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Measuring Farmer Risk Preferences in Europe:

A Systematic Review

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Abstract

We present a systematic review of the extensive body of research on farmer risk preference measurement across Europe. We capture the methodological developments over time and discuss remaining challenges and potential areas for further research. Given the constantly evolving policy environment in Europe, and increasing climate-change related risks and uncertainties, there is large value to be gained from enhancing our understanding of this fundamental aspect of farmers' decision making processes and consequent actions.

Keywords: Risk preferences, Expected Utility, Prospect theory, Methodology, Agriculture

JEL classification: D81, Q12

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1. Introduction

In the agricultural sector, important societal and individual decisions are taken in the context of uncertainty and risk. In particular, uncertainty and risk stem from a multitude of factors such as hazards related to weather, pests and diseases, or changes in both market conditions and the policy context in which farmers operate and trade. Risk attitudes, risk perception and their interaction are fundamental determinants behind risk management and the use of specific risk management tools (Pennings and Garcia, 2004; Pennings and Wansink, 2004; Just and Just, 2016). However, these concepts are unobservable and extremely difficult to measure (e.g., as more recent examples, Gardebroek, 2006; Liu and Huang, 2013; Trujillo-Barrerra *et al.*, 2016). Hence, the development of reliable methods to measure and understand farmers' risk attitude is of great importance for politicians, researchers and advisory offices (Vollmer *et al.*, 2017a). Agricultural policy, economic research and applications that aim to make accurate predictions about farmers' decisions and their responses to policy changes need to take into account their risk preference and the heterogeneity in the level of their risk aversion. Furthermore, recent shifts in European agricultural policies, such as the Common Agricultural Policy (CAP) have emphasized the crucial role of risk management instruments (El Benni *et al.*, 2016; Meuwissen *et al.*, 2018).

In this review, we focus on risk preference measurement methods. The different methods employed include, for example, econometric estimates based on secondary farm level data, techniques based on self-reports on multi-item scales and methods based on lottery-choice tasks. As a result, there is a large literature analysing risk preferences of European farmers with substantial heterogeneity in results across methods, space, time and farm types. We focus on this heterogeneity in the levels of risk preference rather than on the impact of risk on behaviour, e.g. on production, risk management or technology adoption decisions.

Our main contribution is to provide a state of the art review of the main methods used to

measure farmers' risk attitudes, discuss remaining challenges and potential areas for further research. Notably, rapid developments in economics and psychology have resulted in substantial change in the diversity and depth of risk preference elicitation methods, for example, lottery-choice tasks to elicit and assess individual risk preferences.

We focus on European farmers, i.e. farmers who are subject to the Common Agricultural Policy (CAP), plus other states in the European continent with aligned goals of their agricultural, environmental and agricultural trade policies.² We justify the restriction to Europe on the grounds that a cross-continental comparison would introduce additional and potentially confounding variation in institutional frameworks and contextual and circumstantial conditions. In addition, rich European farm level panel datasets, for example from the Farm Accountancy Data Network (FADN) are frequently used to measure risk preferences, and their use is likely to grow in the future. Our aim is to facilitate the use and collection of these data and assist with the comparability of related results.

Existing European studies differ by geographical area and/or geographical scale as well as by producer type and socio-economic or farm characteristics, e.g. specialization in different crops (Groom *et al.*, 2008) or organic producers compared to conventional farmers (Gardebroek, 2006; Serra *et al.*, 2008). There is very substantial heterogeneity in European agriculture within these and other dimensions (e.g. topography, ownership structure, size) which can potentially influence or correlate with risk preference.

Our review provides an overview of the findings in the literature on risk preferences of European farmers. Previous articles have also summarised farmer risk preferences

² The non-European Union countries used in our analysis, i.e. where farmers risk preferences have been reported, include Norway (e.g. Kumbhakar and Tveteras, 2003) and pre-EU accession studies of selected countries (e.g. Groom *et al.*, 2008 for Cyprus). For the remainder of the article, we indicate this broader geographical area by "European Agriculture" or "Europe".

(Gardebroek, 2006; OECD, 2004 and 2009 and Reynaud and Couture, 2012). These authors find support for a general assumption of risk aversion on the basis of a majority criterion (i.e. a count of all the articles that report a similar risk preference of their sample). However, these reviews are now somewhat incomplete given the substantial growth in risk preference methods and more recent estimates of European farmers' risk preferences.

Our comprehensive review of the literature produces a unique compilation of 51 articles focusing on the measurement of farmer risk preferences in Europe. We not only document the characteristics and findings of each article but also categorize the identified articles by the method used to measure risk preferences.

2. Sampling Procedure

2.1 Search strategy and inclusion criteria

In compiling our sample of articles we followed the "Systematic reviews and meta-analyses guidelines" proposed by the Cochrane Collaboration (Higgins and Green, 2011).

Our systematic review used specific search criteria employed over a large range of databases (see Table 1), focusing on reasonable combinations of the keywords listed in the first column of Table 1.³

Table 1. Search Strategy

Keywords	Searched Databases
risk preferences	Academic Search Premier
risk attitudes	AgEcon Search
Arrow-Pratt	Business Source Premier
measurement	EBSCO
Europe	Google Scholar

³ For instance, one example of a search strings used on Scopus was: TITLE-ABS-KEY("risk preferences" AND farmer AND measurement). The list with all combinations of keywords used to identify relevant literature is available in Appendix A1 (on-line).

elicitation	JSTOR
questionnaire	Science Direct
likert	Scopus
farmer	SSRN
expected utility theory	Wiley Online Database
cumulative prospect theory	
Holt and Laury	
Eckel and Grossman	
structural form	

The primary list was screened on the titles and abstracts to exclude articles which did not meet our inclusion criteria. For instance, articles not related to the farming sector and/or focusing on other geographical areas were discarded. Then, a “snowballing” procedure was employed (Longhi *et al.*, 2005), where the reference list of the shortlisted articles was scrutinized along with an examination of articles that cited the shortlisted articles.

The literature search included all relevant articles published in English up until December 31st 2017. Articles appearing as grey literature before this date but published by the final date of this review (November 2018), were also included as the most recent version. In cases where more than one version of an article is available (e.g. a working paper and a peer-reviewed published version) only the published article, or the most recent working paper was included.

Within our broad European geographical focus, our selected studies focus on single countries, regions, or are delimited to smaller geographical areas or look at specific production types such as grape production or hog farms.

The authors’ purpose for eliciting farmer risk preferences was an important factor defining the filters used to build the database. Our focus is on literature measuring farmer risk preferences, so we exclude articles using specific assumptions about farmer’s risk preferences as an explanatory variable for a particular hypothesis. Our initial screening generated a list of 51 articles to be read in more detail. Of these, 36 are peer-reviewed articles and 15 are in the

grey literature representing either reports or unpublished working papers.⁴ We further outline in Appendix A3 (on-line) the process that led to the final selection of articles using a “preferred reporting items for systematic reviews and meta-analyses” (PRISMA) flow diagram (Moher *et al.*, 2009).

A minimum of two of all our co-authors read each article in the long list. Periodic and regular meetings of the five-person research group resolved disagreements regarding the inclusion of a specific article in our review, and clarified other issues such as the most appropriate way to summarize and/or interpret possibly ambiguous findings and methodological categorizations.

2.2 Organizing the data

There is a great deal of variation in the methods which the 51 articles used to measure risk preferences, categorised in Figure 1, We group the 51 articles in two main methodological groups: **observed economic behaviour from secondary data**; **elicited preferences from primary data**, which are then further categorized as shown Figure 1, to summarize relevant metrics for each article.

⁴ Working papers are classified within grey literature if they have not been published within a time span of five years from their first appearance as working papers (Hirsch, 2018).

Figure 1 Categorization of methods to measure farmer risk preferences in Europe. (Numbers in brackets represent the total number of instances a method is used. Some articles rely on more than one method, hence more than one method can be counted within the same article).

1. Observed economic behaviour from secondary data

a. Econometric and Mathematical methods. These are used to measure risk preferences from secondary data. The main principle underlying these methods is to estimate risk preferences by comparing the observed behaviour of agricultural producers with respect to input and output choices to behaviour predicted by theoretical models incorporating risk and risk preferences. Econometric applications dominate this group, but recently there have been interesting developments aimed at estimating risk preferences through farm-level mathematical programming models (Gómez-Limón *et al.*, 2003 and Arata *et al.*, 2017). The seminal work within this group of articles are Keeney and Raiffa, 1976; Antle 1983 and 1987; Chavas and Holt, 1996 and Bar-Shira *et al.*, 1997 and Heckelevi and Wolff, 2003.

2. Elicited preferences from primary data

a. Methods based on multi-item scales. These studies can be context free and/or context specific elicitation of risk preferences by means of answers to a series of multi-item and scale based questions. These methods cannot be linked to economic theory/a utility function and are often used in conjunction with experimental lottery based methods. We selected two articles seminal for the development of this methodological group: Dohmen *et al.*, 2011 and Weber *et al.*, 2002).

b. Methods based on lottery-choice tasks. These methods can be hypothetical or incentive compatible elicitation mechanisms such as incentive compatible experimental lotteries that are generally executed as artefactual field experiments. We identified three seminal articles for this methodological group: Holt and Laury, 2002;

Tanaka, Camerer and Nguyen, 2010, Pennings and Garcia, 2001. Holt and Laury (2002), in particular, has become the most replicated method to elicit risk preferences in the field and laboratory across a number of disciplines, including agricultural economics.

While some information is relevant for all the selected articles (e.g. which European country is covered in the study or the sample size) other key metrics are essential only within one of the sub-groups comprised in Figure 1 by the dashed boxes, but irrelevant or non-applicable in others. For example, whether a study is incentivized or not is a key feature for economic lottery-choice tasks but is a non-applicable metric for methods based on multi-item scales and studies retrieving risk preferences from secondary data of observed economic behaviour. Appendix A4 (on-line) summarizes the specific metrics that were extracted for our systematic review.

We also noted that most articles included in this review seek inspiration from a specific study that set a ‘gold standard’ for a given methodology. Together, the set of studies from which inspiration is drawn is presented in Appendix A5 (on-line).

3. Discussion

Tables 2, 3 and 4 document key elements from articles included in our systematic review. Each table focuses on a specific method of analysis as outlined above. Detailed definition of the metrics used in the headings, as key elements to summarize the studies presented in Tables 2, 3 and 4, are presented in Appendix A4 (on-line).

The key metrics presented in Tables 3 and 4 present several similarities on domains such as geographical focus (e.g. European region) and sample size, reflecting papers comparing different methods (e.g. Menapace *et al.*, 2016; Pennings and Garcia, 2001).

Several papers (e.g. Flaten *et al.*, 2005; Gardebroek, 2006; Groom *et al.*, 2008) explore the extent of variation in risk preferences across producer types or production methods. The focus on a specific production group has been justified on multiple grounds. Some authors stress that

conclusions on risk preference of one group of farmers (production type or method, e.g. cereal farmers, organic producers) cannot be extended to other producers (e.g. vegetable farmers, conventional farming). Others mention concerns of cross-sectional heterogeneity in risk preference as a reason to narrow the sample in their empirical analysis (Koundouri *et al.*, 2009). The literature also suggests that researchers and policymakers should be cautious in drawing conclusions about the risk preference of farmers in a specific country from those elicited from convenience groups, such as students in the same country, or farmers in another country. Other authors specifically restrict their sample to particular farmer groups or types for different, usually policy-related, reasons.

Table 2. Observed economic behaviour from secondary data

Study	Country	Sample category ^a	Sample size(s) ^b	Year of Analysis	Decision-making context	Risk estimate range	ARC ^c	RRC ^d	Other	Summary of results on findings on risk aversion (i.e. Risk Averse, Neutral or Seeking)
Oude Lansink (1999)	NL	Arable crops farmers	46	1975 – 1992	Under price uncertainty	>0 → risk averse		[0.20; 0.31]		Risk averse
Kumbhakar (2002a)	NO	Salmon producers	28	1985 – 1992	Under output price uncertainty	$ \theta > 0 \rightarrow$ risk averse			[-0.0814]	Risk averse
Kumbhakar (2002b)	NO	Salmon producers	216	1992	Under production uncertainty and technical inefficiency	>0 → risk averse		[0.051]		Risk averse
Lien (2002)	NO	Wealthy and non-wealthy farmers; individual case farms	2136 obs.	1988 1993 – 1998		0.5 (hardly risk averse at all) to 4 (very risk averse)		[0.08 to 10.8; 1.45; 1.87; 2.21]		Behaviour ranges from Hardly risk averse to Very risk averse . Absolute risk aversion is a decreasing function of wealth.
Gómez-Limón <i>et al.</i> (2003)	ES	Farmers in an irrigated area	52	1993 - 2000		>0 → risk averse		[18.5]		Risk averse ; 45% of farmers can be classified as risk neutral and 41% can be classified as highly risk averse

Kumbhakar and Tveteras (2003)	NO	Salmon farmers	28	1985 – 1993	Under production risk	>0 → risk averse	[0.396]	Risk averse
Gardebroek (2006)	NL	Organic, conventional arable farmers	37; 143	1990-1999	Organic versus conventional farming	>0 → risk averse	[4.04; 6.07]	Risk averse; Organic farmers are less risk averse when compared to conventional farmers
Sckokai and Moro (2006)	IT	Small, medium and large arable crops farm owners	6858 obs.	1993 – 1999	Under price uncertainty	>0 → risk averse	[0.049; 0.447; 5.531]	Risk averse , with small farms being the most risk averse, and large farms being the least risk averse
Groom <i>et al.</i> (2008)	CY	Cereal, vegetable farmers	283	1998	importance of estimating risk preference when evaluating water policy	>0 → risk averse	[0.3401; 0.0726]	Risk averse; On average both cereals producers and vegetable producers are risk averse but the extent of risk aversion varies across the two groups
Serra <i>et al.</i> (2008)	ES	Organic and conventional arable farms	68; 3626 obs.	2001 - 2003	Organic versus conventional farming	>0 → risk averse	[0.4562; 1.015]	Risk averse; Organic (wealthier) farmers are less risk averse as compared to conventional farmers
Koundouri <i>et al.</i> (2009)	FI	Small, medium and large farm owners	100	1992 - 2003	Under changing policy environment	>0 → risk averse	[-1.476; -0.24; -0.884 to 0.32; 0.223; 0.32]	Risk averse; Risk seeking; Heterogeneity in risk attitudes across farmers and years. Risk coefficient is positive until the EU accession year, after which it becomes negative.

Couture <i>et al.</i> (2010)	FR	All farmers	29	1997 – 2008		0.5 (hardly risk averse at all) - 4 (very risk averse)	[0.29]	Slightly Risk averse
Picazo-Tadeo and Wall (2011)	ES	Rice farmers	130	2004	Under production risk	>0 → risk averse	[0.0027]	Risk averse
Sauer (2011)	UK	All farmers	5811; 7147 obs.	1980 - 2008	Under natural disasters: Flooding	>0 → risk averse	[3.684; 1.072]	Risk averse ; High flood risk area farmer more risk averse than low flood risk area farmer
Vollenweider <i>et al.</i> (2011)	IE	Dairy farmers	242; 815 obs.	1995 - 2009	Adopting rural environment protection scheme	>0 → risk averse	[2.23]	Risk averse
Foudi and Erdlenbruch, (2012)	FR	All farmers	243 obs.	2006-2007	Adopting irrigation technology	>0 → risk averse	[0.006]	Risk neutral
Bozzola (2014)	IT	Cereal, field crops and vegetable farmers	4913; 7671; 7681; 11543; 15928	1981-2003	Adopting irrigation technology	>0 → risk averse	[2.064; 0.687; 0.235]	Risk averse ; On average all producers are risk averse but the extent of risk aversion varies across producers groups and time
Piet and Bougherara (2016)	FR	All farmers	186	1992-2003	Contracting crop Insurance	<1 → risk averse	[0.574; 0.619]	Risk averse ; Risk averse under two theoretical frameworks

Arata <i>et al.</i> (2017)	IT	Arable Crop farmers	42		Crop price volatility	>0 → risk averse	[0.0000 to 0.00592]	Risk averse to Risk neutral
Kobus and Was (2017)	PL	All farmers	485	2004 - 2010	Impact of CAP	>0 → risk averse	[1.117 to 1.717]	Risk averse; Risk aversion decreases with time

Notes: ^a Lists the sample and sub-samples included in the article; ^b Number of farm units included in the study (where available). If a study reports the overall number of observations (e.g. in an unbalanced panel dataset) but not the precise number of farms, we indicate it adding the abbreviation “obs”. If a range is given it is because different sub-samples were used in the particular study; ^c ARC - Coefficient of Absolute Risk Aversion (or Arrow–Pratt risk aversion coefficient). If multiple estimates are given (range or distinct values) it is because different estimates were given in the particular study. Values are means unless otherwise specified; ^d RRC - Coefficient of Relative Risk Aversion. If multiple estimates are given (range or distinct values) it is because different estimates were given in the particular study. Values are means unless otherwise specified. For more details, refer to Appendix A4 (on-line).

Table 3. Methods based on multi-item scales

Study	Country	Sample category ^a	Sample size(s) ^b	Approach	Risk estimate range [RS → RA] ^c	Estimate value ^d	Summary of results on findings on risk aversion (i.e. Risk Averse, Neutral or Seeking)
Pennings and Smidts (2000)	NL	Hog Farmers	346	DSSR	9 → 1		Risk seeking
Pennings and Garcia (2001)	NL	Hog farmers	373	DSSR	4 → (-4)		Risk averse; Risk seeking
Meuwissen <i>et al.</i> (2001)	NL	Livestock farmers	737	DSSR	5 → 1		Risk averse ; More risk averse farmers have significantly larger farms.
Koesling <i>et al.</i> (2004)	NO	Crop farmers (organic and conventional)	109; 379	DSSR	7 → 1	[2.99; 3.95]	Organic farmers perceived themselves to be less risk averse than their conventional colleagues
Flaten <i>et al.</i> (2005)	NO	Dairy farmers (organic and conventional)	162; 363	DSSR	7 → 1		Risk averse ; Organic farmers perceived themselves to be less risk averse than their conventional colleagues
Lagerkvist (2005)	SE	All farmers	120	DSSR	5 → 1		Slightly risk averse
Belhenniche <i>et al.</i> (2009)	FR	Dairy farmers	80	DSSR	1 → 5		Risk averse
Kallas <i>et al.</i> (2010)	ES	Vineyard farmers	147	DSSR	10 → 0		Risk averse ; farmers who are not risk averse are more likely to adopt organic farming
Hansson and Lagerkvist (2012)	SE	All farmers	237	DSSR	1 → 7		Risk averse in all domains
Reynaud and Couture (2012)	FR	All farmers	30	DSSR	7 → 1		Farmers very risk averse

							in ethical and financial matters. They seem to be willing to take more risks in the social context.
Maart-Noelck and Musshoff (2014)	DE	All farmers	104	DSSR; DISR	10 → 0; 1 → 3	[4.9; 2.1]	Risk averse
Sulewski and Kłoczko-Gajewska (2014)	PL	All farmers	600	DSSR	0 → 10		Risk averse , but a little more in terms of their personal health and less in the case of the farm.
Sauter <i>et al.</i> (2015)	DE	All farmers	150	DISR	10 → 1	[4.65]	Slightly Risk averse to Almost Risk neutral
Menapace <i>et al.</i> (2016)	IT	All farmers (but focus on apple farmers)	98	DISR	10 → 0	[5.64]	Risk averse
Rommel <i>et al.</i> (2018)	DE	All farmers	146	DSSR	10 → 0		Slightly risk averse
Sok <i>et al.</i> (2018)	NL	Dairy farmers	415	DSSR	5 → 1	[2.66]	Risk averse
Meraner and Finger (2017a)	DE	Livestock farmers	64	DSSR; DISR	10→1	[5.45]	Risk averse
Howley <i>et al.</i> (2017)	IE	Farmers	364	DSSR	1→7		Risk averse

Notes: ^a Lists the sample and sub-samples included in the article; ^b Number of farmers included in study sample (where available). If a range is given it is because different sub-samples were used in the particular study; ^c Range of Likert Scale values; the arrows indicated that values move from risk seeking behaviour to risk averse behaviour; ^d Mean value of estimate, where available. For more details, refer to Appendix A4 (on-line).

Table 4. Methods based on lottery-choice tasks

Study	Country	Sample category ^a	Sample size(s) ^b	Approach	Incentivized	Risk estimate range	ARC ^c	RRC ^d	Other	Summary of results on findings on risk aversion (i.e. Risk Averse, Neutral or Seeking)
Smidts (1997)	NL	All farmers	253	CE	Hypothetical	>0 → risk averse		[0.031; 0.043; 0.051; 0.053]		Majority of the respondents are intrinsically Risk seeking
Pennings and Smidts (2000)	NL	Hog Farmers	346	CE	Hypothetical	>0 → risk averse	[-0.884; 0.334]			Majority of the farmers were Risk seeking
Pennings and Garcia (2001)	NL	Hog Farmers	373	CE	Hypothetical	>0 → risk averse	[-2.084; -1.580]			Majority of the farmers were Risk seeking
Pennings and Wansink (2004)	NL	All farmers	30; 50; 128	CE	Hypothetical	>0 → Risk averse	[-0.462; 0.118; 0.316]			Average producer exhibits Risk seeking behaviour, the wholesalers and processors are Risk averse
Belhenniche <i>et al.</i> (2009)	FR	Dairy farmers	80	CE	Hypothetical	>0 → risk averse	[0.770]			Dairy farmers are mainly price Risk averse or Risk neutral
Bougherara <i>et al.</i> (2011)	FR	All farmers	30	HL; TCN	Yes	>0 → risk averse		[0.125; 0.803]		Farmers are Slightly risk averse in the expected utility framework
Reynaud and Couture (2012)	FR	All farmers	30	HL; EG	Yes	>0 → risk averse		[0.14; 0.36; 0.62; 1.02]		Risk neutral; Slightly risk averse; Risk averse and Highly risk averse
Roussy <i>et al.</i> (2012)	FR	Cash crop farmers	23	HL; TCN		>0 → risk averse		[0.75]		Highly risk averse
Menapace <i>et al.</i> (2013)	IT	Apple farmers	313	EG	Hypothetical					Highly risk averse

Tubetov <i>et al.</i> (2013)	DE	All farmers	106	HL	Yes	HL = 0-3: risk-seeking, HL = 4: risk-neutral, HL = 5-9: risk averse	[4.8]	Based on the proposed classification, farmers can be classified as lying between risk neutral and risk averse behaviour
Bocqueho <i>et al.</i> (2014)	FR	All farmers	107	TCN	Yes	$1 - r > 0.5$ ~ risk averse	[0.21; 0.28]	Risk averse under both theoretical frameworks
Maart-Noelck and Musshoff (2014)	DE	All farmers	104	HL	Yes	$>0 \rightarrow$ risk averse		Risk averse
Sauter <i>et al.</i> (2015)	DE	All farmers	150	HL; EG	Yes	$>0 \rightarrow$ risk averse	[-0.35; -0.497]	Risk averse ; Higher risk aversion for foresters in comparison to farmers
Rommel <i>et al.</i> (2018)	DE	All farmers	146	HL	Incentivized and Hypothetical			The modal participant is slightly risk averse
Menapace <i>et al.</i> (2016)	IT	Apple farmers	98	EG	Hypothetical	$>0 \rightarrow$ risk averse	[2.80; 3.71]	Risk averse
Vollmer, <i>et al.</i> (2017a)	DE	Farmers	42	HL	Yes	$>0 \rightarrow$ risk averse	[0.35]	Slightly risk averse
Meraner and Finger (2017a)	DE	Livestock Farmers	64	HL	Yes	$>0 \rightarrow$ risk averse	[0.30]	Risk averse
Hermann, <i>et al.</i> (2017)	DE	Farmers	152	HL	Yes			Majority of the farmers are reported to be Risk averse
Vollmer <i>et al.</i> (2017b)	DE	Conventional hog farmers; Organic Hog farmers	84	HL	Yes	HL = 0-3: risk-seeking, HL = 4: risk-neutral,	[6.1; 5.3]	Risk averse ; no significant difference between conventional and organic farmers

Schaak <i>et al.</i> (2017)	DE	Farmers	87	HL	Yes	HL = 5-10: risk-averse HL = 0-3: risk- seeking, HL = 4: risk- neutral, HL = 5-10: risk-averse	[5.16]	Slightly risk averse
Bougherara <i>et al.</i> (2017)	FR	Farmers	197	HL; TCN	Yes	>0 → Risk Averse	[0.614]	Risk averse

Notes: ^a Lists the sample and sub-samples included in the article; ^b Number of farmers included in study sample (where available). If a range is given it is because different sub-samples were used in the particular study; ^c Coefficient of Absolute Risk Aversion. If multiple estimates are given (range or distinct values) it is because different estimates were given in the particular study. Values are means unless otherwise specified; ^d Relative Risk Coefficient. If multiple estimates are given (range or distinct values) it is because different estimates were given in the particular study. Values are means unless otherwise specified. For more details, refer to Appendix A4 (on-line).

We also observe an increase of the number of studies meeting our inclusion criteria (Figure 2), suggesting that a review of the methods and implications is worthwhile.

Figure 2 Evolution of the use of method categories over time

Looking at the evolution of methods through time, methods inferring risk preferences from econometric and mathematical methods dominated until the end of the first decade of the 2000s. In the last two decades, these estimation techniques have become more refined and robust, partly due to the availability of large panel datasets. Earlier studies relied on cross sectional farm level data, recognized as a clear limitation in the empirical estimation of risk preferences (see e.g. Groom *et al.*, 2008). Hynes and Garvey (2009) discuss the advantages of panel data techniques over static frameworks as they allow to control better for unobserved heterogeneity or path dependency. However, a caveat that continues to be frequently mentioned in the literature is the need to control better for unobserved variation, for example in the policy and technology environments in which farmers operate, or due to individual characteristics such as gender and parental background (Eckel and Grossman, 2002; Dohmen *et al.*, 2011; Kim and Lee, 2014) or environment characteristics (Saastamoinen, 2015). Controlling for all (or at least a large range of) possible explanations for the observed behaviour remains to date particularly

problematic when using secondary data. The researcher does not observe the range of attributes that she would observe in experimental data, and this shortcoming substantially increases the chance that the estimated risk aversion coefficients will be biased. Another criticism of these studies is that they mostly focus on production risk, while other potentially important drivers such as price uncertainty are usually not taken into account. Exceptions that take price uncertainty into account include Oude Lansink, 1999; Sckokai and Moro, 2006; Gardebroek, 2006; Serra *et al.*, 2008 and Arata *et al.*, 2017. Isik (2002) shows that results from studies that focus on the impacts of market-based policies on input use and output under either output price or production uncertainty may not hold if both these types of uncertainties are present, because they may have opposite impacts on input use (*ibid*: 558). In addition, new criticisms have emerged over econometric estimation of risk preferences. Just and Pope (2003) state that empirical research on agricultural risk can severely overestimate risk aversion if observed risk responses are attributed entirely to utility function curvature. Gardebroek (2006) recognizes the importance of investigating risk perceptions as well as risk preferences as a topic for further research. Our review reveals that to date this latter topic remains under-investigated although the developments in other methodological approaches seem to help addressing this research question (see for example Pennings and Garcia, 2004; Pennings and Wansink, 2004; Just and Just, 2016). Just and Just (2016) warn that empirical studies of risk behaviour must estimate both unobservable preferences and the unobservable mapping of available information into subjective probability beliefs (Just and Just, 2016: 1182). Lence (2009) and Just and Just (2011) argue that separate identification of (production) risk and risk preferences from behavioural equations (i.e. first order conditions on input choices) estimated on observed data is impossible, hence restrictions have to be imposed either on the technology or on the form of the utility function for parameters to be identified.

Since 2010, methods based on multi-item scales and methods based on lottery-choice tasks are increasingly employed to identify farmers' risk preference (Figure 2). This trend is partly driven

by attempts to overcome the limitations of empirical studies from observed behavioural secondary data but even more so by rapid developments in experimental economics and psychology (e.g. see Menapace *et al.*, 2013 and 2016; Mata *et al.* 2018).

When considering multi-item scales methods, the data presented in Table 3 reveal that while earlier studies mostly use domain *specific* (or contextualized) self-report questionnaires (DSSR), there has been a shift in the last five years towards a more frequent use of studies using domain *independent* questionnaires (DISR) to assess risk preferences. However, domain specific self-assessment questionnaires continue to be more often employed than the domain-independent methodological variant. This reflects the findings of previous research that individuals display different behaviour towards risk in different contexts such as financial, recreational, ethical or health-related decisions, indicating that risk preferences are context dependent, although conventional utility theory supposes that gains are independent of the circumstance of the gamble (Menapace *et al.*, 2016: 116). Overall, while multi-item scale methods offer good potential to elicit risk preferences at a low marginal cost, being quick to execute, straightforward and simple (Menapace *et al.*, 2016), they suffer from disadvantages. First, due to the typical lack of incentives, it has been questioned whether these methods elicit ‘true’ attitudes towards risk, since incentive compatibility is held to be essential for a true understanding of risk preferences (Charness *et al.*, 2013). As these authors also point out, there is a trade-off between the simplicity of the method and the possibility that responses are poorly thought through, and may well lead to inconsistency (Hardaker *et al.*, 2005).

As Table 4 indicates, estimation of risk preferences using the certainty equivalence method by means of lotteries effectively ceased in 2004 (as the date of publication). Since the early 2000s the Holt and Laury lottery (Holt and Laury, 2002), has been used with increasing frequency. In fact, the Holt and Laury lottery was the most frequent within this category in 2017, with five out of the six articles using this lottery type and only one based on Cumulative Prospect Theory.

While lottery-choice tasks based on Cumulative Prospect Theory allow for an understanding of behaviour in the loss domain, this method suffers from the disadvantage of being rather complex, and some respondents possibly failing to understand the procedure or the probabilities involved (Charness *et al.*, 2013) or being more prone to errors, because of the larger number of lottery-choices to respond to during one experimental session.

Lottery-choice tasks lend themselves to an adoption in a variety of contexts and allow for a less fragmented approach to the study of risk attitudes (Charness *et al.*, 2013), but these methods too, have their own challenges and limitations, generally acknowledged in the literature. For example, Menapace *et al.*, (2016) have shown that while framing matters in eliciting farmers' preferences in hypothetical lottery-choice tasks, there is still a paucity of studies that employ lottery-choice tasks or artefactual field experiments in a manner that allows elicitation tasks to be contextualized and resemble real on farm decision problems. A recent attempt to bridge this literature gap is Cerroni (2018), who conducts an incentivized framed field experiment with Scottish farmers to elicit risk and ambiguity preferences.

Another challenge faced in these studies is that real-word farming decisions such as number of pesticide applications or crop insurance participation generally involve in Europe a gamble over substantial sums of money. Constraints in the budget available to the researchers usually allow a payout only to a randomly assigned portion of participants (e.g. Maart-Noelck and Musshoff, 2014), or consider small-stakes gambles (e.g. Andersen *et al.*, 2008), that may not capture the appropriate attitude towards risk of farmers in real-world settings involving more substantial stakes (see Rabin, 2000, Menapace *et al.* 2016 and Vollmer *et al.*, 2017a for discussions on this aspect). Another problematic issue is that responses may cluster around a few options. For instance, Andersen *et al.* (2006) put forth evidence that experimental subjects display a slight tendency of anchoring and choose a switching point around the middle for risk elicitation tasks. Owing to the statistical inefficiencies of such a bias, running a pre-test and adjusting the

multiple price list could help boost statistical efficiency. Csermely and Rabas (2016) employed a randomization in the order in which risk elicitation tasks appear, as a way to address the anchoring problem. Implementing such measures is of even greater relevance within the study of agriculture which often faces the pre-existing constraint of limited farmer samples.

Despite the aforementioned challenges, while the use of lottery-choice tasks was limited in the 90's, this method has witnessed the strongest growth rate across the three categories as seen in Figure 2, becoming dominant in the most recent, 2010-2017 years. Additionally, it is important to note that a decision with regards to using one particular method over another is not without trade-offs. For instance, multi-item scales are more intuitive but they cannot be linked to economic theory/a utility function. Hence, we cannot exclude that people perceive these scales in different ways, and the results may not be meaningfully compared across individuals. This lack of standardization becomes a disadvantage of this method. Lottery choice tasks overcome this problem, due to their link to economic theory. However, it can be argued that non-contextualized lotteries lack the intuitive nature that multi-item scales possess.

Overall, the studies using secondary data estimate a broader range of risk preferences parameters. Since risk attitudes, perceptions and preferences cannot be directly observed, measuring them in a realistic and accurate manner is a difficult task (Pennings and Garcia, 2004). Methods based on multi-item scales and articles estimating risk preference from secondary data generally find a majority of their samples exhibiting risk preferences that range from highly risk averse to risk seeking. Results from the methods based on lottery-choice tasks range from highly risk averse to risk neutral.

Looking at the geographical coverage, although studies focusing on (regions of) Germany tend to be more recent, with the first peer-reviewed study we found published in 2013, this is the country that sees the highest number of academic explorations on eliciting farmer risk preferences. The countries that follow are France, The Netherlands, Italy and Norway. The

paucity of studies looking at new member states and Eastern European countries (see Appendix A2, on-line), calls for interesting avenue of further research, as these countries are generally characterized by different type of production, prices and policy risks.

In sum, our systematic review shows some methodological advances within each method group but also a shift across methods, for example towards a more prominent use of multi-item scales and incentive compatible elicitation techniques. Eliciting risk preferences in agriculture from primary data is becoming more popular with a substantial increase in the number of studies eliciting or estimating risk preferences, reflecting both an increase in the total population of empirical articles, and a growing recognition of the importance of understanding risk attitude in economics and policy analysis.

4. Conclusions

We analyse two decades (1997-2017) of literature estimating farmer risk preferences in Europe, which resulted in a systematic review of 51 relevant studies.

Our review identifies key features of this literature, which include: capturing the heterogeneity in the contexts in which risk preferences are measured; summarizing the key elements and methodological specifics of the selected articles; presenting and classifying their results.

We find a strong increase of studies eliciting risk preferences of European farmers over time: in the period 2010-2017 37 studies were identified, compared to two in the period 1990-1999 and 20 in the period 2000-2009. Overall, the findings also point to the heterogeneity of methods, samples and results. This finding not only re-establishes the need to document the breadth of work in a review of this nature but also raises questions for the direction of future research in this domain.

While this review aims to contribute to the domain of risk preference measurement looking at European agricultural context, there are certain limitations that require acknowledgement.

In general, our review suggests that it is reasonable to support the assumption that European farmers are risk averse, although risk aversion is necessarily a relative concept and measure, and likely to be context and circumstance specific. In particular, it seems at least possible that farmers, in choosing to be farmers in a particular sector, reveal differences in risk preferences compared to the population in general.

However, it is important to note that this claim is based on a counting principle and does not address the question of whether the average European farmer is risk averse based on a statistical analysis of the underlying estimates. A numerical meta-analysis of the existing estimates would strengthen or weaken this claim. Unfortunately, the comprehensive requirements for a meta-analysis are not fulfilled by the data that can currently be generated from the literature. A meta-analysis requires coefficients that are directly comparable to one another. While at initial glance it may seem that all the risk aversion coefficients (e.g. Arrow-Pratt coefficients) across studies satisfy this assumption, the challenge surfaces when the nature of the coefficient is considered. As noted in OECD (2004), comparisons of absolute risk aversion estimates are difficult because the risk aversion estimate is dependent on prices, quantities or income used in its calculation. Seeing as a large number of studies report constant absolute risk aversion (CARA) coefficients, this limits the sample of available estimates to constant relative risk aversion (CRRA) coefficients.

Another limitation of our study is that we rely on authors' self-proclaimed research design and results, which introduces a possible source of bias. In principle, systematic reviews should be backed up by correspondence with the authors and subsequent replication and/or reproduction of their results, which is often not feasible due to resource constraints. Duvendack and Palmer-Jones (2012) highlight the need for replication or reproduction, as even results from articles published in top rank peer-reviewed journals may not be replicable. The increasing publication of entire datasets on risk elicitation tasks with farmers (e.g. Meraner and Finger, 2017b) will

enable and improve quantitative meta-level conclusions on risk aversion and its determinants. This speaks to the larger need for increased transparency, data sharing and reproducibility of results. Lack of transparency thwarts attempts to conduct a meta-analysis of risk preferences or for researchers to replicate previous analysis.

Additionally, the influence of a number of external factors such as cultural background or location (Hsee and Weber, 1999) increase challenges to aggregate farmers' preferences across a larger geographical region. This limitation can be also circumvented in a meta-regression analysis while the use of a systematic review restricts the ability to make an aggregate claim. Along these lines, a European wide research project, e.g. under the umbrella of the European Commission, may be useful to derive consistent and comparable information on risk preferences of European farmers.

We do not address the question of whether farmers in other OECD countries (e.g. the US and Australia) or farmers in developing countries are method variant with respect to risk preference measurement. We cannot answer the question of whether two farmers from two different regions would have the same level of risk aversion but would respond differently to the risk attitude elicitation techniques. Furthermore farmers from different regions or with different organizational structures may face dissimilar economic constraints and conditions that might lead to differences in risk preferences, as well as a different choice of tools to manage risk. A related aspect that deserves further investigation is whether, and under what conditions, risk preferences of farmers in a given country can be approximated through those of convenience groups. For example, results in Maart-Noelck and Musshoff, (2014) suggest, though not conclusively, that differences in the risk preferences across groups result from the particular participants' affiliation to different occupational groups than from their different nationalities. These questions are left for future research.

We hope that this review helps researchers to continue to improve and develop our

understanding of risk preferences exhibited by farmers, and partly determining their responses to evolving policy and market conditions.

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Measuring Farmer Risk Preferences in Europe:

A Systematic Review

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On-Line Appendices: Supplementary Material

Appendix A1: Search strategy: keywords combinations

Table A1: Search strategy: keywords combinations

Keywords
“risk preferences” AND farmer AND Europe
"risk preferences" AND farmer AND measurement
“risk preferences” AND measurement AND farmer
(“risk preferences” OR “risk attitudes”) AND farmer
(“risk preferences” OR “risk attitudes”) AND measurement AND farmer
(“risk preferences” OR “risk attitudes”) AND (elicitation OR measurement) AND farmer
(“risk preferences” OR “risk attitudes”) AND “Arrow-Pratt” AND farmer
(“risk preferences” OR “risk attitudes”) AND likert AND farmer
(“risk preferences” OR “risk attitudes”) AND questionnaire AND farmer
(“risk preferences” OR “risk attitudes”) AND “expected utility theory” AND farmer
(“risk preferences” OR “risk attitudes”) AND “cumulative prospect theory” AND farmer
(“risk preferences” OR “risk attitudes”) AND “Holt and Laury” AND farmer
(“risk preferences” OR “risk attitudes”) AND “Eckel and Grossman” AND farmer
(“risk preferences” OR “risk attitudes”) AND “structural form” AND farmer

Notes: These combinations of keywords were used across all the databases listed in the second column of Table 1. Searches involving more than one word were executed using double quotation marks to ensure that the ordering of the words remains intact in the search results.

Appendix A2: Inclusion criteria geographical focus

This appendix shows the map and the list of countries for which we found at least one study eligible for inclusion in our systematic review.

Figure A2 countries for which at least one study met the inclusion criteria of this review. Numbers indicate the number of selected studies by country.

Table A2: Number of studies by country and methodology

	[1] Number of studies conducted	[2] Secondary Data	[3] Multi-item scales	[4] lottery-choice tasks
Cyprus	1	1		
Finland	1	1		
France	9	6	2	3
Germany	10		4	9
Ireland	2	1	1	
Italy	5	3	1	2
The Netherlands	8	2	4	4
Norway	6		2	4
Poland	2	1	1	
Spain	4	2	1	1
Sweden	2		2	
United Kingdom	1	1		

Notes: Column 1 indicates the number of studies conducted by country. Columns 2 to 4 indicated the number of instances in which a methodology was employed to estimate or elicit risk preferences. If more than one methodology is adopted in a given study, both counts towards the final numbers reported in columns 2 – 4.

Appendix A3: PRISMA Flow Diagram

Figure A3 Preferred reporting items for systematic reviews and meta-analyses (PRISMA) (Moher *et al.*, 2009) flow diagram.

Appendix A4: Review's Metrics

Metrics common to all methodologies

Country	Indicates a possible dominant geographical area of research.
Sample category	Captures aspects related to the sample of farms/individuals. Allows to gauge the diversity in the samples and sub-samples analyzed.
Sample size(s)	Number of farmers or farm units included in the study sample. When a range is given, it is because different sub-samples were used.
Risk estimate range	Range of Risk preferences. Anderson <i>et al.</i> (1992) specified threshold values of CRRA estimates that are often used by studies (e.g.: see Reynaud <i>et al.</i> , 2010). However, a number of articles that elicit risk preferences through a self-assessment questionnaire define their own respective thresholds of risk preferences which must be document when interpreting the output.
Summary of results on findings on risk aversion (i.e. Risk Averse, Neutral or Seeking)	The risk preference estimate can take a number of forms that include a coefficient of absolute (ARC) and relative (RRC) risk aversion or a multi-item scale value. Documenting the estimate type is essential when interpreting results. If multiple estimates are given (range or distinct values) it is because different estimates were given in the particular study. Values are means unless otherwise specified. For methods based on multi-item scales (Table 3), we report the mean value of estimate, where available. In Table 2 and 4 we report in separate columns ARC, RRC (when available) as well as the final conclusions of the articles in term of the (sub)sample's risk preferences.

Metrics: Econometric and Mathematical methods

Year of Analysis	Some articles use data over a number of years to be able to apply more refined techniques (e.g. panel data versus cross sectional studies).
Decision-Making Context	Articles often attempt to measure risk preferences within a context for e.g.: under the influence of price uncertainty (Oude Lansink, 1999).
ARC	Coefficient of Absolute Risk Aversion. Where applicable, multiple values of risk coefficients are reported as being representative of the risk taking propensity of the different sub-samples or different conditions within a given study. Since RRC is a transformation of ARC by wealth, the review reports RRC by default. If RRC value is not reported, ARC is reported. If both are reported, the present review only reports the RRC values.
RRC	Coefficient of Relative Risk Aversion. Where applicable, multiple values of risk coefficients are reported as being representative of the risk taking propensity of the different sub-samples or different conditions within a given study. Since RRC is a transformation of ARC by wealth, the review reports RRC by default. If RRC value is not reported, ARC is reported. If both are reported, the present review only reports the RRC values.
Other	In some cases, articles do not report absolute or relative risk aversion coefficients and instead, choose to report results in other forms. One example is the value reported in Kumbhakar (2002a).

Metrics: Methods based on multi-item scales

Approach	Within each method, some articles replicate an earlier study. For these methods, articles generally follows a domain specific or domain independent self-reporting approach. The data in this field has been coded as follows: DSSR – Domain Specific Self-Report DISR – Domain Independent Self-Report
Risk estimate range [RS → RA]	Within each study, authors specify the range of values that risk can take, with a specification of two bounds (one representing risk aversion and the other representing risk seeking behaviour). As values move in one direction, behaviour becomes more risk seeking (or risk averse, depending on the direction and what the bounds represent).
Estimate value	The mean value for risk in the sample. The values can be interpreted as risk averse, seeking, or neutral after being placed within the risk estimate range.

Metrics: Methods based on lottery-choice tasks

Approach	<p>Within each method, some articles replicate an earlier study. For instance, Menapace <i>et al.</i> (2016) directly employed the lottery design devised by Eckel and Grossman (2002). Data in this field is coded as follows:</p> <p>CE – Certainty Equivalence method HL – Holt and Laury (2002) EG – Eckel and Grossman (2002) TCN – Tanaka <i>et al.</i> (2010)</p>
Incentivized	<p>Indicates whether a study was incentivize compatible (yes), or specifies otherwise. A number of studies involve incentivizing the sample (e.g.: Bocqueho <i>et al.</i> (2014)) whereas some designs are hypothetical (e.g.: Pennings and Garcia (2001)).</p>
ARC	<p>Coefficient of Absolute Risk Aversion. Where applicable, multiple values of risk coefficients are reported as being representative of the risk taking propensity of the different sub-samples or different conditions within a given study. Since RRC is a transformation of ARC by wealth, the review reports RRC by default. If RRC value is not reported, ARC is reported. If both are reported, the present review only reports the RRC values.</p>
RRC	<p>Coefficient of Relative Risk Aversion. Where applicable, multiple values of risk coefficients are reported as being representative of the risk taking propensity of the different sub-samples or different conditions within a given study. Since RRC is a transformation of ARC by wealth, the review reports RRC by default. If RRC value is not reported, ARC is reported. If both are reported, the present review only reports the RRC values.</p>
Other	<p>In some cases, articles do not report absolute or relative risk aversion coefficients and instead, choose to report results in other forms. One example is the Holt and Laury (HL) value where the reported result takes a value between 0-10 (Holt and Laury, 2002).</p>

Appendix A5: Seminal Articles by Sub-Methodology

Table A5 outlines the most influential articles by methodological sub-group. Most of the articles included in our review seek inspiration from some specific studies which we refer to as “seminal articles”. We define seminal articles as those with the two highest number of frequency of mentions⁵ across all articles belonging to that specific method category within the database. For instance, within the category of identified articles based on multi-item scales, Pennings and Garcia (2001) and Dohmen *et al.* (2011) are the two studies referred most frequently as important⁶ influencers within the survey methodology domain.

An alternative strategy would entail using the number of times the article has been cited by other studies. However, this approach has the disadvantage that a given study could be frequently cited by articles that fall within the domains of other disciplines like other economics fields or psychology which could lead to a bias with regards to its importance within the agricultural domain. However, it is important to note that seminal articles themselves were purely selected for their methodological impact on subsequent work and do not necessarily focus on the agricultural sector. For instance, a number of articles based on lottery-choice tasks seek inspiration from the lottery proposed by Holt and Laury (2002) despite the fact that this study did not employ a sample of farmers in their experiment

Looking at the evolution of methods through time, methods inferring risk references from observed economic behaviour dominated until the end of the first decade of the 2000s. However, since 2010 methods based on multi-item scales and lottery-choice tasks are also increasingly employed as a mean to understand farmers’ risk preferences (Figure 2). This trend is driven by fast developments in economics and psychology (e.g. see Menapace *et al.*, 2013 and 2016; Just and Just, 2016; Mata *et al.*, 2018).

⁵ Counted as sum of the number of mentions received by a given article across the Introduction or Literature Review sections of articles within our sample.

⁶ Articles associated with words like “important”, “based on”, “seminal”, “pioneering”.

Table A5. Seminal articles

Methods	Methods Sub-categories	Influential/seminal article(s)
Econometric	Reduced-form / Non Structural	Antle (1983 and 1987) ; Chavas and Holt (1996)
	Structural form	Bar-Shira <i>et al.</i> (1997)
Mathematical	Multiple criteria paradigm	Keeney and Raiffa (1976); Heckelei and Wolff (2003)
Multi-item scale	Domain independent self-report	Dohmen <i>et al.</i> (2011)
	Domain specific self-report	Weber <i>et al.</i> (2002)
Lottery-choice tasks	Certainty equivalence	Pennings and Garcia (2001)
	Expected utility theory	Holt and Laury (2002)
	Cumulative prospect theory	Tanaka <i>et al.</i> (2010)