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Farmers' risk perception, risk aversion and strategies to cope with production risk: an empirical study from Poland

Agriculture is an activity burdened with multiple risk factors, some of which are related to the biological nature of production. Climate change, liberalisation of international agricultural trade and changes in the agricultural support system mean that the importance of risk in agriculture will increase. This means that increasing attention will be given to risk management at the farm level, although implementation of the appropriate risk management strategy is connected to farmers' perception of, and aversion to, risk. This study, which integrates these three aspects of risk in agriculture, is based on data collected from almost 600 participant farms from the Polish FADN system. It was shown that drought is perceived by farmers as the main factor of risk in production in Poland. Polish farmers are rather risk averse, but a little more in terms of their personal health and less in the case of the farm. The analysis showed that the following factors increased the level of risk aversion of Polish farmers: debt ratio, losses in production in previous years, soil quality and concentration on financial independence as a hierarchy of priorities. The most important risk-coping strategy was crop insurance. Knowledge of farmers' perception of risk, risk aversion and preferred risk management strategies is essential for creating policy instruments to support agricultural risk management, and for the development of training programmes tailored to the needs of farmers.

Keywords: risk perception, risk aversion, agricultural practices, family farms

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Introduction

Agriculture is exposed to several types of risks; apart from ordinary business risks, such as price and demand fluctuations, farmers have to deal with risk factors specific to this branch of the economy (weather conditions, crop and animal diseases etc.). Authorities and researchers need to consider the problem of risk in agriculture, especially as it seems to be increasing due to observed climate changes (Alcamo *et al*., 2007; Kundzewicz and Kozyra, 2011; Olesen *et al*., 2011), slow but constantly ongoing trade liberalisation (Bureau *et al*., 2005; CBD, 2005; Wróbel, 2012) and changes in the Common Agricultural Policy, CAP (Majewski *et al*., 2008; Matthews, 2010; Tangermann, 2011). Increasing risk in agriculture can be seen in growing income fluctuations (EC, 2008; Vrolijk *et al*., 2009; EC, 2011). The observed instability of economic and farming conditions resulted in the issues of farm risk management being added to priorities of the CAP (EC, 2001; EC, 2005). Moreover, income management issues were included in new law regulations concerning the CAP after 2013[1], allowing for the use of a new instrument in the European Union Member States called the Income Stabilisation Tool. However, effective risk management requires coordination of actions at three different levels, i.e. the state, markets and farms (OECD, 2011). Usually governments create certain institutional frameworks supported by instruments that help to cope with catastrophic risks, while markets offer a range of insurances and methods to deal with price risks (options, futures etc.).

Nevertheless, it is the farmers' behaviour that is crucial for proper risk management in agriculture. It refers especially to those risk factors that are called by OECD (2011) 'normal risk' factors. Effective risk management in this field depends strongly on behavioural factors, including risk aversion and perception. Thus, studies of farmers' risk perception and aversion are of high significance in farm risk management and from the point of view of policy makers. This paper addresses this issue by integrating these two aspects of risk with the implementation of risk management strategies by farmers in Poland.

Risk perception and risk aversion among farmers

Appropriate risk perception can be seen as a prerequisite for choosing an effective risk-coping strategy, because a farmer that is not aware of the risks faced is clearly unable to manage them effectively. This problem was discussed, among others, by Pennings and Leuthold (2000). Farmers' risk perception was studied by several other authors, and most of them concentrated on identifying the risk factors that were seen by farmers as the most important. The farmers quoted various risk factors as being important such as drought (Greiner *et al*., 2008), animal disease, pests, personal safety and health risk (Boggess *et al*., 1985; Patrick *et al*., 1985; Blank and McDonald, 1995), yield risk and price risk for agricultural products (Wilson *et al*., 1988; Patrick and Musser, 1997; Meuwissen *et al*., 2000; Palinkas and Székely, 2008), institutional risk connected with farm support (Lien *et al*., 2003; Flaten *et al*., 2005), and weather and natural disasters (Palinkas and Székely, 2008). Some authors dealing with the issue of risk perception (Borges and Machado, 2012) focused on finding factors determining differences in the level of risk perception. They concluded that these differences are determined by the socio-economic features of the farmers and the characteristics of their farms. One has to be aware of the fact that farmers from various countries live within different climatic and institutional conditions, thus the differences of risk perception can be a result of either different probabilities of certain risk factors, or different farmers' mentality and awareness, or a mixture of both.

In comparison to risk perception, attitudes towards risk were addressed more often in recent decades. The problem of risk aversion is one of the main research questions in contemporary agricultural economics (Cao *et al*., 2011)

[1] Regulation (EU) No 1305/2013.

and proper measurement of attitude towards risk is crucial to the real understanding of the economic behaviour of farmers. The propensity to risk affects the choice of appropriate agricultural policy tailored to the needs of the sector and the national economy. Bard and Barry (2001) stress that understanding how farmers react to risk factors is important not only for the farmers themselves, but also for the extension services, the agri-food industry (both supplying farmers with production factors and food processing) and authorities. Most of the studies of farmers' attitudes to risk concluded that the farmers are characterised by risk aversion (OECD, 2004; OECD, 2009).

Risk aversion is a term that is very difficult to operationalise, nevertheless many researchers make an attempt to measure its level. In general, there have been three approaches towards this issue. The most popular one assumes that the actor has fixed preferences, which enables the researcher to determine the actor's utility function (its convexity or concavity), thus allowing his or her risk aversion to be assessed (Pennings and Garcia, 2001). Experiments and hypothetical alternatives are usually used to determine risk aversion using this method. This approach was used by Officer and Halter (1968), Lin *et al*. (1974), Webster and Kennedy (1975), Dillon and Scandizzo (1978), Halter and Mason (1978), Young (1979) and Collins *et al*. (1991). The second approach stands on a position that risk aversion is a latent feature and can be observed only indirectly (for example through observing farmers' investment activities). Binswanger (1982) remarked that experiments and hypothetical alternatives in laboratory conditions can give different results than real-life situations, thus their results can be misleading. Robison (1982), Machina (1987) and Schoemaker (1991) made similar comments. The most popular alternative to experiments are various types of opinion polls (Damodaran, 2009). Participants of such inquiry are asked to self-assess their risk aversion using an 11-point scale (see for example Spector, 1992 and DeVellis, 1991). Research carried out in Germany by Dohmen *et al*. (2005) on a sample of roughly 22,000 individuals showed that this method gives similar results as other ways of measuring risk aversion. This method was quite often used in measuring the attitudes of farmers (Kastens and Featherstone, 1996; Patrick and Ullerich, 1996; Bard and Barry, 2000; Pennings and Garcia, 2001; Uematsu and Mishra, 2011). However, some studies have shown inconsistent results: Bard and Barry (2001) found no correlation between self-assessment and other methods such as observation of utilisation of risk management tools, and Fausti and Gillespie (2006) pointed out that the self-assessment of risk aversion may vary according to the context in which the question is posed.

Studies of farmers' risk perception and aversion are very rare in Poland as well as other Central and Eastern European countries. Moreover, most of the available papers concerning farmers' risk perception and risk aversion do not discuss farmers' risk management strategies in this context (see Kouamé, 2010). According to the dominant economic theory of risk by von Neumann and Morgenstern (1953), risk aversion determines microeconomic choices of individuals under risk and uncertainty. It leads us to conclude that, in practical aspects, risk aversion determines farmer's decisions on risk mitigation strategies at the farm level. Although risk management strategies in agriculture were a subject of interest to some authors (Meuwissen *et al*., 2000; Nguyen *et al*., 2007; Akcaoz *et al*., 2009), the problem of risk aversion and risk management strategies usually were not analysed jointly. Hence the question of the influence of risk aversion on risk management strategy decisions has not been considered in detail.

In the light of the above evidence, we sought to identify the factors determining the level of risk aversion of Polish farmers, and to find a relationship between the level of risk aversion and the chosen risk-coping strategies. We tested three hypotheses: (a) Polish farmers can correctly identify agricultural risk factors; (b) as in other countries, Polish farmers are risk averse; and (c) the level of risk aversion affects the choice of risk-coping strategies. The factors influencing the level of farmers' risk aversion were also studied.

Methodology

The sample consists of almost 600 farms participating in the Polish Farm Accountancy Data Network (FADN) system. They were chosen with the use of stratified random sampling, taking into consideration: four layers according to farming specialisation, three layers according to production size and four layers according to regions of the country. The number of analysed farms in each layer was calculated with the use of the Nayman method in a similar way to which it is used for choosing the FADN sample (FADN 2008):

$$n_h = n\frac{N_h\sigma_h}{\sum_{K=1}^{L} N_k\sigma_k}$$

where: n_h – sample size in layer h, n – sample size, N_h – population size in layer h, σ_h– standard deviation in layer h, and L – number of layers.

The farmers were surveyed in 2012 by the extension service workers who coordinate FADN data collection. Completed questionnaires were sent to the Institute of Agricultural and Food Economics - National Research Institute, Warszawa (the institution responsible for FADN in Poland) and added to the database of appropriate farms studied within the FADN framework. This allowed the authors to use a dataset of almost 600 farms, containing both financial farm data and farmers' behavioural data, including attitudes towards various types of risks. Stratified random sampling made it possible to represent the structure of farms that is observed within FADN framework, thus it is representative according to economic size, production type and region (Table 1). However, the FADN covers only farms with standard output above EUR 4 thousand, thus it refers only to the farms producing for market (in Poland there are 738 thousand such farms and they produce almost 90 per cent of total farm output).

Descriptive statistics, correlations and regression analysis were used to analyse the data, as explained in the following part of the paper.

Table 1: Average characteristics of the farms of the surveyed farmers according to type of production and economic size, compared to mean data for the Polish FADN sample.

Category of farm	No. farms	Utilised agricultural area (ha)	Area of grassland (ha)	Rented land (ha)	No. animals per farm (livestock units)	Full time employees per farm	Farm income (PLN)
Type of production							
Crops	96	41.4	1.3	12.7	1.2	1.62	94,674
Orchards	79	6.8	0.1	1.1	0.2	2.34	44,688
Mixed	47	18.6	2.4	4.9	8.1	1.59	35,884
Cattle	234	16.4	4.2	3.7	15.7	1.65	32,732
Pigs	125	17.9	0.6	5.5	35.5	1.73	50,034
Economic size (standard output in EUR thousand)							
4-25 ha	326	14.7	2.3	2.8	7.1	1.75	27,266
25-100 ha	208	45.6	5.6	15.4	30.2	2.11	124,427
>100 ha	47	143.4	6.8	74.7	115.3	4.58	445,602
Sample	581‡	20.5	2.7	5.6	11.7	1.69	46,444
FADN sample	11,114*	19.6*	2.8**	5.6*	11.7**	1.70*	43,539*

‡ The final sample size was 581 farms due to incomplete data on 19 questionnaires
Sources: own data; * FADN 2013; ** own calculation based on FADN database

Results

Risk perception

The farmers were given a list of risk factors and were asked to assess their importance on a 1-5 point Likert scale. The respondents perceived the most important risk factor on their farms to be drought (mean value 3.1), while the least was wind storm (mean value 1.7) (Figure 1). The mean values for the other four risk factors were 2.1 (stormy rain), 2.2 (hail) and 2.6 (poor overwintering and spring frosts).

The correlations between the perceptions of specified risk factors were calculated. Because the variable was ordinal, nonparametric Spearman's correlations were applied. All listed correlations were statistically significant at the α=0.05 level.

There is a relatively strong correlation between spring frosts and poor overwintering (Table 2). It can mean that the occurrence of both factors (or neither of them) at the same time is more likely than of only one of them. However, it might be that the farmers have problems with distinguishing one from the other and they find it difficult to assess which of these factors caused certain damage. The correlation of 0.57 between hail and stormy rain may indicate that certain farms have higher and certain farms lower probability of strong rains or hail (which seems logical), or that particular crops are more affected by both heavy rain and hail. Similarly, stormy rain and wind storm can occur simultaneously and have similar effects on certain types of crops. The medium strength correlation between drought and spring frosts seems interesting. If we assume that the farmers' perception reflects real-life experience, we could hypothesise that spring frosts are frequently followed by droughts.

Any differences between risk perception by farm type should reflect the differences in the level of risk exposure. The Kruskal-Wallis test[2] was used in order to investigate differences between the average evaluation of perceived risk factors by farmers representing different production types. Considering the fact that all the risk factors directly concern crop production, we expected a much greater significance of the specified factors for crop farms than for other farm types. Surprisingly, it turned out that the differences in average scores were rather small (data not shown). Moreover, the results of the Kruskal-Wallis test showed that almost all observed differences were statistically insignificant at the p value = 0.05. Only wind storm had a statistically significant difference, but surprisingly it was seen as a more important risk factor for animal farms than for

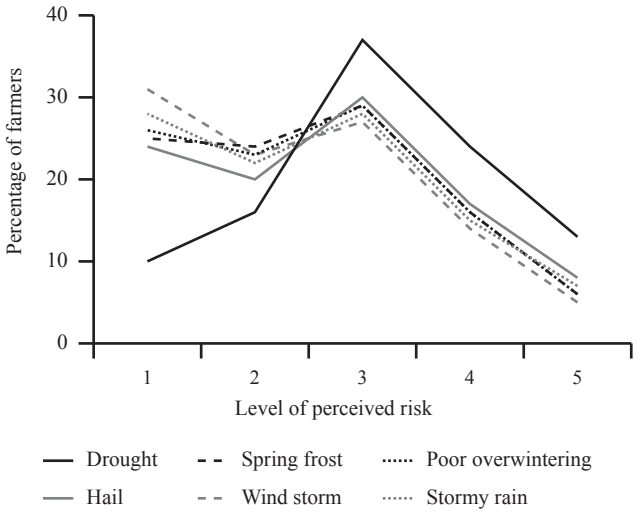

Figure 1: Surveyed Polish farmers' perception the importance of sources of risk (1 = very low, 5 = very high).
Source: own composition

Table 2: Correlation between Polish farmers' perceptions of certain risk factors.

Risk factor	Drought	Hail	Stormy rain	Poor over-wintering	Spring frosts	Wind storm
Drought	1					
Hail	0.16	1				
Stormy rain	0.16	**0.57**	1			
Poor overwintering	**0.39**	**0.31**	**0.33**	1		
Spring frosts	**0.43**	**0.36**	**0.34**	**0.7**	1	
Wind storm	0.17	**0.36**	**0.41**	0.22	0.23	1

Correlations significant at the 0.05 level are shown in bold
Source: own calculations

[2] This is a nonparametric substitute of a t-test in the case of interval scale qualitative data.

mixed or crop farms. It may be connected with damage to farm buildings, which is much more important for livestock farms than for crop production. However it does not change the fact that 'wind storm' was perceived by the farmers as the weakest risk factor out of the set. In general, in most of the cases the perception of specified risk factors does not depend on farm type.

Risk aversion

In the questionnaire there were four questions concerning risk aversion: to what extent do you see yourself as a person characterised by (a) general risk aversion; (b) risk aversion when it comes to your personal health; (c) risk aversion in the context of financial matters; and (d) risk aversion when it comes to your farm and farming methods? We were interested mostly in the answers concerning the latter (farms and farming methods), and the other questions were asked to make the farmers think more deeply about the issue.

Generally, the farmers are the most risk averse when it comes to their personal health, and the least with respect to their farms (Figure 2). There are no significant differences between farm production types. The analyses below concern only the fourth question, namely risk aversion in the context of farm and farming methods.

The determinants of the level of risk aversion of Polish farmers were analysed using regression analysis. The dependent variable was the self-evaluation of the farmer of his/her risk aversion on a 10-point scale, where '0' stood for no risk aversion, and '10' for extremely high risk aversion. Even though it was an ordinal variable, it is customary that ordinal variables with more than five levels can be treated as additive variables (Berry, 1993), thus they can be used in the regression analysis (Jaccard *et al*., 1990).

Risk aversion was modelled using a set of explanatory variables chosen on the basis of the literature and expert knowledge. These were: economic size (in terms of standard output in EUR thousand), farm area (ha), livestock units, farmer's age, farmer's level of education (scale: 1: primary; 2: vocational; 3: secondary; 4: higher), soil quality (scale: 0: theoretical minimum; 1: theoretical maximum), number of fully employed workers (annual work units), assets value (PLN thousand), debt ratio (value of debt divided by value of assets), being exposed to losses exceeding 30 per cent of total production in the years 2005-2011 (binary variable), and the importance of the following priorities (on a 1-5 scale): income maximisation, income stabilisation, financial independence, farm modernisation, and yield maximisation. The results of the analysis are shown in Table 3.

The following variables were statistically significant (p value <0.05): economic size, debt ratio, losses in production (>30 per cent of expected value), indicator of soil quality, and the financial independence priority. The model explains only 25 per cent of the variability of the endogenous variable (risk aversion), however this is a relatively high level taking into consideration that it is a latent variable, resulting also from the personal characteristics of the farmer. The b-coefficients show that only the economic size of the farm has a negative impact on risk aversion (the bigger the farm is, the lower the risk aversion is). The remaining variables are positively correlated with risk aversion.

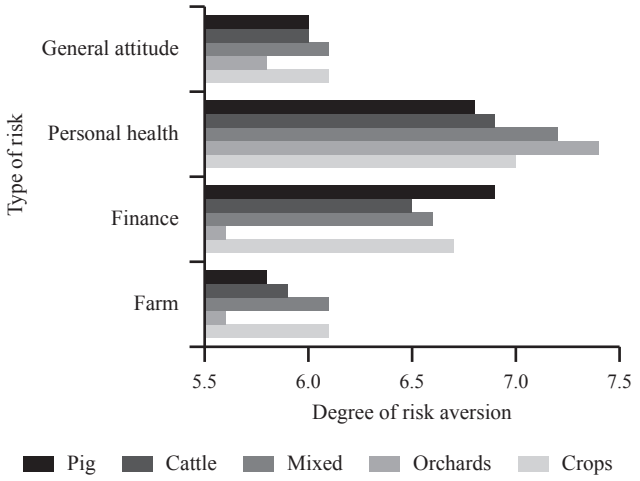

Figure 2: Surveyed Polish farmers' levels of self-assessed risk aversion according to type of farm (0 = very low, 10 = very high).
Source: own composition

Table 3: Regression analysis (exogenous variable: self-assessed risk aversion of Polish farmers in the context of farm and farming methods).

Explanatory variable	b	t(559)*	P value
Intercept	-58.370	-2.34	0.020
Economic size	-0.003	-2.68	0.008
Debt ratio	1.689	2.94	0.003
Losses in production (> 30% of expected value)	0.619	2.50	0.013
Indicator of soil quality	0.517	2.01	0.045
Priority: financial independence	0.194	2.61	0.009

R^ = 0.24868; F (7.545) = 5.1323 p < .00001 Standard error of estimation: 2.2684
* The final sample size was 559 farms due to incomplete data on 41 questionnaires
Source: own calculations

It might be expected that debt ratio would be negatively correlated with risk aversion, i.e. those farmers that are less risk averse should be more willing to take credit. However, our question concerned already existing indebtedness – the higher it is, the more cautious the farmers are when it comes to taking risk, out of fear of losing financial liquidity. This interpretation fits well to the importance of the priority 'financial independence': the higher the priority is, the higher the risk aversion is (probably those who wish to have financial independence are at the same time risk averse, because their financial situation could be at the edge of insolvency).

Adoption of risk coping strategies

It is expected that the level of risk aversion influences the farmers' choice of risk-coping strategies. The list of potential strategies is quite long, and the strategies influence various spheres of farming. Insurance is a method of risk transfer through the market – it does not reduce the probability of occurrence, but mitigates the scope of potential financial losses. Off-farm business activity and an additional job reduce the risk of financial problems in the farmer's family during difficult economic conditions for agricultural production. Diversification of agricultural production

(portfolio diversification) reduces the impact of fluctuations on different agricultural markets. Any form of integration increases the bargaining power of farms, allows them to achieve higher margins and increases safety of transactions. Maintaining financial reserves can help farmers to survive difficult periods when the economic results are not adequate. Not taking credit may increase financial security, however it may also slow down the farm's development.

In our study the farmers were given a set of risk management statements concerning strategies that are now realised or could be realised on the farm in the future. The list was prepared on the basis of the literature (Bard and Barry, 2000; Lagerkvist, 2005). Firstly, the farmers were asked to assess (on a 1-5 scale) to what extent the methods of reducing risk were used at the time of the research (Figure 3a). For each category of level of use, the average level of risk aversion among farmers was calculated for each strategy used (Figure 3b). It is clear that higher levels of use of certain strategies correlate with higher risk aversion.

Secondly, planned strategies were taken into consideration. Owing to the fact that more detailed assessment of the importance of future strategies would be pointless (the answers were merely declarations and not statements of fact), the variable was binary (whether the use of certain strategy

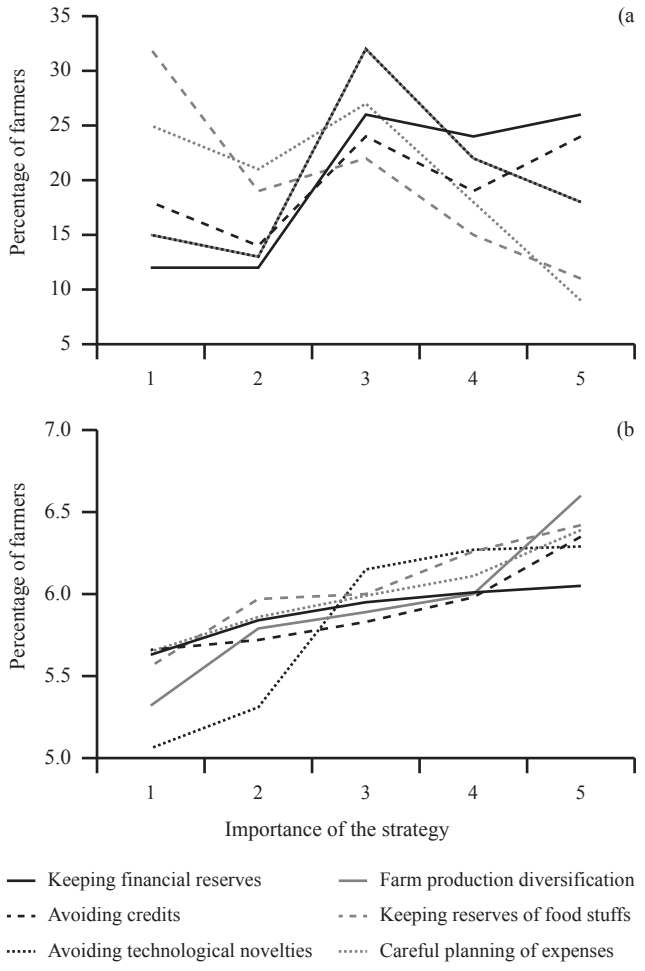

Figure 3: (a) Importance of risk reducing strategies on the farms (1 = very low, 5 = very high); and (b) average level of risk aversion (self-assessed; 0 = very low, 10 = very high) of a sample of Polish farmers.

Source: own composition

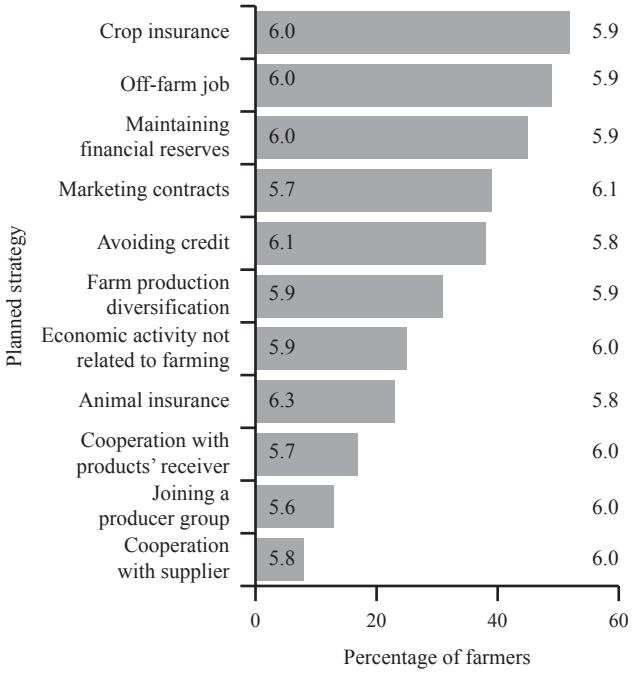

Figure 4: Percentages of a sample of Polish farmers with plans concerning future risk-coping strategies and average level of risk aversion (self-assessed; 0 = very low, 10 = very high) of (left column) those planning and (right column) not planning each strategy.

Source: own composition

was planned or not). Crop insurance is the most often chosen strategy, while the least chosen are strategies that require cooperation with other participants in the market (farmers, clients and suppliers) (Figure 4). Surprisingly, the levels of risk aversion between farmers that plan to implement certain strategies and those that do not are very similar. Those farmers who plan to implement such activities as insuring crops, getting an off-farm job, maintaining financial reserves and avoiding taking credit may have a slightly higher than average level of risk aversion. Those farmers who do not plan any activities connected with cooperation with other people may be marginally more risk averse. This could result from the fact that Polish farmers are generally unwilling to cooperate (according to Wołek and Łopaciuk-Gonczarczyk (2010) only about 30 per cent of Polish farmers are ready to cooperate in business activity). Cooperation means for them additional risk of being cheated or just additional work to compromise, which they are not used to doing.

Discussion

Agriculture is a risky business. Climate change, progressing liberalisation of international agricultural trade and changes in agricultural support schemes increase the problem of risk management. It can even be argued that with time general farm management will have to focus mostly on risk management. The surveyed farmers see drought as the main source of risk on their farms. Similar observations were made by climatologists (Górski *et al*., 2008), who note a growing number of unfavourable weather events (including drought) that affect agriculture. More frequent droughts are thought

to be a result of climate change (Kozyra *et al*., 2009). The proper perception of risk factors is the first step towards creating an effective risk management system. From this point of view, the surveyed farmers were able to acknowledge correctly the most important agricultural risks. Moreover, risk perception does not depend on the type of farm, which implies that this knowledge is of universal character.

The second important factor affecting risk management is risk aversion. The questions dealing with risk aversion concerning issues not related to farming were intended to put the farmers' answers into context and check their reliability. The respondents self-assessed higher risk aversion concerning their personal health, and lower when dealing with their farm and farming methods; this seems logical from the perspective of hierarchy of values among people in general. This much higher risk aversion concerning personal health than business allows a higher level of trust in the results. Overall, the respondents showed clear, but not very high, risk aversion, confirming the results obtained by other authors (Meuwissen *et al*., 2001; OECD, 2009).

According to our analyses, factors increasing the level of risk aversion of Polish farmers are the following: debt ratio, losses in production in previous years, soil quality and concentration on financial independence, as a hierarchy of priorities. Taking into consideration that risk aversion is a latent variable and cannot be observed directly, the knowledge of a farmer's and farm's characteristics influencing risk aversion can be used by the extension services when preparing risk management courses and workshops dedicated to certain groups of farmers.

It seems especially important that we consider correlations between risk aversion and farmers' plans concerning future risk coping strategies. Our research shows that higher risk aversion increases the chances of implementation of most of the considered strategies (average aversion level was higher in the groups that attributed greater importance to specific strategies). Even though most of the strategies will be implemented by farmers with higher risk aversion level, there were relatively small differences in average risk aversion depending on whether certain strategies were planned or not. It can mean that some farmers do not have sufficient knowledge concerning positive outcomes of certain actions on risk reduction. Strategies that involve cooperation seem especially undervalued, which probably results from the general unwillingness among Polish farmers to cooperate. The most popular tool declared to be used in the future was crop insurance, even though this requires important state intervention and faces a number of additional problems (c.f. OECD, 2011; Kemény *et al*., 2013). Consequently, their effective use depends not only on farmers, but on the institutional background as well.

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