Perception of risk by farmers and crop insurance decisions – Polish case

Monika Kaczała
Poznan University of Economics and Business
Poznań, Poland

1. Introduction

Farmers' perception of risk has been extensively researched, especially in the USA and developing countries (Chiotti, Q., Johnston, T., Smit, B., Ebel, 1997; Harwood, Heifner, Coble, Perry, & Somwaru, 1999; Meuwissen, Huirne, & Hardaker, 1999; Tucker, Eakin, & Castellanos, 2010; van Duinen, Filatova, Geurts, & van der Veen, 2015). Some studies have shown that personal risk perception influences risk attitudes of farmers (Ullah, Shivakoti, & Ali, 2015). Although the correlation between risk perception and mitigation behavior is ambiguous (Birkholz, Muro, Jeffrey, & Smith, 2014; Grothmann & Patt, 2005; Kaczała & Wiśniewska, 2015; Liu, Corcoran, Tao, & Cheng, 2016; Sherrick, Barry, Ellinger, & Schnitkey, 2004; Tucker et al., 2010; Ullah, Shivakoti, Kamran, & Zulfiqar, 2016; Wachinger, Renn, Begg, & Kuhlicke, 2013; Wheeler, Zuo, & Bjornlund, 2013; Woods, Nielsen, Branth Pedersen, & Kristofersson, 2017) identification of the structure of perceived risk and the formation of farmers' risk perceptions seems to be crucial both for designing a government risk management policy applicable in the agriculture sector and for suppliers of risk management tools (Lo, 2013; Ogurtsov, Van Asseldonk, & Huirne, 2009; Sherrick et al., 2004).

Several studies have investigated the determinants of farmers' risk perceptions, i.e. biophysical, sociodemographic, psychological, and social influence variables. Within the natural perils they are mostly concentrated on climate changes or (separately considered) drought or flood. There is hardly any research concerning hail, winterkill or spring frost risk perception. Nevertheless, the interdependencies between the risk perception and acceptable yield fluctuation or level of loss in yield leading to a farm's bankruptcy (catastrophic events) have been hardly revised yet. This relationship could be crucial for a farm's response to risk on the one hand, and farms' state support strategy on the other (Boholm & Corvellec, 2011).

The perception of risk among farmers could vary depending on the country they operate in (Boholm, 2003; Dessai et al., 2004; Eakin, 2006). However, almost no research has been conducted so far to determine farmer's risk perception in the Eastern and Central Europe, (especially in the post-communist countries).

Bearing the above in mind, the purpose of this research is to investigate the perception of risk with respect to natural hazards among Polish farmers, the factors which have an impact on this perception and the impact of acceptable (normal) and catastrophic event on risk perception and the use of crop insurance.

Poland as an example of a Central European post-communist country has been selected for this study, because it is one of the main suppliers of area and people in the EU agriculture (it accounts for 8% of the EU arable land and over 28% of the EU population economically active in agriculture (CSO, 2017).

2. Determinants of farmers' risk perceptions

According to relational theory of risk developed by Boholm and Corvellec we understand risk as "a product of situated cognition that establishes a causal and contingent relationship of risk between a risk object and an object at risk so that the risk object is considered, in some way and under certain circumstances, to threaten the value attached to the object at risk" (Boholm & Corvellec, 2011, s. 13). Hence, risk perception is a social phenomenon that expresses the relationship an observer establishes between risk object and object at risk (Dobbie & Brown, 2014). It relates both to the object risk and to the object at risk as well. Object at risk "is to be endowed with a value that is considered at stake" (Boholm & Corvellec, 2011, s. 7) and it is in our case yield income. The object risk "refers to something that is identified as dangerous" (Boholm & Corvellec, 2011, s. 6) and is held to threaten the value of the object at risk. In our case, object risk refers to different perils (hazards), such as drought, flood, hail, spring frost, winterkill and hurricane and others like plant diseases, health problems, increase in the agricultural input prices, price volatility on the crop markets, political changes, property damage, sudden changes in agricultural technology.

There are a number of factors, that directly or indirectly influence the relationship an observer establishes between a risk object and an object at risk. Originally the theory of expected utility assumes that agents have perfect information on the probabilities and potential damages related to risky events, and for this reason their assessments of risk are "objective". Hence, factors which influence this perception are considered objective. They could be divided into two groups: the factors determining farmers' risk exposure (e.g. biophysical characteristics of the farm location) and the determinants of farmers' risk sensitivity[1] (van Duinen et al., 2015). In our research we took into consideration the following objective features influencing risk exposure or risk sensivity: types of cultivated crops, province where the farm is located, farm size, dominant soil quality class, dominant production, production purpose, the use and character of additional non-farming sources of income.

The observed discrepancy between individual risk assessment and expert risk estimates based on classical approach has caused the shift in theory on risk perception towards the psychological approach. It started with the heuristic paradigm (Kahneman & Tversky, 1974, 1979, 1984). The research based on this paradigm is concentrated on heuristics used by people to evaluate information. These heuristics are usually convenient mental shortcuts and may lead to inaccurate judgments in some situations – in which case they become cognitive biases, e.g. representativeness, availability heuristic or anchoring and adjustment heuristic.

Within the psychological approach "the psychometric paradigm" was created as well (Paul Slovic, 1987; P Slovic, Fischhoff, & Lichtenstein, 1985; Paul Slovic, Fischhoff, & Lichtenstein, 1984, 1985). It focuses on the roles of affection, stigmas or emotion influencing risk perception. Factor analysis has revealed that these diverse characteristics are reducible to three factors: firstly, "unknown risk" (composed of scales such as: unknown to the exposed, unknown

[1] Understood as "the extent of the transformation of a system per unit of change in the disturbance, sometimes referred to as the dose-response relationship" (Gallopı, 2006; after van Duinen et al., 2015).

to science, unfamiliar and involuntary), secondly, “dread risk” (including: severity of consequences, dread, and catastrophic potential) and finally the number of people “exposed to the risk”. This is also valid for the Polish case (Goszczynska, Tyszka, & Slovic, 1991).

As it was mentioned before, studies concerning farmer’s risk perception with respect to natural hazards refer to climate changes, drought or flood. Therefore the set of the variables is chosen by the assumption that factors affecting risk perception in these phenomena will be also valid for hail, winterkill or spring frost. It is limited by the available data. The group of psychological determinants in the study consists therefore of the following variables : sex, age, educational background (Botzen, Aerts, & Van Den Bergh, 2009; Deressa, Hassan, & Ringler, 2010; Kellens, Terpstra, Schelfaut, & De Maeyer, 2013), experience related to different perils: the frequency of various adverse occurrences in the previous 10 years and the scope of adverse occurrence affliction, i.e. the evaluation of the influence the adverse phenomenon had on the farm’s income from crops (Ho, Shaw, Lin, & Chiu, 2008; Kellens et al., 2013; Paul Slovic, Finucane, Peters, & Macgregor, 2004).

Research into risk perception was extended by sociological analysis, taking into consideration social, cultural and organizational factors. The roles of trust, knowledge, values, social interest, attitudes, beliefs were studied, which led to a more comprehensive risk framework (Dobbie & Brown, 2014; Kasperson et al., 1988; Ortwin & Bernd, 2000; Sjoberg, 2000; Sjöberg, 1997). These factors, however, are not introduced in our analysis because of the lack of our own data.

“An object becomes a risk object only in relation to an object at risk; reciprocally, an object at risk emerges only in conjunction with a risk object, through a causal – contingent relationship of risk that brings the two together. “ (Boholm & Corvellec, 2011, s. 181). Therefore, for the same hazard a multitude of risks is possible, i.e. a multitude of different risk perceptions (Dobbie & Brown, 2014). This multitude can be driven by different levels of acceptance concerning a loss of value represented by object at risk., The levels of acceptance are established in the process of risk management. (Ortwin Renn, 1998; Rohrmann, 1993). Therefore we included in the analysis two additional variables as factors affecting risk perception: the degree of crop loss which does not jeopardise the farm operation (taken as a normal yield fluctuation) and the degree of crop loss leading to bankruptcy (catastrophic event).

The following hypotheses were tested with the use of the methods described below:

H1: The objective factors have less explanatory power with regard to risk perception than the subjective ones.

H2: Risk perception is affected by the level of acceptable losses in crop.

H3: Risk perception is affected by the level of non-acceptable losses in crop.

Additionally, two other hypotheses were verified:

H4: Crop insurance use is affected by the stated normal yield fluctuation or catastrophic events.

H5: Acceptance of a new risk management tool, i.e. drought index insurance, is affected by the stated normal yield fluctuation or catastrophic events.

3. Methods

3.1. Study Area

The primary data was gathered on the basis of a survey conducted in March 2012 by means of CATI method, with the use of the structured questionnaire schedule, on a focus group of 750 farmers across Poland, who cultivate plants. A representative sample was selected on the basis of the farm location and size.

3.2. Data and measurement

Risk perception was obtained promptly from the answers to the following question: 'What are the most dangerous perils for your farm - please assess them using the scale from 1 to 7, where 1 denotes negligible peril, while 7 stands for a definitely dangerous phenomenon'. The list included 13 versatile perils – natural ones, like drought, flood, hail, spring frost, winterkill and hurricane and others like plant diseases, health problems, increase in the agricultural inputs prices, price volatility on the crop markets, political changes, property damage, sudden changes in agricultural technology. The statistical description of the answers is presented in table 1.

Table 1 Risk perception of different perils – descriptive statistic (*N=750)*

Risk	Mean	Min.	Max.	SD
Drought	4,62	1	7	1,74
Flood	3,08	1	7	2,00
Hail	3,51	1	7	1,81
Spring frost	4,70	1	7	1,59
Winterkill	4,52	1	7	1,70
Hurricane	2,96	1	7	1,88
Plant diseases	4,7	1	7	1,72
Health problems	3,61	1	7	2,08
Increase in the agricultural inputs prices	5,25	1	7	1,62
Price volatility on the crop markets	4,96	1	7	1,78
Political changes	4,21	1	7	1,98
Property damage	3,56	1	7	2,11
Sudden changes in agricultural technology	3,18	1	7	1,95

Source: author's own calculations.

An attempt to develop a single measure for natural hazards risk perception was undertaken. As the variables are not normally distributed, the Spearman's rang correlation between the perception of single hazards was calculated (table 2).

Table 2 Spearman's rang correlation between perceptions of natural hazards

Variable	Drought	Flood	Hail	Spring frost	Winterkill	Hurricane	Average
Drought		0.06	0.19*	0.24*	0.23*	0.16*	0.18
Flood	0.06		0.22*	0.09*	0.16*	0.30*	0.16
Hail	0.19*	0.22*		0.29*	0.28*	0.37*	0.27
Spring frost	0.24*	0.09*	0.29*		0.56*	0.33*	0.30

Winterkill	0.23*	0.16*	0.28*	0.56*		0.28*	0.30
Hurricane	0.16*	0.30*	0.37*	0.33*	0.28*		0.29

*Significant at the 5% level
Source: author's own calculations.

Most correlations are statistically significant (except for flood and drought), which is confirmed by Bartlett's test. Therefore it was decided to apply a principal component analysis (PCA) to reduce the dimension of explained phenomena. The PCA shows that the structure of all natural hazards risk perception is very complex and only 39% of total volatility could be described by one component. Factor loadings for flood or drought are apparently lower than with other hazards and additional two components – one describing flood and the other one describing drought – would be needed to explain the volatility of these two hazards. It is predictable, considering the relative lower average correlation level for flood and drought (table 2). However, after drought and flood have been excluded from the initial set, PCA shows that the perception of another four hazards could be described by a single measure (table 3) – the first principal component explains 52% of total variance. The correlation coefficients between perception of given hazard and principal component are strong. The new measure (principal component) was calculated for all respondents and represents the risk perception score of the four natural hazards (RPS4). The new variable ranges from -3,47 to 3,44.

Table 3 Results of principal component analysis of perception of four natural hazards

Items	Factor loadings
Hail assessment	0.66
Spring frost assessment	0.79
Winterkill assessment	0.75
Hurricane assessment	0.68
Eigenvalue 2.08, explained variance 52%	

Source: author's own calculations.

Objective factors included in the analysis were measured as follows. Farm size indicates the number of hectares (own and leased) categorized into three classes: small (1-7 ha), medium (7,1-20 ha) and large (more than 20 ha). Location of a farm means the province, where the farm is located (one of the 16 provinces in Poland). Type of crops expresses the cultivated crops in the year of the survey or in the previous year, where more than one of the following options could be selected: rape, winter wheat, winter barley, winter triticale, rye, oats, spring barley, maize grain, sugar beets. Dominant soil quality class reflects one of the six quality soil classes numbered from 1 (the best) to 6 (the worst) according to the official soil classification. The dominant soil is determined on the basis of the biggest area of a given class, measured in hectares. Dominant production means the core production of a farm, i.e. plants, milk, livestock or no specialization. Production purpose indicates whether a farmer produces mainly for the market, for his own needs or both. The structure of farm's income was reflected by two variables. The first one indicates the use of additional, non-farming sources of income. The second one informs about its seasonal or permanent character.

Subjective factors were measured as follows. The age of a farmer was categorized in four brackets: up to 40, 41-50, 51-60 and above 60. The educational level is also a categorical variable with three categories: secondary or tertiary, vocational, lower secondary or none. The data on acceptable losses in crops and losses in crops leading to a farm's bankruptcy were obtained according to farmers' declarations. Farmers were asked to answer the questions: 'What is the level of yield loss that you consider as unthreatening to the farm's operations?" and 'What is the level of yield loss that you consider to be the reason for the bankruptcy of the farm?' Answers to the first question were categorized as follows - up to 10% yield less, from 11 to 20% yield less, from 21 to 30%, over 30% less, 'I don't accept any losses', 'It is hard to assess'. Answer options to the second question were as follows: up to 10% yield less, from 11 to 20% yield less, from 21 to 30%, from 31 to 40% yield less, from 41 to 50% yield less, over 50% yield less, 'I don't accept any losses', 'It is hard to assess'. Because the numerical content of the open intervals turned out to be very small, it was decided that they should be closed. For the analysis the midpoints of the intervals were taken. Answers 'It is hard to assess' were introduced in the model as the average level of acceptable or non-acceptable yield loss was calculated from the whole sample. The acceptable and non-acceptable loss in crop is not normally distributed. The Spearman's rank correlation coefficient between these two variables amounts to 0.26 and is significant at the level of 5%.

Experiences related to different natural perils were characterized by two variables: the frequency of various adverse occurrences in the previous 10 years (discrete variables) and the scope of adverse occurrence affliction, i.e. the evaluation of the influence which the adverse phenomenon had on average on the farm's income from crops in the last three years. The influence was measured in the scale of 1 to 4, where 1 denotes lack of influence on the income, and 4 denotes a very large influence. According to PCA results it was possible to reduce the four variables for frequency of occurrence of hail, winterkill, spring frost and hurricane to two principal components (PC_N_Nat4_1 and PC_N_Nat4_2) (table 4). The first one PC_N_Nat4_1 explains mainly the number of winterkill or spring frost occurrences. The second one PC_N_Nat4_2 describes the volatility of hail or hurricane events. The cumulative explained variance amounts to 74%. The new variable PC_N_Nat4_1 ranges from -1,98 to 5,64 and PC_N_Nat4_2 from -2,69 to 7,22.

Table 4 Results of principal component analysis of frequencies of occurrence of four natural hazards

Items	PC_N_Nat4_1 Factor loadings	PC_N_Nat4_2 Factor loadings
Frequency of hail	0.54	0.56
Frequency of spring frost	0.84	-0.38
Frequency of winterkill	0.85	-0.34
Frequency of hurricane	0.43	0.71
Eigenvalue	1.89	1.08
Explained variance	47%	27%

Source: author's own calculations.

Similarly, the four variables reflecting the influence of hail, spring frost, winterkill or hurricane on an average income from crops were reduced to two new variables (PC_INFL_Nat4_1, PC_INFL_Nat4_2). They both explain 69% of the total volatility, where PC_INFL_Nat4_1 describes mainly the influence of spring frost and winterkill and PC_INFL_Nat4_2 the influence of hurricane. PC_INFL_Nat4_1 ranges from -2,97 to 3.13 and PC_INFL_Nat4_2 from -2,10 to 3,92. The results of PCA are presented in table 5.

Table 5 Results of principal component analysis of influence of occurrence of four natural hazards on average income from crops

Items	PC_INFL_Nat4_1 Factor loadings	PC_INFL_Nat4_2 Factor loadings
Influence of hail	0.56	0.49
Influence of spring frost	0.78	-0.39
Influence of winterkill	0.78	-0.39
Influence of hurricane	0.52	0.63
Eigenvalue	1.80	0.94
Explained variance	45%	24%

Source: author's own calculations.

The frequency of the other natural hazards – drought and flood - and the influence of their occurrences on crop income stay as four separate variables. Except for plant diseases there is no data on frequency of other hazards (see table 1) available. However the data about the influences of their occurrences on income from crop is readily obtainable. As the six variables describing the influence of particular hazard events were significantly cross-correlated they were reduced to four new variables by means of PCA (table 6). PC_INFL_Other_1 describes the volatility of all hazards, PC_INFL_Other_2 explains the volatility of prices, PC_INFL_Other_3 - refers to volatility of health problems and PC_INFL_Other_4 encompasses property damages. The four new variables explained the variance at the level of 84%. PC_INFL_Other_1 ranges from -3,51 to 3,91, PC_INFL_Other_2 from -3,77 to 2,21, PC_INFL_Other_3 from -2,30 to 2,87 and PC_INFL_Other_4 from -2,97 to 3,13.

Table 6. Results of principal component analysis of influence of occurrence of non-natural hazards on average income from crop

Items	PC_INFL_Other_1 Factor loadings	PC_INFL_Other_2 Factor loadings	PC_INFL_Other_3 Factor loadings	PC_INFL_Other_4 Factor loadings
Influence of health problems	0.63	-0.34	-0.60	-0.13
Influence of increase in the agricultural inputs prices	0.56	0.62	-0.35	0.13
Influence of price volatility on the crop markets	0.62	0.60	0.19	0.01
Influence of political changes	0.72	-0.08	0.46	-0.26
Influence of property damage	0.60	-0.37	0.15	0.70
Influence of sudden changes in agricultural technology	0.71	-0.32	0.04	-0.32
Eigenvalue	2.47	1.11	0.75	0.69
Explained variance	41%	19%	12%	12%

Source: author's own calculations.

The crop insurance use is a binary variable, which takes the value 1 if a farmer had any insurance crop contract in the last year and 0 if not. The degree of acceptance for the new concept of index-based crop insurance against drought without specified price was measured as follows. The drought index product, set up on the basis of the Climatic Water Balance (CWB)[2] indications, was presented to the respondents. Afterwards, they were asked, if they liked the new idea of insurance product. The answer variants were: 1- I definitely do not like, 2 - I do not like, 3 - I quite like it, 4 - I like it, 5 - I like it very much, 6 - I like it extremely. Acceptance of index based drought insurance was categorized into two classes: “I like the concept” (if it takes variants from 3 to 6) and “I don’t like the concept” (if it is set to 1 or 2).

The qualitative (nominal) features were introduced into the model through a number of binary variables; hence, if a given variable had *i*-variants, one of them was assumed to be the base and *i*-1 of the variables were introduced into the model.

4. Results

To investigate the perception of natural hazards nine regression models were estimated with ordinary least squares. The first three for RPS 4 , another three for flood perception and the last three for drought perception. In all the cases, i.e. RPS4, drought risk perception and flood risk perception the first model considers objective factors, the second refers to subjective factors and the third one is based on all statically significant factors form the previous two models. The results of least squares regression for RPS4 are presented in table 7, for drought perception in table 8 and for flood perception in table 9. The goodness fit of the models were measured by adjusted R^2. The significance of the variables was estimated using a two-sided t-Student test. The existence of outliers was verified in all models by means of DFFITS . Multicollinearity was not a concern, because the most of the variables are binary and the PCA-variables are orthogonal. In all the cases the change of R^2 that was achieved through expanding the set of variables with subjective factors was assessed by applying F-test – corresponding p-values will be presented.

According to the results presented in table 7 the variation of risk perception of hail, spring frost, winterkill and hurricane is explained to a greater extent by subjective risk model than by the objective ones. The R^2 difference amounts to 52 percentage points (p=0,000) which is in line with H1. Only three objective features remain statistically important in a model respecting both objective and subjective variables. Inclusion of the objective factors in the subjective models increases the explanatory power slightly by 1 percentage point (but it is significant: p= 0.0003).

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[2] The Climatic Water Balance (CWB) index is the main drought-monitoring tool in Poland, additionally including soil’s water retention qualities. The CWB index meets the requirements of index-based insurance systems because it defines the potential yield losses against the average conditions. CWB expresses the difference between precipitation and potential evapotranspiration.
CWB = P - ETP
Where:
CWB - Climatic Water Balance
P - precipitation in a given period
ETP - Penman evapotranspiration in a given period

Among the subjective features, experiences seem to be crucial. Basically, the greater the magnitude of the crop income loss which a peril caused in the past, the higher is the risk perception of the four natural hazards. One exception to this rule is price hazard. Among different perils affecting risk perception spring frost and winterkill are the most important.

Risk perception of the four selected natural hazards depends on the acceptable loss, which as the independent variable remains significant in Model 2 and Model3 (at the 10% level in Model 2 and 5% level in Model3). It is in line with the Spearman's rank correlation coefficient between RPS4 and acceptable loss that amounts to -0.08 and is significant at the 5% level. These results confirm H2 in case of hail, spring frost, winterkill and hurricane risk perception. As we could expect, risk perception decreases if the level of losses that do not disturb the normal operation of a farm is higher.

However, the direction of the correlation between non-acceptable losses and risk perception seems to be confusing. According to the results, the higher is the loss in crop leading to a farm bankruptcy, the greater is the risk perception. The non-acceptable loss in crop stays statistically significant in Model2 and Model3 at the level of at least 5%, but Spearman's rank correlation coefficient between non-acceptable loss and RPS4 is insignificant at this level. It is possible, that both variables, i.e. acceptable and non-acceptable loss in crop that are statistically significant in the models are corrective variables towards each other (they are correlated). Therefore H3 in the case of hail, spring frost, winterkill and hurricane has to be rejected.

Table 7. Results of regression estimation of three risk perception models for four natural hazards (RPS4)

Variables	Model 1 – objective features		Model 2 –subjective features		Model 3 –objective and subjective features	
	Coefficients	Standard deviation	Coefficients	Standard deviation	Coefficients	Standard deviation
Constans	0.04	0.10	-0.47***	0,15	-0.38**	0,16
Milk production dominant	-0.44***	0.17			-0.14	0.11
Agriculture income only	0.24**	0.11			-0.00	0.07
Winter wheat cultivated	-0.20*	0.11			-0.02	0.08
Winter barley cultivated	0.48***	0.13			0.32***	0.09
Oats cultivated	-0.23**	0.11			-0.09	0.07
Kujawy- Pomerania Province	0.46**	0.19			0.24**	0.13
Warmia-Masuria Province	-0.75*	0.45			-0.24	0.30
Podkarpacie Province	-0.56**	0.24			-0.33**	0.16
PC_N_Nat4_2			-0.07*	0,04	-0.07**	0.04
PC_INFL_Nat4_1			0.79***	0,03	0.77***	0.03
PC_INFL_Nat4_2			0.21***	0,04	0.21***	0.04

PC_INFL_Other_2			-0.07**	0.03	-0.06*	0.03
Influence of drought on crop income			0.06**	0,03	0.04	0.03
Influence of flood on crop income			0.05**	0,02	0.06**	0.03
Acceptable loss in crop			-0.01*	0.00	-0.01**	0.00
Bankruptcy by loss in crop			0.01***	0.00	0.01**	0.00
Adjusted R^2	0.06		0.58		0.59	

*Significant at the 10% level, **Significant at the 5%level, ***Significant at the 1% level

Source: author's own calculations.

Similarly to the previous four natural hazards, volatility of drought risk perception is to a greater extent explained by a subjective feature (table 8). The difference in R^2 amounts to 53 percent points (p=0.01). Introducing objective features in subjective model has not increased explanatory power of the model (p=0.85). Only two objective variables denoting sorts of crops remain statistically significant in the model based on all variables. These results support H1. Among the subjective features number of peril occurrences and their influence on crop income are the most important again. They basically increase the risk perception except for the influence of price fluctuation on crop income. Risk perception of drought is also lower in older (over 50 years) and better educated farmers (secondary or higher education background).

The results do not support H2 and H3 as either acceptable or non-acceptable loss in crop are statistically significant in any drought risk perception model.

Table 8. Results of regression estimation of three risk perception models for drought

Variables	**Model 4 – objective features**		**Model 5 –subjective features**		**Model 6 –objective and subjective features**	
	Coefficients	**Standard deviation**	**Coefficients**	**Standard deviation**	**Coefficients**	**Standard deviation**
Constans	4.47***	0.15	2.22***	0,11	2.26***	0.15
Soil quality class 3 or 4	-0.40***	0.12			-0.13	0.08
Pork production dominant	0.54***	0.19			0.18	0.12
Ray cultivated	0.47***	0.13			0.21**	0.09
Maize grain cultivated	0.79***	0.27			0.15	0.18
Rape cultivated	0.41*	0.21			0.08	0.14
Triciale cultivated	0.27**	0.12			-0.03	0.08
Oats cultivated	-0.39***	0.13			-0.16*	0.09
Lubelskie Province	-1.37***	0.27			-0.00	0.18
Age over 60			-0.25**	0.12	-0.25**	0.12

Age from 51 to 60			-0.16*	0.08	-0.16*	0.09
Secondary or tertiary education			-0.18**	0.08	-0.18**	0.08
PC_N_Nat4_1			0.06**	0.03	0.06*	0.02
PC_N_Nat4_2			0.07*	0.04	0.06*	0.04
N_plant deseases			0.02*	0.01	0.02**	0.01
N_drought			0.11***	0.02	0.10***	0.02
Influence of drought on crop income			0.91***	0.04	0.90***	0.04
PC_INFL_Other_2			-0.13***	0.04	-0.13***	0.04
Adjusted R^2	0.09		0.62		0.62	

*Significant at the 10% level, **Significant at the 5%level, ***Significant at the 1% level

Source: author's own calculations.

The results presented in table 9 clearly indicate that subjective variables explain the volatility of flood risk perception to a much greater degree than objective ones. The R^2 difference is equal to 69 percentage points (p=0.0000). Juxtaposition of objective and subjective variables improves the R^2 only by 1 percent point, which is not significant (p=0,158). The results are in line with H1. Within the subjective features the scope of influence of flood, hurricane and hail occurrences on crop income increases flood risk perception. Once again, the scope of influence of price volatility is adversely correlated with the dependent variable. One has to notice that socio-demographic features of a farmer are statistically significant with respect to flood risk perception. The older and better educated a farmer is, the less often he/she perceives flood as a dread for their crop income. Additionally, male respondents tend to dissimulate risk assessment. The results fail to find the relationship between flood risk perception and acceptable and non-acceptable loss in crop. Hence, H2 and H3 have to be rejected.

Table 9. Results of regression estimation of three risk perception models for flood

Variables	Model 7 – objective features		Model 8 –subjective features		Model 9 –objective and subjective features	
	Coefficients	Standard deviation	Coefficients	Standard deviation	Coefficients	Standard deviation
Constans	3.47***	0.14	2.24***	0.12	2.44***	0.14
Winter wheat cultivated	-0.27*	0.16			-0.02	0.09
Winter barley cultivated	0.38**	0.18			0.04	0.10
Oats cultivated	-0.38**	0.15			-0.36***	0.08
Rape cultivated	-0.62**	0.25			0.03	0.14
West Pomerania Province	-0.63*	0.35			-0.10	0.19

Wielkopolska Province	-0.76***	0.20			-0.21*	0.11
Podlasie Province	0.76**	0.36			0.18	0.20
Female			0.15*	0.08	0.13*	0.08
Age over 60			-0.38***	0.12	-0.39***	0.12
Age from 51 to 60			-0.26***	0.09	-0.26***	0.09
Vocational education			-0.46***	0.12	-0.47***	0.12
Secondary or tertiary education			-0.53***	0.12	-0.55***	0.12
PC_INFL_Nat4_2			0.11***	0.04	0,1***	0.04
PC_INFL_Other_2			-0.19***	0.04	-0.19***	0.04
Influence of flood on crop income			1.14***	0.03	1.13***	0.03
Adjusted R^2	0.04		0.71		0.72	

*Significant at the 10% level, **Significant at the 5%level, ***Significant at the 1% level

Source: author's own calculations.

Because acceptable and non-acceptable loss in crop is not normally distributed, nonparametric U Manna-Whitney test was applied to test H4. The use of crop insurance is significantly correlated (p=0.03) with the declared level of loss that does not jeopardize the normal functioning of a farm and with the catastrophic level of loss in crop, that leads to farm bankruptcy (p=0.00). However, the direction of the correlation is more adverse than one could expect – the average acceptable loss is higher in people who signed a crop insurance contract within the last year and the catastrophic loss is higher in the insured as well. To test H5, the Kruskal-Wallis test was applied. The results failed to support H5.

5. Discussion

This paper discusses the factors affecting risk perception of natural hazards by Polish farmers and the influence of subjective assessment of acceptable and non-acceptable loss on crop insurance decision. Based on the previous research, five hypotheses were formulated. They were verified on the basis of a representative survey of 750 farmers.

With all natural hazards, i.e. hail, spring frost, winterkill, hurricane, drought and flood, volatility of risk perception was explained to a much greater extent by subjective factors rather than by the objective ones. The R^2 difference amounts from 52 to 67 percentage points.

The only objective features that remain significant in objective and general models are some types of crops cultivated and localization. The very low level of explanation power of objective models could be caused by inadequate objective variable set. In the case of flood, additionally, objective and subjective variables were introduced in other surveys. On the other hand, R^2 of subjective models is high, especially in the case of flood, which raises most doubts. This could lead to the statement that in the quite equal conditions related to irrigation rate and flood protection systems in the whole country, subjective factors deliver high explanation power.

Subjective features that are statistically significant in the subjective models and in the models based on all features are primarily those describing experiences. As for the perception of particular hazards, the most important are direct experiences with this particular phenomenon. That stays in line with other studies of natural hazards (Kellens et al., 2013; Wachinger et al., 2013) and indicates the absence of negative correlation between low severity and seldom experienced events and risk perception. Other natural hazards affect one's perception to a much smaller degree. As far as non-natural agricultural hazards are concerned, the only significant one is price hazard, i.e. increase in the prices of agricultural input or price volatility on the crop market. In terms of perception of a particular hazard the frequency of occurrence of a given phenomenon is less important than its severity measured as a drop in crop income. This rule is valid both for perils that have occurred in the year of the survey or in the previous year (like winterkill or spring frost), and for other natural phenomenon that irregularly occurred in the more distant past.

Age and education are statistically significant only in the case of drought and flood perception. In the latter case demographic features are supplemented by gender. The older and better educated a farmer is, the lower is his/her risk perception. Females' perception of flood is higher than males'. These findings fit into results related to demographic features in other surveys on risk perception (Botzen et al., 2009; Deressa et al., 2010; Ho et al., 2008), although one has to notice that the findings concerning the correlation between risk perception of flood and draught and age, educational level and gender are ambiguous.

The level of acceptable loss in crop, i.e. loss that does not disturb the normal functioning of a farm influences hail, spring frost, winterkill and hurricane risk perception and is irrelevant to flood and drought risk perception. Acceptable loss indicates the level of crop loss, when a farmer will probably start to undertake risk management activities (prevention, repression, seeking for or using the financial aids to cover the loss). The higher this level is, the higher is the level of accepted yield fluctuation. Hence, the risk perception is lower. This stays in line with the relational theory of risk. However, it is hard to explain why this pattern does not apply to drought or flood risk perception. The dependence between non-acceptable level of loss, i.e. loss that leads to bankruptcy of a farm and risk perception failed to be confirmed in this study.

The use of crop insurance is affected by acceptable and non-acceptable loss in crop. As both of the levels are higher in the case of the insured farmers, one can suppose that signing a contract by a farmer increases his/her level of fluctuation in yield taken as normal and the ability to assimilate the (catastrophic) yield loss. The indifference of acceptable and non-acceptable loss regarding new risk management solution (index insurance) is also confirmed by a more advanced analysis (Kaczała & Wiśniewska, 2014).

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