	1.174	1.605**	1.916**	1.105	1
	(53.29)	(65,172)	(0.591)	(0.239)	(7.139)	(2.498)	(0.620)	(0.455)	(0.343)	(0.616)	(0.108)	(0)
Observations	819	819	819	819	819	819	819	819	819	819	819	819
Number of groups	8	8	8	8	8	8	8	8	8	8	8	8

[1] *** p<0.01, ** p<0.05, * p<0.1

4 CONCLUSION

In the current study the adoption rates of different risk management tools and determinants of farmers' choice were quantified. Adoption rates of insurance contracts, price contracts, off-farm income, other risk reduction measures and other gainful activities vary widely across Member States and farming type. Monitoring and evaluating the adoption rates, and determinants of adoption, of aforementioned strategies is important to evaluating CAP policies where targeting is relevant and where linkages or trade-offs between policy objectives exist. For example, the existing direct payments stabilise farm incomes, potentially reducing the demand for risk management strategies (OECD, 2009). It is expected that in the near future agricultural insurance will gain momentum because of the recent CAP reforms (2014-2020). CAP entails a toolkit to subsidize animal and plant insurance (article 37), mutual funds for animal and plant diseases and environmental incidents (article 38), and income stabilization strategies (article 39) in the form of mutual funds to address income volatility. At the same time the reduced level of market management brought about through recent and ongoing CAP reforms has significantly reduced the CAP´s price supporting effects. Despite the potential positive benefits of contracts, no specific measures were included in the 2013 reform thereby leaving it up to the market to establish contracts. Given the continuous evolution of the CAP and the expectation that risk management will continue to grow in importance, it is now both timely and relevant to take stock of current evaluation practices and specifically focus on which risk management indicators could help to evaluate and develop future polices.

In the scope of the FLINT project a number of indicators for risk management strategies have been added to the regular FADN data collection for a recent accountancy year. This allows for an extended set of analyses because the availability of information on insurances is very limited in the current FADN (EC, 2015). In the input tables only the totals of agricultural insurances (insurances for agricultural income and insurances for death of livestock and crop damages) and other insurances (for example fire and third party liability) are recorded. Expenditures on cost items compensated during the accounting year or later (e.g. repairs to a tractor as a result of an accident covered by an insurance policy or by a third party liability) are not entered as farm costs, and the corresponding receipts are not included in the farm's accounts. Compensation payments during the year are included in the sales of the product category and cannot be identified separately. Subsidies a farmer receives for insurance payments are being recorded in the subsidies table under 'grants and subsidies on costs'. The information on contracts is even more limited. Data is only recorded in case when the holder does not assume the economic risk normally involved in the agricultural activity (for example in case of contract rearing or fattening of animals, the amounts for contract rearing are recorded).

For the other measures that could be considered as risk management such as other gainful activities, off-farm employment, diversification, off-farm investment, credit avoidance, and holding financial reserves, the picture is more diverse. FADN does not provide any information on off-farm employment and off-farm investments (see Hill, 1996, and OECD, 2004). Revenues, costs and labour input of other gainful activities are recorded in FADN (contract work (using production means of the holding); tourism; processing of farm products, e.g. cheese, butter, processed meat; production of renewable energy; forestry and wood processing and some other gainful activities (fur animals, care farming, handicraft, aquaculture)). Diversification, credit avoidance and financial reserves can be inferred from the structural and financial data of the FADN dataset but the dataset does not give a clear answer whether adoption of such instruments is because of a risk management strategy or because of some other reasons.

Given this lack of information, studies based on FADN have focussed on income volatility, down side risk, and price and yield volatility (Vrolijk and Poppe, 2008; Kimura et al., 2010). FADN results are also used to show that the risk in gross margin of family farm income is significantly higher in organic than conventional dairy farming in The Netherlands (coefficient of variation of 30% versus 45%) caused by both higher price and production risks (Berentsen et al., 2012). More detailed analysis revealed that risks at crop level for organic farms were higher with respect to yields, output prices and variable input costs (Berentsen and Van Asseldonk, 2016). These studies are however not able to relate the risks at farm level to the risk management instruments

applied on the farm due to current lack of data. With the FLINT indicators the adoption rates can be analysed and future research allows analysing the link with the economic and sustainability performance of farms.

Most elicited new indicators focus on the adoption of risk management strategies and are therefore binary. Yet, farmers' decisions to adopt a specific risk management tool are often continuous choice decisions. For example decisions to insure or contract follow a (binary) adoption decision and subsequently a (continuous) conditional decision about the amount (e.g. proportion of production insured or contracted). This simplification holds for all insurance adoption indicators, as well as indicators capturing on-farm processing and the use of other gainful activities. In the current approach, the decision is being modelled as a discrete choice decision. Eliciting continuous farm level indicators would enable to use double-hurdle models distinguishing the determinants of the adoption decision from those of the uptake amount. In the first-stage of the double-hurdle model, a Probit regression model would be estimated where decision is transformed into a binary variable. The second-stage model would be a truncation estimation procedure (Heckit model) whereby only observations of farmers who adopted are included (Heckman, 1979). Refined model estimates could be applied for the FLINT indicators capturing contract use (i.e., proportion of turnover contracted) and off-farm employment (i.e., hours worked).

In addition to analysing adoption rates there is a strong policy and research interest in the impact of risk management strategies. The impact of risk management strategies are difficult to assess with performance indicators obtained from a cross-sectional design as is the case in this pilot study. Decisions of adopting risk management strategies depend on the associated cost (e.g., premium for insurance) relative to the benefit perceived from the reduction in risk (e.g., indemnities in adverse years). Analysing these within farm trade-offs require mean profits and loss distributions obtained from multiple years. This downside-risk reduction and thus impact can only be estimated if the FLINT data collection will be continued to build up a panel data set.

In summary, if data collection would be continued for several years the trends in adoption rates could be analysed as well as the impact on the economic and sustainability performance of farms could be estimated. The integrated character of the FLINT+FADN database allows combining economic, social and environmental aspects of farming. The impact of social indicators on the adoption rates can be analysed and the impact of risk management instruments on the environmental performance can be established (e.g. is there a trade-off between crop insurance and use of pesticides). For policy analyses these indicators are a step forward for the determination of the net impacts and establishment of counterfactuals on the long run with FADN (i.e., time series encompassing also adverse years) for measuring the impact of the CAP at farm level.

Acknowledgements

This work was partly funded by the EU Seventh Framework Programme grant number 613800 (FLINT). The opinions expressed in this paper are not necessarily those of the EU.

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