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# Factors Influencing the Take-Up of Agricultural Insurance and the Entry into the Mutual Fund: A Case Study of the Czech Republic

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**Abstract:** The objective of the study was to identify the main factors influencing farmers' willingness to take up agricultural insurance and participate in a mutual fund for non-insurable risks in the Czech Republic. Responses from 214 representative farms were processed using descriptive statistics, paired *t*-tests, binary logistic regression, and contingency analysis. The regression model showed the influences of agricultural area, distrust in insurance companies, the probability of losing more than 20% of production, the price of insurance premiums, and having a developed formal strategy on the likelihood of taking up agricultural insurance. Unlike previous empirical studies, this study did not attempt to look at agricultural insurance as an isolated risk management tool but rather to show the interrelationship between farmers' decisions to join a mutual fund and their choice of agricultural insurance. Farmers expect most agricultural production risks to become significantly more important. With the ongoing economic crisis in the EU, there is growing pressure to reduce ad hoc public spending on coverage of non-insurable risks and to seek alternative solutions. The study also shows the need for a holistic approach to the design of risk management support systems in EU countries.

**Keywords:** agriculture; insurance; mutual funds; risk management

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## 1. Introduction

Agriculture is an important sector that involves the livelihood of society, maintaining jobs in rural areas, caring for the landscape, and, increasingly, environmental issues. However, agriculture is also vulnerable to risks of various origins related to climate change (Tedesco 2018). Farmers must deal with these risks by adopting alternative risk management strategies. A significant threat to agribusiness is non-insurable risk, which is systemic and difficult for insurers to diversify. Examples of risks that are hard to insure are drought or spring frost in fruit. However, in some European Union (EU) countries, such risks can also be insured or hedged, and it is therefore important to know more about such instruments.

Agriculture is massively supported in the EU, mainly through subsidies and financial aid. Given the greater vulnerability of agricultural production to weather risks and mass animal diseases, many EU countries have resorted to various forms of support for agricultural risk management. While insurance subsidies are the most common intervention, other support measures, such as legal and regulatory frameworks, reinsurance, technical and administrative support, and linkages with government extension services in agriculture, animal health, or meteorology, are also important (Dick and Wang 2010).

Agricultural risk management was not explicitly included in the EU Common Agricultural Policy (CAP) until 2009, when member states could support insurance premiums through "financial envelopes" for direct payments of up to 10%. With the 2013 CAP reform, risk management instruments became part of the "second pillar" for the 2014/2020 period, with support for livestock and crop insurance (Article 37), mutual funds (Article 38), and income stabilization instruments (Article 39), all of which are allowed in the form of mutual funds (Meuwissen et al. 2018). The development of a common risk management model for member states, regulated by EU legislation in the form of support for insurance, mutual funds, and the income stabilization instrument, is a frequently discussed topic in the EU's multi-annual framework for the Common Agricultural Policy 2020+ (CAP 2020+).

However, the introduction of a common framework is complicated by the different climatic conditions and farm structures in European countries. An important aspect of the application of the CAP risk management tool in the Czech agricultural market is the specific farm structure in the Czech Republic. On the one hand, large farms dominate in terms of production volume, with production diversified in terms of space and production technology, which enables them to partially mitigate production risks. On the other hand, there is a large number of small farms in the Czech Republic, which are very vulnerable to natural risks (Čechura et al. 2022). This important factor should be considered when designing the risk management system in the Czech Republic.

Different EU countries have different agricultural models. Different agricultural models can lead to different approaches to agricultural risk management systems. CAP is not flexible enough to accommodate farmers' different agricultural risk management (Myyrä and Liesivaara 2015). Differences on the demand and supply side of the crop and livestock insurance market point to different policy approaches to the role of agriculture in EU countries (Soliwoda et al. 2017).

Subsidizing agricultural production insurance alone is not the most appropriate agricultural policy measure in countries with Mediterranean climates characterized by drought waves and high temperatures, such as Italy (Capitanio and De Pin 2018) or Spain (Pérez-Blanco et al. 2016). In these countries, more complex risk management tools are used in the form of income insurance, multiperil crop insurance, and state reinsurance schemes. In contrast, farmers in the northwestern part of the EU, in the Netherlands and Germany, face relatively heavy rainfall and storms with localized impacts, and the liberal nature of governments makes them reluctant to financially support agricultural insurance. The typical insurance in Germany is single-peril hail insurance, while more complex forms of insurance, such as multi-peril crop insurance and livestock insurance, are used in mutual funds in the Netherlands (Meuwissen et al. 2018).

In countries where drought is a non-insurable risk, there is growing concern about increased government spending on ad hoc compensation for drought losses due to climate change. Although index-based insurance is available in some countries, such as Austria, it is still a rather marginal solution to drought risk in developed and emerging economies (Barnett and Mahul 2007) because effective use of index insurance requires a high correlation between the drought index and crop yields; i.e., the lowest possible basis risk (Lichtenberg and Iglesias 2022).

Nowadays, there is a governmental interest in moving to a more systemic and comprehensive solution to non-insurable risks, which would be feasible under certain conditions. One of these conditions would be the establishment of a mutual fund for non-insurable risks to complement agricultural insurance products for large losses. Well-defined and credible ex ante rules for the use of disaster relief are essential for the development of insurance markets. One option would be to make farmers' eligibility for disaster relief conditional on their participation in insurance schemes (van Asseldonk et al. 2013). In general, agricultural insurance should not be considered as an isolated tool for agricultural risk management but as part of a comprehensive system of measures including mutual funds, advisory services, credit services, information services, and any kind of support from national or regional governments (Ali et al. 2020).

Theoretically, the farmer's choice between alternative risk management instruments is based on McFadden's random utility theory, which assumes that, given a set of attribute values, an individual chooses the alternative that provides the greater utility (McFadden 1974).

The random utility model provides a framework for discrete choice models that explains and predicts the choice between two or more than two alternatives, which was critical to the choice of the logit model in this study.

From a theoretical point of view, the demand for agricultural insurance is driven by risk aversion, which is characterized by the propensity of the subject to avoid risky activities even at the cost of reducing expected utility (in the case of agricultural insurance, increasing costs in the form of premiums). However, risk aversion is not the only factor influencing the demand for agricultural insurance. Age, farmer income, and farm size play important roles in explaining the demand for insurance in emerging markets (Stojanović et al. 2019), as well as the economic performance of the farm (Baráth et al. 2017), the share of nonfarm income in the farmer household (Njegomir and Demko-Rihter 2018), the regional location of the farm (Lefebvre et al. 2014), previous experience with risk, the value of agricultural production, cropping intensity, soil quality (Was and Kobus 2018b), preference and probability of risk realization (Knapp et al. 2021), farmers' risk appetite (Kaczala 2017), price relative to insurance benefits (Stoeffler and Opuz 2022), limited liquidity, degree of time preference, basis risk, trust (Ali et al. 2020), previous experience with insurance (Santeramo 2018), transparency of the insurance product (Linhoff et al. 2022), and reluctance to pay premiums due to loss aversion (Feng et al. 2020). In terms of the cost of insurance, it has been shown that farmers who believe that paying insurance premiums is only a cost tend not to purchase agricultural insurance, in contrast to farmers who view insurance premiums as an investment (Njegomir and Demko-Rihter 2018). On the other hand, the farmer's education does not affect the insurance decision (Was and Kobus 2018a), nor does it affect the level of subsidies. However, the models estimated for farms with different levels of subsidies indicate the importance of subsidies as a stabilizing factor of income (Was and Kobus 2018b).

Insurance subsequently leads to significantly higher agricultural investments and riskier agricultural production decisions (Karlan et al. 2014). Insurance coverage has implications for the use of agricultural inputs. Empirical results show a positive and economically significant relationship between crop insurance and pesticide (Möhring et al. 2020) and fertilizer use in agriculture (Mishra et al. 2005). The moral hazard problem, however, may adversely affect production practices in which uninsured farmers are more productive and efficient in resource use than insured farmers (Petriashvili 2020). However, another study has shown that insured farms are more productive than farmers who do not use this risk management tool (Zubor-Nemes et al. 2018). Thus, the direction of the relationship between farm insurance and agricultural production efficiency is not clear in the literature, as agricultural production efficiency is largely determined by the quality of farm management.

Mutual funds, the second cornerstone of the institutional framework that supports risk management in CAPs, are based on the accumulation of financial reserves from participants' contributions (often sector-specific), which members can withdraw in the event of a loss according to predetermined rules (Meuwissen et al. 2013). The purpose of mutual funds is to address risks that are beyond the capacity of individual farmers. However, they are not very systematic because the group of farmers in a mutual fund is sufficiently diverse to manage without bankrupting the fund (Cordier and Santeramo 2020). Research findings support regionally differentiated rules for fund financing and indemnity (Severini et al. 2019). Member states' experience with the use of mutual funds is limited, but the examples of countries where mutual funds work (Italy, the Netherlands, France) suggest that they can be a structurally simple but very effective tool for covering risks that cannot be managed by the insurance market (Janowicz-Lomott and Łyskawa 2014).

In the Czech Republic, the main risk management tool in agriculture is subsidized agricultural insurance for crop and livestock production combined with ad hoc support for non-insurable risks from the state budget in cases of large systematic losses caused, for example, by drought (Soliwoda et al. 2017). Although there has long been political interest in creating a state-guaranteed mutual fund for managing non-insurable agricultural risks, no such fund has yet been established because farmers and the government do not agree on the parameters of the fund (Špička 2020). At the political level, there has long been a debate on the establishment of a risk management system in Czech agriculture, considering the role of the relatively established agricultural insurance, the upcoming fund for non-insurable risks, and the income stabilization support offered under the CAP.

The article therefore focuses on agricultural insurance and the forthcoming mutual fund for non-insurable risks. The aim of the article is to identify important factors influencing farmers' willingness to take up agricultural insurance and participate in the mutual fund for non-insurable risks in the Czech Republic. Unlike the previous empirical studies, the paper does not attempt to look at agricultural insurance as an isolated risk management tool but rather attempts to show its interdependence with farmers' decisions to join a mutual fund. Building on these previous findings on the determinants of demand for risk management tools in agriculture, the following research questions were formulated to address the knowledge gap.

- Question 1: Which agricultural risks do farmers believe will become significantly more important in the future?
- Question 2: What incentives influence individual demand for agricultural insurance?
- Question 3: At what acreage does the chance of purchasing agricultural insurance increase?
- Question 4: Does the purchase of agricultural insurance influence farmers' opinions about the conditions for indemnity from the upcoming fund for non-insurable risks?

The following section provides an overview of the data sources and quantitative methods with respect to the research questions. The overview of the data and methods is followed by the results and discussion about the authors' own assumptions and literature. The paper uncovers new determinants of individual demand for agricultural risk management tools that are informative to practitioners, particularly policy makers, agricultural insurers, and professionals interested in developing a more comprehensive form of agricultural risk management.

## 2. Data and Methods

To answer the research questions, the authors chose quantitative research with the main data source being a questionnaire survey employing online data collection. Agricultural enterprises were contacted directly and through NGOs (associations). A total of 214 valid responses were obtained in the second half of 2021. The average area of farms in the sample was 274 hectares (standard deviation = 862 hectares, average area of the 25% quartile = 15.8 hectares, median = 62 hectares, and 75% quartile = 175 hectares). The sample included both landless farms and large farms of up to 10,000 hectares. The average area of the sample was close to the average area of agricultural land in the Czech Republic (253 hectares in 2020 according to the Farm Accountancy Data Network (FADN CZ)). The sample was composed of 81.8% natural persons and 18.2% legal entities, which corresponds to the structure of agricultural holdings in the Czech Republic. The average share of agricultural land in naturally constrained areas was 55.7%, with farms in production-intensive areas and farms operating exclusively in naturally constrained areas represented in the sample. The main types of farming were represented:

- Enterprises with 100% of their revenues from crop production (26.9%);
- Enterprises with more than 75% of their revenue from crop production (16.5%);
- Enterprises with more than 75% of their revenue from livestock production (20.8%);
- Enterprises with 100% of their revenue from livestock production (8%);
- Enterprises with mixed crop and livestock production (27.8%).

Men made up 82.5% of the sample and women 17.5%, which corresponds to the predominance of men in leadership positions in agriculture. The largest shares of farmers in the sample were 40–50 years old (32.5%) and 50–60 years old (28.3%), which corresponds to the unfavorable age structure of workers in Czech agriculture (Šimpach and Pechrová 2015).

The respondents were experienced managers who had been in management positions for a relatively long time, more than 10 years (76.7%). The structure of the sample corresponded to the structure of agricultural enterprises in the Czech Republic. The data were processed using the software IBM SPSS Statistics 27.

The questions on risk perception (Research Question 1 (RQ1)) were based on subjective assessments of the importance of risks in the present and in the future. Self-reporting is a common method of research in the social sciences. As opposed to objective measures, which are not affected by personal biases and are represented by facts, subjective self-assessment can be associated with biases negatively affecting validity and reliability.

With ongoing climate change affecting the frequency and severity of risks, the purpose of the survey was to test farmers' expectations that most of the risks assessed would increase in severity in the coming years. Current risk perception was assessed with the question, "Please indicate the risks that have affected the company in the last five years, and for each risk, rate the economic impact of the risk on the company" on the following scale: "The risk has not affected the business" (0)—"Not significant" (1)—"Less significant" (2)—"Significant" (3)—"Very significant" (4). Farmers' perceptions of the significance of future risks were estimated using the question, "Please indicate the risks that you think will affect the company in the coming years, and for each risk, estimate the potential economic impact on the company". Thus, each respondent indicated the importance of the risks in the present and an estimate of the importance of the risks in the future (RQ1: for more information about the statistical testing, see Appendix A).

A logit regression model was used to examine the determinants of interest in agricultural insurance (Research Question 2 (RQ2)). The dependent variable was "Do you have agricultural insurance with your insurance company?" with respondents able to answer either "Yes" (1) or "No" (0). A total of 91 respondents answered "Yes", 119 respondents answered "No", and 4 respondents did not answer the question. Due to the binary nature of the dependent variable, a binary logistic regression method was chosen to identify predictors of agricultural insurance purchase (Anderson et al. 2020). (RQ2: for more information about the statistical testing, see Appendix B).

The question "At what acreage does the likelihood of purchasing agricultural insurance increase?" (Research Question 3 (RQ3)) was answered using the optimal binning statistical procedure incorporated into IBM SPSS Statistics (RQ3: for more information about the statistical testing, see Appendix C).

A long-discussed issue in the preparation of the mutual fund for non-insurable risk is the link between indemnity from the mutual fund and the purchase of agricultural insurance (Research Question 4 (RQ4)). Responses to two questions were compared:

- Have you purchased agricultural insurance? (Yes = 1, No = 0);
- How should the indemnity payment be tied to commercial agricultural insurance (check only one option)?
    - ○ No conditions (indemnity from the fund should not be linked to the purchase of commercial agricultural insurance);
    - ○ Agricultural insurance of at least 50% of annual production (otherwise no indemnity);
    - ○ Agricultural insurance of at least 50% of annual production (otherwise indemnity is halved).

    (RQ4: for more information about the statistical testing, see Appendix D.)

## 3. Results

This section contains the answers to the four research questions. The answers were supported by statistical tests. The section is divided into subsections according to the research questions.

### 3.1. Expected Changes in the Importance of Agricultural Risks

Farmers perceived drought (mean score = 2.95), excessive rainfall at harvest (1.92), diseases and pests (1.55), and vole risk (1.46) as the most important risks in crop production at present. In livestock production, animal injury (1.02), noninfectious disease (0.72), and disease (0.5) risks were perceived as the most important. A paired *t*-test showed that farmers expected different levels of importance for most risks, except for frost in grapevines, drought, and voles. However, farmers expected most risks to increase in subsequent years (Table 1).

**Table 1.** Scores for selected risks in farms now and in the future.

| Risk | Average | SD [1] | SE [2] | t | *p*-Value |
|---|---|---|---|---|---|
| Hailstorm (present) | 1.28 | 1.392 | 0.099 | 7.489 | 0.000 |
| Hailstorm (future) | 1.97 | 1.277 | 0.091 | | |
| Fire (present) | 0.51 | 1.086 | 0.077 | 8.013 | 0.000 |
| Fire (future) | 1.22 | 1.217 | 0.087 | | |
| Windstorm (present) | 1.09 | 1.236 | 0.088 | 6.758 | 0.000 |
| Windstorm (future) | 1.66 | 1.174 | 0.084 | | |
| Flood (present) | 0.72 | 1.115 | 0.079 | 6.061 | 0.000 |
| Flood (future) | 1.13 | 1.226 | 0.087 | | |
| Soil flooding (present) | 0.64 | 1.057 | 0.075 | 6.171 | 0.000 |
| Soil flooding (future) | 1.04 | 1.145 | 0.082 | | |
| Freezing out (present) | 0.92 | 1.090 | 0.078 | 5.109 | 0.000 |
| Freezing out (future) | 1.30 | 1.123 | 0.080 | | |
| Spring frost (present) | 1.29 | 1.247 | 0.089 | 4.809 | 0.000 |
| Spring frost (future) | 1.60 | 1.264 | 0.090 | | |
| Frost on the vine (present) | 0.16 | 0.642 | 0.046 | 0.925 | 0.356 |
| Frost on the vine (future) | 0.19 | 0.717 | 0.051 | | |
| Drought (present) | 2.95 | 1.218 | 0.087 | −0.706 | 0.481 |
| Drought (future) | 2.91 | 1.160 | 0.083 | | |
| Grain sprouting (present) | 0.95 | 1.137 | 0.081 | 3.033 | 0.003 |
| Grain sprouting (future) | 1.14 | 1.141 | 0.081 | | |
| Harvest rainfall (present) | 1.92 | 1.297 | 0.092 | 5.006 | 0.000 |
| Harvest rainfall (future) | 2.26 | 1.170 | 0.083 | | |
| Diseases and pests (present) | 1.55 | 1.307 | 0.093 | 5.452 | 0.000 |
| Diseases and pests (future) | 1.87 | 1.305 | 0.093 | | |
| Voles (present) | 1.46 | 1.353 | 0.096 | 1.963 | 0.051 |
| Voles (future) | 1.59 | 1.316 | 0.094 | | |
| Animal disease (present) | 0.50 | 1.053 | 0.093 | 10.251 | 0.000 |
| Animal disease (future) | 1.58 | 1.218 | 0.108 | | |
| Acute poisoning (present) | 0.37 | 0.855 | 0.077 | 7.439 | 0.000 |
| Acute poisoning (future) | 1.02 | 1.028 | 0.093 | | |
| Natural disaster—animals (present) | 0.33 | 0.852 | 0.078 | 9.517 | 0.000 |
| Natural disaster—animals (future) | 1.28 | 1.154 | 0.105 | | |
| Overheating of animals (present) | 0.41 | 0.860 | 0.079 | 5.100 | 0.000 |
| Overheating of animals (future) | 0.85 | 0.921 | 0.085 | | |
| Non-infectious disease (present) | 0.72 | 1.052 | 0.094 | 7.144 | 0.000 |
| Non-infectious disease (future) | 1.38 | 1.083 | 0.097 | | |
| Animal injury (present) | 1.02 | 1.015 | 0.088 | 4.606 | 0.000 |
| Animal injury (future) | 1.46 | 1.077 | 0.093 | | |

[1] Standard deviation, [2] standard error. The Wilcoxon paired signed-rank test confirmed the results of the paired *t*-test for all pairs examined. Source: authors' calculation.

The reason why no significant differences were found in the perceived importance of drought in the future may be that the risk itself was already considered very important (highest score of all risks in the present) and farmers expected drought risk to be very important in the future (highest score of all risks in the future). The risk of voles was also rated as relatively important, and farmers expected it to be very important in the future. Both risks—drought and voles—are difficult to insure in the country and the management of these risks should be supported by a mutual fund for non-insurable risks. The average score for the vine risk was the lowest, but this is explained by the fact that winegrowers were not well-represented in the population.

The largest effect sizes, as measured by Cohen's d, were found for livestock disease risk (current score = 0.5, future score = 1.58, Cohen's d = 0.91) and livestock natural events (current score = 0.33, future score = 1.28, Cohen's d = 0.869). The effect sizes in crop production were generally smaller and did not exceed 0.571.

Overall, farmers were concerned about the increasing importance of most agricultural risks. Therefore, it is necessary to create an effective system for the management of insurable and non-insurable risks in the Czech Republic that would place the least possible burden on public budgets.

### 3.2. Incentives Influencing the Individual Demand for Agricultural Insurance

Most insured farmers had crop insurance (75.8%) and/or livestock insurance (54.9%). Most farmers who ad crop insurance had only a basic package of insurance against selected natural hazards; i.e., hail (97.2%), fire (55.6%), and windstorm (54.2%). Farmers rarely insured against floods, freezing out, and spring frost. In the livestock sector, the most frequently used insurance products were insurance against diseases (94%), natural disasters (83.3%), and acute poisoning (53.3%).

The majority of uninsured farmers were not considering insurance in the future (71.4%). On the other hand, 10.1% of the uninsured farmers would be interested in insurance in the future. Farmers had some interest in insuring themselves against risks for which they do not yet have insurance coverage. However, the absolute frequencies for this group of respondents were relatively low.

The original set of predictors entering the stepwise logistic regression is listed in Appendix E. Theoretically possible predictors were entered into the model, from which statistically significant uncorrelated predictors were then selected using the forward likelihood ratio (LR) stepwise regression method with a 0.05 significance level. At the same time, the optimal binning method was used to calculate the farm area boundaries that most strongly determined insurance coverage: interval (0) = less than 73 hectares (reference category), interval (1) = from 73 hectares to 312 hectares, interval (2) = 312 hectares or more. Table 2 shows the final model.

**Table 2.** Logistic regression results—significant predictors of purchasing agricultural insurance.

| Model Variable | B | SE [1] | Wald | df | p-Value | Exp(B) [2] | 95% CI [3] for Exp(B) | |
|---|---|---|---|---|---|---|---|---|
| Area of agricultural land (farm size) | | | 29.411 | 2 | 0.000 | | | |
| Area of agricultural land—interval (1) | 2.064 | 0.518 | 15.904 | 1 | 0.000 | 7.876 | 2.856 | 21.717 |
| Area of agricultural land—interval (2) | 5.844 | 1.220 | 22.958 | 1 | 0.000 | 345.276 | 31.616 | 3770.723 |
| Distrust of insurance companies | −0.569 | 0.239 | 5.658 | 1 | 0.017 | 0.566 | 0.354 | 0.905 |
| Probability of losses exceeding 20% of production | 0.569 | 0.241 | 5.555 | 1 | 0.018 | 1.766 | 1.101 | 2.835 |
| The price (premium) influences the probability of taking out an insurance policy | −0.628 | 0.237 | 7.020 | 1 | 0.008 | 0.534 | 0.335 | 0.849 |
| Risks are managed in the company according to a formal strategy | −0.480 | 0.239 | 4.036 | 1 | 0.045 | 0.619 | 0.387 | 0.988 |
| Intercept | 1.903 | 1.181 | 2.596 | 1 | 0.107 | 6.704 | | |

[1] Standard error, [2] odds ratio, the predicted change in odds for a unit increase in the predictor, [3] confidence interval. −2 log likelihood = 112.459; Nagelkerke's $R^2$ = 0.603; Hosmer–Lemeshow chi-square test = 6.666 (df = 8, p-value = 0.573); specificity = 90.4%; sensitivity = 71.4%; accuracy = 82.2%; area under the ROC curve = 0.858 (asymptotic significance at a cutoff value of 0.5: p-value < 0.001). Source: authors' calculation.

The model was of relatively high quality, with a high success rate in predicting both the purchase of agricultural insurance (71.4% correct predictions for the answer "yes") and the reluctance to purchase agricultural insurance (90.4% correct predictions for "no"). The quality of the model was also confirmed by the relatively favorable value of Nagelkerke's $R^2$ (0.603) and the large area under the ROC curve (0.858).

Logistic regression analysis identified land acreage, distrust of insurance companies, probability of losing more than 20% of production, premium price, and risk management according to a developed formal strategy as significant predictors of purchasing agricultural insurance. The following conclusions can be drawn from the model presented in Table 2:

- The likelihood of taking out agricultural insurance (ceteris paribus) increases with the farm size;

- With higher distrust towards insurance companies, the likelihood of taking out agricultural insurance decreases (ceteris paribus);
- With a higher probability of suffering a loss of more than 20% of production, the likelihood of purchasing agricultural insurance increases (ceteris paribus);
- With a higher level of agreement with the statement that the decision to take out agricultural insurance is influenced by price, the likelihood of taking it out decreases (ceteris paribus);
- With a higher level of agreement with the statement that risks on the farm are managed according to a developed formal strategy, the likelihood of taking out agricultural insurance decreases (ceteris paribus).

### *3.3. Farmers' Views on Upcoming Fund for Non-Insurable Risks (the Fund)*

Most Czech farmers had never heard of the Fund and have no information about it (52.3%), while less than one third of farmers had heard something about the Fund at informal meetings but had no specific information about it (30.4%). Only 9.8% of respondents had basic information about the Fund from the media, while only 7% had sufficient information not only from the media but also from the Chamber of Agriculture or professional organizations. Only one respondent indicated that he/she was directly involved in preparing and setting the parameters of the Fund. Thus, most respondents did not know anything in detail about the fund. In any case, farmers were able to express their opinions about the characteristics of the Fund.

A total of 65% of respondents indicated that the Fund should be managed by the Paying Agency (Support and Guarantee Fund for Agriculture and Forestry), with the second most common response being management by producer/breeder associations (16.8%). The remaining respondents indicated that the Fund should be managed either by the Chamber of Agriculture (8.9%) or by a legal entity managing its own assets (9.3%).

Most respondents preferred differentiated contributions to the Fund depending on the type of farming (92.6% in total). At the same time, farmers preferred quick indemnity for damages within three months of application (57.6%) or within six months of application (35.1%).

Table 3 confirms the relationship between the purchase of agricultural insurance and farmers' preferences for indemnity from the Fund. Responses indicated that farmers who had not purchased agricultural insurance preferred indemnity without conditions. In contrast, farmers who had taken out agricultural insurance preferred to take indemnity from the Fund conditionally on taking out agricultural insurance covering at least 50% of annual production (otherwise indemnity would be zero).

**Table 3.** Relation of indemnity from the fund of non-insurable risks to agricultural insurance.

| | | Have You Purchased Agricultural Insurance? | | |
|---|---|---|---|---|
| **How Should the Indemnity Payment Be Tied to Commercial Agricultural Insurance?** | | **No** | **Yes** | **Total** |
| No conditions (indemnity from the fund should not be linked to the purchase of commercial agricultural insurance) | Count | 83 | 44 | 127 |
| | % | 65.4% | 34.6% | 100% |
| | Adjusted residual | 4.1 | −4.1 | |
| Agricultural insurance of at least 50% of annual production (otherwise no indemnity) | Count | 12 | 27 | 39 |
| | % | 30.8% | 69.2% | 100% |
| | Adjusted residual | −3.3 | 3.3 | |
| Agricultural insurance of at least 50% of annual production (otherwise indemnity is halved) | Count | 15 | 22 | 37 |
| | % | 40.5% | 59.5% | 100% |
| | Adjusted residual | −1.8 | 1.8 | |
| Total | Count | 110 | 93 | 203 |
| | % | 54.2% | 45.8% | 100% |

Notes: Frequencies highlighted in red indicate statistically significant differences in proportions at the 0.05 significance level. Chi-square statistic for two degrees of freedom = 17.771 ($p$-value < 0.001), Cramer's V = 0.296 ($p$-value < 0.001). Source: authors' calculation.

## 4. Discussion

Research has shown that farmers in the Czech Republic expect an increase in the importance of major production risks in the future, with the exception of drought, which is already considered one of the most important systematic and non-insurable risks in agriculture. However, the results cannot be generalized to all European countries due to differences in climatic conditions. Polish and Hungarian farmers, for example, consider the risks of weather and natural disasters to be very severe. The importance of natural risks is considered somewhat lower (but still high) by farmers in Spain, where weather and natural disaster risks have serious consequences. The third group of countries comprises Germany and the Netherlands, where farmers rate the impact of natural risks as lower compared to other European countries. On the other hand, in the Netherlands and Germany, the risks of animal diseases and epidemics are estimated to be very high (Palinkas and Székely 2008).

Weather and climate information is important for more effective production risk management. In the Czech Republic, for example, the Intersucho web portal ("Intersucho" 2022) was launched in 2012 to monitor drought in Central Europe. However, weather and natural disaster risks cannot be considered in isolation. Effective climate change adaptation measures need to link climate change risks to other production risks, as farmers often perceive climate change in the context of other risks (Eitzinger et al. 2018).

However, recent research has shown that perceptions of the main sources of risk in the agricultural sector do not have a significant influence on the intention to use any of the risk management strategies. In contrast, attitude towards risk has a significant influence (van Winsen et al. 2016). A distinction can be made between farmers who are more inclined to apply risk management strategies ex ante and farmers who are less inclined to apply risk management strategies ex ante but are more likely to cope with the consequences and reduce their impact ex post once the risks have occurred. Secondary risks arising from the management of primary risks also need to be considered (van Winsen et al. 2013).

In 2021, a similar issue was addressed by a team of authors from the Slovak Republic. The article showed that moving away from ad hoc compensation and using insurance or mutual funds has some complications. One potential problem could be the willingness of farmers to cooperate, as these instruments are not common in many member states. This implies a lack of solidarity and limited availability of capital. The cooperative nature of the mutual fund is not yet strongly rooted among the actors as there is a very low demand for the activation of such instruments (Vecchio et al. 2022). The low level of awareness of these instruments among farmers' organizations and the usually ineffective cooperation between them and the Ministry of Agriculture also play a major role in the issue of mutual funds (Boháčiková et al. 2021). Similar results emerged from our research, which also examined farmers' attitudes toward mutual funds. It turned out that more than 80% of respondents had either no or minimal information about it. There were differences in the willingness of companies to join mutual funds. The largest companies structurally and economically were not interested in joining a mutual fund. On the other hand, small and medium-sized companies were willing to join the fund, while small companies were more likely to invest a proportionally larger amount in the fund than the medium-sized companies (Vecchio et al. 2022). This study was conducted in the fishing industry and a similar analysis could be potentially interesting in agriculture.

The logistic regression model revealed several important determinants of the take-up of agricultural insurance as a strategy for managing agricultural production risks. First, the chance of taking out agricultural insurance increased with increasing cultivated area. In the Czech Republic, two thresholds for cultivated area were identified. Very small farms of up to 73 hectares were least likely to have agricultural insurance. Compared to this reference area category, medium and large farms with areas of over 312 hectares had a significantly higher chance of taking out agricultural insurance. This category of farms included larger corporations; notably, joint stock companies and large agricultural cooperatives. In the Czech Republic, agricultural enterprises of all sizes can receive subsidized insurance. Any restriction on the participation of large producers in crop insurance would negatively impact the insurance fund and lead to an increase in premiums and administrative costs per hectare (Sharma and Walters 2020).

In general, larger farm size reflects greater management capacity and, possibly, greater economies of scale in the application of various risk management practices (Sherrick et al. 2004). Small farms are generally characterized by a larger share of off-farm activities, as agricultural production alone may not provide a sufficient standard of living for the farm household (Dabkienė 2020). If small farms diversify a larger share of their income into off-farm activities, the incentive to purchase agricultural insurance decreases (Palinkas and Székely 2008). On the other hand, however, farm insurance may be more effective in mitigating income decline on small farms because small farms have a lower degree of on-farm diversification and lower spatial diversification of activities (Špička and Vilhelm 2013). Therefore, whether the unit of study is the farm or the farm household is important for the choice of risk management strategy. For large farms, the degree of diversification of business activities into main production and secondary production, as well as the degree of spatial diversification of activities, are important. For small farms, especially family farms, the diversification of household income into off-farm activities is important.

Another important and logical finding is that the likelihood of take-up of agricultural insurance decreases as distrust of insurance companies increases. Farmers did not trust insurance companies because of delayed and incomplete indemnity, red tape, unfamiliarity with insurance products, or bad personal experiences. Leakage of premium support to insurance companies may also be a reason for farmers' distrust of insurance companies. Above all, bad experiences in the past and fear of the complexity of the contract terms were the main reasons for distrust of insurance companies (highest score). Distrust not only towards insurers but also towards the government is typical for small businesses. Distrust is due to low support, non-transparent information services, and lack of policies that favor small businesses over large businesses. However, the literature on trust has not yet examined the processes that shape farmers' distrustful behavior toward insurance companies. Therefore, follow-up studies should examine how these past experiences influence farmers' trusting behaviors and how they can be addressed to improve the use of agricultural insurance (Ali et al. 2020).

Price (premium) also affects the probability of purchasing agricultural insurance. In this case, the sensitivity of farmers to the level of premiums and the inverse relationship between the amount of insurance demanded and the price was confirmed, which was consistent with the downward sloping demand curve. In the Czech Republic, premiums are subsidized for both crop and livestock production. The subsidies have helped develop the agricultural insurance market (Vilhelm et al. 2015). However, farmers are interested not only in the price but also in information about the calculation of premiums and the relationship between the costs incurred and the impact of risk coverage, which is associated with building trust in insurers (Stoeffler and Opuz 2022).

The model also showed that the probability of suffering a loss of more than 20% of production increased with the probability of purchasing agricultural insurance. The 20% threshold was consistent with the parameters of the CAP, which, beginning in 2018, requires subsidy-eligible insurance products to be designed to compensate only losses that exceed 20% of the farmer's average annual production or income over the previous three years or the average of a three-year period based on the previous five-year period, excluding the highest and lowest values (Meuwissen et al. 2018).

Until 2018, the threshold was 30% of annual production. The likelihood of damaging more than 30% of the value of agricultural production varies according to the type of farming and the farm size. Farms with perennial mixed crops, cereals, oilseeds, protein crops (COP), pigs and poultry, fruits, and vegetables are more likely than average to face an income loss of more than 30%; in contrast, farms specializing in dairy, livestock, and mixed crops with livestock face a lower than average risk (European Commission 2017). The Czech Republic, where 25% of farms are at risk of a decline in agricultural production of more than 30%, ranks at the bottom of the list of countries at risk, along with Germany and Belgium.

The Czech Republic's relatively favorable ranking may be due to the large influence of large farms, joint stock companies, and cooperatives, which are sufficiently diversified in terms of area and income to avoid a significant decline in the value of agricultural production. The duality of farms in the Czech Republic is illustrated by the fact that farms with more than 100 hectares account for 10% of the population but manage 85% of agricultural land (Ministry of Agriculture 2021). Therefore, the CAP support programs for agricultural risk management are not as favorable for Czech farmers as for other European countries.

Finally, the model showed that the chance of take-up of the agricultural insurance decreases when farm risks are managed according to a developed formal strategy. This assertion can be justified by the fact that farm insurance is not the only risk management tool. If a business has a risk management strategy, it is likely that it also manages risk with other tools, such as income diversification, technology selection, futures and production contracts, financial provisioning, and hedging. This reduces the incentive to purchase agricultural insurance. The results support a holistic risk management system, which is based on an analysis of the farm as a system in which many elements interact, particularly sources of risk, farmer strategies, and government policies (OECD 2009). However, farmers should not rely solely on public support as the main incentive for agricultural insurance. Farmers should consider risk management tools as indispensable technical means to protect and stabilize their income, not only as accessories to farm activity (Frascarelli et al. 2021).

The interrelation between the different tools of risk management in farms is also related to the answer to the fourth research question. The research showed that there is an association between the take-up of the agricultural insurance and the opinions of farmers about the conditions for the indemnity from the upcoming Fund for non-insurable risks, which is managed by the government. Any government intervention must respect agricultural risk management policies. Policies must allow farmers to make their own risk management decisions and have access to a variety of tools and strategies, keeping in mind that farmers are much better informed about the nature of their own risk environment than public sector institutions (OECD 2011). A previous study confirmed the need for tailor-made settings for the Fund because these would seem to be useful to set different contribution rates for farmers belonging to different regions to reflect area-specific levels of risk and risk aversion (Severini et al. 2021). The same study suggested that the EU income stabilization tool could be financially sustainable under the CAP public support. However, in the presence of adverse selection, increasing the contribution level makes the less-risky farmers exit the scheme and, as a result, the mutual fund is left with the riskier farmers (Severini et al. 2021).

This research in the Czech Republic highlighted the inconsistent attitudes of farmers in determining the parameters of the future Fund for non-insurable risks. The fact that not all farmers in the EU have equal access to all risk management tools supports the development of a more flexible risk management framework. From the tools available, farmers choose the combination of tools and strategies that reflects their risk exposure, risk aversion, and expected benefits (OECD 2009).

## 5. Conclusions

State compensation for weather-related losses and other production risks has become an integral part of agricultural risk management policy in the Czech Republic. However, the model of frequent ad hoc compensation from the public budget is no longer sustainable. This has the undesirable consequence of weakening farmers' willingness to adapt to risk threats and other consequences while ad hoc aid increasingly burdens the public budget. One impetus for conducting this research was to determine the potential of publicly funded interventions to create sustainable agricultural risk strategies on different types of farms. The results of the study may indicate, for example, which of the external incentives are effective.

The objective of the study was to identify significant factors influencing farmers' willingness to take up agricultural insurance and participate in a mutual fund for non-insurable in the Czech Republic. The results of the research indicate the expected higher importance of most agricultural production risks and the need for a comprehensive and effective solution for the risk management system in agriculture. Although farmers agreed that production risks will increase in the future, the sources of agricultural business risks did not significantly influence the choice of risk management strategy. Attitude toward risk, which is a subjective characteristic of each farmer, and the availability of risk management tools in each country play an important role. These determinants make it difficult to develop a uniform framework for risk management in agriculture in the EU and argue for a more customized approach that takes into account conditions in a specific region.

The research also shows that risk management tools are interrelated, with the farmer choosing the optimal portfolio of tools that provides the highest benefit at the lowest cost. For example, if a farmer is uninsured, he or she seeks to participate in a mutual fund where indemnification is not tied to the purchase of farm insurance. In contrast, insured farmers prefer insurance as a prerequisite for indemnification from the mutual fund and see the fund for non-insurable risks as a complement to agricultural insurance. Some specific sectors of agriculture, such as fruit production, prefer technological measures in production (e.g., installing anti-hail nets) over insurance, which does not protect the crop but helps mitigate losses. The holistic approach to risk management is supported by the finding that the likelihood of purchasing agricultural insurance decreases on farms where risks are managed according to a developed formal strategy.

A limitation of this study is that it focuses only on agricultural production risks. Farmers are also affected by price and institutional risks. The parameters of the mutual fund for non-insurable risks should be defined as part of a holistic approach in terms of expected risks, risk attitudes, risk appetite, other risk management tools, and sources of farmer confidence in them. It would also be interesting to investigate the impact of COVID-19 and the public health crisis on the selection of an effective portfolio of risk management tools in the agri-food industry.

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## Appendix A

The hypothesis of a difference between the means of the paired responses was tested with a paired *t*-test and, as support, with a nonparametric paired Wilcoxon signed-rank test to account for the nonnormal distribution of the data. Effect sizes were tested using Cohen's d (Anderson et al. 2020).

## Appendix B

The binomial model can be viewed as a special case of the general utility maximization model (U). For example, the farmer is assumed to have preferences defined in a set of alternative risk management strategies $j$ ($j$ = 0, 1), where 0 means "uninsured" and 1 means "insured". The two strategies are assumed to be jointly exhaustive and mutually exclusive.

The logistics function takes a general form:

$$P(x) = \frac{1}{1 + e^{-(\alpha+\beta x)}}$$

where $P$ is the probability of 1, $e$ is the base of the natural logarithm, and $\alpha$ and $\beta$ are the model parameters. The value of $\alpha$ gives $P$ when $x$ is a zero predictor and $\beta$ adjusts for how fast the probability changes as $x$ changes by one unit. As the relationship between $x$ and $P$ is nonlinear, $\beta$ does not have a straightforward interpretation in this model as in ordinary linear regression.

Logistic regression is sensitive to outliers and the presence of multicollinearity. Therefore, the predictors in Appendix E were entered into the model, from which statistically significant uncorrelated predictors were subsequently selected using the forward likelihood ratio (LR) stepwise regression method with a significance level of 0.05.

Logistic regression results were evaluated using the following tests:

- The Hosmer–Lemeshow test checks the fit of the model to the data. It tests the null hypothesis of a match between the values of the dependent variable and the expected values based on estimates of the probability that the explained variable takes the value 1. The test follows a chi-squared distribution under the assumption that the null hypothesis of model–data agreement is valid (Hosmer et al. 2013);
- Nagelkerke's $R^2$ expresses the strength of the association between the dependent variable and the predictors (Nagelkerke 1991);
- A classification table containing information on sensitivity and specificity. Sensitivity represents the proportion of participants who (a) had the characteristic of interest, and (b) were correctly predicted by the logistic regression equation to have the characteristic (correct classification of true positives). On the other hand, specificity represents the proportion of participants who (a) did not have the characteristic, and (b) were correctly predicted to not have that characteristic (correct classification of true negatives). Both sensitivity and specificity are measures of classification accuracy (Hatcher 2013);
- The area under the ROC curve was used to determine how well the predictors (the classification ability of the model) could predict the value of the binary variable. The higher the value, the better the model was, in this sense.

## Appendix C

The optimal binning procedure was developed to optimally categorize one or more numerical variables given a categorical variable. Thus, it looks for points that divide the values of the input variable into intervals such that the resulting variable has the strongest possible relationship to the target variable. The newly derived categorical variable(s) can then be used for further analysis. The algorithm is based on the minimum description length principle (MDLP) method and entropy statistics. The extent of agricultural land was initially continuous. The goal was to identify the boundaries that separate farms with agricultural insurance from farms that are not insured. The MDLP method looked for boundaries where the categorical variable was associated with the target variable, insurance. The solution relies on Occam's razor and is based on information theory. MDLP is a forward boundary search method to minimize entropy in the resulting classes (Liu et al. 2002). Entropy is a measure of the uncertainty of a class with respect to the target variable and is larger for a given class if there are more categories of approximately the same size.

## Appendix D

A contingency table, a chi-square test for association, and Cramer's V were used to assess the association of responses to the two questions (Anderson et al. 2020). Cramer's V takes values between 0 (independent variables) and 1 (complete contingency). Further analyses were performed using descriptive statistics and relative frequencies.

## Appendix E

The original set of potential predictors:

a. Age categories: 18–40 years (reference category), 40–50 years, 50–60 years, 60+ years.
b. Agricultural land area—intervals: <73 ha (reference category), 73 ha to <312 ha, 312 ha or more (interval boundaries were determined from the original numerical and non-normally distributed variables using the optimal binning procedure in IBM SPSS).
c. Type of farming: predominantly crop production (reference category), predominantly livestock production, mixed agricultural production.
d. Gender: female (reference category), male.
e. Number of years in an executive position (managing director, director, chairman, etc.): up to and including 10 years (reference category), 11–20 years inclusive, more than 20 years.
f. Education: primary and secondary (reference category), university graduates.
g. Fruit growers: not engaged in fruit production (reference category), engaged in fruit production.
h. Distrust of insurance companies: a numerical variable calculated as the average of five sub-statements. All questions had a Likert response scale (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Don't Know, 4 = Somewhat Agree, 5 = Strongly Agree). The reliability of the battery of questions was high (Cronbach's alpha = 0.858). The higher the score was (arithmetic mean), the higher the respondent's distrust of insurance companies. The set of statements from which the score was calculated consisted of the following statements:
    - I don't trust insurance companies for fear of delayed or incomplete indemnities.
    - I don't trust insurance companies because of complicated contracts or terms and conditions.
    - I don't trust insurance companies because of bad personal experiences.
    - I don't trust insurance companies because of my ignorance of insurance products.
    - Insurance premium subsidies are not a direct support to farmers but an indirect support to insurance companies.
i. Please indicate on a five-point scale how likely it is that a loss equal to or greater than 20% of average annual production will occur from a company-wide perspective (please check only one option): 1 = Almost impossible or very unlikely (1 to 20%), 2 = Extremely likely (21 to 40%), 3 = Ordinarily likely (41 to 60%), 4 = Very likely (61 to 80%), 5 = Highly likely to border on certain (81 to 100%).
j. Who is actively involved in risk management in your company?
    - Owner/shareholder/shareholders/shareholders (Yes = 1, No = 0).
    - Director or CEO (Yes = 1, No/Function in the company independently does not exist = 0).
    - Financial director, chief economist or accountant (Yes = 1, No/Function in the company alone does not exist = 0).
    - Risk Management Specialist (Yes = 1, No/Function in the company alone does not exist = 0).
    - Chief agronomist, head of the crop production center (Yes = 1, No/Function in the enterprise independently does not exist = 0).
    - Chief zootechnician, head of the livestock production center (Yes = 1, No/Function on the holding alone does not exist = 0).
    - Official employees (Yes = 1, No = 0).
k. In addition to farm insurance, what risk management tools do you use on your farm? (Yes = 1, No = 0)
    - Diversification within agricultural production (on-farm diversification).

- ○ Diversification into associated production or secondary production (on-farm diversification).
- ○ Off-farm income.
- ○ Ad-hoc compensation of damages from the state budget in the event of a crisis.
- ○ Use of the operating loan.
- ○ Technological prevention tools.
- ○ Anti-hail nets or other mechanical safeguard against weather hazards.
- ○ Price hedging through contractual agreements.
- ○ Price hedging through futures contracts on a commodity exchange.
- ○ The safety net of a group of companies or a holding company.
- ○ Creation of own financial reserves.
- ○ Subsidy program to support recovery of arable and specialty crops.
- ○ Marketing organization services.
- ○ Cooperation with other farmers outside the marketing organization.
- ○ Disease Fund Grant Programme.

l. Please indicate on a point scale the extent to which you agree or disagree with the following statements. All questions have a Likert scale response (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Don't Know, 4 = Somewhat Agree, 5 = Strongly Agree). Rated statements:

- ○ Risks are managed within the company according to a formal strategy.
- ○ We actively cooperate with farmers' associations/NGOs.
- ○ The cost of insurance is high for our company due to potential insurance claims.
- ○ Farmers need to anticipate and prepare for risks that are difficult to insure.
- ○ The fund for non-insurable risks should guarantee the return of the invested money in case of crisis.
- ○ Compensation by the mutual fund in case of higher average loss is fair.
- ○ A significant reduction in compensation for uninsured farmers is fair.

m. Please indicate what influences your decision to take out agricultural insurance. All questions have a Likert scale response (1 = Strongly Disagree, 2 = Somewhat Disagree, 3 = Don't Know, 4 = Somewhat Agree, 5 = Strongly Agree). Rated statements:

- ○ Price (premium).
- ○ Average company loss ratio (the ratio between the indemnity and the premiums paid in the policy period).
- ○ Prompt indemnity from the insurance company.
- ○ Financial advisory services or insurance broker.
- ○ The amount of the premium subsidy from the Ministry of Agriculture.
- ○ Administrative burden of premium subsidy from the Ministry of Agriculture.
- ○ Recommendations from friends or experience of other farmers.
- ○ The portfolio of covered risks.
- ○ Competitors' offers.

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