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REGULAR ARTICLE

RISK MANAGEMENT OF GERMAN FRUIT PRODUCERS

*Annkatrin PORSCH *[1], Markus GANDORFER [2], Vera BITSCH [3]*

Address:
[1] Technical University of Munich, Chair of Economics of Horticulture and Landscaping, Alte kademie 16, 85315 Freising, Germany, Phone: +49 176 344 91 272
[2] Bavarian State Research Center for Agriculture, Institute for Agricultural Engineering and Animal Husbandry, Vöttinger Str. 36, 85354 Freising, Germany and Technical University of Munich, Chair of Economics of Horticulture and Landscaping, Alte Akademie 16, 85315 Freising, Germany
[3] Technical University of Munich, Chair of Economics of Horticulture and Landscaping, Alte Akademie 16, 85315 Freising, Germany
* Corresponding author e-mail: annkatrin.porsch@tum.de

ABSTRACT

Horticultural farms in Germany face substantial business risks. However, fruit farms often struggle to implement appropriate risk management processes, and the risk management literature widely has ignored this farm type. The aim of the study was to improve the assessment of risks by farmers and the choice of suitable risk management instruments. Therefore, a risk management process based on subjective probabilities and suitable for small and medium-sized farms was developed, considering the specific needs of family run businesses. An online survey was conducted to achieve a comprehensive view of the risk perception and risk management practices of German fruit producers. Price and production risks are the most relevant risk categories for fruit farmers. However, among single risk sources, those in the people risk category were seen as the most important. Results show significant interactions among risk categories and a significant correlation between loss experience and the rating of risk categories. The assumption that risk averse farmers generally rate risks higher than risk neutral or risk seeking farmers cannot be confirmed. Diversification seems to be the most important risk management instrument for many fruit producers, especially diversification of marketing channels, farm income, and production activities. Further research should focus on the apparent inconsistency between the satisfaction with instruments reported by farmers and the actual implementation of many of them (e.g., hail insurance and anti-hail net). Furthermore, there is a need for research, to develop decision models considering the interactions of risks and risk management instruments, loss experience and risk seeking attitudes.

Keywords: horticulture, people risk, risk management instruments, subjective probabilities
JEL: D81, Q12, Q14

INTRODUCTION

Horticultural farms face substantial challenges regarding business risks. The approval of the minimum wage in Germany, low producer prices due to the Russian import ban, yield losses due to weather extremes and food scandals have increased the need for an appropriate risk management. However, only few prior studies investigate risk management of horticultural farms (e.g., **Martin 1996; Röhrig and Hardeweg 2014; Vassalos and Li 2016**). Because substantial differences between horticultural (e.g., fruit, vegetables) and agricultural farms (e.g., cash crop, dairy) exist (Table 1), the findings of the existing agricultural risk management literature are often not transferable to horticultural farms. Additionally, most fruits are perennial crops, implying that the decision to plant a perennial crop is comparable to a long-term investment decision. Thus, in contrast to vegetable and cash crop farms, the flexibility is limited.

Table 1. Average key operating figures relevant for risk management of different full-time farm types in Germany (three-year-average; 2012/2013 to 2014/2015) (**BMELV, 2016a, b, c**)

Farm type	Total cost €/farm	Share of labour expenses on total cost %	Share of subsidies on profit %
Fruit	208.500	23	20
Vegetable	367.877	25	8
Cash crop	284.298	7	63
Dairy	220.959	3	68

Although there is no doubt that farm management needs an appropriate risk management process, the implementation remains a challenge for many horticultural farms, who are typically small and medium sized family run businesses, in contrast to larger farms with more resources to implement a risk management process (**Reynolds-Allie, Fields, and Rainey 2013**).

The agricultural risk management literature provides different approaches for analysing risks and the choice of risk management instruments. These methods can be assigned to two fields: approaches with objective probabilities and approaches with subjective probabilities (**Barodte 2008; Hardaker and Lien 2010**). The risk management literature in agriculture mostly focuses on economic decision models, and therefore, on approaches with objective probabilities. According to **Hardaker and Lien (2005, p. 3)**, the "expected utility theory has been widely, if not universally, adopted as the best basis, at least for prescriptive decision analysis". Expected utility theory is commonly used for investigating particular research questions in the context of risk management decisions, such as the use of insurance, commodity marketing, or storage. However, farmers' actual decisions are often not consistent with results of decision models (**Hardaker and Lien 2010**; **Shaw and Woodward 2008**). In addition, **Just (2003)** and **Hardaker and Lien (2010)** criticized the research bias towards short run production decisions, instead of long term or larger risks. One of the main reasons for neglecting long term or larger risks is the lack of data (**Just 2003; van Winsen et al. 2013**) to derive objective probabilities for these risks. Thus, a possible solution is to use subjective probabilities. These approaches focus on risk perception and the analysis of risk behaviour and show various advantages compared to the approaches with objective probabilities: (1) all relevant risks and potential risk management instruments are taken into consideration, (2) they have fewer requirements for data availability, (3) and they are easier to apply and provide an overview of the risks and potential opportunities of the farm business (**Barodte 2008**).

Therefore, the first objective of the study was to develop a framework to capture the entire risk management process of small- and medium-size family run fruit farms - from risk perception to risk behaviour - based on subjective probabilities. The second objective of the study was to apply the framework developed to examine the risk management practices of German fruit producers. The third objective was to determine the role of risk attitude in risk perception and in the use of risk management instruments.

MATERIAL AND METHODS

Data

For data collection, an online survey was conducted. The survey consisted of five parts: questions related to, (1) risk perceptions, (2) applied risk management instruments, (3) satisfaction with applied risk management instruments, (4) risk attitudes and (5) socio-demographic data and farm characteristics. The survey was pretested to reduce ambiguities and misinterpretation. Three consultants, two fruit producers, and nine external experts were involved in the pre-test. The revised survey was sent to 16 German fruit producer associations. These associations forwarded the survey to their members in the period of October through December 2014.

Analysis of risk perception and risk behaviour of German fruit producers

To address the special needs of family run fruit farms and to provide comprehensive insights into the risk perception and risk behaviour of German fruit producers, a framework for small and medium sized non-agricultural enterprises developed by **Barodte, Montagne, and Bouttelier (2008)** is adapted in this study (Part 1 through 3 in the survey). They proposed a four-step procedure (Table 2), which is conducted in workshops with employees. In total, they tested the framework on 34 Swiss enterprises. The present study follows the general structure of the framework suggested. However, targeted changes were introduced (Table 2), because German fruit farms are typically family run businesses, and the decision-maker is normally the farm owner solely. Qualified employees to discuss farm risk management are often not available. Therefore, group discussions did not seem suitable for this study, and were replaced by surveying farm managers.

Table 2. Structure of the risk management process analysed, and adaptations introduced to address the specific characteristics of fruit farms

Steps in the risk management process	Proposed procedure by **Barodte, Montagne, and Bouttelier (2008)**	Adaptations in this study
(1) Identification of risk categories	Group discussion with employees to evaluate risk categories	Rating the risk categories by farm managers
(2) Identification of most relevant risk categories and risk sources	Visualizing the risk categories from step (1) into a risk matrix; group discussion with employees on the main risk sources within the risk category	Rating the risk sources for each category by farm managers
(3) Identification of appropriate risk management instruments	Group discussion with employees to identify appropriate risk management instruments to reduce relevant risk sources	Choice of the applied risk management instruments for each risk source by farm managers
(4) Evaluation of the applied instruments	Group discussion with employees to evaluate the effectiveness of the instruments applied	Rating the satisfaction of the applied risk management instruments by farm managers

In the first step (Table 2), farm managers had to assess relevant risk categories (e.g., production risk). For each risk category, a definition was given, e.g., production risks mean strong negative deviation of yield or quality parameters from the average. Respondents were asked to rate the risk category on 5-point Likert scales regarding "probability of occurrence" (1 = very unlikely; 5 = very likely), and "extent of damage" (1 = negligible; 5 = catastrophic). The resulting risk score is the product of "probability of occurrence" and "extent of damage", and can range from 1 to 25.

In the second step, respondents were asked to rate single risks, associated with the risk category (e.g., hail damage in the case of production risk). Farmers rated the risk in terms of the importance for the farm on a 5-point Likert scale (1 = not important; 5 = very important) (**Meuwissen, Huirne, and Hardaker 2001; Flaten et al. 2005**). The questions were close-ended questions, but after each risk category respondents had the possibility to enumerate further sources of risk.

In the third step, respondents were asked to identify the risk management instruments applied. Therefore, a list with possible risk management instruments within a specific risk category was presented to the respondents. In the fourth and last step, respondents rated their satisfaction with the risk management instruments applied on another 5-point Likert scale (1 = extremely unsatisfied; 5 = extremely satisfied). The results were visualized in a risk matrix to identify the most relevant risk categories.

Afterwards, an analysis of internal consistency was conducted for each risk category, to determine, if the items proposed to the farmers for each risk category were suitable and reliable (**Santos 1999**). Cronbach's alpha, which is "the most widely used measure of scale reliability" (**Peterson 1994, p. 381**), served as the indicator of reliability. Items within a category are seen as reliable, if Cronbachs's alpha value is above 0.7 (**Santos 1999**). Further, the ratings of single risk sources, the use of risk management instruments, and the satisfaction with applied instruments were analysed. For testing the significance of differences among means for more than two groups (e.g., risk averse, risk neutral, and risk seeking farmers), the Kruskal-Wallis-Test was applied. All calculations were conducted using IBM SPSS (version 23) for Windows.

Elicitation of risk attitudes

Risk attitude is considered as a crucial factor in risk perception and for the decision to apply a specific risk management instrument. Many experimental techniques have been developed to elicit risk attitudes; a detailed overview can be found in **Charness, Gneeze, and Imas (2013)**. In recent years, the Holt-and-Laury Lottery, a multiple price list experiment, has become a standard method to elicit risk attitudes. Advantages of this method include the easy interpretation of the results, and the determination of critical limits of relative and absolute risk aversion coefficients (**Ewald, Maart, and Mußhoff 2012**). Still, there are several limitations of this method. First, the Holt-and-Laury Lottery is incentive conform, making it a cost-intensive elicitation technique. Second, its integration in surveys is much more difficult than psychometric methods (**Ewald, Maart, and Mußhoff 2012**). Therefore, in studies investigating risk perception and risk behavior, psychometric methods in the form of business-related statements (**Meuwissen, Huirne, and Hardaker 2001; Koesling et al. 2004; Flaten et al. 2005**) or self-assessment (e.g., **Reynaud and Couture 2012**) are commonly used. Both forms of psychometric methods are easy to apply and less time-consuming compared to a Holt-and-Laury Lottery in survey research. While some studies found that risk attitudes vary depending on elicitation method (**Reynaud and Couture 2012**), **Ewald, Maart, and Mußhoff (2012)** compared three different methods to measure risk attitudes (Holt-and-Laury Lottery, self-assessment, and business-related statements) for German farmers and found statistical significant correlations between all methods.

In the present study, self-assessment and business-related statements are used to measure farmers' risk attitudes. In the case of business-related statements respondents can choose between three statements adapted from statements proposed by **Ewald, Maart, and Mußhoff (2012)**:

1. I am willing to spend money to reduce risks, because risks concerning my business are a threat to me. (risk averse)
2. I am not willing to spend money to reduce risks concerning my business. (risk neutral)
3. I am willing to take entrepreneurial risks consciously, if there is a chance of success. (risk seeking)

As proposed by **Ewald, Maart, and Mußhoff (2012)**, an 11-point Likert scale (0= not at all risk seeking; 10 = very risk seeking) for self-assessment, and the question proposed by the SOEP (Socioeconomic Panel) (How do you consider yourself: Are you rather a risk seeking person, or do you try to avoid risks?) (**DIW 2009, 6**) are used.

To analyse the risk attitudes, which have been measured through self-assessment and to compare them to the risk attitudes, which have been measured through business-related statements, the Likert scale was condensed into three groups. The risk averse group includes respondents assessing themselves 0 through 4, the risk neutral group includes respondents selecting with 5, and the risk seeking group includes respondents, assessing themselves 6 through 10 (**Ewald, Maart, and Mußhoff 2012**).

RESULTS AND DISCUSSIONS

The study's results are based on the fully completed questionnaires of German fruit farmers. In total, 263 questionnaires have been registered in the online survey system. The length of the questionnaire resulted in a high dropout rate. For the analysis 105 questionnaires remained, due to the requirements of complete risk assessment and socio-demographic questions. The average time needed to complete the survey was 37 minutes. The desirability of a larger dataset in terms of statistical analysis notwithstanding, the sample includes

2% of the population of German fruit farmers (Table 3) and provides representative insights in the risk perception and the use of risk management instruments of German fruit farmers.

Fruit producers' risk perception

The first step of the applied risk management framework consisted of the subjective assessment of risk categories by the respondents. Results are illustrated in a risk matrix, which serves to identify relevant risks with a high damage potential, and/or a high probability of occurrence. According to the risk matrix (Figure 1), production and price risk are the most important risks, while asset risk appears least important.

Table 3. Description of the sample (n=105)

	Description	Frequency %	Mean
Age	Years		49.0
Gender	Male	85.7	
	Female	14.3	
Education	Journeyman	3.8	
	Foreman	49.5	
	Technician	4.8	
	Engineer	24.8	
	Student	5.7	
	Others	11.4	
Farm size (ha)			51.7
	<30	54.3	
	30 to 60	26.7	
	<60	19.0	
Share of rented land (%)			50.2
	0 to 50	51.4	
	>50	48.6	
Number of different fruit crops grown on the farm			2.7
	<2	21.9	
	2 to 4	65.7	
	>4	12.4	
Degree of diversification			2.1
Number of horticultural or agricultural branches (not fruits)			
	0	6.7	
	1	28.6	
	2	33.3	
	3	19.0	
	>3	12.4	
Number of marketing channels			2.6
	<2	27.7	
	2 to 4	59.0	
	>4	13.3	
Production system	Conventional	18.1	
	Organic	10.5	
	Integrated	71.4	
Farm financial assessment	Very positive	5.7	
	Mainly positive	43.8	
	Rather positive	41.9	
	Rather negative	6.7	
	Mainly negative	1.9	
	Very negative	0.0	
Financing farm investments (above 30.000 €)	Equity capital	52.4	
	Borrowed capital	43.8	
	No investments	3.8	
Family employees (including farm operator)			1.8
Non-family employees (without seasonal workers)			3.2

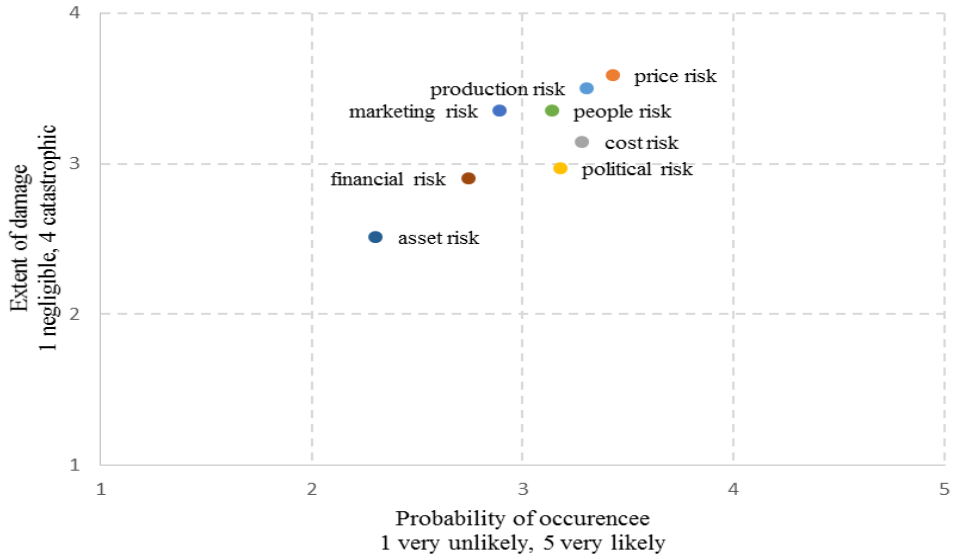

Figure 1. Risk matrix of German fruit famers

Various authors have studied farmers' perceptions of risks and risk management strategies (e.g., **Meuwissen, Huirne, and Hardaker 2001; Hall et al. 2003; Koesling et al. 2004; Flaten et al. 2005; Lien et al. 2006; Bergfjord 2009; van Winsen et al. 2013; van Winsen et al. 2014**). In these studies, price and production risk are among the highest scoring risks. Furthermore, many studies agree that political risk, i.e., changes in regulations related to farms, are important for farming. The analysis of correlations between the mean risk scores of risk categories shows significant interactions in many cases (Table 4). Interactions between risk categories were mentioned as causing inconsistency in prior studies (**Girdžiūtė 2012; van Winsen et al. 2013**). In decision models, interactions of risks can hardly be considered due to the trade-off between the complexity of the decision model and a valid description of reality.

Further correlation analysis shows that loss experience within a risk category is significantly correlated with the mean risk score of each risk category, except in the case of asset risk (Table 5). The influence of loss experience is also discussed in some recently published studies (e.g., **Menapace, Colson, and Raffaeli 2013; Hamilton-Webb et al. 2017**), concluding that farmers with loss experience are more concerned about the specific risk source compared to farmers without this first-hand experience. Therefore, recent loss experience can cause bias in the subjective assessment of risks.

Risk perception of single risk sources

The next step of the analysis was to identify relevant single risks for each risk category (Table 6). Following **Meuwissen, Huirne, and Hardaker (2001)**, risk sources rated with a risk score higher than 3.0 are relevant. In terms of production risk, frost (risk score 4.2), hail (risk score 4.0), animal pests (risk score 3.9), and plant diseases (risk score 3.6) are the most important single risks. All risk scores of single risks have standard deviations around 1.0 or less, implying a high level of consensus among fruit farmers. Cronbach's alpha for the production risk category is 0.729 and, therefore, the items are considered reliable. Frost, hail, and plant diseases can be also found in **Menapace, Colson, and Raffaeli (2012)** as relevant sources of production risk in fruit farming. Also, **Martin (1996)**, examining risk perception and risk management of eight farm types in New Zealand, stated that production risks caused by pests and diseases were very important to fruit growers.

Fruit farmers considered the growing market power of the customers (risk score 3.4), oversupply due to market liberalization (risk score 3.1), and low prices due to changing consumer preferences (risk score 3.1) as important risk sources in the price risk category. Cronbach's alpha for the price risk category is 0.821, indicating high reliability of single items. This finding is in line with **Martin's (1996)** finding that farm operators considered market risk as very important; and that changes in producer prices were of particular concern for fruit and vegetable growers.

The assessment of single risks belonging to each risk category can differ from the risk assessment of the category. For example, in the people risk category single risks within this category are rated highly, whereas the category itself seems to play only a moderate role (Figure 1). In particular, disability of the farm owner (risk score 4.7), long-term illness of the farm owner (risk score 4.7), disability of an important family employee (risk score 4.0), and long-term illness of an important family employee (risk score 4.0). With the exception of quitting of an important non-family employee (risk score 3.4), all other single risk sources in the people risk category score above 3.5. The high impact of people risk sources is in line with prior studies. Most studies agree that personal risks (e.g., death, disability, or illness of farm operator) play an important role (**Martin 1996; Meuwissen, Huirne, and Hardaker 2001; Koesling et al. 2004; Flaten et al. 2005; Lien et al. 2006**). Personal risks rank among the top 30% of all risk sources in these prior studies. Cronbach's Alpha is low for the items in this category, with a value of 0.593.

Table 4. Spearman's rho correlation coefficients of mean risk scores for risk categories (n=105)

	Production risk	Price risk	Cost risk	Political risk	Marketing risk	People risk	Asset risk	Financial risk
Production risk	1	0.331*	0.131	-0.278**	0.244*	0.240*	0.016	0.023
Price risk		1	0.337*	0.060	0.313**	0.024	-	0.128
Cost risk			1	0.191	0.107	0.205*	0.072	0.201*
Political risk				1	0.111	-0.197*	0.149	0.073
Marketing risk					1	0.016	0.141	0.124
People risk						1	0.151	0.257**
Asset risk							1	0.454**
Financial risk								1

Note: *, ** implies p <0.05 and p < 0.01 respectively

Table 5. Spearman's rho correlation coefficients[1] of mean risk scores and loss experience for risk categories (n=105)

Risk category	Spearman's rho
Production risk	.317**
Price risk	.577**
Cost risk	.301**
Political risk	.522**
Marketing risk	.263**
People risk	.364**
Asset risk	.095
Financial risk	.379**

Note: ** implies p < 0.01

Separating the single risk sources into risk sources stemming from the farm family (personal risk), and risk sources stemming from non-family employees (personnel risk) leads to an increase of Cronbach's Alpha to 0.754 and 0.663, respectively. This implies that farm owners distinguish in the risk assessment between personal risk and personnel risk.

Within the cost risk category, increasing input costs are perceived as important (risk score 3.8). The low Cronbach's alpha (0.596) for this category can be explained by analyzing the answers to the open-ended questions after each risk category. As further important risk source 21 respondents mentioned increasing personnel costs within the cost risk category. In addition, in 2014, when the survey was conducted, minimum wage legislation, including seasonal workers, was passed in Germany. In the political risk category, changing political conditions (risk score 4.1), and the macroeconomic development (risk score 3.6) are perceived as important. As expected, potential reduction of subsidies has the lowest rating (risk score 2.2), since direct payments have only a 28% share in farm profits (Table 1). Sources of marketing risk (Cronbach's alpha 0.687) are mainly marketing difficulties due to pesticide residues (risk score 3.5), and difficulties in sales due to food scandals (risk score 3.5). Sales difficulties due to low quality (risk score 3.5) is an important issue because producer prices strongly depend on fruit quality. Within the category financial risk (Cronbach's alpha 0.687), only high profit variability was rated as relevant (risk score 3.6). Reasons for high profit variability in recent years were low yields due to alternate bearing (a year with a high apple yield is followed by a year with light yield), yield losses due to weather extremes (frost in 2011, flood in 2013), and low producer prices due to the Ukraine crisis. Further risk sources within the financial risk category seem to be less relevant, which can be explained by the stable financial situation of the farms (Table 3). As expected, fire is the most important risk source in the category asset risk.

Risk management instruments and farmers' satisfaction with the instruments applied

In contrast to comparable studies, respondents were asked which risk management instruments they actually use, instead of asking for risk management instruments they perceive as relevant. To manage price risk, mainly direct farm marketing is used by 82% of respondents, and 69% sell their products through diversified marketing channels (Table 7). With a satisfaction score of 3.7 in the case of direct marketing (3.6 for diversified marketing channels), farmers seem satisfied with the effectiveness of these instruments. Further, the low standard deviation of satisfaction scores indicates a high consensus among farmers' assessments. Other instruments for price risk reduction are storage, extension of the harvest season, and processing the fruits for juice or jam. Processing has the advantage that fruits with lower quality can also be used. For example, in juice production the quality requirements are less stringent than for fresh fruits. Only 15% of all respondents manage price risk through supply contracts.

For frost risk prevention, 51% of respondents use foils and fleeces, and 45% use frost irrigation. Frost insurance is part of a multiple peril crop insurance. Only 4% of all respondents buy multiple peril crop insurance. This type of insurance plays a minor role and is not subsidized in Germany, in contrast to other countries. Therefore, insurance premiums are typically rather high in relation to the perceived benefits. To manage hail risk, many producers buy hail insurance (49%), or they opt for anti-hail nets (28%).

Table 6. Risk sources (MV = Mean Value, SD = Standard Deviation)

Single risks	Fruit farms (n=105)	
	MV	SD
Price risk		
Growing market power of the customers	3.4	1.4
Oversupply due to market liberalization	3.1	1.2
Low prices due to changing consumer preferences	3.1	1.1
Strategic misalignment of producer organization	2.7	1.6
High dependency on a single customer	2.7	1.4
Production risk		
Frost	4.2	0.9
Hail	4.0	1.1
Pests	3.9	0.9
Diseases	3.6	0.9
Storm	2.9	1.0
Drought	2.9	1.1
Heavy rain	2.8	1.2
Perishability in storage	2.6	1.3
Deer damages	2.5	1.0
People risk		
Disability of the farm owner	4.7	0.7
Long term illness of farm owner	4.7	0.5
Disability of an important family employee	4.0	1.2
Long term illness of an important family employee	4.0	1.3
Disability of an important non-family employee	3.7	1.1
Insufficient quality of work	3.6	1.0
Seasonal worker shortage	3.6	1.2
Quitting of an important non-family employee	3.4	1.2
Cost risk		
Increasing input costs	3.8	1.0
Increasing capital costs	2.9	1.2
Increasing land rents	2.7	1.3
Political risk		
Changes of political conditions	4.1	0.9
Macroeconomic situation	3.6	0.9
Increasing market liberalization	2.6	1.3
Bio-energy subsidies	2.3	1.3
Reduction of state support	2.2	1.1
Reduction of direct payments	2.2	1.0
Marketing risk		
Pesticide residues	3.5	1.3
Sales difficulties due to food scandals	3.5	1.4
Insolvency of a customer	3.3	1.4
Sales difficulties due to low quality	3.1	1.2
Financial risk		
High profit variability	3.6	1.1
High debt-services	2.9	1.4
Restricted access to loans	2.7	1.4
Low equity ratio	2.7	1.3
Asset risk		
Fire	3.7	1.1
Loss of data	3.0	1.3
Theft	3.0	1.0
Machinery breakdown	3.0	1.0
Vandalism	2.8	1.2

Table 7. Applied risk management instruments and associated satisfaction (MV = Mean Value, SD = Standard Deviation)

Risk management instrument	Fruit farms (n=105)		
	Usage	Satisfaction score	
	%	MV	SD
Price risk			
Direct farm marketing	81.9	3.7	0.8
Diversified marketing channels	68.6	3.6	0.6
Storage	58.1	3.3	0.6
Extension of harvest period	49.5	3.4	0.8
Fruit processing	48.6	3.4	0.7
Supply contracts	15.2	3.1	0.8
Production risk			
Foils or fleeces	48.6	3.5	0.7
Hail insurance	48.6	2.7	0.9
Frost protection sprinkler irrigation	42.9	3.8	0.7
Resistant varieties	42.9	3.0	0.6
Prophylactic crop protection	41.9	2.8	0.8
Rain protection system	30.5	3.6	0.8
Anti-hail nets	27.6	3.7	0.8
Bird nets	27.6	3.5	0.6
Weather derivatives	5.7	-	-
Multiple peril insurance	3.8	-	-
Wind machines	1.9	-	-
People risk			
Early consultation with seasonal workers	81.0	3.5	0.7
Disability insurance	78.1	-	-
Accident insurance	78.1	-	-
Focus on employee satisfaction	73.3	3.5	0.7
Life insurance	72.4	-	-
Mechanization	63.8	3.2	0.6
Documentation of working processes	49.5	3.0	0.7
Cost risk			
Early ordering	63.8	3.1	0.6
Buying groups	36.2	3.1	0.6
Invitation to tender	26.7	3.1	0.5
Claim default insurance	2.9	-	-
Financial risk			
Low debt service	70.5	3.3	0.9
Financial reserves	66.7	3.1	0.8
Short-term loans	38.1	2.9	0.9
Consulting with my house bank	30.5	3.0	0.9
Asset risk			
Fire insurance	92.4	3.2	0.6
Building measures (e.g., fire protection)	64.8	3.2	0.5
Machinery breakdown insurance	15.2	3.3	0.9
Business interruption insurance	11.4	3.3	1.1
General			
Diversification by branches	75.2	3.6	0.8
Use of state extension services	75.2	3.5	0.8
Spatial diversification	51.4	3.3	0.7
Use of quality management programs	42.9	2.8	0.8
Income diversification	38.1	3.4	0.8
Off-farm investments	35.2	3.2	0.6

Although more producers use hail insurance compared to anti-hail nets, results indicate that producers' satisfaction with anti-hail nets is higher (satisfaction score 3.7) than with hail insurance (satisfaction score 2.6). An explanation for the higher satisfaction score of anti-hail nets may be that hail insurance only covers the direct monetary losses from damaged fruits. The long-term consequences of an extreme hail event (e.g., loss of customer relationships) are not covered by hail insurance. Furthermore, anti-hails

nets have additional positive phytosanitary effects. It is notable that 16% of the farmers use anti-hail nets and, additionally, buy hail insurance. One explanation for the combination of both instruments originates from the diversification of marketing channels. Anti-hail nets can help prevent yield and quality losses caused by hail. Consequential damages, e.g., loss of customer relationships due to the inability to fill orders, are avoided by preventing damages.

Although the people risk category seems not very important for fruit farmers (Figure 1), all single risks listed within the risk category are rated high (Table 6). The high relevance of single risk sources within the people risk category is further demonstrated by the fact that five out of the eight listed instruments to manage people risk are used by more than 70% of respondents. Particularly, different kinds of insurance, such as disability insurance, accident insurance or life insurance, play an important role to reduce personal risk. For personnel risk management, the early consultation with seasonal workers and the focus on employee satisfaction are important risk management tools. The establishment of financial reserves, as well as low debt service, are the instruments applied most commonly to manage financial risk (see also **Martin, 1996**). For reducing cost risk the common risk management instrument seems to be the early ordering. To manage asset risk, 92% of respondents purchased fire insurance.

In general, diversification is a common risk management strategy among fruit farmers. Most respondents (75%) are active in at least one other agricultural activity beyond fruits. The satisfaction scores with different diversification activities are high. Other forms of diversification applied by farmers are spatial diversification (51%), and the diversification of income sources (38%). The high relevance of diversification corresponds to other studies in agriculture (**Martin 1996; Meuwissen, Huirne, and Hardaker 2001; Koesling et al. 2004; Flaten et al. 2005; Lien et al. 2006**). Furthermore, diversification could be the reason why supply contracts and multiple peril crop insurances are used by few respondents. Several studies found that the degree of diversification had a negative influence on implementing single risk management tools, because farm income is stabilized sufficiently through different sources of income (**Finger and Lehmann 2012; Foudi and Erdlenbruch 2012**). Although 43% of respondents take part in a quality management program, satisfaction with this instrument is comparatively low (satisfaction score 2.7). A reason for lower satisfaction was identified by **Soon and Baines (2012, p. 400)**, where referring to quality management programs farmers criticized that they were "inundated with various types of paper or electronic-based risk assessments which at times were fragmented".

Fruit producers' risk attitudes

German fruit farmers, on average, appear to be risk neutral (mean value of self-assessment: 5.7; mean value of business-related statements: 2.1). However, the results of the risk attitude measurements indicate a bipolar distribution (Table 8). In both risk measurement instruments applied, most farmers described themselves as risk seeking (self-assessment 60%, business related statements 56%). Only 31% of respondents describe themselves as risk averse based on self-assessment (38% for business related statements). This result corresponds with findings by **Röhrig and Hardeweg (2014)** of a high share of risk seeking respondents (48%) among German fruit farmers based on a Holt-and-Laury Lottery. An explanation for the high share of risk seeking farmers may be that most fruit farmers described the farm financial situation as positive (Table 3).

Table 8. Response behaviour to risk attitude (n=105)

	Self-assessment (0-4 = risk averse, 5 = risk neutral, 6-10 = risk seeking)	Business-related statements (1 = risk averse, 2 = risk neutral, 3 = risk seeking)
Average value	5.7	2.1
Risk averse (%)	31.4	38.1
Risk neutral (%)	8.6	5.7
Risk seeking (%)	60.0	56.2

Ewald, Maart, and Mußhoff (2012) also found a bipolar distribution of risk attitudes and a majority of risk seeking farmers, when risk attitudes were measured based on self-assessment. However, when using business-related statements, they found a higher share of risk averse farmers (**Ewald, Maart, and Mußhoff 2012**). In the present study, only half of the participants (52%) answered the questions of both instruments to measure risk attitude consistently. Consequently, correlation analysis shows a weak, albeit significant, relationship between self-assessment and business-related statements (Spearman's rho 0.177; $p<0.05$). The significant correlation of both risk elicitation methods corresponds with the findings of **Ewald, Maart, and Mußhoff (2012)**. A possible explanation for the low correlation may be the different contexts of both risk attitude elicitation methods (**Reynaud and Couture 2012**). The low correlation of both methods to measure risk attitudes indicates that no conclusion can be drawn as to which method is most appropriate for elucidating risk attitudes.

Both, risk perception and risk attitude are expected to be relevant factors for the choice of risk management instruments (**van Winsen et al. 2014**). Therefore, in an additional analysis, the total sample was split according to the risk attitudes of respondents. Thus, the three groups (risk averse, risk neutral and risk seeking farmers) were compared according to their assessment of single risk scores. A separate analysis was conducted for each of the two methods to measure farmers' risk attitudes applied. If risk attitude is measured through the self-assessment method the only statistically significant difference relates to growing market power of the customer; this single risk source is rated higher by risk averse farmers. If risk attitude is measured through the business related statement the single risk sources drought, long term illness of an important family

employee, and pesticide residues are statistically significant. In case of drought and long term illness of an important family employee risk neutral farmers rated these risk sources higher, whereas pesticide residues were assessed higher by risk seeking farmers.

Therefore, the results presented in this study do not support the conclusions of other studies (e.g., **Meuwissen et al. 2001**) that risk averse farmers generally rate single risk sources higher than risk neutral or risk seeking farmers. Furthermore, no significant differences between the three groups (risk averse, risk neutral and risk seeking) were identified regarding the use of risk management instruments. This result corroborates **Vassalos and Li (2016**) who examined the effect of risk perception and risk attitude on the choice of marketing contracts of vegetable growers. They found that neither risk perception nor risk attitude had an impact on growers' choice of marketing contracts.

CONCLUSION

The present study provides insights into the risk perception and use of risk management instruments of German fruit farmers, using a risk management framework based on subjective probabilities. Furthermore, the role of risk attitude, which was expected to be an important factor for risk perception, and risk behaviour were analysed. Fruit farms are particularly relevant for agricultural risk management research because they represent the farm type "horticulture" and are typically family run businesses, both of which often struggle to implement risk management processes and were widely neglected in previous risk management studies.

The adopted risk management framework to analyse risk perceptions consists in two steps, the assessment of risk categories and of single risk sources within these categories. Results show that assessing risks only at the category level is not sufficient (see also **Cox 2008**). Farmers may overestimate or underestimate the risk categories (see e.g., people risk), when not considering the individual risk sources within each category. Therefore, it is crucial to identify the single risk sources. Nevertheless, the rating of risk categories by risk matrices is also valuable in terms of prioritization and to identify neuralgic points threating the farm.

Although other studies found that people risk is important for farm managers, the management of this risk is widely neglected in risk management literature. Exceptions are the studies of **Bitsch and Harsh (2004)** and **Bitsch et al. (2006)**, providing insights in risk management issues regarding non-family employees. Especially in family run farms, which are highly dependent on the farm manager, it is crucial to highlight the people risk category. Thereby, a substantial finding consists in the fact, that farm managers distinguish between people risks within the family (personal risks), and the non-family workforce (personnel risks). In case of the family workforce, farm managers prefer to hedge risk by purchasing insurance. To improve personal risk management, managers need to pay more attention to the documentation of work processes. This measure enables family members to continue the farm business, if the farm manager is absent. In case of personnel risk, early arrangements with seasonal workers, and a focus on employee satisfaction are typical instruments applied to reduce risk. These findings are in line with **Bitsch and Harsh (2004, p. 743),** who emphasize that a "timely start of the hiring season [of seasonal employees]" is necessary to "avoid manager overload during peak labor needs". As good practice for employee satisfaction, **Bitsch and Harsh (2004)** mentioned the training of new employees, regular performance evaluations, occasional get-togethers and shared meals, showing interest in employees' lives, flexibility in scheduling, sharing of business information with employees, and providing bonuses. The management of non-family labour is one of the big future challenges of horticultural farms in Germany. Thus, more research is needed on personnel risks and suitable risk management instruments.

The analysis of the applied risk management instruments indicates that various forms of diversification have high relevance for fruit farms. Although specialization is important due to economies of scale, diversification is an effective risk management strategy. Further research should focus on the farm-specific assessment of the trade-offs between economies of scale due to specialization, and risk reduction due to diversification. For example, growing different kinds of fruits may reduce price risks, but increases the number of plant protection strategies required and related input costs due to small lots and additional work steps.

In most cases, farmers are satisfied with the instruments applied for risk management. When more than one instrument is available to manage a risk source, the present study shows inconsistencies between farmers' satisfaction with risk management instruments and their actual use. As this study shows, satisfaction with hail insurance is low in comparison to anti-hail nets, despite the fact that hail insurance is applied more often. Few studies (e.g., **Pennings et al. 2008; Barnham et al. 2011; Foudi and Erdlenbruch 2012**) discuss complementary and substitution effects of risk management instruments (e.g., irrigation and drought insurance). However, the effects of interactions between different risk management instruments should receive more attention among scholars.

The bipolar distribution of farmers' risk attitudes is a far-reaching finding, since most risk management literature assumes risk averse decision makers. Furthermore, the findings of this study do not confirm the common assumption in literature that risk averse farmers generally rate risk higher than risk neutral or risk seeking farmers. Therefore, it is important to also consider risk seeking attitudes, when advising farm managers regarding risk management.

Although risk management becomes more important, many fruit farmers still struggle to implement an appropriate risk management process. The presented risk management framework addresses the special needs of family farms and is based on subjective probabilities due to the often-noticed lack of sufficient farm level data to derive objective probability distributions for single risks or for risks, which cannot be quantified (e.g., people

risk). Therefore, it will allow fruit producers to identify the important risks for their business, to assess the interactions between risk categories, and to evaluate the risk management instruments they already use in terms of their satisfaction with their performance.

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