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Adoption of risk management strategies in European agriculture

Given the increased attention to risk management in the European Union's (EU) Common Agricultural Policy (CAP), it is important to monitor and evaluate the rates of adoption by farmers and their determinants over time. Current European agricultural statistics (Farm Accountancy Data Network) capture few indicators that assess such strategies, but complementing data collected during the EU Framework 7 project FLINT have allowed the adoption of risk management strategies and the determinants of farmers' preference for complementary or substitute instruments to be assessed. Adoption rates of risk management instruments such as insurance contracts, price contracts, off-farm income, other types risk of reduction measures and other gainful activities vary significantly across EU Member States and farming types. Econometric analysis indicates that larger farms more often adopt crop insurance, occupational accident insurance, price contracts and diversification but are less likely to adopt credit avoidance and off-farm employment (at a significance level of 1 per cent). For policy analyses these indicators are a step forward for the determination of the net impacts and establishment of counterfactuals in the long term (i.e. time series encompassing also adverse years) for measuring the impact of the CAP at farm level.

Keywords: insurance, contracts, off-farm income, diversification, gainful activities

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Introduction

Farming is a heterogeneous sector in a complex and multi-faceted environment facing a variety of sources of risk beyond the control of farmers (McElwee and Bosworth, 2010). Farm income is 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 entire agricultural value chain (Darnhofer *et al.*, 2016). Within this context, farmers need to apply strategies and instruments to balance their income and risks and to achieve income stability (Hardaker *et al.*, 2004). The reduction of risks to income over time will improve farmers' well-being, their competitiveness and the ability to expand their operations through innovation and the appropriate investment decisions (EP, 2014).

Extensive theoretical and empirical research has been conducted to understand the issue of risk and to develop instruments to support farmers (see, for example, OECD, 2009; Kimura *et al.*, 2010). Options include risk-transfer strategies (marketing contracts, production contracts, hedging on future markets, participation in mutual funds and insurance) or on-farm measures (selection of products, diversification, self-insurance, farm financial management and savings/credit) (Meuwissen *et al.*, 1999).

Diversification is widely used in agriculture to deal with multiple sources of risk. Through diversification, being either multi-commodity farm activities or combining on-farm and off-farm income or a combination of both, risks are mitigated, enabling more stable incomes to be generated (Hardaker *et al.*, 2004; Bowman and Zilberman, 2013; Barnes *et al.*, 2015). Certain characteristics are associated with diversification, for example, age, education, farm size, financial structure, labour use and farming experience (Bowman and Zilberman, 2013; Barnes *et al.*, 2015).

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Marketing or production contracts transfer risk along the food chain. 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 but he/she loses the opportunity of achieving a higher price on the open market. Although the empirical literature highlights the main determinants of choosing marketing channels, such as locational and geographical disparities, temporal specificities, and transaction costs in combination with farm and farmer characteristics, there is little information available about the risk transfer throughout the value chain (OECD, 2000).

Production contracts typically give the contractor control over the production process. This kind of contract 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 per cent 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 (Van Asseldonk and Van der Meer, 2016). Farmers shift the price risk to the processor but are dependent on only one buyer. In the USA, production contracts have been shown to reduce income risk to a large extent, increase specialisation on farms, help create lower costs and improve efficiency (Harwood *et al.*, 1999). However, production contracts have been criticised 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).

Agricultural insurance has a long history and plays a significant role in the compensation of crop damage (hail, drought), livestock disease outbreaks, farm assets and disability of farmers (Hardaker *et al.*, 2004). Insurance tools have been included in the risk management toolkit of the recently-reformed Common Agricultural Policy (CAP) (EC, 2013a). The tools available to manage agricultural risk through insurance are very diverse and not common for all EU Member States. There are mainly single-risk insurance tools (such as hail or frost insurance) while some Member States (e.g. France, Italy and Spain) also have multi-peril risk insurance schemes that secure against different kinds of weather risks, but yield and revenue insurances are far less developed (Bielza *et al.*, 2008). In contrast, in some non-European countries more sophisticated tools are available (Mahul and Stutley, 2010). The agricultural insurance spectrum ranges from Member States in which the public sector provides no support (private non-subsided insurance schemes), those in which governments heavily subsidise agricultural insurance up to Member States, such as Greece and Cyprus, where the system is public and mandatory (Bielza *et al.*, 2008).

In practice, agricultural insurance has been a costly way of transferring the risk from farmers to governments and other insurers (Nelson and Loehman, 1987). In the 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. Agricultural insurance also faces the problem of asymmetric information which refers either to moral hazard or adverse selection problems. Some attempts aim to alleviate these problems (e.g. farmer mutual funds, index-based insurance) with the support of the CAP reforms (2014-2020) that allow premium subsidies.

Thus, European farmers may choose from three general types of risk management strategies: on-farm (e.g. diversification), price risk transfer (e.g. contracts) and yield risk transfer (i.e. insurance with or without public assistance). This paper examines the adoption rates and determinants of farmers' choice of such strategies. We consider insurance contracts, price contracts, off-farm income, other risk reduction measures and other gainful activities, and our analysis is conducted using farm-level data for farms located in eight EU Member States.

Methodology

Econometric model

For farmers, whether or not to adopt 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, the adoption of a specific risk management tool is therefore modelled as a discrete-choice decision (and continuous 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 type for all EU Member States, farm data are naturally nested in farming type and Member States. This hierarchical structure gives rise to multi-level mixed-effects modelling by incorporating random effects at the levels of Member States and farming type (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 is likely to 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 Member State relief programmes) and differences in demand (e.g. cultural differences). Formally, the econometric model for the probability of adoption is described as follows:

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

where $Pr(y_{ijk}=1|x_{ijk}, w_j, z_{jk})$ denotes the conditional probability of $y_{ijk}=1$ given a set of variables 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, x_{ijk} is a vector of explanatory variables related to demand factors. In equation (1), $H(\cdot)$ is the logistic cumulative distribution function ($H(\theta) = \dfrac{\exp(\theta)}{1+\exp(\theta)}$) which maps the linear predictor to the probability of adoption ($y_{ijk}=1$). In this model, the linear combination $x_{ijk}\beta$ represents the fixed effects of the explanatory variables on the likelihood of adoption. The terms w_j and z_{jk} represent random effects at the level of Member States and farming type respectively. ε_{ijk} represents the random error term at farm level. The model is estimated using the melogit procedure of Stata® 14.0 (StataCorp LLC, College Station TX, USA).

The adoption of one strategy can affect (substitute or complement) 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 simultaneous adoption decision of other risk management strategies. Similar three-level logistic models are applied as presented in Equation 1 to estimate odds ratios.

Data

In the selection plan the heterogeneity of the farming sector was explicitly considered. In designing the selection plan the same stratification was used as in Farm Accountancy Data Network (FADN) (EC, 2015) which is based on farming type and farm 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 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 farming types in each Member State.

In line with the regular FADN data collection, the data collection was organised in different ways in each of the participating countries in terms of who collected the data and how the data were collected (Vrolijk *et al.*, 2016). Collection processes and strategies were designed and 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 the EU Framework 7 FLINT, Farm-Level Indicators for New Topics in Policy Evaluation) were merged with the FADN database. The analysis in this paper is based on data from 821 farmers collected in eight Member States.

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 focused 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 per cent, [20-50 per cent>, [50-79 per cent>, [80-99 per cent>, 100 per cent); 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/healthcare, nature management, production of renewable energy and contract work for others.

Explanatory variables

The demand for risk management strategies is often hypothesised to be influenced by numerous explanatory variables (see, for example, Goodwin, 1993). In the multivariate regression analysis, explanatory variables described farm structure, farm income, farm financing and personal characteristics.

The hypothesis is that farm structure influences the adoption of risk management instruments. Two main components of farm structure, namely farming type and farm size, were distinguished. Risks and the rationale of adopting specific risk management strategies differ for obvious reasons between agricultural produce (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 farming type based on Eurostat's farm typology (FADN code: GENERAL). Eight farming types are listed as dummy variables in the analysis, i.e. farms with mainly field crops, horticulture, wine, other permanent crops, milk, other grazing livestock, granivores or mixed (i.e. crops and livestock). The classification of farms according to type is based on the (relative) mix of their output. The impact of farm size was previously tested by, for example, Goodwin *et al.* (2004) and Sherrick *et al.* (2004), who found a positive relationship between farm size and insurance purchase. Farm economic size is included as a linear variable and expressed in standard output units (FADN code SE005).

Two variables were included as indicators for farm income, 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. Farms with higher farm income may have less need to adopt risk management strategies because of opportunities for self-financing adverse losses. The reverse situation could be hypothesised for farmers with low income. The total amount of subsidies received on current operations included EU-financed and co-financed decoupled and coupled payments. In the EU, direct payments represent around 30 per cent of farm income (but this differs between farming types). It has been claimed that such payments have an income stabilising role (Cafiero *et al.*, 2007) and the somewhat scant empirical evidence available supports this hypothesis (Agrosynergie 2011; El Benni *et al.* 2012). The fact that direct payments are fixed induces a decrease in the variability of income and creates what is called a 'wealth effect'. This additional stream of income affects preferences for adopting risk management strategies. For this reason, it is not easy to disentangle the risk management component from the support component of many measures (OECD, 2009).

The financial structure of the farm is often tested in explaining adoption of risk management strategies. Farmers with more debt (total liabilities, FADN code SE485) would be expected to adopt more often risk management strategies (Ganderton *et al*., 2000; Mishra and Goodwin, 2003; Mishra *et al*., 2005; Sherrick *et al*., 2004). The reverse situation may be hypothesised for farmers with larger net worth (total assets FADN code SE501). Ultimately, the capacity to bear the risk

Table 1: Percentage adoption by farmers of crop, livestock, building and occupational accident insurance and number of observations per EU Member State.

Member State	Crop		Livestock		Building		Occupational accident	
	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: own data

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 previously-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 (Sherrick *et al*., 2004; Ogurtsov *et al*., 2007; Mishra *et al*., 2005). but the direction of the effect is difficult to predict and is often non-significant. From the FLINT survey 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.

Results

Adoption of insurance

All farming types in this study cultivated land and hence crop insurance adoption was estimated for all surveyed farms. 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).

Adoption of crop insurance varies across Member States, and this can be explained in part 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 crop insurance is not adopted since 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 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 of EU (2013b) (e.g. subsidised multi-peril crop insurance in The Netherlands). Other Member States that have chosen not to make use of the toolkit despite the possibility of EU co-financing continued their national subsidised insurance schemes under the state aid rules (e.g. Spain) or deploy other policy instruments to increase uptake (EP, 2014).

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). Both Member States also have high adoption rates of private-based livestock insurance. In Germany most insurance policies sold are the standard epidemic livestock coverage, while in the Netherlands farmers take out cover protecting their livestock against accidents such 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 it 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.

Adoption of contracts

The level of price protection depends on the type of price contract and contracted turnover. Descriptive statistics show distinct adoption rates of market price, pool price, minimum price or fixed price contracts (Table 2). The contracted amount was in the majority of cases below 50 per cent of the total turnover. Price contracts are less frequently applied in Ireland and Greece. However, the adoption rate is also 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

Table 2: Percentage adoption by farmers of different types of contracts and number of observations per Member State.

Member State	No price contract	Market price	Pool price	Minimum price	Fixed price	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: own data

Table 3: Percentage adoption by farmers of other risk management strategies and number of observations per Member State.

Member State	Diversification	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: own data

can be seen as a delivery contract. Yet in a pool contract a famer receives the average market value of a commodity over a specified period and thus smooths 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 60 and 38 per cent respectively. Contracted activities mainly comprised cereals, industrial crops, potatoes and milk. In three quarters of the contracts the duration was one year or less and quality standards were specified in 50 per cent of the contracts.

Adoption of other risk management strategies or gainful activities

The adoption rates of other risk management strategies or adopting other gainful activities also greatly differ across Member States (Table 3). The highest reported overall adoption rates included the avoidance of credit use to minimising external dependency, diversification to reduce the variability of farm income, holding financial reserves to ride out adverse times and off-farm employment to diversify income streams. 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. The use of specified strategies differed between farming types partly because of how the typology of farms was defined (e.g. mixed farming systems apply diversification by definition) and inherent characteristics of a farming system (e.g. field crop farms, particularly arable farms, apply diversification widely not only as a risk management tool but also for agronomic reasons).

The aforementioned binary elicited FLINT indicators are more subjective indicators that express 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 measured straightforwardly with an index on the basis of the revenue stemming from each activity jointly determining total output.

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 was not feasible given the limited uptake. 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 type are presented in Table 4. Likelihood-ratio tests comparing each model to its ordinary logistic regression approach showed that all were highly significant for these data. Reversing the order of the upper two levels did not affect the main findings.

The larger farms adopted crop insurance, occupational accident insurance, contracts and diversification more often but were less likely to adopt credit avoidance and off-farm employment (at a significance level of 1 per cent). Although the latter 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 significantly affected by farming type while the Member State effect was not significant.

The relationship between adoptions of different strategies was also analysed with a three-level mixed-effects logistic regression model to determine whether they are substitutes ($OR < 1$) or complements ($OR > 1$) (Table 5). The main findings are described within and between the three mainstream categories of risk management strategies (i.e. insurances, contracts and alternative methods). Within-category odds ratios 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 ORs within the category of alternative methods revealed that most strategies complemented each other. For example, farmers opting for credit avoidance were three times more likely also to hold financial reserves. 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, but half as likely to have off-farm employment.

Table 4: Estimates of the adoption models (parameters are odds ratios) and standard errors for insurance and other risk management strategies.

Variables	Crop insurance	Livestock insurance	Building insurance	Occupational accident insurance	Price contract	Diversification	On-farm processing/sales	Off-farm investment	Credit avoidance	Financial reserves	Off-farm employment	Other gainful activities
Fixed effects												
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‡	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‡	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‡	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‡	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‡	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‡	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)
Farming 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)

Number of observations = 782; number of groups = 8; standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$; ‡ EUR 10,000
Source: own data

Table 5: Estimates of the adoption models (parameters are odds ratios) and standard errors between risk management strategies.

Variables	Crop insurance	Livestock insurance	Building insurance	Occupational accident insurance	Price contract	Diversification	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)
Farming 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)

Number of observations = 819; number of groups = 8; standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Source: own data

Discussion

We quantified the adoption rates of different risk management tools and determinants of farmers' choice. In the scope of the FLINT project several indicators for risk management strategies were added to the regular FADN data collection to allow for an extended set of analyses. The availability of information on insurances and other risk management tools is very limited or too much aggregated in the current FADN (EC, 2015). The FLINT indicators revealed that adoption rates of 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. Bielza *et al.*, (2008) also report that insurance uptake in agriculture is heterogeneous across Member States. Moreover, current results are in line with past results with respect to hedging against price risks which is adopted by only 2-3 per cent of European farmers (Szekely and Pálinkás, 2009). The econometric analysis indicates that larger farms more often adopted 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 per cent). The positive relationship between farm size and insurance purchase was also shown in other studies (Goodwin *et al.,* 2004; Sherrick *et al*., 2004). Previous studies mostly focused on insurance adoption while our work focused on a broader set of risk management strategies. Also Huirne *et al.* (2007) emphasised that whole-farm risk management approaches, i.e. approaches in which multiple risks and farm activities are considered simultaneously, are essential in understanding adoption levels and determinants of adoption at farm level.

Monitoring and evaluating the adoption rates, and determinants of adoption, of the aforementioned strategies is important when evaluating policies where targeting is relevant and where linkages or trade-offs between policy objectives exist. For example, the existing CAP direct payments stabilise farm incomes potentially, reducing the demand for risk management strategies (OECD, 2009). Recent CAP reforms (2014-2020) encourage the adoption of agricultural insurance by providing premium subsidies. 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.

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 follows 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 the use of 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 is estimated where a decision is transformed into a binary variable. The second-stage model is 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 impacts 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. Given this lack of information, studies based on FADN have focused on income volatility, down-side risk, and price and yield volatility (Vrolijk and Poppe, 2008; Kimura *et al.*, 2010). FADN is generally also used to analyse differences in risks between farming systems. For example, Berentsen *et al.* (2012) show that gross margin volatility is significantly higher in organic than conventional dairy farming in the Netherlands (coefficient of variation of 30 vs. 45 per cent) caused by both higher price and production risks. Similarly, organic arable 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. Decisions on adopting risk management strategies depend on the associated cost (e.g. insurance premium) relative to the benefit perceived from the reduction in risk (e.g. indemnities in adverse years). Analysing these within farm trade-offs requires 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 can be analysed and 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 in the long term with FADN (i.e. time series encompassing also adverse years) for measuring the impact of the CAP at farm level.

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