INSTITUTE OF AGRICULTURAL
AND FOOD ECONOMICS
NATIONAL RESEARCH INSTITUTE

MULTI-ANNUAL PROGRAMME
2015 - 2019

Assessment of the functioning of crop and livestock insurance in Polish agriculture

60.1
MONOGRAPHS
OF MULTI-ANNUAL
PROGRAMME

WARSAW 2017

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Edited by
dr inż. Joanna Pawłowska-Tyszko

Authors:
mgr inż. Aleksander Gorzelak
mgr inż. Justyna Herda-Kopańska
prof. dr hab. Jacek Kulawik
dr inż. Joanna Pawłowska-Tyszko
dr inż. Michał Soliwoda
dr Barbara Wieliczko

MULTI-ANNUAL PROGRAMME 2015 - 2019

THE POLISH AND THE EU AGRICULTURES 2020+
CHALLENGES, CHANCES, THREATS, PROPOSALS

Warsaw 2017

All the authors are the researchers from the Institute of Agricultural and Food Economics – National Research Institute

The paper was prepared under the research subject **Financial and fiscal factors in the improvement of efficiency, sustainability and competitiveness of the Polish agriculture**, in the task: *Taxes, quasi-taxes, transfers and social and farm insurance, instruments of risk management in ensuring competitiveness, financial stability and social security in agriculture and rural areas*.

The study reviews and assesses functioning of subsidized crop and livestock insurance as regards the level of their use and determination of factors motivating and demotivating to conclude insurance contracts by farmers.

Reviewers:
Dr Piotr Gołasa, Warsaw University of Life Sciences
Dr Przemysław Litwiniuk, Warsaw University of Life Sciences

Proofreader
Katarzyna Mikulska

Translated by
Summa Linguae S.A.

Cover project
Leszek Ślipski

ISBN 978-83-7658-702-8

Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej
– Państwowy Instytut Badawczy
ul. Świętokrzyska 20, 00-002 Warszawa
tel.: (22) 50 54 444
fax: (22) 50 54 757
e-mail: dw@ierigz.waw.pl
http://www.ierigz.waw.pl

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Introduction

Agricultural production is exposed to many different risk factors, which is due not only to the very nature of running a business (price fluctuation, behavior of economic entities on the market), but above all, specific characteristics of agriculture, resulting from e.g. the biological nature of production processes. The most serious threats to agricultural production include external climatic and environmental conditions leading to the occurrence of such phenomena as drought, hail, freeze, flood and frost damage, etc. in crop production, and epidemics and diseases in livestock production. Such diverse and specific risk factors translate into high variability of production and economic results, which in turn leads to uncertainty whether the agricultural producer will achieve the intended income effects (Hardaker, 2000). As a result, the farmer must take action to limit the effects of the risk involved. There are many alternative solutions to be used in agricultural risk management. The most popular ones include measures involving production diversification, accumulation of funds to compensate for future losses, risk sharing or its transfer to other entities. It follows from the above that risk management comes down, on the one hand, to action taken by the farmer himself, but on the other, the case may be much more complex. This relates primarily to measures taken by the state, which involve the provision of effective instruments to prevent negative effects of risk, whereby such measures must be acceptable to their beneficiaries.

Poland has many years of experience in risk management, although its selected instruments (cultivation contracts and contracts for crop and livestock insurance) were widely applied only in the 1950s-1980s. The introduction of the Insurance Activity Act in 1990s hindered the development of crop and livestock insurance, which used to be the most common risk management tool in Poland. The problem of the lack of this instrument in Polish agriculture was raised again only in 2005, just after the European Commission had taken action to strengthen risk management tools dedicated to agriculture (in particular subsidized agricultural insurance).

At present, crop insurance is one of the most important tools used by farms in their management risk strategies. It should be, however, clearly emphasized that despite the marked state's support in subsidizing premiums for crop and livestock insurance, its development is very slow. Therefore, it seems worthwhile to seek factors that motivate to conclude such insurance contracts and ones which discourage from doing so. The search for solutions to the problem should consider all of its aspects, i.e. primarily the state, insurance companies and policyholders – farmers.

The aim of the paper was to review and assess the functioning of subsidized crop and livestock insurance – in terms of the degree of its use – and identify what motivates farmers to conclude insurance contracts and what discourages them from doing so. This review is supposed to help to develop recommendations as regards legal changes of importance to the further development of this tool.

The paper was written based on literature on the subject, the Act concerned, statistical data derived from various sources, mainly the Ministry of Agriculture and Rural De-

velopment, the Central Statistical Office (Polish: *Główny Urząd Statystyczny, GUS*), the Polish Financial Supervision Authority and the FADN, as well as a questionnaire completed by private farmers entered in the FADN database. The results of the research covered the period between 1985 and 2016 and are presented in tables and figures.

The paper consists of 9 chapters. The **first chapter** describes the theoretical basis of risk and traditional agricultural insurance. This chapter contains a review of the development of economic theories pertaining to risk and insurance. The main research focused on an analysis of factors of an optimal insurance system in agriculture and their impact on the development of the agricultural sector. The authors also seek, based on scientific theories, reasons for subsidizing agricultural insurance. Particular attention was paid to the impact of crop insurance on the situation of agricultural producers, food consumers and taxpayers, referring to the economic well-being theory.

The **second chapter** includes a substantive assessment of subsidizing agricultural insurance. The analysis concerns market and regulatory obstacles that justify public intervention in this area. Particular attention was paid to systemic risk issues, information problems, emergency assistance in case of natural disasters, market infrastructure, legal framework relating to insurance as well as the nature of insurance in the context of benefits it offers. The chapter also reviews availability of insurance schemes on the international level.

The **third chapter**, analyses the evolution of national legal regulations relating to crop and livestock insurance from 1952 to 2016. This chapter focuses on the analysis and critical assessment of key statutory provisions and the impact of adopted solutions on the stable development of agricultural insurance.

The **fourth chapter** includes an assessment of the impact of changes in statutory provisions on the functioning of agricultural insurance in terms of its universality, availability and flexibility. The analyses cover the years between 2006 and 2016 and relate to the degree of implementation of the Act in terms of the area of insured crops, the average insurance cost, the number of insurance policies taken out, the use of budgetary funds allocated to subsidies or claims under such insurance. The research was to assess the reasonableness of insurance subsidies in terms of introducing relevant changes in this area.

In the **fifth chapter**, the authors present the income and financial situation of farms taking out crop and livestock insurance. The results of the analyses related to the characteristics of entities maintaining crop and livestock insurance, entered in the FADN. The situation of the analyzed farms was described using income from the family farm, ROA and ROE, as well as equity and asset debt.

The **sixth chapter** includes an analysis of determinants of the demand for crop insurance. These determinants were identified using logit and probit models which helped the authors to draw special attention to qualitative phenomena affecting the purchase of insurance. Particular attention was paid to the farm specialization, the farmer's age and education and the region where the farm is located.

In the **seventh chapter**, the authors analyzed the impact of insurance purchase on selected characteristics of farms, in particular the utilized agricultural area (UAA), output volume, income from the family farm and the amount of loans. The analysis was performed using the propensity score matching (PSM) method.

The **eighth chapter** includes an assessment of the purposefulness of taking out crop insurance, performed with the use of Barry's decision-making model adapted to the Polish conditions. This chapter focuses on calculating the cost-effectiveness of purchasing insurance for selected crops. The results of the analyses are presented using various options, e.g. for insurance with subsidized premiums and insurance not covered by subsidies, which allowed for their broader interpretation.

The **ninth chapter** presents the outcomes of surveys conducted on a sample of FADN private farms. The assessment covered both farms that used this type of tool in 2015 and those that did not. The authors analyzed factors motivating farmers to take out crop insurance and those dissuading them therefrom. Particular attention was paid also to the adequacy of legal solutions and insurance offers to farmers' needs and changes required as regards crop insurance.

The entire report ends with a synthetic summary.

Dr inż. Joanna Pawłowska-Tyszko

1. Risk and traditional agricultural insurance – theoretical foundations

Prof. dr hab. Jacek Kulawik

In the constantly developing socio-economic environment various types of threats intensify, and their size and type depends on the nature of the risk and the uncertainty associated with it. The indisputability of the existence of these phenomena and of their impact on the behavior of business entities is hard to undermine, but in economic theories these issues are permanently ignored. This is due to the fact that both risk and uncertainty do not fit the concept of rational economic behavior which underlies the whole theory of economics. Hence, the first, imperfect economic models and theories relating to risk and uncertainty were developed only in the second half of the 20th century. However, the incorporation of risk and uncertainty into economic sciences undoubtedly contributed to their development.

The concept of risk and understanding of its essence is of fundamental importance both to the insurance theory and practice (Ronka-Chmielowiec, 2002). This was noticed already in 1826-1863 by J.H. von Thünen (a representative of spatial economics), who emphasized that risks associated with doing business can be calculated and insured, but there are also such economic initiatives that no insurance company would insure (Thünen, 1910). A similar position was adopted by A.H. Willett, who believed that man is unable to change the course of events, but can predict undesirable consequences and protect oneself from them (Willett, 1901). This was further clarified by F.H. Knight, who clearly indicated that it was only risk that could be insured and measured using the probability calculus, which is due to its features (this relates to adverse quantitative events which actually occur) (Knight, 1921). Other uncertain events cannot be insured, as they lack risk features. This means that events that may affect the uncertainty of achieving expected profits (as uncertainty is attributed by F.H. Knight to favorable results) cannot be insured.

The concept of uncertainty was considered much more broadly by K.J. Arrow, the author of the choice theory, who noticed that uncertainty means unawareness of the consequences of various actions (due to the lack of knowledge of the state of the world), and can be the cause or source of risk (Arrow, 1979). He also noticed that the burden of all risks due to uncertainty falls in the market system on enterprises' owners, who may transfer them, e.g. to insurance institutions. A similar view is presented by B. Minc, who claims that event and object insurance is one of risk mitigation measures (Minc, 1997). What is more, he draws attention to the fact that insurance fees are an element of the company's costs and lead to an increase in prices. Nonetheless, the lack of insurance may result in a loss well in excess of the premium amount (fees). Understanding the essence of risk and uncertainty was facilitated to a great extent by considerations of C.W. Williams, M.L. Smith and P.C. Young concerning the possibility of benefiting and incurring losses due to the occurrence of these phenomena. The above-mentioned researchers identified pure and speculative risks. Pure risk was defined by them as a threat of incurring losses, while not obtaining any benefits. Speculative risk, which we can link with uncertainty, is a broader concept, as it involves both a threat of incurring losses and possible benefits (Williams, Smith and Young, 2002).

Considering these issues from the perspective of the agricultural sector, it can be said that only part of the activity pursued in this area is subject to pure risk, which is due to the variability of weather events or the possibility of the occurrence of epidemiological diseases of animals. All these events lack the features of the previously defined uncertainty, which means that they are insurable. However, there are areas in the agricultural sector that are exposed to uncertainty or speculative risk. These include the volatility of prices of agricultural products and raw materials as well as changeable legal and political conditions. Looking at the situation in the agricultural sector from the perspective of insurance companies, it would be difficult for them to accept this type of risk.

What is of fundamental importance in the case of insurance supply is, however, the ability to take an insurable risk by a private insurance company. This risk usually has the following six characteristics:

1. The existence of a sufficiently large number of willing, homogenous customers experiencing, independently from each other, the same types of risks. Only in such circumstances is it possible to create a risk pool in which one can predict the loss level relying on the law of large numbers. These losses are registered for a longer period, and their costs are distributed among all the insured.
2. Losses must be accidental and unintentional. Ideally, losses should be unpredictable and unexpected, and should be beyond the control of the insured, as the law of large numbers is based on randomness of the occurrence of insurance events, and moral hazard increases when the insured consciously contribute to the occurrence of losses.
3. Losses must be determinable and measurable. Items that must be determined include the cause, time, place and amount. Only then is the insurer able to clearly determine the level of loss coverage under a given insurance policy and the amount of any indemnities.
4. A loss cannot be catastrophic. This means that the total risk exposure cannot be dominated simultaneously by individual insureds. An otherwise created risk pool ceases to function, as policy prices would have to be very high. Moreover, insurance companies, even aided by available techniques, would not be able to properly disperse risk without jeopardizing their solvency. Although insurers may try to face even catastrophic risk by reassuring their portfolios and diversifying them to a greater extent geographically and sectorally, but these are only partial remedies. In practice, catastrophic risk can also be managed using financial instruments, but these issues are not accounted for in the reviewed Act. They are, therefore, not dealt with further in this monograph.
5. The likelihood of a loss must be calculable. In other words, the insurer can determine the frequency of threatening events and their average consequences with predetermined accuracy. This is necessary to calculate the policy value in an actuarially equitable manner and add mark-ups so that the insurer is able to generate certain profit and a return on the invested capital. Catastrophic risk does not meet the above-mentioned condition by definition. This opens up some field for public intervention to make private entities concerned about the above risk at all.

6. The insurance premium must be economically viable. On the one hand, its amount must be acceptable to potential policy buyers, hence it should be rather low, but on the other, it must be satisfactory also for the insurance company. The probability of loss must be, therefore, low. A too high premium rate is likely to encourage potential customers not to transfer risks and try to manage them using available methods, or even to ignore the risks, hoping that in case of their materialization, the state will come to their rescue (Hardaker, Gudbrand, Anderson and Huirne, 2015; Rejda and McNamara, 2017).

It clearly follows from the above that all these conditions are met only by some types of standard third party liability insurance policies applicable to individuals and companies as well as most real estates. For the purposes of these entities, a private insurance market may operate without any major obstacles, provided it is properly regulated. However, as regards market, financial, production and political/institutional risks, these are difficult to be insured by private entities, as these risks are characterized by certain assumptions only, and sometimes they are merely speculation. As a consequence, serious problems ensue as regards the precise calculation of the probability of their occurrence. As it has already been mentioned, catastrophic risks are a separate issue.

General considerations regarding business insurance refer usually to the concept of the expected utility (EU) hypotheses, presented in 1944 by J. von Neumann and O. Morgenstern. This hypothesis is embedded in neoclassical economics and refers directly to the achievements of P.F. Ramsay and H.F. Knight, especially when it comes to the known distinction made by the latter between the terms "risk" and "uncertainty". On closer examination, we can even find in the background a reference to the famous St. Petersburg paradox formulated by D. Bernoulli in 1738. This concept is mainly used to explain the demand for insurance products. In this monograph, the authors will also refer to the hypothesis of J. von Neumann and O. Morgenstern, using the approach developed by B.K. Goodwin and V.H. Smith (Goodwin and Smith, 1995). These two American economists chose, as a starting point, an agent who has at his disposal s possible results and wants to maximize his expected utility calculated using the following equation:

$$\sum_{s=1}^{S} \pi_s u(x_s)$$

where:

π_s – probability that the s^{th} result will be obtained,

x_s – expected value of the s^{th} outcome,

$u(\cdot)$ – utility function.

As we can see, the agent seeks to maximize the weighted expected utility, where the probabilities of π_s are the weights. It should be further clarified that in accordance with the dominant convention, the agent is assumed to have risk aversion, so his utility function is concave. This further means that he may be more inclined to take out insurance than a high-risk person or a person who is risk neutral. A low-risk person will take

out insurance only if it pays off for him/her and the insurance premium is set actuarially fair. The latter condition will exist where the premium rate (percentage relative to the sum insured) is equal to the probability that the insurer will have to pay the agreed indemnities to the agent (Czarny, 2006). Alternately, a fair premium, also referred to as "fair value" or – in insurance jargon – "pure premium" or "only risk premium", may by assumed to be equal to the expected indemnities (Zweifel and Eisen, 2012).

An agent, e.g. a farmer, considering the purchase of insurance faces two uncertain situations:

- $w_1 = W$, i.e. no loss,
- $w_2 = W - L$, a loss.

Where W stands for the agent's wealth, L – loss incurred, and π – exogenously determined probability of its occurrence. The insurance contract specifies premium α and provides for payment of amount L, where the agreed insurance event occurs. Assuming that the insurer is a risk-neutral person, which is usually the case, his profit will amount to zero, which implies that we are dealing with a competitive market. The charged premium is then fair in actuarial terms, as expressed by the following formula:

$$\alpha = \pi L$$

If now, instead of the monetary amount, the premium (α) is given as percent, q (either not related to anything or per physical unit of the object of insurance), i.e. as a premium rate, and z stands for the amount of purchased insurance coverage (e.g. hectare, a livestock head or a specified monetary sum insured), then the insurer's zero profit condition is expressed as:

$$q = \pi$$

This is the first method of determining a premium which is fair in actuarial terms.

Now the agent has to select parameter z that is to maximize its usability:

$$\max\left[(1-\pi)U(w_1) + \pi U(w_2)\right]$$

given the following restrictions:

$$w_1 = W - qz$$

$$w_2 = W - L + z - qz$$

The first-order necessary condition for the existence of a maximum is written as follows:

$$(1-\pi)qU'(W-qz) = \pi(1-q)U'(W-L+z-qz)$$

If the premium is actuarially fair $(q = \pi)$ we get:

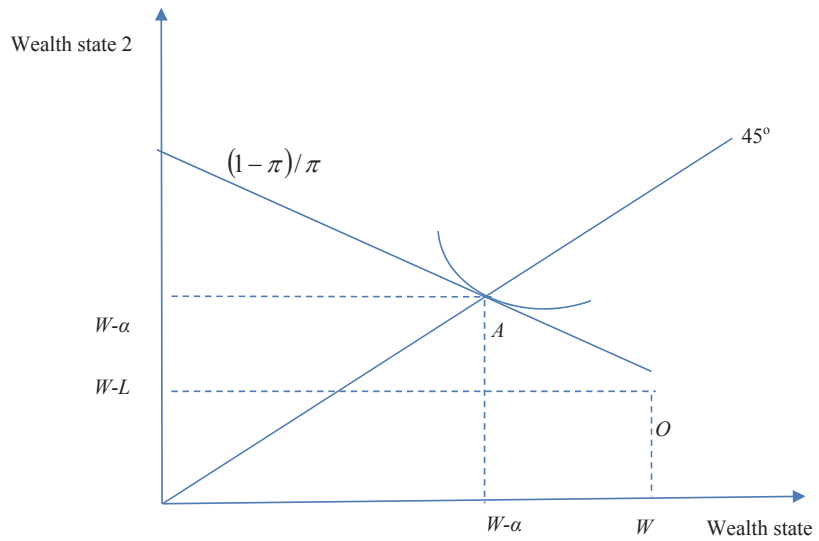
$$U'(W-qz) = U'(W-L+z-qz)$$

where U' stands for the first derivative.

It follows from the above that the optimal value of purchased insurance coverage (z) should be equal to the expected loss (L). In other words, insurance coverage should be full, so there should be neither under-insurance or excessive insurance and over-insurance. In practice, as will be shown further, actuarially unfair premiums prevail and insurers want to generate profits.

The above considerations can be summarized graphically (Figure 1). The starting point here is the agent's initial wealth of 0, where wealth W in state w_1 is equal to wealth W-L in state w_2. An agent with risk aversion, i.e. a low-risk agent, may, however, seek insurance which has a slope of $-(1-\pi)/\pi$, trading along the fair-odds line, i.e. one in which the player's gains are on average equal to zero (expected value, EV, is zero) or for participation in it one has to pay as much as its expected value. In other words, it is a game in which values expected by each player are the same. As can be seen, point A is the optimal level. In literature devoted to insurance, the fair-odds line is also referred to as an insurance line or a transformation line along which wealth is transferred from state w_1 to state w_2. In Figure 1, there is also a 45° line. This is the so-called line of certainty, which state w_1 is identical to state w_2. This line simply implies a case of risk neutrality.

Figure 1. Optimal insurance purchases in a competitive market



The remaining definitions are provided in the text.

Source: Goodwin K.B., Smith H.V., The Economics of Crop Insurance and Disaster Relief, AEI Press, Washington DC 1995.

On the insurance market, just like on other financial markets, we deal with wide-spread information asymmetry. Such asymmetry exists when not all economic entities have the same, thus equal or symmetrical information. This situation has a simple explanation: most of information is private and its acquisition and transformation into

knowledge requires certain costs to be incurred. Publically available information has to be assessed in terms of its credibility. Therefore, in economic practice, this even leads to disinformation. In economic theory, asymmetry of information is considered as one of the manifestations of market imperfections, which justifies some public intervention. In our considerations, the following two consequences of information asymmetry are important:

(1) adverse selection,

(2) moral risk/hazard, in Poland referred to also as "temptation to abuse".

Adverse selection is understood as a situation where the insurer has insufficient information about the insured. As a consequence, the insurer usually charges all customers with average insurance rates that prove to be too high for low-risk entities and too low for risk-takers. Then, the pool of insured entities becomes increasingly more dominated by risk-takers, and this in an extreme scenario, may prevent the emergence and development of a private insurance market (Stiglitz and Rosengard, 2015).

As regards moral hazard, it occurs when the purchaser of insurance changes its behavior, which leads to higher likelihood of damage or enhancing its negative consequences. Goodwin and Smith explain in detail the adverse selection in the agricultural insurance market. The economists start with identifying two groups of farmers: ones characterized by high probability of loss π^H and those with low probability of loss $-\pi^L$. They keep arguing that the insurance premium is actuarially fair, thus insurers do not make any profit. As they are not able to differentiate risks faced by farmers in these two groups, the premium they charge is the same irrespective of the group. Therefore, we have:

$$\pi^L < q < \pi^H$$

For a risk-taking farmer, the maximization problem looks as follows:

$$\max\left[\pi^H U\left(W - L - qz^H + z^H\right) + \left(1 - \pi^H\right) U\left(W - qz^H\right)\right]$$

The first-order condition for the existence of an optimal solution can now be written as:

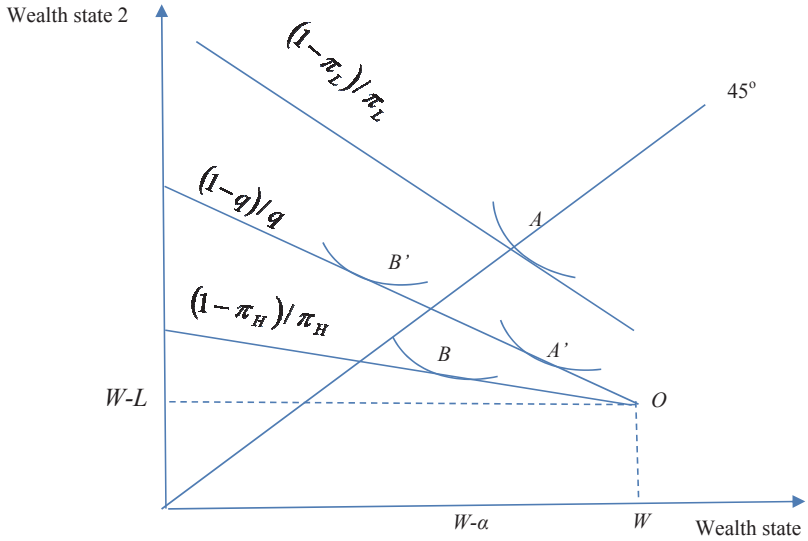
$$\frac{U'\left(W - L - qz^H + z^H\right)}{U'\left(W - qz^H\right)} = \frac{\left(1 - \pi^H\right)q}{\pi^H\left(1 - q\right)}$$

In the case of a low-risk farmer, this condition looks as follows:

$$\frac{U'\left(W - L - qz^L + z^L\right)}{U'\left(W - qz^L\right)} = \frac{\left(1 - \pi^L\right)q}{\pi^L\left(1 - q\right)}$$

Because $\pi^H > \pi^L$, there is also $z^H > z^L$. In other words, more risky farmers should purchase more insurance. If the insurer increases the premium rate *q*, the problem will become even more acute, since the low-risk agents will compose an ever-decreasing proportion of the insured pool.

Figure 2. Effects of adverse selection on insurance purchases



The remaining definitions are provided in the text.
Source: as for Figure 1.

Figure 2 presents the effects of adverse selection on demand for insurance services. We can see that the low-risk farmer faces a much steeper fair-odds line than the high-risk farmer does. This means that the former has a more elastic demand for change in the insurance price than the latter. If the insurance companies were able to discriminate perfectly the risk propensity of farmers wishing to purchase insurance, it could offer them, for instance, different rates of actuarially fair premiums. As a result, low-risk farmers would reach the optimal insurance coverage at point *A*, while high-risk ones – at point *B*. However, if insurers face information asymmetry, which is usually the case, the fair-odds line has a slope of $(1-q)/q$. Consequently, new optimal values are now in points *A'* and *B'*. This means that premiums paid now by high-risk farmers are too low, while those paid by low-risk farmers are too high. As already mentioned, higher rates will make these differences even more pronounced. In the extreme case, low-risk farmers may even completely resign from purchasing insurance. Theoretically, public intervention in the form of high subsidies for the purchase of insurance policies by farmers can significantly mitigate the scale of adverse selection, but in practice, it has also numerous undesirable effects, not only those relating to reduced prosperity caused by the need to finance insurance subsidies through taxes or a higher budget deficit.

According to Goodwin and Smith moral hazard results from the insurer's inability to control the farmer's efforts to preserve due foresight, which ultimately again gives rise to problems relating to the appropriate differentiation of premium rates. The formal analysis of this phenomenon required the introduction of a level of foresight,

marked as a certain monetary value *x*. The endogenous probability of loss was further defined as $\pi(x)$, provided that $\pi'(x) < 0$. The two previously analyzed situations were now written as:

$$w_1 = W - x - \pi(x)z \rightarrow \text{no loss}$$

$$w_2 = W - x - L - \pi(x)z + z \rightarrow \text{loss}$$

for x ≥ 0.

A farmer considering insurance purchase must now face the following optimization problem by selecting the appropriate parameters *x* and *z*. First, the expected utility function needs to be written:

$$\max\left[(1-\pi(x))U(w_1) + \pi(x)U(w_2)\right]$$

given the following restrictions:

$$w_1 = W - x - \pi(x)\text{z}$$

$$w_2 = W - x - L - \pi(x)\text{z} + \text{z and } x \geq 0$$

The first-order conditions for the existence of the maximum have the following form:

$$\left[U(w_2) - U(w_1)\right]\pi'(x) - \pi(x)(1+\pi'(x))U'(w_2) - (1-\pi(x))(1+\pi'(x)z)U'(w_1) = 0$$

$$\pi(x)\left[1-\pi(x)\right]U'(w_2) - \left[1-\pi(x)\right]\pi(x)U'(w_1) = 0$$

It follows from the latter that $U'(w_1) = U'(w_2)$, hence again $z = L$, which implies that the insurance contract is complete (full insurance). This conclusion is the same as that drawn in the case of adverse selection. However, if we are currently dealing with moral hazard, the insurer is not able to fully control parameter *x*. Consequently, the insurer calculates premium rate *q* instead of one dependent on *π(x)*. The maximization problem looks then as follows:

$$\max\left[(1-\pi(x))U(W - x - zg) + \pi(x)U(W - x - L + z(1-q))\right]$$

and the first-order conditions of its solution are:

$$\pi'(x)[U(w_2) - U(w_1)] - \pi(x)U'(w_1) - (1-\pi(x))U'(w_2) \leq 0 (= 0, when\ x > 0)$$

$$\pi(x)(1-q)U'(w_2) - (1-\pi(x))qU'(w_1) = 0$$

It follows from the second condition that again $U'(w_1) = U'(w_2)$. This simplifies a part of the first conditions, i.e.:

$$-U'(w_1) \leq 0 (= 0, when\ x > 0)$$

However, as $U'(w_1)$ should be greater than zero, *x* = 0, i.e. being not foresighted is the optimal solution for the farmer. This outcome is not, however, acceptable for the insurer.

Expected usability is also a starting point for the analysis of decisions made by farmers as regards the selection of risk management instruments and strategies. This issue is presented in a very interesting way by B.J. Sherrick et al. (Sherrick, Barry,

Elinger and Schnitkey, 2004). These researchers assumed that the agricultural producer has at his disposal certain assets, A, which give him an average stochastic return (profitability) $\bar{r}_A$, characterized by the variance of σ_A^2, reflecting the structural and economic risks. The above assets are financed with debt, D, and equity, E. A known balance sheet condition: $A = D + E$ applies here. Assuming that the debt cost is constant and amounts to r_D, the return from equity (profitability) should be calculated as follows:

$$\bar{r}_E = \bar{r}_A\left(\frac{A}{E}\right) - r_D\left(\frac{D}{E}\right)$$

while its variance is:

$$\sigma_E^2 = \left(\frac{A}{E}\right)^2 \sigma_A^2$$

The analyzed farmer aims to maximize the value of his wealth at the end of a given period, which is equivalent to the maximization of the certainty equivalent (*CE*). The latter simply means a guaranteed amount of money that the farmer would consider equally desirable as a high-risk asset. If the farmer demonstrates risk aversion, which is the case here, the CE figure will be lower than the value of a high-risk asset. Having explained that, we can now present the formula of utility function maximized by the farmer:

$$W_{CE} = \overline{W} - \lambda\sigma_W^2$$

where:

W_{CE} – certainty equivalent for risk-bearing wealth at the end of the period,

$\overline{W}$ – average value of wealth,

σ_W^2 – variance W,

λ – attitude to risk (half of the Arrow-Pratt measure of risk aversion).

The maximization of parameter W_{CE} is in practice the same as the maximization of the certainty equivalent of return on equity:

$$r_{CE} = \bar{r}_E - \lambda\sigma_E^2$$

which can be further generalized as follows:

$$r_{CE} = \bar{r}_A\left(\frac{A}{E}\right) - r_D\left(\frac{D}{E}\right) - \lambda\left(\frac{A}{E}\right)^2 \sigma_A^2$$

For the model to be complete, insurance has to be introduced. It was assumed that this would be a fixed payment, P_i, linked to crop insurance only. As a result of the purchase of the i^{th} insurance product, the return on assets, expressed now as $\bar{r}_{Ai}$, will change, so will its variance $\left(\sigma_{Ai}^2\right)$. Of course, this will be accompanied with a reduction

in the return on equity and the quotient P_i / E. Hence once crops are insured, the certainty equivalent of equity will amount to:

$$r_{CE,i} = \bar{r}_{Ai}\left(\frac{A}{E}\right) - r_D\left(\frac{D}{E}\right) - \frac{P_i}{E} - \lambda\left(\frac{A}{E}\right)^2 \sigma_{Ai}^2$$

It would be most beneficial for the farmer if the reservation premium made his utility equal with a situation without insurance. This premium is expressed as P_i^*, and can be calculated using the following formula:

$$\bar{r}_A\left(\frac{A}{E}\right) - r_D\left(\frac{D}{E}\right) - \lambda\left(\frac{A}{E}\right)^2 \sigma_A^2 = \bar{r}_{Ai}\left(\frac{A}{E}\right) - r_D\left(\frac{D}{E}\right) - \frac{P_i^*}{E} - \lambda\left(\frac{A}{E}\right)^2 \sigma_{Ai}^2$$

which gives:

$$P_i^* = A\left(\bar{r}_{Ai} - \bar{r}_A\right) - \lambda A\left(\frac{A}{E}\right)\left(\sigma_{Ai}^2 - \sigma_A^2\right)$$

Assuming that the variance of the profitability of assets following crop insurance is lower than without coverage, the following inequalities are also true:

$$\frac{\partial P_i^*}{\partial E} < 0,\ \frac{\partial P^*}{\partial \bar{r}_{Ai}} > 0, \text{ and } \frac{\partial P_i^*}{\partial \sigma_{Ai}^2} < 0$$

Generalizing the above considerations, we can conclude that:

1. The greater the increase (decrease) in the average insurance effectiveness, expressed as the difference $\bar{r}_{Ai} - \bar{r}_A$, the more (less) the farmer is inclined to purchase such insurance.
2. The greater (smaller) the difference between asset variances, i.e. $\sigma_{Ai}^2 - \sigma_A^2$, the higher (lower) willingness to purchase insurance is demonstrated by agricultural producers.

The theoretical model developed by Sherrick et al. was extended in an interesting way by Velandia et al. (Velandia, Rejesus, Knight and Sherrick, 2009). Instead of the reservation premium, P_i^*, these authors use the initial cost of insurance purchase, C_j^*. The method of determining the latter parameter is the same as in Sherrick et al., except that the farmer's preferences as regards risk are now expressed as *p*. What is a novelty here is the introduction of an unambiguous decision rule regarding insurance purchase. Hence using $\hat{C}^D$ to express the difference between C_j^* and the actual insurance cost, this decision will be rational if $\hat{C}^D$ is greater than zero. Unfortunately, $\hat{C}^D$ is a hidden unobservable variable. Nonetheless, actual decisions (*Yj*) made by farmers can be recorded. This can be illustrated as follows:

$$Y_j = \begin{cases} 1 \text{ where } \hat{C}^D > 0 \\ 0, \text{ where } \hat{C}^D \leq 0 \end{cases}$$

where:

$Y_j = 1$ means insurance purchase,

$Y_j = 0$ means resignation from insurance purchase.

Thus, we are now passing on from theoretical considerations to the construction of empirical models describing the various determinants of purchasing agricultural insurance or resigning from it to choose other risk management instruments. These issues will be discussed in more detail later on in this monograph.

Some of Goodwin's and Smith's considerations regarding insurance supply include references to the achievements of H. K. Borch from the 1980s. This Norwegian economist assumed that a premium calculated by a private insurer, *Pp*, consists of three components: expected payment of indemnities, *E*, its own administrative expenses, *A*, and the necessary return on invested capital, *R*. Therefore, we have:

$$P_p = E + A + R$$

A and *B* are very often totaled, which gives a certain surcharge, referred to in the literature on the subject as the loading factor ($L = A + R$). A risk averse person interested in purchasing an insurance policy will be willing to pay for it where $E + L$ is greater than *E*, but surcharge *L* is not too high. This rule is applied also by farmers, which was unequivocally proved by V. Smith and J. Glauber (Smith and Glauber, 2012).Otherwise, the private insurance market may, at some point, simply cease to exist.

The expected return on capital invested by an insurance company (*R*) directly depends on its attitude to risk. If it is characterized by aversion, the return will be higher than in the case of risk neutrality, whereby the latter assumption prevails in literature and models. A high-risk insurer will be satisfied even with a lower *R* than a low-risk one. The prevalence of risk neutral behavior can be explained by the possibility of risk pooling, based on the law of large numbers, and risk spreading. Risk pooling, referred to also as loss pooling, is a process of creating a group of individuals wishing to have insurance coverage, as a result of which risk is distributed among all members, and predicting future losses becomes easier. This is followed by a decreased variance of possible outcomes, and the current loss risk is replaced with the average risk. As a consequence, the insurer may, and in fact should, charge lower premium rates (Rejda and McNamara, 2017). Risk pooling in agriculture, especially when one wants to offer multiple-peril or all risks insurance (in Poland this type of insurance is called bundled insurance), may face a barrier in the form of systemic (catastrophic) risk, when a larger area is exposed to risks and farmers' exposure to them shows strong correlation. In this case, the amount of losses suffered by the entire group may exceed the amount of premiums paid by it. This can be counteracted,

to some extent, by risk spreading, i.e. transferring it onto the entire national economy, or by choosing reinsurance services. Here, however, we usually have to do with another barrier, i.e. the effects of moral hazard.

Moral hazard leads directly to an increase in the premium rate, at least by the amount covering the cost of monitoring of behaviors agreed upon in the agreement by the insureds. However, in the case of bundled contracts, these costs can be very high. Raising the franchise by the private insurer automatically reduces the cost--effectiveness of the insurance policy for the insured. Sometimes long-term insurance contracts are offered as a remedy. Here there is, however, yet another threat, namely dynamic cycling. In this case, the farmer deliberately increases production in some years and reduces it in others to obtain higher indemnities. Besides, in the last year of the duration of such a contract, when the farmer has no intention to renew it, moral hazard behaviors may intensify. These are some reasons why most researchers believe that in order to achieve a satisfactory level of farmers' interest in all risks insurance, premiums need to be subsidized. If the subsidy rate per monetary unit of indemnities is s, the reduced premium, P_g, can be determined as follows:

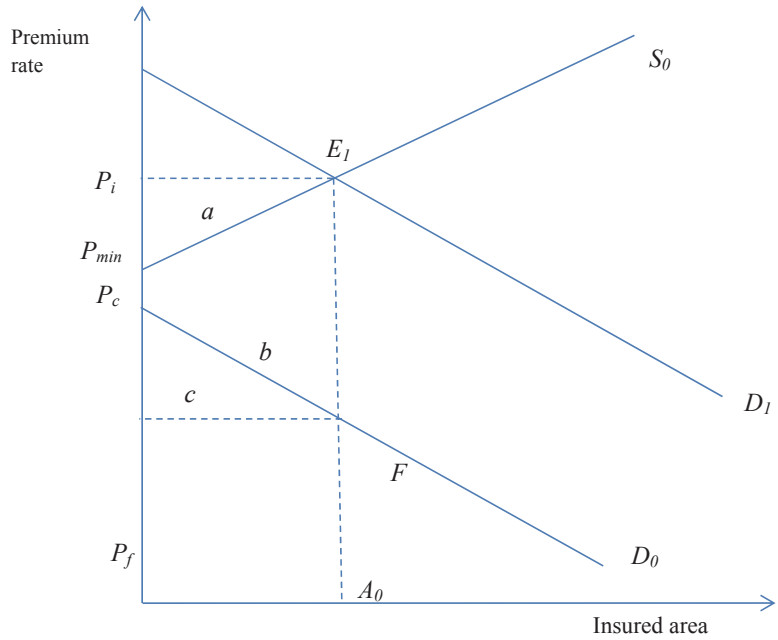
$$P_g = (1 - s)E$$

The thus calculated premium is evidently lower than the actuarially fair premium. This circumstance clearly shows that apart from reducing risks in agriculture, governments treat subsidies to insurance also as an additional channel for stabilizing income in this sector. There is still a lot of controversy about the transfer efficiency of such subsidies relative to other government programs focused explicitly on maintaining agricultural income.

There are still no comprehensive studies on the simultaneous impact of agricultural insurance, particularly crop insurance, on the situation of agricultural producers, food consumers and taxpayers, hence ones conducted in the convention of economic well-being analysis. In this context, the paper by V. H. Smith and J. W. Glauber of 2012 should be treated as essential and valid (Smith and Glauber, 2012). The core of their considerations is presented in Figure 3. Without government intervention in the crop insurance market the demand for this insurance would be expressed by line D_0, while line S_0 would show its supply by private insurers. For the latter, P_{min} is the minimum price, i.e. the premium rate. Unfortunately, this price is not acceptable to farmers due to the occurrence of the choke price, P_c. At this price, the demand for specific goods or services reaches zero. Only when the price is lower than P_c, some demand may occur. Therefore, in the above circumstances a private crop insurance market will not come into being. The situation will start to change only with government subsidies granted to farmers and/or insurance companies. If, for example, the premium subsidy rate is E_1F, a new demand line, D_1, will appear, and the area of insured crops will be A_0. Of course, the market itself will reach equilibrium at E_1, but at price P_i, but the farmer will now pay a lower P_f price. At the same time, costs to be paid by taxpayers arise, whose amount is shown by rectangle $P_i E_1 F P_f$, which is the sum of areas *a, b* and *c*. Area *c* is consumer surplus resulting from an increase in farmers' income and its enhanced stability. As for

insurers, they obtain producer surplus (triangle *a*). Trapezoid *b* represents the minimum deadweight cost of insurance subsidies financed through taxes. The full analysis should obviously take into account also all benefits and external costs generated by the above-mentioned subsidies. Unfortunately, nowhere in the world a relevant research has been carried out yet in such a broad convention. An interesting prelude to such an approach may be, however, the work by P. Hazell et al., which will be further commented on (Hazell, Pomareda and Valdes, 1986).

Figure 3. Effects of crop insurance subsidies on wealth

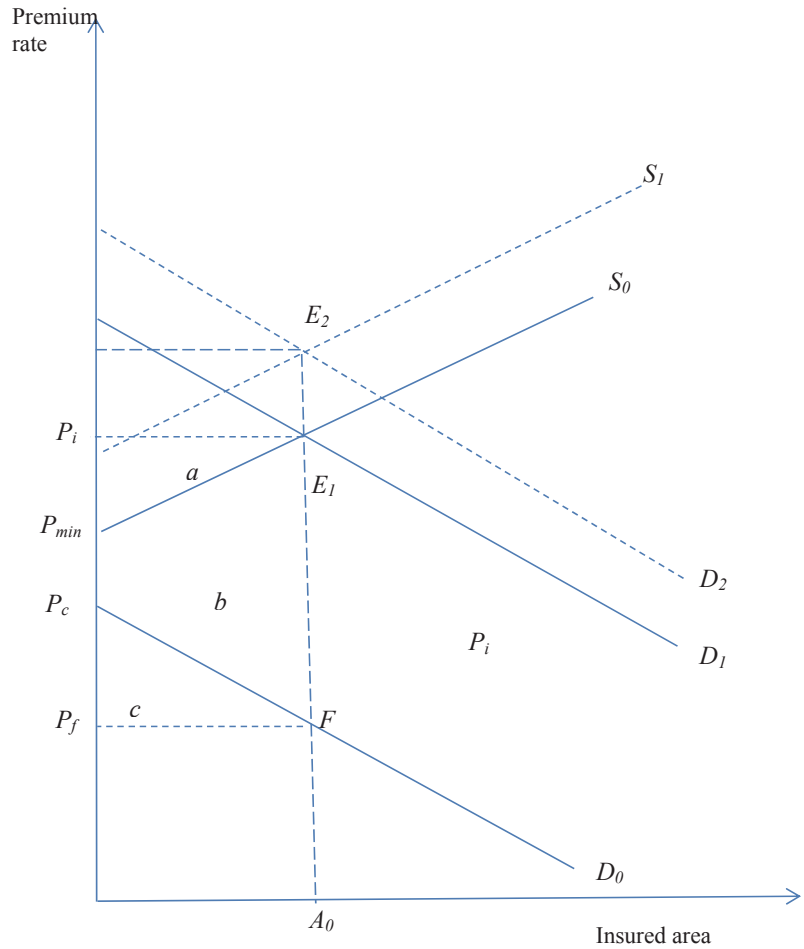


Source: authors' own study, based on: Smith H.V., Glauber W.J., Agricultural Insurance in Developed Countries: Where Have We Been and Where Are We Going?, "Applied Economic Perspectives and Policy", vol. 34, no. 3, 2012.

Looking only at Figure 3, one can see that any reduction in the costs of the operation of the agricultural insurance system on the side of insurance companies could result in a reduction in insurance prices, to be precise – premium rates, which would give impetus to revive demand. This issue is explained in Figure 4. Market equilibrium is also at E_1, with the same area of insured crops as previously, equal to A_0. The price of farmer-paid insurance rate (P_f) also remains unchanged. Unfortunately, the costs of insurance companies increased, leading to a shift of the efficient supply curve, S_0, i.e. supply delivered at the minimum marginal cost, to the inefficient position S_1. Market equilibrium is described now by point E_2, which represents an increase in the premium

subsidy rate by $P_{i1} - P_i$, and hence also in the ultimate insurance price. The implications are straightforward: the program's cost to be paid by taxpayers increases additionally by the area of rectangle $P_{i1}\ E_2\ E_1\ P_i$. The same increase is recorded also in welfare costs. Here again, a full analysis should account for the costs of lobbying measures taken by insurance companies, incurred by them in the course of rent-seeking activities aimed at obtaining additional subsidies. Sometimes these costs can be significant, as shown by the latest American research (Goodwin, 2011; Smith, Glauber, Dismukes, 2016; Pearcy, Smith, 2015). Another important factor as regards these costs is that modeling covers also fees charged by agents and brokers offering insurance to farmers.

Figure 4. Effects of excessive costs of crop insurance offered to farmers by insurance companies

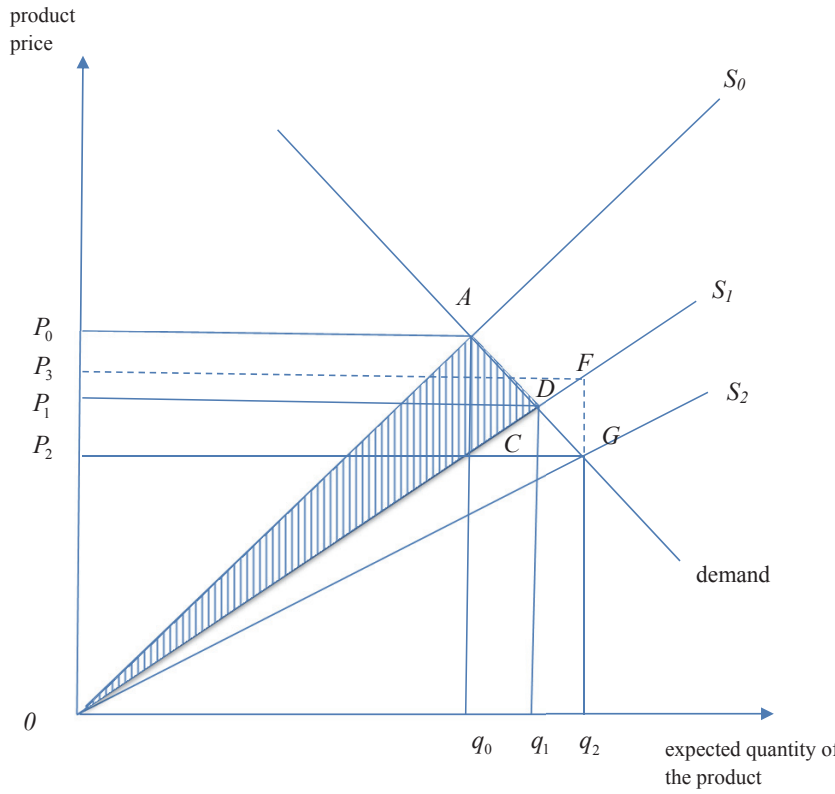


Source: as for Figure 3.

In the context of the situation in the Polish agricultural insurance market, two well-based conclusions can be drawn from the above analysis:

1. Insurance premiums paid by farmers should not be increased if demand is not to choke, as this would jeopardize the program's objectives, i.e. achieving the assumed level of insurance coverage.
2. Total insurance premiums, i.e. those accounting also for costs incurred by insurance companies, should be verified by licensed actuaries. Their assessment should cover also fees paid to agents and insurance brokers. This is to achieve a satisfactory level of the accomplishment of the second objective of the program, i.e. minimizing its costs for taxpayers, as all insurance programs should be based on actuarial reliability.

Figure 5. Welfare gains from insurance for customers and producers



Source: authors' own study, based on: Crop Insurance for Agricultural Development Issues and Experience, edited by P. Hazell, C. Pomareda, A. Valdes, The Johns Hopkins University Press, Baltimore and London 1986.

It is also worth presenting the views of P. Hazell et al. on agricultural insurance issues. We will start with the analysis of Figure 5. As we can see, there is a simple relation here: the price of an agricultural product – its quantity. Insurance is here an in-

stitutional innovation. If it is purchased by farmers on a commercial basis, the initial supply curve, S_0 – in the absence of insurance coverage – shifts to position S_1. If the demand for a given product is not perfectly elastic, then its price will drop from P_0 to P_1, while the supply volume will increase from q_0 to q_1. As a result, consumer surplus will occur represented by rectangle P_0ADP_1.

This surplus can be treated as an external gain. Some individuals consider it a reason why this surplus should be compensation for farmers, e.g. in the form of premium subsidies. At this point, Hazell et al. immediately add that in the case of perfectly elastic demand, farmers would, however, fully capture the above-mentioned surplus, which automatically excludes any need for their subsidizing. The three researchers use yet another argument against the latter. After all, a farmer that purchases commercial insurance gets a reduction in costs that include the cost of the insurance purchase, equal to the *AC* section, and his total savings are presented by triangle *DAC*. However, as a result of a drop in the price of the agricultural product, his net welfare gain will be P_1DO less P_0AO. This value may be positive or negative – both for the whole sector and individual agricultural products. The consumer gain is represented by trapezoid P_0ADP_1. The net change in the total society welfare in represented by shaded triangle *OAD*, whose area depends on the position of supply curves S_0 and S_1 and the price elasticity of supply and demand.

If the government decides now, for redistributive purposes and guided by the belief that farmers insure insufficient quantities of crops and livestock, to subsidize insurance, an adaptation process will start to achieve new equilibrium on the market. As a result, the new supply level is now represented by curve S_2. The price will thus drop to P_2, but the production volume will be q_2. Consumer and producer surpluses, which will always be lower than the subsidy costs (P_2P_3FG), are represented by triangle *ODG*. Thus, regardless of the subsidy scheme applied (subsidies to farmers' premiums and/or support for insurers), the society will eventually suffer its welfare losses.

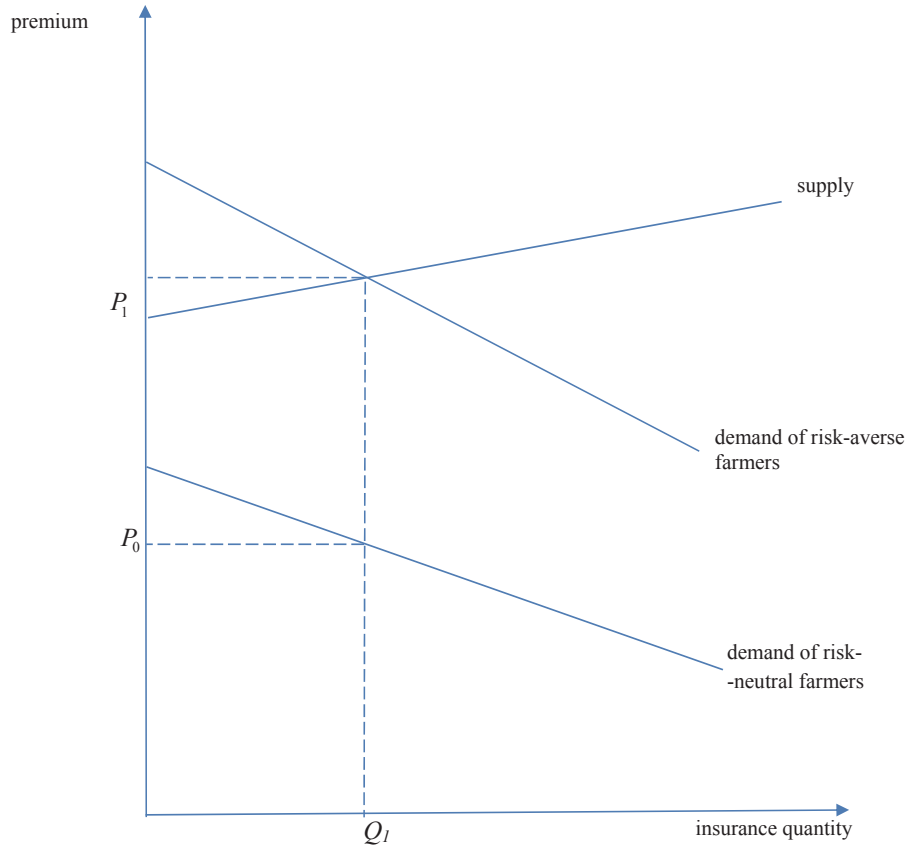
Although Hazell et al. treat the introduction of insurance to agriculture as an institutional innovation, they do not consider it a kind of public good. This means that the state does not bear any special responsibility for its delivery, although it cannot disregard the importance of insurance. By analogy to product innovations, the three economists concerned suggest that it would probably be more beneficial for the society to support research and implementations in the area of business insurance in agriculture with budgetary funds than just subsidizing farmers and/or insurance companies. They believe that all around the world there is a widespread ignorance when it comes to robust actuarial grounds of agricultural insurance. If we treat them as action to reduce information asymmetry, only now, thus in an indirect and unintuitive way, do we get premises for public intervention, which will probably be time-limited (sunset), and limited in terms of amounts of subsidies.

Hazall et al. are considering also another two arguments of a social nature that could be taken into account in case of subsidizing agricultural insurance:

1. Suffering severe losses and dramatic deterioration of the living standards by small farmers who would not be able to purchase commercial insurance.
2. The occurrence of external network effects, i.e. transfer, within the framework of multiplier mechanisms, of a reduction in funds' resources due to the occurrence of risk with a significant spatial reach, i.e. systemic/catastrophic risk, onto entire local economies.

However, they immediately add that public authorities should consider all other available options before they decide to introduce subsidized insurance. Following such a comprehensive analysis of costs and benefits, it may even turn out that *ad hoc* support may sometimes be the best option.

Figure 6. Demand and supply in the agricultural insurance market



Source: as for Figure 5.

Hazell et al. analyze, in a very interesting way, the demand for agricultural insurance and the supply of this financial service. This is shown in Figure 6. If there were only risk neutral farmers in the private market, no equilibrium would be reached. The situation may change only when farmers with risk aversion start to seek insurance

coverage. At P_1 insurance policy price, insurance sales may reach Q_1. In order for risk neutral farmers to become interested in purchasing insurance its price should not exceed P_0. However, without government subsidies, whose rate should correspond to P_1 - P_0 section, this is not possible.

As shown above, farmers' preferences regarding risk seem to be one of the most important determinants of their demand for insurance coverage. There is still serious controversy in this matter. On the one hand, we have the research by P.H. Binswanger, V.H. Smith and M.A. Watts, who argue that risk aversion prevails particularly among small farmers. On the other, according to B.K. Goodwin's research 68% of farmers indicated – in a ten-point risk assessment scale – up to five points, while only 13% of 593 respondents could be considered to demonstrate extreme risk aversion (up to two points). At this point, a comprehensive analysis of Polish farmers' attitudes to risk would be very useful, but no such analysis has been performed yet. As suggested by Hazell et al. such studies are well-suited to be financed from the budget.

The demand for insurance services depends on a great deal of determinants, which will be discussed later in this monograph. At this point, we will only mention the most general issues related to its price and income elasticity, using the approach applied by Zweifel and Eisen. The starting point here is a simple equation to calculate the amount of gross premiums collected by the insurance company:

$$PV = p \cdot I$$

where:

PV – premium amount/volume,

p – premium rate as a percentage of the monetary unit of the sum insured,

I – sum insured.

Following complete differentiation we get:

$$dPV = dp \cdot I + p \cdot dI$$

By diving both sides by $PV - pI$, we get:

$$\frac{dPV}{PV} = \frac{dp}{p} + \frac{dI}{I}$$

We can now see that a change in the premium volume results from changes in the insurance premium rate and the sum insured. The latter can be expressed as a function of rate p and income Y:

$$I = I(p, Y)$$

Following complete differentiation of the above equation we get:

$$dI = \frac{\partial I}{\partial p} dp + \frac{\partial I}{\partial Y} dY$$

By diving by I and adding $1 = p/p$ and $1 = Y/Y$, we get:

$$\frac{dI}{I} = \left(\frac{\partial I}{\partial p} \cdot \frac{p}{I}\right)\frac{dp}{p} + \left(\frac{\partial I}{\partial Y} \cdot \frac{Y}{I}\right)\frac{dY}{Y} = \eta \cdot \frac{dp}{p} + \varepsilon \cdot \frac{dY}{Y}$$

where: $\eta := \frac{\partial I}{\partial p} \cdot \frac{p}{I} < 0$ is the price elasticity of demand,

$\varepsilon := \frac{\partial I}{\partial Y} \cdot \frac{Y}{I} > 0$ is the income elasticity of demand.

We can, therefore, conclude that the sum of the percentage change in prices of insurance products (weighted by price elasticity) and the percentage change in income, where the income elasticity rates are the weight, is the approximate percentage change in the demand for these products. Generally, in highly regulated insurance markets, the price elasticity of demand is low, while in liberalized markets it clearly grows (in absolute terms), sometimes becoming unitary elasticity, i.e. an increase in the price results in the same decrease in demand and, as a consequence, the product of these two quantities does not change. The income elasticity of insurance demand is positive, and almost universally greater than unitary, especially on dynamically developing markets.

Having formulas for both demand elasticities, these elasticities can now be linked to changes in the collected premium amount. This is expressed by the following two formulas:

$$\frac{dPV}{PV} = \frac{dp}{p} + \eta \cdot \frac{dI}{I} + \varepsilon \cdot \frac{dY}{Y}$$

$$\frac{dPV}{PV} = (1 + \eta)\frac{dp}{p} + \varepsilon \cdot \frac{dY}{Y}$$

In studies relating to the elasticity of the demand for insurance services, practically only one price component is taken into account. Such studies are conducted mainly in the USA and Australia, but they are now relatively rare, as most estimates come from the 1980s and 1990s. It was established then that this demand is quite inelastic relative to insurance prices, as shown in Table 1.

Table 1. Price elasticity of the demand for crop insurance in the USA in 1986-1993

Study's authors and the year of publication	Elasticity
• Goodwin (1993)	-0.73 [a] -0.32 [b]
• Goodwin and Kastens (1993)	-0.51 [a]
• Gardner and Kramer (1986)	-0.92 [a]
• Barnett, Skees and Hourigan (1990)	-0.20 [b]
• Smith and Baquet (1993)	-0.69 [a] -0.58 [b]
• Coble et al. (1993)	-0.26 [a]

Symbols: [a] – for the sum insured, [b] – for the insured acreage.

Source: authors' own study, based on: Goodwin K.B., Smith H.V., The Economics of Crop Insurance and Disaster Relief, Washington, DC, AEI Press, 1995.

Later studies did not bring any significant changes. For example, in 1996, K.H. Cable et al. estimated the above-mentioned elasticity at – 0.429 (Coble, Knight, Pope and Williams, 1996). T. Serra, B.K. Goodwin and A.M. Featherstone (study from 2003) established that the price elasticity for almost 1.5 thousand farms in Kansas in 1993-2000 ranged from 0.065 to -0.575 (Serra, Goodwin and Featherstone, 2003). Finally, in 2008, S. Shaik et al. published an analysis showing that for four states: Indiana, Mississippi, Nebraska and Texas, the average elasticity was – 0.40 (Shaik, Coble, Knight, Baquet and Patrick, 2008).

Australians researches dealing with studies on the farmers' insurance demand clearly prefer the category of willingness to pay (WTP) for products they are offered. WTP is understood as the maximum price that the customer is willing to pay for a product/service. Sometimes, however, this value is determined within a certain range. WTP is estimated, by asking potential buyers directly what its acceptable level is. It can also be established indirectly, based on an analysis of consumers' choices between alternatives they are offered. Unfortunately, neither of these two approaches is perfect. The major challenge here is the transition from hypothetical situations to real purchasing decisions. Moreover, the context in which these decisions are made is also important. Keeping in mind all these reservations, Australian studies clearly show that no more than half of local farmers were willing to insure their crops, even if insurance coverage was subsidized (Smith, 2011). These farmers accepted only a 10% surcharge on actuarially fair premiums, charged to cover the costs of insurance mediation. Such a poor result is explained by the occurrence of adverse selection, and thus the reluctance of low-risk farmers to pay for high-risk ones, the fact that insurance purchase means first the outflow of cash, while compensation is a random variable, and the availability of other risk management tools and strategies. The last issue is mentioned, as a global problem, also by O. Mahul and Ch.J. Stutley (Mahul and Stutley, 2010) and V.H. Smith and J.W. Glauber (Smith and Glauber, 2012). It clearly follows from the above that also in Poland, risk in agriculture should be approached comprehensively/holistically, perceiving crop and livestock insurance as well as insurance of property in kind as one of the options of its management. We should also definitely begin intense and advanced theoretical studies and empirical analyzes aimed at identifying determinants of the farmers' demand for insurance. To this end, permanent and significant budget support is necessary.

Insurance demand and supply as well as the functioning of the entire infrastructure developed to offer insurance to its final purchasers, are subject to regulatory capture. This term was introduced as the theory of economic regulation into economics, and more precisely to the theory of public choice, by G.J. Stigler, American Nobel Prize winner in 1982. According to Stigler, industry interest groups, often having an information and knowledge advantage over the regulator, at some point, having invested relevant resources in rent-seeking, impose the government institutions their way of thinking and identifying the private interest with the public one (Stigler, 1971). Thus, he undermined the view that regulations cost nothing and are ordained to elimi-

nate market inefficiencies. Apart from capture in the form of gaining financial benefits, which is often connected even with political corruption, the intangible dimension of this capture, i.e. the above-mentioned imposition of thought patterns to solve specific problems, also needs to be taken into account. Observation of real political processes shows that also small economic entities, including small farmers, can be very effective in regulatory capture. A good strategy in this regard is to use the rhetoric of the weakest, the most aggrieved by the market and globalization of individuals (Schmitz, Moss, Schmitz, Furten and Schmitz, 2010). It is also very helpful to make this message reach the general public, which can be done via the media and scientific centers, and even popular culture. Such actions are referred to as deep capture. Eventually, however, rent-seeking usually leads to certain welfare losses. We should, therefore, minimize hazards caused by regulatory capture. This can be done through:

- isolating the regulator as far as possible from the influence of various interest groups and lobbyists;
- full transparency of the regulator's action and ensuring that it has credible and up-to-date information and human resources able to resist the arguments of regulated entities and effectively defend the interests of all citizens, in particular taxpayers;
- taking new regulatory actions with extreme caution, as, according to the second-best theory, it is often better to accept some market deficiency than initiate public intervention which will later transform into a whole sequence of corrective interventions;
- striking the right balance between centralization and decentralization of the implementation of a specific sectoral policy; after all, it may happen that regulatory capture will appear also at the regional level, which can lead to a distortion gap (Fritsch, 2014).

P. Zweifel and R. Eisen, who have already been mentioned several times in this monograph, are extremely skeptical when it comes to proving the rightness of Stigler's hypothesis regarding regulatory capture in the insurance practice. First of all, individuals working for the regulator often have different goals than regulated entities. Secondly, susceptibility to capture, if any, depends to a great extent on the historical and cultural context. Thirdly, it is very difficult to explain the international differences in regulation intensity and in deregulation and reregulation processes. In this regard, Zweifel and Eisen present yet another two hypotheses:

1. With respect to public interest. The regulation is to be focused on mitigating markets imperfection, e.g. preventing the insolvency of insurance companies. At this point, however, three challenges arise: (1) how to define and rank market imperfections?; (2) what instruments should be chosen?; (3) what incentives should be offered to the regulator so that it really works for the common good?
2. With respect to market regulation. This hypothesis was presented in 1976 by S. Peltzman, a student of G. Stigler, hence a follower of the Chicago school of economics. Peltzman simply combined regulatory capture with the public interest hypothesis/theory. The supply of additional regulation is for him a derivative of the regulator's actions oriented also to political goals, i.e. on the famous Niskanen's

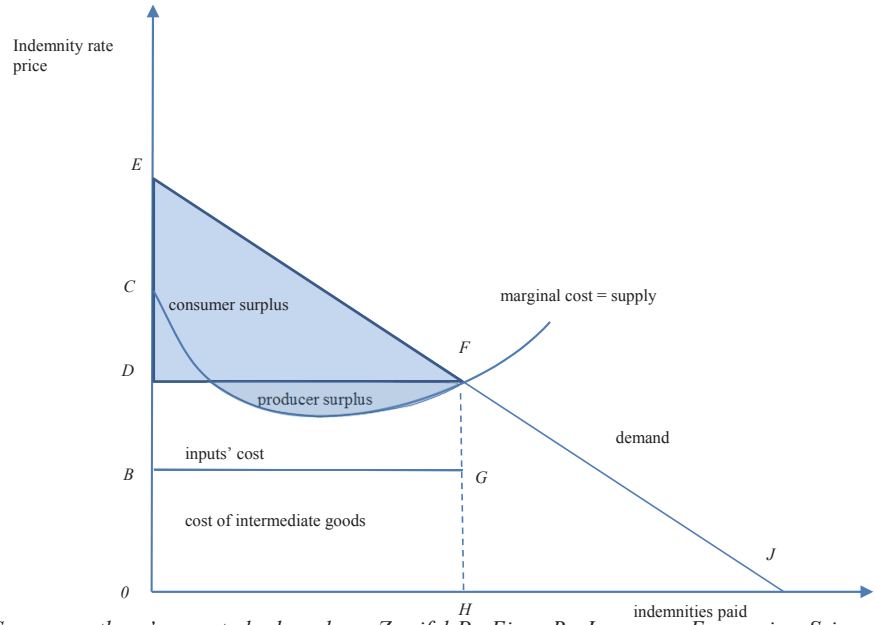
"3Ps" (power, prestige, pay). The regulator must each time weigh the key costs and marginal benefits of additional regulation, which allows for determining the regulation supply and its price. Demand for more intensive regulation in insurance may be created by its buyers, hoping that higher premiums will reflect higher actuarially fair risk and will increase the probability of receiving contractual indemnities. Insurance companies may also be interested in more stringent regulation, as this will result, for instance, in protection of the oligopolistic structure of the market. We can now determine the different curves of the demand for regulation and the points of their intersection with the supply curve/curves, which will be tantamount to determining the market equilibrium for regulation. Zweifel and Eisen verify then five quite complex hypotheses, to finally conclude that Peltzman best explains the regulatory practice in contemporary insurance markets.

In the case of agricultural insurance, Smith et al. proved that the situation in the US is reminiscent of the hypothesis of regulatory capture by insurance companies and independent agents and brokers (Smith, Glauber and Dismukes, 2016). It turns out that in recent years, well over 50% of subsidies for agricultural insurance in the United States went to the abovementioned entities. A similar conclusion was drawn, though using a different methodology by Goodwin and Smith (Goodwin and Smith, 2013). All American researchers strongly emphasize that the risk regulatory capture grows dramatically when the budget for supporting agricultural insurance is significantly increased. This is now the case in Poland, as this year subsidies for this insurance are 4.5 times greater than in 2016. The effectiveness of the insurance sector, its innovativeness and social gains from its existence, as well as the satisfactory utilization of budget support it receives, depend, *inter alia*, on the structure of this industry. This issue is explained in a very interesting way by P. Zweifel and R. Eisen (Zweifel and Eisen, 2012), who identify two classic variants of competition in the insurance sector:

1. Perfect competition,
2. Monopoly.

Perfect competition is presented in Figure 7 which is drawn up in the already well-known convention of welfare economics, so it refers to, e.g. the consumer and producer surplus category. The former is expressed by triangle *DEF*. It should be noted that insurance buyers pay, in fact, lower prices than those resulting directly from insurance premium rates, as they receive part of their expenses as indemnities. Accomplishing producer surplus in the form of insurance companies' income requires certain additional measures. First, the volume of the collected premium, i.e. rectangle *ODEF*, needs to be established, and then the total costs of production inputs, both fixed and variable ones, hence the *COFH* area needs to be calculated. By subtracting the latter from the *ODFH* area, we finally get the producer surplus, *DCF*. By adding the two above-mentioned surpluses, we get the volume of social welfare, *ECF*, contributed by the insurance sector. The contribution of this sector in generating value added, i.e. GDP, is presented by triangle *DBGF*. For formal reasons only, we would also like to add that a competitive insurance market achieves equilibrium at point *F*.

Figure 7. Insurers' contribution to social welfare in a perfect competitive environment



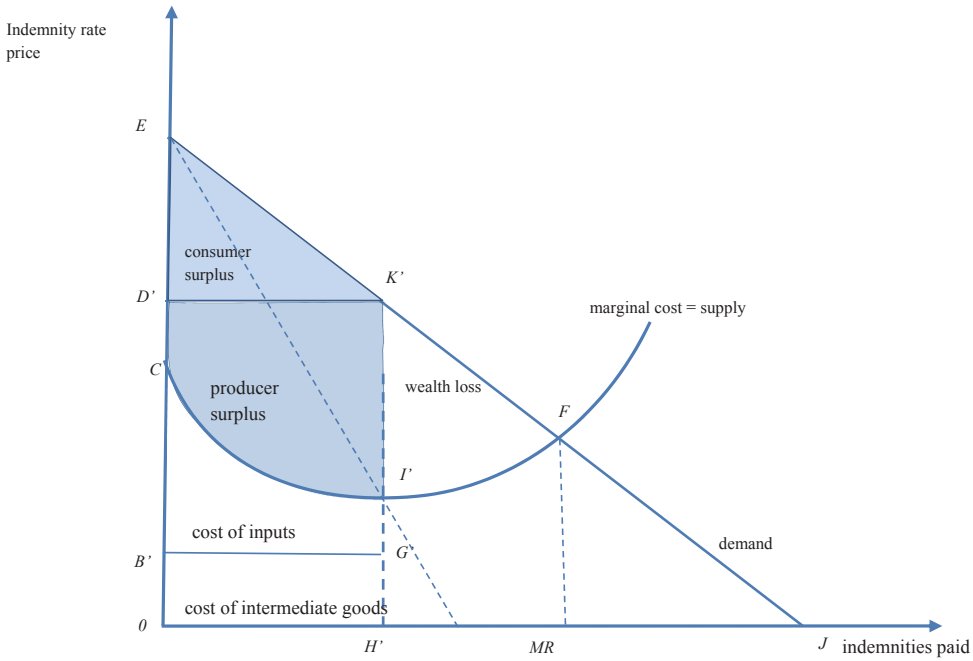
Source: authors' own study, based on: Zweifel P., Eisen R., Insurance Economics, Sringer-Verlag, Berlin, Heidelberg 2012.

Figure 8 shows a case of monopoly. According to the microeconomics theory, a monopolist seeks balance at the point where its marginal revenue (*MR*) equals the marginal cost (*MC*). This is point *I'*. It should be noticed here that now the quantity of insurance provided is decreasing, from *H* to *H'*, but the insurance price increases from *D* to *D'*. As a consequence, the consumer surplus drops (triangle *D'EK'*), while the producer surplus grows (area *D'CI'K'*). As a result of the adaptations, the society as a whole suffers a loss (area *I'FK'*), because some customers of insurance companies leave the market following an increase in insurance prices. The market may, unfortunately, continue to shrink, if high-risk consumers start purchasing insurance now, adverse selection will occur on a wider scale. The impact of the monopolization of the insurance industry on the costs of inputs is not clear, as the number of products sold decreases, but on the other hand, their prices increase.

Pure monopolies are rare in the contemporary insurance industry. What we deal with more often is oligopoly, i.e. the operation of several insurance companies. This is the case in Poland. The microeconomics theory clearly indicates that such situation is not favorable for customers either, which is because insurers may in this case resort to collusion. Whereas collusion reduces competition and increases the prices of services, with all the negative consequences for their purchasers and the whole society, thus leading to concentration. Even if there is no oligopolistic collusion, in such a market structure insurance companies behave in a strategic way, i.e. they take into account the behavior of other members of the oligopoly, playing different games. At this point, an

obvious recommendation for the Ministry of Agriculture and Rural Development is that it should continue its efforts to ensure that an increasingly greater number of insurance companies offer farmers adequate protection against risks. It also seems worthwhile to start research to identify determinants of the insurance supply for Polish farmers. As this is a very complex issue, highly specialist and advanced know-how is needed, the financing of which undoubtedly deserves budgetary support. What is also needed is cooperation between insurers, which may be, however, difficult, as evidenced by the fact that they refused to participate in a survey developed specifically for the purpose of this monograph.

Figure 8. Insurers' contribution to social welfare in a monopolistic environment



Source: as for Figure 7.

The expected utility concept/hypothesis presented above, referred to also as the standard model, is multifariously criticized, but it can be generally stated that it only provides recommendations on how people should behave and does not sufficiently explain their actual decisions. Mathematicians criticizing the standard model, as being a completely axiomatic and normative construction, indicate mainly two paradoxes: that formulated by M. Allais in 1953 and the paradox formulated by D. Ellsberger in 1961 (Ackert and Deaves, 2012; Kureuther et al., 2013). Economists and behavioral financiers focus mainly on deviations from the classic models of decision making in risk conditions (effect of certainty, reflection, isolation, disposal) and cognitive biases (Döring, 2015; Zaleśkiewicz, 2012).

Such biases are quite numerous, as shown in Table 2. Some of the advocates of the standard model would respond to these allegations claiming that these are only anomalies that do not challenge it in anyway. All orthodox neoclassical economists respond to this criticism in a similar way.

Table 2. Main cognitive biases

Bias	Essence of the bias
• excessive confidence	excessive self-confidence about subjective abilities and knowledge
• *status quo*	taking a rigid position as regards the characteristics of the current situation
• excessive optimism	the possibility of becoming a victim of adverse events is perceived as less likely than being a beneficiary of favorable changes
• endowment effect	what one owns is considered more valuable
• calculatedness	information which is favorable to current views is primarily taken into account
• effect of certainty	an event which is considered to be relatively more probable is assigned excessive importance
• loss aversion	possible losses overweigh potential profits that are equal to these losses in quantitative terms
• concentration illusion	up-to-date mentally available information is classified as particularly important
• influence	duration of effective emotions is overestimated
• projection	it is assumed that the present mood will prevail also in the future
• self-control	the importance of one's control to getting out of a difficult situation is overestimated
• facilitation	even a minor mention of some idea or concept is strongly reflected in the way one thinks or behaves
• time perspective	looking back at certain events, we get reaffirmed that it had to be like that

Source: authors' own study, based on: Döring T., Öffentliche Finanzen und Verhaltensökonomik: Zur Psychologie der budgetwirksamen Staatstätigkeit, Springer Gabler, Wiesbaden, 2015.

The results of modelling using the expected utility hypothesis in crop insurance are shown in recently published studies by X. Du, H. Feng and D.A. Nennessy (Du et al., 2017). These three American economists analyzed the local subsidized crop insurance market. Using a very advanced differential and integral calculus, they maximized the expected utility of purchasing various insurance policies, while distinguishing three component effects of the final function subjected to optimization, namely:

- insurance effect, i.e. actuarially fair determination of the terms and conditions of the insurance contract;
- effect of a surcharge on the premium used by insurance companies;
- effect of income transfer to farmers due to subsidies.

As regards empirical tests, these were performed with respect to two hypotheses, whereby only the first one can be considered universal, while the second one is applicable only to the situation in the USA. Therefore, only the first hypothesis will be considered. According to it, if the subsidy to the premium increases depending on the degree of insurance coverage, farmers should choose its highest level. If the subsidy amount grows as coverage increases at its low level, and decreases at high levels, farmers should not opt for coverage lower than that which maximizes the subsidy amount.

Using a very demanding mixed logit model, Du et al. were unable to positively verify any of the adopted hypotheses. It turned out that in reality the probability of insurance purchase declined when the amount paid from farmers' private funds in-

creased, even if such higher expenses improved their welfare. These expenses seem, therefore, to be more important to them than uncertain future benefits of subsidized premiums. As advocates of the standard model usually do, Du et al. referred to the deviations from it first as anomalies, but they fortunately gave more insight to this matter. Although very briefly, but still, they listed several alternative interpretations of the deviations they found, i.e. arbitrage, preferences for income stability, for low franchise policies, hyperbolic discounting, the principle of "choosing the best bits", the theory of perspective and loss aversion and the asymmetry hypothesis. In the summary of their paper, Du et al. wrote that the US government recognized the identification of real preferences of local farmers as a very serious matter, allocating for this purpose alone USD 7 million from the federal budget in 2015.

Although the expected utility concept/hypothesis was extended and modified in a variety of ways, it remains set in neoclassical microeconomics. The most important "improvements" are as follows:

- subjective expected utility, where instead of empirical probabilities, their estimates are made by farmers themselves;
- rank-dependent expected utility theory (RDEU) developed by J. Quiggin in 1982;
- minimization of variance, i.e. the portfolio theory developed by H. Markowitz in 1952;
- equivalent of certainty;
- alternative methods of revealing the utility functions (ELCE, ELRO) (Hardaker et al. 2015, Applied Risk..., 2010).

What these modifications have in common is still referring to the product of some probability of occurrence of a particular risky or uncertain event and the utility of its outcome. It must be admitted, however, that they better describe the actual behavior of decision-makers.

The prospect theory (PT) developed by D. Kahneman and D. Tversky seems now the most interesting alternative to the standard model. This theory was presented for the first time in 1979, and then in 1992 it a modified version. The word "alternative" is here a slight exaggeration, because this theory is in fact an attempt to generalize the expected utility (EU). It is a two-stage descriptive concept. The first stage, termed editing, involves operations relating to prospects (lotteries, plants): coding, combination, segregation, cancellation, simplification and detection of domination. Generally, these are heuristics, hence relatively simple procedures for detecting facts and relationships between them, mainly by testing hypotheses.

The second stage involves evaluation of prospects to select the one with the highest utility. Its explanation requires a reference to a relatively simple formal apparatus. At this point, the approach used by N. Wilkinson and M. Klaes (Wilkinson and Klaes, 2012) will be used. The total value of prospect V results from two scales: v, assigning each outcome x the number $v(x)$, hence its subjective value; π, probability p of the decision weight, i.e. $\pi(p)$, i.e. the influence of this probability on the total prospect value. In the first scale, three categories of critical importance to the PT are involved:

reference points, loss aversion and decreasing marginal sensitivity. On this phase there is also reformulating of the standard expected utility function, $u(x) = x^b$, into the following function of values:

$$(x-r)^{\alpha}, \text{ if } x \geq r$$

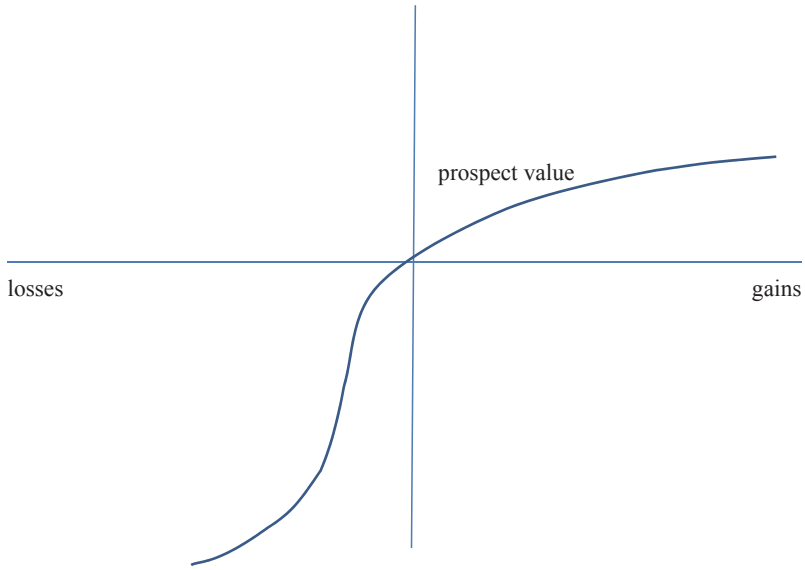
$$v(x) = -\lambda(r-x)^{\beta}, \text{ if } x < r$$

where:

r – reference point,
α – decreasing marginal sensitivity rate for gains,
β – decreasing marginal sensitivity rate for losses,
λ – loss aversion rate.

Let us note right away that the utility function in the PT consists of two parts regarding gains and losses, as shown in Figure 9.

Figure 9. Utility function in the prospect theory



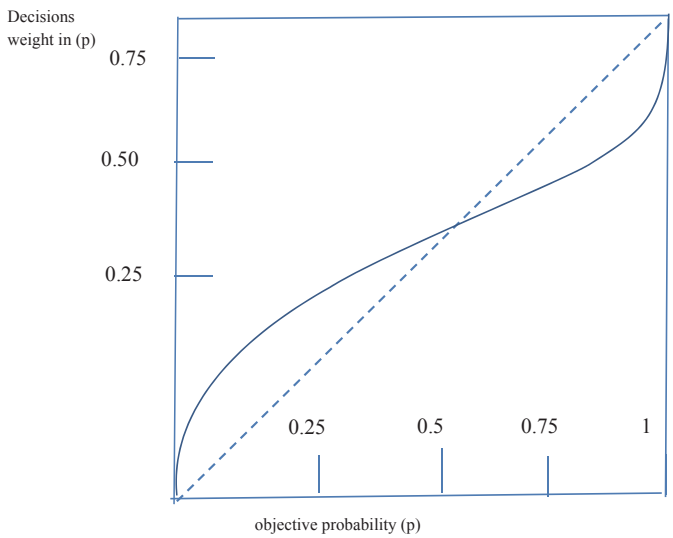
Source: authors' own study, based on: Wilkinson N., Klaes M., An Introduction to Behavioral Economics, 2nd Edition (2012), Palgrave Macmillan, New York.

The second phase, i.e. decision weighing, is formally expressed by the following function:

$$\pi(p) = \frac{p^{\gamma}}{\left(p^{\gamma} + (1-p)^{\gamma}\right)^{1/\gamma}}$$

where γ is the curvature of the utility function, whose typical course is shown in Figure 10. As usual, line 45° reflects risk neutrality.

Figure 10. Typical decision weighing function in the prospect theory



Source: as for Figure 9.

The first generation of the PT, the one from 1979, used a prospect of: (*x, p; y, q*), in which *x* and *y* are outcomes, and *p* and *q* are their respective probabilities. It was also assumed that a maximum of two of the above parameters may be non-zero. The prospect is strictly positive when *x, y> 0* and $p + q = 1$. If *x* and *y* are negative, the prospect is strictly negative. However, the prospect may be regular, if it is neither strictly positive nor strictly negative. In this case, we have:

$$V(x, p; y, q) = \pi(p)\, v(x) + \pi(q)\, v(y)$$

The distinction between a strictly positive and strictly negative prospect is important, as in the editing phase we can identify a risk-free component, i.e. the minimum loss or gain to settle/cover or obtain, and a risk-bearing component, i.e. an additional gain or loss at risk. To perform evaluation it has to be assumed that $p + q = 1$ and either $x > y > 0$ or $x < y < 0$. The overall prospect value is expressed by the following formula:

$$V(x, p; y, q) = v(y) + \pi(p)[v(x) - v(y)]$$

The four main categories used in the PT also need to be explained.

1. Reference point. This is the point denoting zero on the value scale, relative to which losses and gains are determined. This may be current values of assets or equity or some other measures of welfare. However, their past levels and expected future values are also allowed.

2. Loss aversion means that people are more concerned with losses than they enjoy equivalent gains. This phenomenon is usually explained by the occurrence of the endowment effect and the effect of aggregate settlement.
3. Decreasing marginal sensitivity is explained as increasing indifference to greater gains and losses. The utility function is accordingly concave in the gain area and convex in the loss area. In other words, people tend to show gain aversion and seek risks in case of loss, depending, however, on how they weigh their decisions.
4. Decision-making weighs imply that while evaluating outcomes, people are usually not guided by their objective probability. This is because people generally find it difficult to estimate probabilities. Even if they somehow cope with this, probabilities estimated by them are generally subjective. Accordingly, people may sometimes have a tendency to purchase probabilistic insurance, i.e. such which provides only partial protection against risks (Kunreuther et al., 2013; Cutler and Zeckhauser, 2004; Wilkinson and Klaes, 2012).

The perspective theory is criticized both as regards its theoretical aspects and empirical ones. These issues are too broad, however, to be presented in this monograph. Let us only mention at this point that H. M. Birnbaum (2008, following Wilkinson and Klaes) enumerated as many as 11 paradoxes associated with it. These are:

- lack of normative status,
- internal contradictions,
- incompleteness,
- problems with determination of reference points,
- violations of the combination principle,
- violations of stochastic domination,
- failure to explain the Allais paradoxes,
- ambiguous nature of the utility function,
- violations of gain-loss separability,
- debatability of the hypothesis of disclosing preferences,
- complicated conceptual framework.

Of course behavioral economists and economic psychologists responded to this criticism. In 2008, U. Schmidt, C. Staumer and R. Sugden published a paper entitled "Third-generation perspective theory". In this paper, they proposed, a new approach to the selection of a reference point under uncertainty, explained in more detail two anomalies of the standard model (contradiction as regards willingness to pay – WTA; preference reversal in some types of games), and embedded in the PT reference point dependent subjective expected utility (RDSEU), suggesting a self-developed version of the prospect value function. According to its authors, PT^3 is a more complete generalization of decisions made under uncertainty and risk, and offers three advantages:

1. It combines preferences (attitudes) with the consequences, probabilities and distributions of gains and losses.

2. It allows for savings while modelling, as only preferences are used here as a parameter determining the relations specified in point 1.
3. It is consistent with reality, as confirmed in experimental and field studies (Dhami, 2017).

Behaviorally oriented researchers offer yet other concepts – complementary, but also competitive to the PT and the standard model – explaining people's behaviors under uncertainty and risk. These concepts are presented in a paper by N. Wilkinson and M. Klaes. As they are beyond the scope of this report, they are listed below with no detailed analysis. These are:

- probabilistic mental models,
- random tracking,
- priority heuristics,
- imprecision theory,
- configuration weight models.

Rather mature research devoted to the application of the prospect theory in agricultural economics was launched only in this decade. Four representative works are commented on very briefly below, paying special attention to insurance-related aspects.

G. Bocquého, F. Jacquet and A. Reynaud focused on issues related to maximizing expected utility and the prospect value function in the second-generation prospect theory, hence the one from 1992 (Bocquého et al., 2014). In the case of expected utility, they established that surveyed French farmers were characterized by a concave utility function, i.e. they showed risk aversion in the gains area. The PT generally confirmed this conclusion, showing, however, that they were twice as sensitive to losses as to gains. In other words, these farmers showed definite loss aversion, i.e. they paid excessive attention to rather unlikely events, but with severe economic consequences.

If we assumed that farmers maximize the prospect value, it would mean that the aforementioned symmetry of risk-orientation (the dominance of aversion in the case of gains and the prevalence of risk-seekers in the loss area) would also lead to their known behaviors regarding the demand for insurance. According to the expected utility theory, farmers with risk aversion should be more willing to purchase insurance, provided that its price is not higher than the expected risk premium. In reality, however, it is very difficult to achieve such an effect in voluntary schemes, i.e. non-subsidized ones, especially in the case of multi-peril insurance coverage (in Poland referred to as bundled insurance). This is due to the already mentioned phenomena: adverse selection, moral hazard and high administrative costs of the system, which make the premium higher than the risk premium expected by the farmer. Using other risk management solutions, competitive to purchased insurance, can be another explanation. Finally, we should take into account the symmetry effect, i.e. the fact that farmers' risk-seeking attitudes in the loss area can make them consider the insurance premium to be small and loss to be certain.

Farmers, who maximize the prospect value, may introduce in a distorted way objective probabilities as decision weights. This means overweighing results that are little likely to occur but can lead to major losses, at the expense of more probable events, although with less acute consequences. This way of weighing the probability is quite well explained by the fact that in some countries, there are resilient private markets for insuring single risks, for example against hail. Such risks are, by nature, rare, hence moral hazard is also minor in this case. According to the standard model, the insurance company can then calculate the premium at a relatively low level, acceptable to the farmer relative to the risk premium he expects. The prospect theory provides also that due to the specific hypersensitivity to potentially significant adverse effects of such an unlikely event, the farmer can even over-insure his crops.

Bocquého et al. present also a very interesting analysis of probabilistic insurance. As has already been mentioned, in the case of such insurance there is always some, even very low, probability that the insurance company will not cover damage where the customer is allowed to purchase a proportionately cheaper insurance policy. However, due to the prevalence of such an event, people usually buy full insurance instead of probabilistic one. This can be expressed in yet another way: people do not like the latter and the insurer would have to offer them a very large discount from the policy price to choose it. In fact, potential buyers of insurance policies are unable to fully protect themselves against the bankruptcy of their sellers. In other words, all types of insurance are probabilistic. This seems to be a factor that by itself reduces the demand for insurance.

P. Laurent and D. Bougherava modelled in one approach insurance decisions of 186 French farmers, based on expected utility and the second-generation prospect theory, which means that they used in their considerations the increasingly popular mixed modelling method. The two researchers had at their disposal data from twelve years (1992-2003), hence 2,232 observations. It was generally confirmed that also in this case the PT better reflects farmers' preferences regarding risk than the standard model does. It turned out that 21% of them did not buy insurance, because it was simply not profitable for them, although the estimated expected utility clearly suggested that insurance purchase was well-founded. If, however, one wanted to encourage these 21% of farmers to purchase insurance, they would have to be offered a subsidy of 27.5% of the insurance price determined using the standard model.

B.A. Babcock also applied the second version of the prospect theory, focusing on explaining the reasons for a very common phenomenon, namely that farmers actually purchase lower insurance coverage than its optimal level, suggested by the expected utility model (Babcock, 2015). To this end, he used three representative farms in Nebraska, Kansas and Texas and data on three crops (maize for grain, wheat and cotton) from 2009. It turned out that the predictive capacity of the PT was determined primarily by loss aversion and the selection of a reference point. The latter was shown

in three options. It is also extremely important to identify the purpose for which the farmer purchased insurance. When it is treated as an instrument of comprehensive farm risk management, the optimal solution, i.e. the level of insurance coverage maximizing net indemnities (less premiums paid with his private funds), suggested by the PT, was not consistent with actual choices of agricultural producers. If, however, the insurance policy becomes an independent investment, and if indemnities are perceived to be lower than the policy price, farmers in fact incurred a loss, but the optimal coverage calculated using the PT most often confirmed their actual choices. Everywhere, however, subsidizing the insurance premium led to an increase in the real and theoretically optimal level of crop insurance. In Babcock's study, it was also PT that turned out to be on average a tool more consistent with farmers' insurance decisions than expected utility theory.

T. Sproul and C. P. Michaud made a direct reference to Babcock's findings, but they also extended field and experimental research of T. Tanaka, F.C. Camerer and Q. Nouyen published in 2010, which concerned preferences as regards time and risk of 181 rural households in Vietnam in June 2005 (Sproul and Michaud, 2017). The second-generation prospect theory was also used here as a modelling tool, but the focus was on the main distributions of its components, i.e. loss aversion, curvature of the value function and a parameter describing the prevalence of low probabilities of functions of their weighing. To determine individual and combined distributions of the above parameters, Sproul and Michaud used the Bayesian version of the mixed Gaussian model which they estimated using the algorithm developed by P.A. Damster in 1997 (as in: Sproul and Michaud, 2017) to maximize expectations. Generally, this probabilistic tool allows for separating subpopulations within a certain population with no requirement that the observed data set should identify individuals belonging to them. As a result, we can make statistical conclusions about the properties of such subpopulations, having information relating only to the entire population. Without going into details of these complex methodical and calculative issues, it should be stated that only loss aversion showed a very specific distribution, as it was bimodal. To put it more specifically, about 80% of the surveyed households demonstrated moderate risk and loss aversion, but only 20% of them, showing still moderate risk aversion, demonstrated extreme loss aversion. Relying on these findings, Sproul and Michaud refer in the summary of their paper to crop insurance. At this point, these economists sensitize authors of subsidized insurance programs that they should first carefully and continuously monitor farmers' preferences regarding risk, gains and losses; otherwise budgetary support can very easily become an income transfer instead of a risk management instrument.

To conclude these, out of necessity, very short theoretical considerations, it is worth presenting available findings regarding the psychological aspects of insurance. It turned out that risk aversion itself is not a simple determinant of willingness to buy an insurance policy. It is external pressure that is more often more important. Even the

purchase of an insurance policy can be not always considered as a rational decision when insurance covers, e.g. unlikely events and ones with insignificant financial consequences. As a result, we often overpay for an insurance policy and purchase coverage we do not need. Most of us have huge problems with estimating even the subjective probability of damage, the cost of coverage and its cost-effectiveness. Some people try to cope with this, setting certain thresholds of damage, which they will finance in the future on their own, using to this end sometimes very sophisticated calculations, which are, however, only heuristics. Purchase decisions should also account for the adequacy of recognizing one's position, risk perception, positive and negative emotions in a specific place and time. Finally, there are some people characterized by the so-called magic thinking. Such thinking is based on the conviction that they are able to influence to a great extent the course of future events. This way of thinking is manifested, e.g. in tempting fate, when abandoning the purchase of insurance is as if consenting to the increased likelihood of unfavorable developments (Cutler and Zeckhauser, 2004ł Kunreuther, Pauly and McMarrow, 2013; Zaleśkiweicz, 2012). The above psychological mechanisms are familiar also to Polish farmers, but, unfortunately, we do not know their distribution and intensity.

2. Subsidizing agricultural insurance

Mgr Aleksander Gorzelak, dr inż. Joanna Pawłowska-Tyszko, dr Barbara Wieliczko

Recently, governments in developed and developing countries have been increasingly more involved in supporting agricultural insurance programs. China is a prominent example in this regard. In this country, partially due to subsidizing the insurance premium by the central government and the provinces, the agricultural insurance market grew spectacularly in 2008and became the second largest market in the world (following the USA). In India and Mexico, catastrophic crop insurance has been introduced on a large scale to protect farmers mainly against vagaries of the weather. Many other countries have carried out feasibility studies to examine the functioning of agricultural insurance, and some of them have implemented pilot programs with budgetary support.

Only a few countries, such as Argentina, Australia and Ecuador, support the general development of rural areas and agriculture instead of subsidizing agricultural insurance premiums. In order to design and implement agricultural insurance, many governments in developing countries and in those undergoing market transformation sought technical assistance from the international community, including the World Bank. The following aspects of public support for agricultural insurance were of particular interest: technical, operational, financial and institutional. The literature on the subject concerns mainly the practice and experience derived from public-private programs (PPP) carried out on a large scale in North America and Europe (Mahul and Stutley, 2010). A significant share of state subsidies is the driving force of the most of them.

Market and regulatory obstacles are an argument which is frequently used to substantiate public intervention in the area of agricultural insurance. Governments should identify and eliminate these obstacles, which are briefly described below, to help farmers complement their risk management activities with potentially profitable financial tools such as insurance.

One of the main arguments substantiating government intervention in the distribution, administration and supervision of agricultural insurance programs is related to the presence of systemic risks, i.e. ones which affect a large number of business entities at the same time. The systemic component of agricultural risk may generate significant losses in insurance portfolios. The estimated maximum losses associated with large scale accidents, such as those occurring once in a hundred years, may be many times bigger than the expected average loss and seriously affect the solvency of insurance companies. Public intervention would be reasonable, as no private reinsurer or pool of reinsurers is able to cover such a significant loss when the risk, even small, is very difficult to diversify.

The two most serious information problems found in each insurance program, i.e. adverse selection and moral hazard, are derivatives of information asymmetry (Horowitz and Lichtenberg, 1993). They are closely related to difficulties with measuring risk and monitoring the farmer's behavior. Risk measurement can be very difficult for private entities, just like collecting relevant data, monitoring the behavior of

producers and developing and enforcing insurance policies. These difficulties may result in significant, sometimes even prohibitive, transaction costs that prevent the development of private insurance markets. Governments have an important role to play in reducing this asymmetry. The development and maintenance of databases related to agriculture and weather conditions as public goods can help insurers to properly design and calculate agricultural insurance contracts, thus reducing the risk of adverse selection. Using public assistance and supervision services in the production risk management by farmers before and after the occurrence of an extraordinary loss may help to reduce the temptation to abuse (Smith and Goodwin, 1996).

Governments are generally ready to mitigate the effects of disasters or catastrophic events by providing post-catastrophic direct indemnities as a state aid measure. This poses a "Samaritan dilemma", whereby government post-disaster aid discourages farmers from insuring their crops with insurance companies that provide more efficient financial solutions and sustainably reduce the amount of possible losses resulting from future adverse events (Coate, 1995). As regards Poland, the budget act provides for special funds to be used in case of e.g. drought.

Access to the international reinsurance market is often limited in developing countries, especially as regards specialist industries such as agricultural insurance. In recent years, agricultural reinsurers and insurance brokers have shown growing interest in developing business in low- and middle-income countries, especially large ones such as China and India. Smaller countries with far fewer business opportunities may have difficulty with attracting these international companies. Reinsurers report their capacity to reinsure crop and livestock programs which are properly designed and have rates that generate sufficient premium volume to cover losses, operating costs and costs of equity.

A serious supply-side impediment to the provision of agricultural insurance may be the lack of support for market infrastructure. The government can create public goods, such as agricultural and weather databases or crop risk assessment models, providing domestic agricultural insurers with access to reliable data and quantitative tools to better assess their catastrophe risk exposure and thus enable actuators to design fair agricultural insurance products.

Farmers are much aware of the production risk. However, they tend to exhibit "cognitive failure" in that they may underestimate the likelihood or severity of catastrophic events. Consultations with stakeholders in India and Mongolia (Mahul and Stutley, 2010) revealed that farmers are able to recall the occurrence of serious past catastrophic events, but tend to underestimate their severity. Government programs can play an important role in providing education programs to farmers and in supporting marketing and promotion of private, commercial insurance sector programs.

A commonly cited reason for the low demand for agricultural insurance, especially in developing countries, is the limited understanding of its benefits. Insurance is often perceived as a nonviable investment because premiums are collected every year, while indemnities are paid less frequently or even not at all. Part of the population, in particular farmers, perceive insurance as a privilege of the rich.

The regulatory framework governing the insurance markets in many low- and medium-income countries tend to be underdeveloped. Therefore, relevant regulation may in some cases inhibit increased market penetration by insurers, including agricultural ones. Innovative agricultural insurance products, such as index crop insurance or parametric (weather-based) crop insurance, require an enabling regulatory framework.

From the early 1950s to the end of the 1980s, there was a significant increase in insurance programs in Latin America (e.g. in Brazil, Costa Rica and Mexico) and Asia (e.g. in India, the Philippines) related to seasonal loan programs for small farmers. Similar public programs were implemented in Europe (e.g. in Portugal and Spain) and the former Soviet Union. In the 1990s, poor results of the majority of public sector insurance systems and their limited use by farmers made many governments, including the Spanish one promote agricultural insurance offered by the private commercial sector, often supported financially by the government under public-private partnerships.

Agricultural insurance is complemented by other instruments designed to stimulate producers' income. Governments have traditionally put particular emphasis on the management of agricultural production and markets for production factors as a way of stabilizing producers' income, through marketing organizations, quotas, price support mechanisms, investment subsidies and other instruments. Authorities consider agricultural insurance as a supplement to these traditional measures of dealing with production risk. With very few exceptions (e.g. agricultural income insurance products available in the United States), agricultural insurance does not cover price volatility.

Multi-Peril Crop Insurance (MPCI) programs sponsored by the government were generally disappointing. Limited insurance penetration despite high premium subsidies, prevailing underestimation of catastrophic risks in agriculture, poor financial results, claims and administrative costs exceeding premium amounts, incorrect valuations, uncontrollable moral hazard and adverse selection are the main problems related to endemic agricultural insurance programs worldwide, both in developed and developing countries.

Hazell, Pomareda and Valdes (1986) and Hazell (1992) discuss the experiences derived from several crop insurance programs. They conclude that MPCI failed to meet a number of its objectives, mainly because administrative costs were generally too high to the benefits gained by farmers whose risks were reduced. Wright and Hewitt (1994) suggest that the perceived demand for agricultural insurance may be overstated, as farmers can benefit from diversification and savings to cushion the impact of production and income shortfalls on consumption.

Innovative insurance products, such as index insurance, offer new opportunities for agricultural insurance in developing countries (e.g. in Senegal, Mongolia), although their long-term stability has not yet been proven. Under index insurance, the payment of indemnities is based on a verifiable and transparent index (such as a rainfall level, total crop yield on a given area or total mortality of livestock). The donor community and international development agencies have helped low- and medium-income countries to develop such products to complement traditional indemnity-based products.

Agricultural insurance (crop and livestock insurance) is currently available in more than 100 countries, both under well-developed and pilot programs. Most high--income countries (58%) have well-established agricultural insurance markets (Table 3). As regards low- and medium-income countries, only 35% of them offer such products and programs. The availability of agricultural insurance is particularly low in low-income countries (8%) (World Bank, 2010). Pilot programs that reach only a limited number of farmers and breeders are implemented in various forms (including crop insurance against specific risks, index-based crop or livestock insurance) in eight medium-income countries and eight low-income countries. The intensity of insurance programs is the greatest in Latin America and the Caribbean. Only some Sub-Saharan African countries (Mauritius, Nigeria, South Africa, and Sudan) offer insurance, hence this intensity is there geographically the lowest.

Table 3. Availability of insurance in 2008 by the development status and region

Item	The number of countries offering property insurance	The number of countries that do not have property insurance	Number of countries introducing pilot property insurance	No information	Number of countries by income groups
Countries by development status					
High-income	38	8	2	17	65
Low- and medium-income	48	39	16	41	144
Low-income	4	21	8	16	49
Lower-middle-income	17	14	8	15	54
Upper-middle-income	27	4	0	10	41
Countries by region					
East Asia and Pacific	5	10	3	5	23
Europe and Central Asia	13	1	0	10	24
Latin America and the Caribbean	19	3	5	2	29
Middle East and North Africa	3	2	1	7	13
South Asia	4	3	1	0	8
Sub-Saharan Africa	4	20	6	17	47
All countries	86	47	18	58	209

Note: Agricultural insurance includes both crop and livestock insurance.
Source: World Bank Survey 2010.

In some developed countries, agricultural insurance was offered for over a century. In contrast, the agricultural sector is under-insured in low- and middle-income countries. Penetration of agricultural insurance exceeds 1% in high-income countries, but it is still much lower than the penetration of other insurance products, e.g. life insurance. In low- and middle- income countries, the agricultural insurance penetration is less than 0.3%. The gap between the penetration of non-life insurance and agricultural insurance increases as development status decreases.

The government grants farmers premium subsidies under numerous MPCI programs. Such subsidies have been rarely applied to certain types of risks, such as hail insurance, partly because the costs of such insurance are generally low and farmers can afford to pay themselves their premiums (however, there are countries were these subsidies are used, e.g. Poland).

Government subsidies are usually supposed to increase insurance penetration by reducing the insurance premium paid by the insured. Such public subsidies may be justified by the existence of market imperfections, but there is a risk that public intervention distorts price signals, suppresses the private sector and generates irrefutable costs for the taxpayer.

In a well-functioning private insurance market, premiums should be risk-based and diversified so that each buyer pays them at a level sufficient to cover their own predicted loss and the costs borne by the insurer, while allowing it to make profit. In the case of risk-based premiums, buyers bear the full costs of their risk-generating activities, thus there are incentives to take measures to mitigate risk, instead of taking risky actions on an excessive scale. Subsidized agricultural insurance results in over-investment in areas at risk. These adverse incentive effects increase expected losses caused by disasters and burden governments and taxpayers with costs (World Bank, 2010).

Numerous economists question the economic rationale for such subsidized premium schemes. Siamwalla and Valdes (1986) indicate many situations in which subsidies could be justified. These include situations where it can be proven that the development of support capacity (in particular technology and information) is public (contrary to private); positive external effects can be seen (e.g., farmers apply risk reduction practices that increase output over time); decapitalization of small farms can be avoided; and rural consumption can be stabilized in an efficient manner. Their arguments are in line with the literature on getting out of the poverty trap (Barnett, Barrett and Skees, 2008).

Governments usually rationalize subsidizing premiums based on their impact on demand, supply and the state budget. As regards demand, they argue that farmers cannot afford to cover high costs of comprehensive crop or livestock insurance, and therefore subsidies are needed to promote broad interest therein. As regards supply, they argue that these subsidies provide incentives for private trading companies, as they enable them to cover expected losses and high administrative and operational costs of providing services to the agricultural sector. From the fiscal point of view, these subsidies are justified as a way to replace *ad hoc* government payments after the occurrence of a natural disaster.

Two main types of insurance subsidies can be identified (Cummins and Mahul, 2009): market-enhancing subsidies and premium subsidies. The former support the development of the risk market infrastructure which enables the functioning of competitive insurance markets. These subsidies concentrate on the development of public goods and technical assistance that improve the risk market infrastructure and facilitate the private insurance sector's participation.

If primary imperfections exist in the insurance market, government intervention can increase total social welfare. Market failure can cause suboptimal resource distributions, and the coordination of the private sector is not always effective. Public policies should facilitate the development of the risk market infrastructure, thus enabling the creation of public goods. Governments should avoid creating new, permanent state

institutions that replace private solutions, although this can be done by government institutions in very special circumstances, in which risk is poorly defined and private market solutions are not available (Cummins and Mahul, 2009).

Insurance subsidies fortifying the market are aimed at creating and supporting healthy and lasting competition between insurance and reinsurance companies by reducing friction costs, information costs and barriers to entry. As mentioned above, several market and regulatory imperfections can be eliminated to create a competitive agricultural insurance market. The provision of public goods, such as data sets, collective risk models, capacity building and other types of technical assistance, can contribute to the development of the agricultural insurance market. Financing the costs of starting business with public subsidies can generate a social surplus. An accommodative legal framework may allow insurers and reinsurers to develop innovative insurance products, such as index insurance.

Governments can also provide financial capacity by acting as insurers of last resort with respect to risk, where both uncertainty and possible extreme losses make insurance very expensive or inaccessible. For example, Agroasemex, a Mexican public reinsurance company, provides unlimited reinsurance (up to 100% of the sum insured) to local Fondos; traditional private contracts on stop-loss reinsurance are usually capped.

Subsidies reinforcing the market reduce insurance premiums, and thus bring benefits to farmers. However, their impact can be difficult to quantify. Furthermore, these indirect subsidies to premiums are not always visible to the farming community. Governments usually want to take action that benefits potential voters in a more visible way.

Subsidies to premiums are sometimes insufficient to encourage farmers to purchase agricultural insurance. In this case, governments may be willing to introduce compulsory agricultural insurance in order to eliminate, or at least reduce, the need for repeated public intervention.

Compulsory insurance is sometimes suggested when farmers underestimate the likelihood of catastrophic events and do not prepare for them (cognitive failure). It can also be suggested when economic agents do not fully internalize the financial consequences of their actions (e.g. liability insurance). This argument is valid for all types of catastrophe risks. Compulsory property insurance programs have been implemented, at least temporarily, in many developed and developing countries, including France, Romania, Turkey, and the United States.

Compulsory insurance is sometimes viewed as the response to adverse selection. Distorted insurance premium rates induce high-risk farmers to purchase insurance, while low-risk ones remain unwilling to do so. The results of the insurance program deteriorate, as lower-risk farmers do not participate in it, which leads to its collapse. Compulsory insurance ensures low-risk farmers' participation in the program, forcing them to subsidize high-risk farmers, thereby ensuring the viability of the program. However, this may be socially suboptimal, as the aggregate loss of welfare of low-risk farmers may exceed the aggregate welfare surplus of high-risk farmers. The problem of adverse selection can be solved through a sound insurance program based on risk discrimination.

Compulsory insurance is sometimes invoked when it is required to pool risks and cover fixed costs. The economic rationale is here somewhat questionable, as the basic concept of pooling relies on a group of homogeneous risks in which all participating entities will benefit from risk pooling. Compulsory insurance forces low-risk agents to participate in a scheme based on a wealth transfer not a risk-pooling mechanism.

Several developing countries, including Honduras, India and the Philippines, provide compulsory credit-linked insurance. These programs aim at transferring the farmers' default risk as a result of adverse natural events to the insurance industry, thus increasing the farmers' creditworthiness.

Between the late 1950s and the end of the 1980s, there was a major growth in the public MPCI sector in Latin America (Brazil, Costa Rica, Ecuador, Mexico and Venezuela) and Asia (India and the Philippines), often linked to seasonal credit programs for small farmers. In Western Europe, national programs for subsidized MPCI were introduced in Portugal and Spain in 1980. In the former Soviet Union, public sector MPCI was implemented on state farms. Many of these public sector programs involved high operating costs and very high loss ratios, which were exacerbated by low rates of premiums paid by farmers and poor management. In Latin America, most public sector programs were terminated in 1990 due to their poor results. In India, the Philippines, Portugal, Spain and the United States, various measures were introduced to strengthen and reform national programs.

In the past, many MPCI programs subsidized by governments brought very poor results, with excessively high administration costs and claims significantly exceeding premiums collected from farmers. In order to assess the full economic costs of these programs, Hazell (1992) presented his analysis in terms of the ratio of paid indemnities (I) to the nonsubsidized portion of the premium (P) paid by the farmer, termed the producer loss ratio. This measure is distinct from a conventional or gross loss ratio, which is calculated as the ratio of paid indemnities to total gross premiums. The amount of contributions (P), damages (I) and administrative and organizational costs (A) per unit are presented in the form of I / P, A / P and (I + A) / P ratios in Table 4.

Table 4. Financial performance of subsidized MPCI insurance

Country	Years	I/P	A/P	(I+A)/P
Brazil (PROAGRO)	1975-81	4.29	0.28	4.57
Costa Rica (INS)	1970-89	2.26	0.54	2.80
India (CCIS)	1985-89	5.11	—	—
Japan all sectors	1947-77	1.48	1.17	2.60
Japan (agriculture)	1985-89	0.99	3.57	4.56
Mexico (ANAGSA)	1980-89	3.18	0.47	3.65
Philippines (PCIC)	1981-89	3.94	1.80	5.74
United States (FCIP)	1980-89	1.87	0.55	2.42

Source: Hazell 1992.

Hazell's (1992) analysis shows that for every dollar in collected premiums paid by farmers, the paid indemnities and administrative costs on these programs ranged from USD 2.40 (in the United States) to USD 5.70 (in the Philippines). An (I+A)/P ratio of more than 1.0 indicates that the program is not collecting adequate premiums from the insured to cover indemnities and administrative costs. The programs carried out in Brazil and Mexico were eventually terminated.

Since the 1990s, a trend has been observed for governments to promote agricultural insurance through the private sector, often backed by government subsidies (public--private partnerships, PPP). Following the collapse of the Soviet Union in 1990, many of the state-owned monopolistic agricultural insurers in Eastern Europe were privatized, and markets were opened up to competition by new private companies providing crop and livestock insurance. In the United States, the Federal Crop Insurance Program's MPCI program is implemented through 17 private insurers or managing general agents. In Latin America, new private commercial agricultural insurance was introduced in Brazil, Chile, and Ecuador in the last decade.

In some countries, e.g. Spain, the government has also replaced *ad hoc* natural disaster compensation programs with *ex ante* formal crop and livestock insurance programs implemented by the private insurance sector and promoted and supported by the government through providing premium subsidies or reinsurance. In other countries, such as the United States, the government continues to provide public aid in case of a disaster, in addition to highly subsidized crop and livestock insurance.

Ever since Hazell (1992) presented his assessment of MPCI's failure in the 1980s, significant changes have occurred as regards agricultural insurance. These changes have included primarily switching to private sector-implemented agricultural insurance (stand-alone private sector schemes or schemes backed by government subsidies and other support under various forms of public-private partnerships (PPP). The survey results allow for comparing the performance of various types of programs.

In Brazil, all public sector insurers were replaced with private commercial insurance companies in 2007. The producer loss ratio, i.e. the product (I+A)/P, was 123% for crops (119% for crops and livestock), compared to 429% under the public sector Proagro in the 1980s. The market results for Brazil are, however, distorted due to heavy losses incurred by COSESP, the São Paulo state crop insurer, which was terminated in 2005 following very poor underwriting results. The Brazilian market is, however, still extremely exposed to losses of individual companies offering MPCI.

In Mexico, the former public sector insurer Anagsa was liquidated in 1990 and replaced by Agroasemex (Breusted and Larson, 2006). This market was opened to protect commercial insurance companies. The average underwriting results for 2003-2007 show a significant improvement: the aforementioned producer loss ratio was 73% for crops (80% for crops and livestock), thus it went down from 429% at the time of Anagsa.

In India, the government resolved to continue to offer the National Agricultural Insurance Scheme (NAIS) at very low insurance prices subsidized to support small and low-income farmers. The 2000-2008 average producer loss ratio was 336%, which

represents an improvement relative to the 1980s, when this ratio was 511%, but NAIS continues to generate financial loss. The government is considering moving to the NAIS actuarial regime, in which premium rates will be charged on an actuarial basis and premium subsidies will be paid upfront (James and Nair, 2009).

In the Philippines, the Philippines Crop Insurance Corporation (PCIC) has significantly improved its underwriting results. It continues, however, to face very high administrative expenses. The subsidized PPP program in Japan shows producer loss ratios of 294%, because of very high premium subsidies.

The FCIP program in the United States operates with a breakeven loss ratio (calculated on total premiums) (Table 5). This ratio represents a huge cost to the U.S. taxpayer: in 2003-2007, this was 169%. Relative to Hazell's analyses performed in the 1990s, it was slightly below the average value for this period of 187%. However, once all its costs are taken into account, the program cost the government an average of USD 3.89 per USD 1 of the producer premium in 2003-2008 and USD 2.08 per USD 1 in 1981-2008. These programs were thus not actuarially sound.

The subsidized PPP program in Spain shows producer loss ratios of 294%, because of very high premium subsidies. The specialist agricultural insurer in Portugal had within this period a producer loss ratio of 88% (Table 5).

Sudan has been subsidizing crop and livestock insurance for nearly ten years. Over the five-year period covered by the analysis, its subsidized program generated underwriting profits, with an average producer loss ratio of 64%.

Results for private crop insurance markets varied. These were negative e.g. in the Windward Islands (the Caribbean) and producer loss ratios, e.g. in Germany and South Africa, were high. Insurers in Argentina generated small profits (average total fee levels represented about 30% of original gross premiums). Sustainable profits were recorded in Australia, Chile, Sweden, and especially the United States, where the private crop insurance industry is highly profitable.

Table 5. Subsidized insurance programs in selected countries

Country	Years	Premium (USD million)	Indemnities (USD million)	Loss ratio (%)	Average premium subsidy (%)	Producer premium (USD million)	Producer loss ratio (%)
Poland	2003-07	17.7	17.7	100%	17%	14.8	120%
Portugal	2003-07	55.4	16.3	29%	67%	18.4	88%
Russia	2003-06	730.7	476.2	65%	47%	386.3	123%
Spain	2003-07	3,171.7	2,696.1	85%	71%	918.3	294%
USA	2003-07	22,729.7	15,901.6	70%	59%	9,414.3	169%

Source: World Bank 2010.

Poland differed from other countries, because with an average premium subsidy of only 17% in 2003-2007, the program was actuarially sound, as the I/P quotient was 1, with a producer loss ratio of 1.2 (Table 5).

3. Evolution of national legal provisions regarding crop and livestock insurance in 1952-2016

Dr inż. Joanna Pawłowska-Tyszko

Risk is inherent to every business. This holds true also as regards agriculture. In agriculture, however, it has a specific nature due to the strong dependence of agricultural production on climatic and biological factors, a relatively weak position of agricultural entities on the market, greater volatility of phenomena than in other sectors of the national economy and a long cycle of agricultural production, which makes it difficult to change previously taken production decisions. The problem of risk in agriculture is aggravated by a series of random events affecting the working conditions in this sector, in particular unavoidable weather risk, necessitating the search for effective tools to mitigate it. It is estimated that by 2020 the lack of measures to reduce the adverse impact of weather on investment and business will cost the European economy EUR 100 billion annually, and by 2050, this amount may increase to EUR 250 billion annually (COM, 2013).

According to the EEA report (European Environment Agency), since 1980, 90% of natural disasters have been directly or indirectly caused by the weather and climate (EEA, 2008). Economic losses due to extreme weather events (mainly floods) in Poland amounted to approx. PLN 12 billion in 2010 alone (Kowalewski et al., 2013). Given also the diversity of climatic conditions in a given country (variation in temperatures and the intensity and frequency of precipitation, insolation and the occurrence of local hailstorms and hurricanes), it turns out that the problem requires special solutions addressed to sectors particularly vulnerable to climate change, such as agriculture[1].

The gravity of this problem can be evidenced by risk consequences manifested, e.g. in significant losses in agricultural output or farmers' reluctance to invest due to concerns about growing risk. This problem is aggravated by the lack of risk management instruments adequate to the volume of threats, which applies not only to Poland, but also to many other EU countries. Therefore, many Member States are seeking opportunities and instruments to solve this problem. A review of the literature shows that there are many ways to reduce risk in the agricultural sector (Kłoczko-Gajewska and Sulewski, 2009; Śmiglak-Krajewska, 2014; Rembisz, 2009; Jerzak and Czyżewski, 2006). Transfer of risk away from the farm through insurance is one of the most frequently used methods. According to Kobus, it is also one of the most adequate methods of risk management in agriculture (Kobus, 2013).

A review of Polish legislation regarding risk management instruments in agriculture showed that insurance is the most common and most accessible form of risk mitigation in this sector. However, there is a definite lack of new solutions addressed to agriculture, which could effectively mitigate the effects of risk inherent to this sector. Such solutions include e.g. index insurance, mutual insurance funds or income stabilization funds recommended by the European Commission under the safety net.

[1] Besides agriculture, the sectors that are most affected by climate change include the energy sector and tourism.

Currently, applicable law requires farmers to purchase three types of insurance:

- For buildings belonging to the farm – against fire and other random events such as hurricane, flood, flooding, hail, snowfall, heavy rain, etc. (Act on compulsory insurance..., 2003, Article 4(3)).
- Third-party liability insurance for farmers due to running a farm. This insurance indemnifies not only the person liable for the damage, but also the aggrieved party. It is worth noting that this type of insurance is compulsory not only for the owner of the farm, but also its lessee, tenant and user (Act on compulsory insurance…, 2003, Article 4(2)).
- For crops and livestock covered by state subsidies. This instrument provided for insurance of at least 50% of the crop area on the farm against the risk of loss caused by a hurricane, flood, heavy rain, hail, lightning, landslide, avalanche, drought, overwintering losses, spring frosts and emergency slaughter (Act on crop insurance..., 2005, Article 3(2)). Other risk groups are not subject to compulsory insurance and can be insured on a commercial basis through voluntary crop and livestock insurance.

Besides compulsory insurance, the Polish insurance system provides for voluntary (non-compulsory) insurance, which is not purchased under pain of law, but under a voluntary agreement between the farmer and the insurance company. Voluntary agricultural insurance includes e.g. insurance of movable property, fish bred and kept in ponds, forest stand and permanent plantations, as well as insurance of crops and livestock not covered by compulsory insurance.

Farming insurance in Poland has a long tradition. A review of legal provisions governing the functioning of crop insurance is presented in Table 6, and their detailed description is provided below in the text.

In Poland, crop and livestock insurance was introduced by the Act of 28 March 1952, which adapted insurance to the then prevailing economic model (Act on state insurance ..., 1952). This Act repealed all normative regulations regarding insurance, stipulated the key tasks involved in insurance activity and outlined the development directions of state insurance. Pursuant to its provisions, crop and livestock insurance was compulsory and covered crops insurance against hail and flood as well as livestock insurance against falling. Insurance covered the production of wheat, rye, oats, barley and maize (Regulation..., 1956). As regards livestock insurance, this was regulated by the Regulation of the Council of Ministers of 23 October 1956 (Regulation..., 1956).

Similar provisions were included in the next Act of 2 December 1958 (repealing the Act of 1952) on property and personal insurance, in which compulsory crop and livestock was upheld (Act on property insurance..., 1958). In 1963, the scope of insurance was extended to include buckwheat grain (against hail) and potatoes (against the effects of flooding) (Regulation, 1963). These changes should be considered beneficial, because they extended the range of insured items, thus adjusting the tool to the then structure of sowing and damage in agriculture.

Table 6. Legal provisions regarding crop insurance – amendments made in 1952-2017

Act	Year of entry into force/amendment	Main scope of the regulation
Act on state insurance	1952	- introduction of an obligation to insure crops against hail and flood and livestock against falling - the insurance obligation covers basic cereals (wheat, rye, barley, oats, maize) – 1956 - obligatory insurance of livestock against falling – 1956
Act on property and personal insurance	1958	- the obligation to insure field crops and livestock was upheld - the insurance obligation was extended on buckwheat grain (against hail) and potatoes (against flood) – 1963
Act on property and personal insurance	1984	- the scope of compulsory insurance was extended on cereal mixtures, fodder crops, sugar beets, grass as well as horses, cattle of productive age and pigs (except for piglets) - the scope of the risk covered was extended to include fire and flooding as a result of excessive precipitation, and as regards livestock – emergency slaughter
Act on insurance activity	1990	- abolition of the obligation to insure crops and livestock - compulsory third-party liability insurance and compulsory insurance of buildings belonging to the farm remain in force
Act on crop and livestock insurance subsidies	2005	- introduction of crop and livestock insurance - introduction of crop insurance premium subsidies - voluntary insurance
First amendment to the Act on crop and livestock insurance subsidies	2006	- the scope of the insurance was extended - the scope of the risks covered was reduced
Second amendment to the Act on crop and livestock insurance subsidies	2007	- the name of the Act was changed - an insurance obligation was introduced - the range of crops covered was extended - premium subsidies were increased
Third amendment to the Act on crop and livestock insurance subsidies	2008	- rules for obligatory purchase of insurance were clarified - premium subsidy was reduced - integral franchise and the farmer's deductible were changed
Fourth amendment to the Act on crop and livestock insurance subsidies	2015	- premium subsidy was increased - tariff rates of more than 6% for selected crops were approved

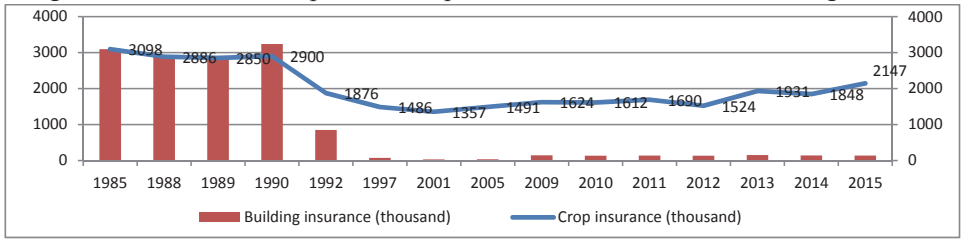
Source: authors' own study, based on: Act on state insurance of 1952, Act on property and personal insurance of 1958 and 1984, Act on insurance activity of 1990 and Act on crop and livestock insurance of 2005, as amended in 2006, 2007, 2008 and 2015.

Subsequent changes were introduced by the Act on property and personal insurance of 20 September 1984. The new regulations extended the scope of compulsory insurance to cereal mixtures, fodder plants, sugar beets, grass against hail, fire, flood and flooding due to excessive precipitation, and horses, cattle and pigs (except for piglets) against falling and emergency slaughter (Act on property and personal insurance, 1984). As a result of the extension of the scope of insurance coverage over 3 million crop insurance policies were delivered in 1985. This result was comparable to that of the then compulsory insurance of buildings and attested to the universality of this insurance. Approximately 3 million crop insurance policies were purchased on average to provide coverage to about 2.2 million (Woś, 1996) farms registered in 1980-1990, which means that about 1.4 of such policies were purchased per farm on average (Figure 11).

Statutory[2] compulsory crop and livestock insurance was in force until 1990, and was abolished with the entry into force of the Act of 28 July 1990 on insurance activity (Act on insurance activity ..., 1990). Instead voluntary insurance was introduced. Insurance of buildings belonging to the farm and farmers' third-party liability insurance for running a farm were the only types of compulsory agricultural insurance that were upheld. These changes were introduced as a result of the systemic transformation conductive to favorable conditions for the development of free competition. This transformation enabled also privatization of the existing insurance companies. This act contributed indirectly to the development of new conditions for Polish agriculture.

It should be noted that the statutory abolition of compulsory crop and livestock insurance had long-lasting negative consequences. First, there was a decrease in the number of policies purchased by farmers. By 1990, around 3 million insurance policies had been sold. After 1990, this number dropped drastically, from 852 thousand in 1992 to 32 thousand in 2001, when the lowest number of sold policies in the analyzed period was reported (Figure 1). Moreover, the lack of compulsory crop and livestock insurance in the market did not translate into increased interest in purchasing voluntary policies. As a result of this change, farms did not have adequate insurance coverage, which significantly increased the risk relating to agricultural activity, especially as a result of more intense adverse weather changes (flood in 1997, drought in 1992 and rain storms with hail reported every year). For example, as a result of the 1997 flood an area of 6,000 km^2 was flooded in Poland. As many as 130,000 Polish farms suffered losses caused by this cataclysm. Losses in agriculture were estimated at PLN 2.5-2.7 billion, of which PLN 1.7 billion was the lost value of the yield of all crops together with a decrease in the value in use. As regards fallen livestock, farmers lost 2,000 head of cattle, 6,000 pigs and over 1 million head of poultry. About 500,000 ha of utilized agricultural area were demolished (Klimowski, 2002).

Figure 11. Number of crop insurance policies and the number of building insurance



Source authors' own study, based on: Roczniki Statystyczne GUS, Warszawa 1986-2009 and data from insurance companies' reports submitted to the Ministry of Agriculture and Rural Development, Warszawa 2009-2015.

[2] Statutory insurance meant the provision of coverage without having to conclude an insurance contract, once the conditions defined in the Act have been met. The amount of the premium was determined by State Insurance Company.

Secondly, farmers were deprived of indemnities in case of losses in agricultural production due to catastrophic events. The only safeguard offered by the state, at that time, was through disaster loans[3] which, according to Stroiński, could cause indebtedness of mainly less efficient farms and, in many cases, lead to discontinuation of agricultural production (Stroiński, 2006). It is difficult to disagree with this opinion, especially given the fact that economic conditions in 1990-1997 were not so favorable for the agricultural sector. Farmers had to cope with new challenges related to the transition from the planned economy to a market economy, which entailed e.g. reduced production viability, emergence of a barrier to demand for agri-food products and lower economic security of farming in agriculture. The lack of insurance and replacing them with disaster loans could aggravate these problems, even more so that agro-climatic conditions prevailing at that time were exceptionally unfavorable for agriculture, as mentioned above. It should be emphasized that alike all loans, disaster loans also bear certain risks, which, given low production viability and seasonality, may make this instrument perceived as ineffective. Moreover, these loans were also a huge burden on the state budget.

Thirdly, the liquidation of insurance forced political decision-makers to use *ad hoc* aid, the amount of which is always dependent on the state's financial capabilities, which does not correlate with farmers' needs and has an adverse impact on the state budget.

The above changes resulting from the abolition of compulsory crop and livestock insurance were one of the reasons to start work on seeking a new form of support, which would ensure that farmers are provided with funds to remove some of the consequences of natural disasters in agricultural production and would also burden the state budget to the lowest possible extent (Orlicka, 2006). Lipińska adds that the work on the new legal solution resulted also from expected Poland's accession to the European Union and the need to harmonize the insurance law with EU legislation (Lipińska, 2012).

This led to the adoption of the Act of 7 July 2005 on crop and livestock insurance under which subsidized insurance for Polish agriculture was introduced (Act on crop and livestock insurance, 2005). The legislator's intention was to make this insurance widely used as well as to reduce the volume of *ad hoc* state aid provided to aggrieved agricultural producers. In 2005-2015, approx. PLN 920 million was allocated annually on average for disaster relief. The volume of this aid increased from PLN 315 million in 2005 to PLN 1.0-1.4 billion in 2009-2015 (Budget Act, 2005-2015). Studies carried out using FADN data showed that *ad hoc* aid in the form of subsidies for disaster relief was provided in 2009-2015 to a total of only 2,600 farms, which represented 3.2% of private entities entered in the FADN database in the analyzed period. It should be added that the number of farms that received these subsidies in 2015 accounted for over 81% of all farms that benefited from this form of assistance in 2009-2015. Detailed information in this respect is presented in Table 7. These data clearly show that

[3] Disaster loans are aid in the form of interest subsidies and are earmarked for the resumption of production on farms and in special branches of agricultural production on areas affected by drought, hail, excessive precipitation, freeze, flood, hurricane, fire, rodent plague and landslides.

by 2014, only a small group of farms benefited from this type of aid, which may undermine the legitimacy of the widespread criticism of this instrument. However, it should be noted that subsidies to remove the consequences of natural disasters are only one of the many instruments that are mobilized in case of emergency. Reduced rates of/exemption from income tax and Farmers' Social Security Fund (KRUS) premiums, preferential disaster loans, etc., which are state aid addressed to the agricultural sector, also need to be mentioned in this respect.

Table 7. Number of farms which received subsidies for disaster relief in 2009-2015 (%)

Year of study	2009	2010	2011	2012	2013	2014	2015	2009-2015
Farms which received subsidies (%)	0.54	2.37	0.61	0.01	0.45	0.32	17.5	3.19

Source: authors' own study, based on the FADN database 2009-2015.

The Act of 2005 laid down the rules governing premium subsidies to insurance contracts covering 12 types of risk. Both subsidies (their amount) and the scope of the risk insured were to encourage farmers to access this type of insurance. In the original form of the Act, premiums were subsidized as follows:

– 40%, but not less than 30% of the crop insurance premium,
– 50%, but not less than 40% of the livestock insurance premium.

Allocation of subsidies depended on the level of tariff rates which for:

– crops – did not exceed 3.5% of the sum insured,
– livestock – did not exceed 0.5% of the sum insured.

The scope of the Act covered basic agricultural crops (cereals, maize, oilseed rape, agrimony, potatoes and sugar beets) and the most important livestock species (cattle, horses, sheep, goats, pigs), which could limit insurance purchases. Subsequent amendments introduced over time extended the range of insured crops and risks covered (Table 8).

In the original version of the Act, subsidized insurance covered the following random events: fire, hurricane, flood, heavy rain, hail, lightning, explosion, landslide, avalanche, drought (both livestock and crop insurance), overwintering losses and spring frosts (crop insurance only) and emergency slaughter (livestock insurance only). It should be noted that such a wide range of risks covered could only be offered jointly, i.e. as all risk insurance, which also limited purchases of this insurance. This problem was solved in 2007.

The Act of 2005 was amended several times to adapt it to the current needs of all stakeholders (farmers, insurance companies and the state). The most important changes introduced in this area are as follows:

– 2006 (the amendment of 27 April 2006):
  - Two risks (fire and explosion) were excluded. This change was recommended by the European Commission, according to which the risk of fire and explosion cannot be covered by state subsidies and should fall within the scope of commercial insurance purchased by the farmer himself, without state interference.

- The crop group was extended with hops, vegetables, fruit trees and shrubs and the livestock group was extended with poultry and fish, which was to contribute to the increase in the number of policies concluded.

– 2007 (the amendment of 7 March 2007):
  - An insurance obligation was introduced for those farmers who obtained direct payments to agricultural land within the meaning of the provisions on payments to agricultural land and a separate sugar payment in the year preceding the conclusion of the insurance contract. The insurance obligation applies to the risk of damage caused by flood, drought, hail, overwintering losses and spring frosts. To fulfil this obligation the farmer has to insure at least 50% of the crop area. Thus, since 1 July 2008, a farmer who has received direct payments to agricultural land has been obliged to insure at least 50% of the crop area. A farmer who does not meet the obligation to conclude such an insurance contract will be charged for the failure to do so. The crop insurance obligation was introduced in connection with the EU requirement to insure 50% of crops by farmers who would apply for other forms of disaster relief from the national budget from 2010. This provision, and above all the amount of the fine for failure to meet this obligation, should be considered ineffective, as pointed out further in the study.
  - The name of the Act was changed from "on subsidies to crop and livestock insurance" to "on crop and livestock insurance".
  - The range of crops was extended to include tobacco, strawberries and legumes, and the term "vegetables" was changed for "ground vegetables".
  - An option to split the various risk groups was introduced in the insurance contract and the "specific risk" crop insurance contract. This has increased the elasticity of concluding insurance contracts in terms of covering the most common risk in a given area. This provision helps to link the premium amount with the risk covered and facilitates its management by adapting policies to farmers' needs. It also reduces risk borne by insurance companies, which can elastically adjust the amounts of premiums within applicable tariff limits for split risk groups. The single risk rate may, therefore, be lower than the statutory one. It is worth emphasizing, however, that due to high insurance prices, farmers, in order to meet their statutory obligation, chose under this provision less expensive policies. In doing so they were guided by economic coercion rather than rational risk management.
  - The definition of the following risk groups was changed: hurricane, lightning, drought, overwintering losses, spring frosts.
  - The maximum rates entitling to an additional payment of up to 6% of the sum insured were increased.
  - The amount of the additional payment was increased from 50% to 60%, but not less than 50% for crop insurance.

- Indemnities paid by the insurance company were increased from 10% and 25% to at least 30% of damage to the main crop, with an option to reduce the amount of this damage by no more than 20%.
- The acreage qualifying for premium subsidies was limited to 300 ha. This change resulted in a reduction in the crop area insured and was unfavorable for large-scale farmers.

– 2008 (the amendment of 25 July 2008):
  - Voluntary insurance became compulsory insurance.
  - A change was made to the definition of spring frosts, which may occur from 15 April, not from 15 May.
  - Subsidies to crop insurance premiums were reduced from 60% to 50%, but not less than 40% of the premium.
  - The rate of losses qualifying for indemnities was reduced from 30% to 10% of the crop value for all risk groups, except for drought (from 30% to 25%). This enables covering globally a greater amount of damage, and thus increases the availability of indemnities under insurance contracts. Here, however, a problem with measuring losses in crops caused by drought appears. At the same time, the proposed levels of integral franchise may adversely affect the claims ratio, which may lead in the future to increased premiums and worse financial performance of insurance companies[4]. To solve this problem another amendment was adopted, which was requested mainly by insurers' representatives.
  - The agricultural producer's deductible was reduced from 20% to 10% of the damage amount; this change may increase sales of these policies to less viable farms.
  - Provisions regarding subsidies received by insurance companies were clarified, in particular with respect to the payment deadline and the refund of subsidies in case of their surplus.

– 2015 (the amendment of 24 April 2015):
  - Crop and livestock insurance premium subsidies were increased from 50% to 65%. Subsidies in this amount are due where the tariff rates do not exceed 3.5% of the sum insured in the case of crop insurance (cereals, maize, spring oilseed rape, agrimony, potatoes and sugar beet) and 5% of sum insured for winter oilseed rape, ground vegetables, hops, tobacco, fruit trees and shrubs, strawberries and legumes. As regards livestock insurance, the tariff rate remained at 0.5%. It is allowed to apply rates of no more than 6% of the sum insured without altering the subsidy amount, i.e. 65%.
  - The acreage limit of 300 ha qualifying for premium subsidies was lifted. This change resulted in an extension of the crop area insured and is favorable for large-scale farmers. However, it should be emphasized that in order to receive

[4] Integral franchise is a kind of limitation of indemnities to be paid by insurance companies, and consists in releasing the insurer from the obligation to pay indemnities where their amount does not exceed a predetermined threshold, usually given in %.

subsidies by a large-scale farm it is necessary to file an application containing a description of its financial situation, present an alternative scenario regarding the scale of insurance coverage once the subsidy is received and obtain the consent of the Minister of Agriculture.
    - An option to use tariff rates in excess of 6% of the sum insured for ground vegetables and fruit shrubs was introduced, which was supposed to enhance the insurance offer and encourage more farmers to participate in the system.
    - An option to enter into "co-insurance agreements" by and between insurance companies was introduced, which was to encourage joint actions in the provision of insurance coverage and bearing insurance risk at the principles set out by the companies.
    - The grace period after which the insurance company's coverage becomes effective following the conclusion of the contract was shortened from 30 to 14 days for flood and drought, which was to encourage farmers to conclude contracts.
- 2016 (the amendment of 15 December 2016):
    - A change was made to the definition of drought which means damage caused by its occurrence in any sixty-day period from 21 March to 30 September, not damage prevailing for a period of at least 2 months, as was previously the case.
    - Tariff rates qualifying for subsidies of up to 9% of the sum insured were increased for all crops and all risks, 12% (crops on agricultural land with V soil valuation class) and 15% (crops on agricultural land with VI soil valuation class).
    - Caps on state budget expenditure for subsidies for 2017-2026 were set.

The functioning of crop and livestock insurance was affected also by provisions of other regulations subjectively related to the Act on crop and livestock insurance.

In the 2008 amendment to the Act on the freedom of economic activity (Act..., 2008) a provision was introduced regarding the rules for conducting inspections in insurance companies by the minister competent for agriculture with respect to the implementation of contracts for subsidies and insurance contracts.

As of 1 January 2010, under the Regulation of the European Commission, *ad hoc* state aid in the event of a natural disaster was reduced to half of the aid rate in the absence of insurance coverage for at least 50% of crops. This reduction was introduced in all 27 Member States (Commission Regulation..., 2006).

The amendment to the Act of 25 March 2011 on limiting administrative barriers changed the provisions regarding the relationship: the minister competent for agriculture and the insurance company in the selection of insurance companies that offer subsidized insurance (Act on limiting administrative barriers..., 2011).

The above amendments to the Act of 2005 were to enhance the farmers' interest in the crop insurance market, increase the profitability of these products in insurance companies and make state budget expenditure more reasonable. It should be added that the diffusion of crop insurance is extremely important for securing the continuation of agricultural activity, and hence also for food security and economic development of the country.

Table 8. Detailed scope of the Act on state-subsidized crop and livestock insurance

Act	Type of risk to be covered	Items insured	Subsidy amount	Maximum rates entitling to subsidies	Risks covered and indemnities paid by the insurance company
Act of 7 July 2005	**Crops:** fire, hurricane, flood, heavy rain, hail, lightning, explosion, landslide, avalanche, drought, overwintering losses, spring frosts **Livestock:** emergency slaughter	**Crops:** cereals, maize, oilseed rape, agrimony, potatoes or sugar beets. **Livestock:** cattle, horses, sheep, goats, pigs	**Crops:** 40%, but not less than 30% of the premium **Livestock:** 50%, but not less than 40% of the premium	**Crops:** max. 3.5% of the sum insured. **Livestock:** max. 0.5% of the sum insured	- hurricane, flood, heavy rain, hail, lightning, landslide, avalanche, overwintering losses, spring frosts – damage to the main crop is at least 10% - drought – damage to the main crop is at least 25%
The Act's amendment of 27 April 2006	Fire and explosion were excluded	**Crops:** hops, vegetables, fruit trees and shrubs were added **Livestock:** poultry and fish were added	Unchanged	Unchanged	Unchanged
The Act's amendment of 7 April 2007	Definitions of the following events were changed: hurricane, lightning, drought, overwintering losses, spring frosts	Tobacco, strawberries and legumes were added	**Crops:** 60%, but not less than 40% of the premium **Livestock:** unchanged	Insurance rate was optionally increased to max. 6% of the sum insured	Up to at least 30% of damage to the main crop, with an option to reduce the amount of this damage by no more than 20%
The Act's amendment of 25 July 2008	The definition of spring frosts and the term of indemnities for damage caused by spring frosts from 15 April were changed	Unchanged	Crop premium subsidy was reduced from 60% to 50%, but not less than 40% of the premium	Unchanged	- hurricane, flood, heavy rain, hail, lightning, landslide, avalanche, overwintering losses, spring frosts – damage to the main crop is at least 10% - drought – damage to the main crop is at least 25%
The Act's amendment of 24 April 2015	Unchanged	Unchanged	Premium subsidy was increased from 50% to 65% – both for crops and livestock	**Crops:** max. 3.5% and 5% of the sum insured **Livestock:** max. 0.5% of the sum insured Max. 6% with no change in the subsidy amount It is possible to increase the rate over 6% for ground vegetables and fruit shrubs	Unchanged

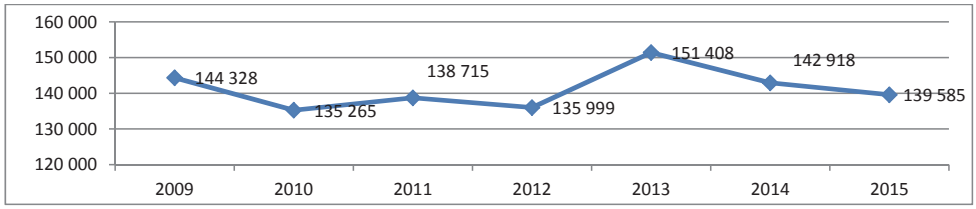
Source: authors' own study, based on the Act on crop and livestock insurance of 2005, as amended in 2006, 2007, 2008 and 2015, and Janowicz-Lomott M., Łyskawa K., Funkcjonowanie dotowanych ubezpieczeń upraw w Polsce, "Wiadomości ubezpieczeniowe" 2/2016, PIU, Warszawa.

4. Assessment of the functioning of crop and livestock insurance in Poland

Dr inż. Joanna Pawłowska-Tyszko

Analyses show that the amendments to legal regulations governing crop and livestock insurance could make farmers purchase insurance, as confirmed by the data presented in Figure 12. It should be noted, however, that the number of these insurance policies has remained almost unchanged since 2009, and is approx. 140-150 thousand per annum.

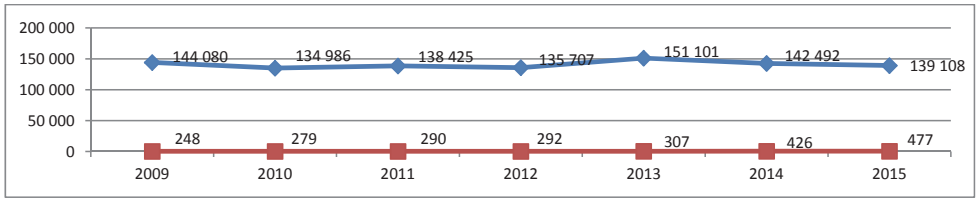
Figure 12. Number of crop and livestock insurance policies purchased in 2009-2016



Source: authors' own study, based on data of the Ministry of Agriculture and Rural Development for 2009-2015.

Analyses show that despite numerous statutory changes introduced to promote insurance subsidized by the state, its potential is still not used. In 2005-2016, farmers purchased annually an average of 83,200 crop insurance policies subsidized by the state, which accounts for only approx. 4.3% of the average level in 1985-1990. In 2012-2013, there was a slight increase in the number of insurance contracts. In the 2013, the number of policies was almost 12% higher than in 2013. However, a downward trend has been observed in that regard since 2008, despite the statutory obligation to insure at least 50% of the crop area (Figure 13). This may be due to the reduction in the premium subsidy from 60% to 50%, which probably translated into an increase in the cost of a single insurance policy (Figure 14), and a too low subsidy limit.

Figure 13. Number of subsidized crop and livestock insurance policies purchase in 2005-2016

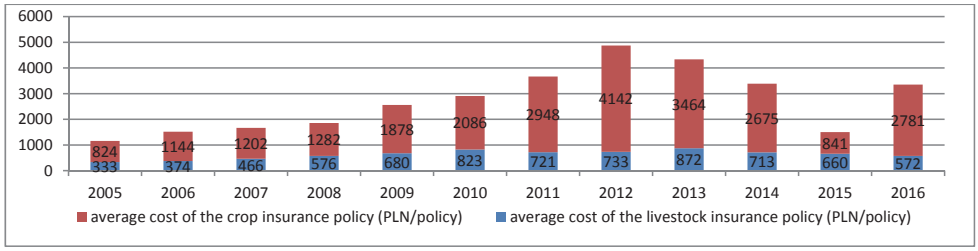


Source: authors' own study, based on data of the Polish Financial Supervision Authority.

In the analyzed period, the cost of insurance of both crops and livestock would increase. This trend was maintained until 2012 (for crops) and 2013 (for livestock). In 2012, the average cost of the crop insurance policy was five times higher than in 2005, and increased from PLN 824 to PLN 4,142. A slightly weaker upward trend was recorded as regards livestock insurance: in 2005, the policy cost PLN 333, while in 2013

– PLN 872 (an over 2.5-fold increase). Since 2013, a slow decline in the prices of crop and livestock insurance has been observed. In 2014, the crop insurance policy price was more than 1.5 times lower than in 2012. If this trend continues, it may be a good predictor for the future, especially that a slow increase in the number of subsidized crop insurance policies has been observed since 2012, except for 2015, which should be interpreted, however, with great caution (see Figure 12).

Figure 14. Average cost of crop and livestock insurance (PLN/policy)



Source: authors' own study, based on data of the Polish Financial Supervision Authority.

Results presented in Figure 14 are confirmed by calculations made by Janowicz-Lomott and Łyskawa (2016) based on data from the Ministry of Agriculture and Rural Development and insurance companies, which show that the average cost of crop insurance policy in 2009-2015 was around PLN 3,700 and ranged from PLN 2,311 in 2009 to PLN 4,850 in 2015 (Table 9). This is also confirmed by calculations made by the Institute of Agricultural and Food Economics – National Research Institute using FADN data, as presented in Table 10.

Table 9. Selected characteristics of subsidized crop insurance in 2009-2015

Year	Average cost of insurance of 1 ha (PLN)	Average sum insured per policy (PLN)	Average acreage per policy (ha)
2009	2,311	45,047	19
2010	2,756	52,472	19
2011	3,376	73,965	22
2012	4,393	89,068	20
2013	4,187	94,190	22
2014	4,076	93,659	23
2015	4,850	98,449	20

Source: authors' own study, based on: Janowicz-Lomott M., Łyskawa K., Funkcjonowanie dotowanych ubezpieczeń upraw w Polsce, „Wiadomości ubezpieczeniowe" 2/2016, PIU, Warszawa.

The analysis of FADN data shows that the average premium amounted in 2009-2015 to approx. PLN 2,760 (Table 10). Its highest amount was recorded with respect to very large farms (over 50 ha of utilized agricultural area), in the case of which its greatest increase was also observed between 2009 and 2015 (by more than two times). It should also be noted that the premium paid by very small farms (less than 5 ha of utilized agricultural area) in 2014 and 2015 was lower than in previous years. In 2014, it decreased to PLN 444, and was almost five times lower than in 2012, when it reached its highest level.

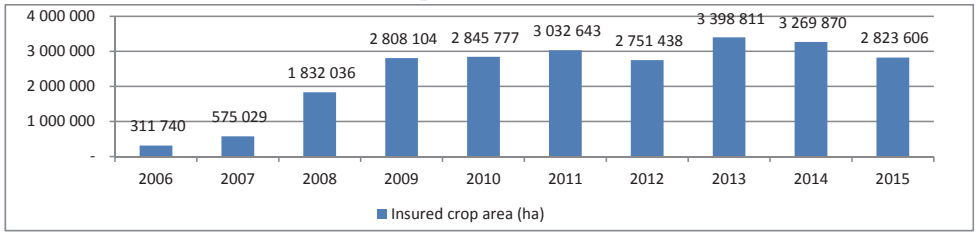
Table 10. Average crop insurance premium by FADN area groups in 2009-2015 (PLN/farm)

Utilized agricultural area	2009	2010	2011	2012	2013	2014	2015
Very small (<=5 ha)	1,044	838	1,825	2,105	1,175	444	664
Small (5<=10 ha)	467	558	567	509	562	696	606
Medium small (10<=20 ha)	505	558	676	869	836	806	815
Medium large (20<=30 ha)	723	744	984	1,318	1,368	1,039	1,263
Large (30<=50 ha)	1,230	1,386	1,650	2,170	2,216	2,084	2,258
Very large (>50 ha)	3,155	3,753	4,965	6,719	6,970	6,265	6,789
TOTAL	1,625	1,874	2,487	3,408	3,415	3,127	3,439

Source: authors' own study, based on FADN data.

An analysis of the operation of the insurance system shows that since the introduction of insurance subsidized by the state, the area of covered agricultural land has been systematically growing. It is, however, still well below the level intended by the legislator in this regard, because as provided for in the Act of 1 July 2008, changes in the insurance obligation were supposed to result in a situation where insurance covered 50% of crops to which subsidies were paid, i.e. approx. 7 million hectares of crops. Meanwhile, these figures were slightly different, although the obligatory nature of insurance undoubtedly contributed to its increased sales, as shown in Figure 15. In 2008 (the year when the insurance obligation was introduced) there was a clear, over six-fold increase in the area of insured crops compared to 2006, and an approx. three-fold increase compared to 2007. In the following years, an upward trend can be seen, except for 2012, 2014 and 2015, when some decreases were recorded. Despite the increase in the insured crop area since the Act entered into force, the results are still far from those expected (Uzasadnienie Projektu ustawy o ubezpieczeniach upraw i zwierząt gospodarskich z 2015 roku), as in 2015, the area of insured crops should be 3.8 million ha, and in 2020, it should increase to 4.5 million ha. It will take another few years to see the projected results. There are, however, concerns about a downward trend observed in 2013-2015, which may result from insufficient incentives to enter into insurance contracts. As regards the demand, these may be frequently changing subsidy levels, too low subsidy limit for a given year, high cost of a single insurance policy, high farmer's deductible, as well as low (virtually non-existent) fines for failure to comply with the insurance obligation. As regards the supply, the following factors should be taken into account: too low tariff rates which qualify for subsidies, high indemnities payable by insurance companies (integral franchise), a high loss ratio recorded with respect to crop insurance and high risk of agricultural activity. These problems may be solved through the 2016 amendments to the Act, which involved increasing tariff rates while maintaining high budget support, and the state's declaration that the limit of the subsidy to premiums will be increased.

Figure 15. The degree of the implementation of the Act's provision as regards the insured crop area in 2006-2015 (in ha)



Source: authors' own study, based on data of the Ministry of Agriculture and Rural Development.

Looking from the perspective of farms insuring their crops, the analysis of FADN data showed that insurance is purchased mainly by large farms with more than 20 ha of utilized agricultural area (Table 11). The group of farms with a utilized agricultural area from 20 ha to more than 50 ha accounted for 76.8% of farms purchasing this type of insurance. These observations are confirmed also by studies performed by Janowicz-Lomott and Łyskawy, which indicate that insurance coverage is provided mainly to large farms, and the average acreage per policy is about 20 ha and did not change significantly in 2009-2015 (Janowicz-Lomott and Łyskawa, 2016) (Table 9). A total of about 21% of entities in the entire population of FADN farms are insured. In 2015, this figure dropped to the level of 2009, i.e. 19%. It should be noted that the 2015 decrease in the number of insured farms was recorded in all area groups. This decrease may be due to e.g. an insufficient amount of funds allocated for subsidies in the analyzed period, as shown in the survey presented further in the study.

Table 11. Percentage of insured farms (paying crop insurance premiums) per FADN area groups in 2009-2015

Utilized agricultural area	Percentage of insured farms in:						
	2009	2010	2011	2012	2013	2014	2015
Very small (<=5 ha)	2.7	2.8	3.1	2.2	1.6	1.9	1.2
Small (5<=10 ha)	7.9	8.2	8.9	7.1	6.8	6.3	5.7
Medium small (10<=20 ha)	11.8	13.1	12.9	13.3	13.8	12.7	11.7
Medium large (20<=30 ha)	19.3	20.6	19.6	18.5	17.8	18.7	16.5
Large (30<=50 ha)	24.7	26.1	26.3	27.3	28.1	27.4	24.0
Very large (>50 ha)	36.5	38.5	39.9	40.1	39.1	38.9	36.3
TOTAL	**19.2**	**20.7**	**21.0**	**21.2**	**21.1**	**21.0**	**19.0**

Source: authors' own study, based on FADN data for 2009-2015.

The above analyses show that subsidized insurance coverage may be not as widespread as it should be due to the amount of budget support set by the Ministry of Agriculture and Rural Development for a given year. This problem results from the fact that subsidies to agricultural insurance are granted until the allocated funds are exhausted. In the analyzed period, this limit was PLN 55 million in 2006, PLN 168 million in 2008, to approx. PLN 100 million in 2010-2016. As indicated by the data

presented in Table 12, from 2011 onwards, the amount of subsidies to crop and livestock insurance premiums has been too low relative to the needs. Therefore, part of the funds to finance these needs was in this period supplemented with funds allocated for other purposes, e.g. co-financing of indemnities for losses caused by drought[5]. The studies show that the funds allocated for subsidies to indemnities due to drought were used on an annual basis, except for 2010 and 2012, in 100% (these funds were used e.g. to supplement the funds allocated for the subsidy to premiums).

Performed analyses indicate that there is a need to increase the budget subsidy limit for crop and livestock insurance, which can significantly increase its prevalence. The foregoing is confirmed by data relating to the utilization of subsidies, which show that these subsidies increased in the analyzed period more than 20 times, from approx. PLN 9.9 million in 2006 to PLN 207.0 million in 2016 (Table 12). Therefore, the planned allocation by the state of about PLN 900 million to subsidies to crop and livestock insurance in 2017 seems to be a very reasonable decision. This can make this instrument much more popular among farmers, and thus enhance the financial security of agriculture.

Table 12. Degree of utilization of budgetary resources allocated for subsidies to crop and livestock insurance in 2006-2016 (in PLN thousand and %)

Year	Amount allocated from the budget for subsidies to crop and livestock insurance (PLN thousand)	Utilization		Amount allocated from the budget for co-financing of indemnities for damage caused by drought (PLN thousand)	Utilization	
		Total (PLN thousand)	%		Total (PLN thousand)	%
2006	55,000	9,861	17.9	-	-	-
2007	59,902	39,348	65.7	210,000	209,902	100.0
2008	168,472	97,596	57.9	545,000	545,000	100.0
2009	150,000	131,139	87.4	150,000	150,000	100.0
2010	108,470	96,679	89.1	300,000	193,147	64.4
2011	100,000	126,141	126.1	100,000	100,000	100.0
2012	103,800	162,412	156.5	100,000	68,641	68.6
2013	103,800	164,407	158.4	80,000	80,000	100.0
2014	100,717	161,363	160.2	100,000	99,500	99.5
2015	100,717	173,177	171.9	100,000	100,000	100.0
2016	100,717	207,030	205.6	100,000	100,000	100.0

Source: authors' own study, based on Reports on the implementation of the Budget Act (2006-2016).

The loss ratio is another problem that may effectively hinder the development of this instrument. For years, the agricultural market has been considered by insurance companies as extremely risky. This is evidenced by the loss ratio in subsidized agricultural insurance, which systematically increased in 2005-2008. In 2008, it was over 124% (Table 13). This is probably the reason why the offer of insurance companies addressed to

[5] Insurance companies which have concluded agreements on subsidies and/or compulsory crop insurance contracts and have concluded a co-insurance agreement are entitled to a grant-in-aid to cover part of the indemnities paid to agricultural producers for damage caused by drought. This aid represents 60% of the difference between the total amount of indemnities paid for damage caused by drought and the amount representing 90% of premiums paid to cover damage caused by drought. If the amount earmarked for this purpose is not used up, it may increase the envelope of funds allocated for subsidies to crop and livestock insurance premiums in a given year.

the agricultural market was poor in that period. In 2009-2010, the loss ratio of subsidized insurance clearly decreased, to around 57% in 2010, to markedly increase in 2011-2012, to approx. 122% in 2011 and 260% in 2012. In 2013-2015, the situation in this sector was somewhat more stable, as analyzed loss ratios fell to slightly more than 42% in 2015. In 2016, the loss ratio was high again, as was the case in 2011-2012, which confirms that the situation in the agricultural insurance market is unstable due to the high risk related to agricultural activity, resulting, among others, from unstable weather conditions.

Table 13. Selected ratios characterizing the situation as regards crop insurance in 2006-2016 (PLN million and %)

Item	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total gross premiums collected (PLN million)	417.4	485.9	523.9	521.7	552.5	640.9	653.8	655.8	668.4	739.5	573.0
of which:											
building insurance	309.4	319.8	352.1	378.2	388.5	421.6	418.8	434.1	447.3	491.1	326.5
farmer's third-party liability insurance	38.2	42.4	47.1	49.3	50.8	54.1	53.2	58.0	57.0	61.9	41.4
subsidized crop and livestock insurance	69.7	123.7	124.7	94.2	113.2	165.2	181.8	163.7	164.1	186.5	205.0
Total indemnities paid (PLN million)	152.8	318.8	314.9	222.6	601.5	422.7	646.5	259.8	271.8	273.6	260.8
of which:											
building insurance	111.9	178.7	132.0	120.6	511.5	195.5	142.9	146.5	117.4	154.4	data unavailable
farmer's third-party liability insurance	16.0	26.5	28.3	24.5	24.9	25.1	31	29.5	38.9	39.6	data unavailable
subsidized crop and livestock insurance	24.9	113.6	154.6	77.4	65.1	202.1	472.6	83.8	115.5	79.5	260.8
Gross loss ratio (%)	36.6	65.6	60.1	42.7	108.9	66.0	98.9	39.6	40.7	37.0	45.5
Loss ratio in the case of compulsory insurance (%)	36.8	56.6	40.2	33.9	122.1	46.4	36.8	35.8	31.0	35.1	data unavailable
Loss ratio in the case of subsidized insurance (%)	35.8	91.9	123.9	82.2	57.5	122.3	260.0	51.2	70.4	42.7	127.2

Source: authors' own study, based on information published in the annual and quarterly bulletin, Rynek ubezpieczeń 2006-2016. The Polish Financial Supervision Authority.

Bearing in mind compulsory agricultural insurance, subsidized insurance may pose a serious problem for insurance companies and discourage them from concluding such contracts. This problem may be solved through the 2016 amendment to the Act, which includes provisions regarding an increase in the level of tariff rates to which insurance companies may receive subsidies, while preserving premium subsidies at the level of up to 65%. The results of these changes will not, however, be known until mid-2017-2018, when the introduced changes will be completely implemented. It should be noted that insurance companies can expect even broader changes, especially in terms of the amount and type of franchise, which is not consistent with farmers' expectations in this respect.

The results presented in Table 13 are based on data of the Polish Financial Supervision Authority. They also confirm analyses made based on FADN data which indicate that the values of the analyzed ratios (loss ratio and claims frequency) in the analyzed period varied, as presented in Table 14.

Table 14. Comparison of claims frequency rates and loss ratios as regards crop and livestock insurance in 2009-2015 in the FADN population

Item	2009	2010	2011	2012	2013	2014	2015
Claims frequency rate (number of claims related to crops)	11.7	6.81	18.32	30.77	4.1	10.39	5.56
Crop loss ratio (%)	**151.71**	**43.83**	**140.17**	**235.54**	**24.77**	**45.95**	**40.86**
Claims frequency rate (number of claims related to livestock)	5.79	3.93	5.30	4.92	2.46	2.88	5.68
Livestock loss ratio (%)	**25.30**	**19.96**	**18.84**	**22.41**	**9.21**	**32.30**	**44.87**

Note: The claims frequency rate is calculated as the number of claims per 100 insurance contracts. The loss ratio is calculated as the quotient of the total indemnities paid to the total premium paid.
Source: authors' own study, based on FADN data for 2009-2015.

The highest loss ratio was recorded in 2009, 2011 and 2012 with respect to crop insurance. This ratio fluctuated in this period between 140% in 2011 and 235% in 2012. The analysis of the claims frequency rate showed that this rate was relatively high, especially as regards crop insurance. In this case it ranged from approx. 4 to over 30 claims per 100 contracts. This means that in extreme cases, about 30% of farmers suffered losses caused by unfavorable events disturbing the proper course of business operations. This indicator was much more favorable as regards livestock insurance and ranged from approx. 2.5 to approx. 6 claims per 100 contracts. If we assume that the number of concluded crop and livestock insurance contracts has remained almost unchanged since 2009 (around 140-150 thousand policies), then the above situation may mean an increase in the weather risk in the analyzed period, hence the need to promote this type of insurance or offer alternative tools protecting against its consequences.

The above analyses indicate that in periods of intense unfavorable weather changes, crop insurance may be deficient for insurance companies, as evidenced by the data presented in Table 15. In 2009, 2011 and 2012, the amount of paid indemnities exceeded the amount of collected premiums. In 2009, indemnities were higher than premiums by only 0.8%, in 2011 – by 3.8%, while in 2012 – by 57.3%. However, if we take into account the whole analyzed period (2009-2016), the balance of premiums and indemnities is positive and amounts to PLN 341,011 thousand. This means that the amount of collected premiums was about 15.8% higher than the amount of paid indemnities. It should be noted, however, that inviability of insurance companies in years of intense unfavorable weather events may discourage them from concluding such contracts (in particular as regards crop insurance), and thus inhibit their popularization. In the case of livestock insurance, the loss ratio ranged from 10% to 40%, which means that this instrument poses low-risk for insurance companies.

Table 15. Balance of premiums and indemnities for crop and livestock insurance in 2009-2016 (PLN thousand)

Year of study / Item	2009	2010	2011	2012	2013	2014	2015	2016
Gross written premium (PLN thousand) (paid by the farmer)	94,213	113,207	165,207	181,791	163,734	164,110	186,049	205,016
State subsidies to premiums (PLN thousand)	131,139	96,679	126,141	162,412	164,407	161,363	173,719	207,030
Total premiums collected	**225,352**	**209,886**	**291,348**	**344,203**	**328,141**	**325,473**	**359,768**	**412,046**
Indemnities paid (PLN thousand)	77,410	65,113	202,192	472,663	83,736	115,477	79,556	260,828
Subsidies to indemnities for draught (PLN thousand)	150,000	100,000	100,000	68,641	80,000	99,500	100,000	100,000
Total indemnities	**227,410**	**165,113**	**302,192**	**541,304**	**163,736**	**214,977**	**179,556**	**360,828**
Balance of premiums and indemnities	**- 2,058**	**44,773**	**- 10,844**	**- 197,101**	**164,405**	**110,496**	**180,212**	**51,218**

Source: authors' own study, based on data from Annual Reports of the Polish Financial Supervision Authority and the Budget Act for 2009-2016.

An increase in the loss ratio with respect to crop insurance results, on the one hand, in limiting the insurance companies' exposure to risk by, e.g., reducing the lump sum paid for overwintering losses from 25% to 15% of the sum insured, and on the other – raising the premium rate for crop insurance. The situation of insurance companies should, however, be assessed not only through the prism of collected premiums and paid indemnities, but also payments from reinsurers, since – as Janowicz-Lomott and Łyskawa (2016) emphasize – reinsurance contracts have clearly reduced the impact of adverse results on the operation of insurance companies.

5. Income and financial situation of farms using crop and livestock insurance

Dr inż. Michał Soliwoda

The study sample included farms belonging to natural persons, entered in the Polish FADN. The research period was narrowed down to 2009-2015. The adoption of the Polish FADN database as a source of empirical data was fully justified, as data are gathered in this system in a very systematic way, and what is more, data verification tools guarantee high reliability of the analysis of the income and financial situation of family farms (Kulawik (ed.), 2014; Góral (ed.), 2016). As was also the case with statistical analyses presented in publications on the impact of the EU subsidies on the economic and financial condition of family farms (Kulawik (ed.), 2014; Góral (ed.), 2016), the empirical sample included entities keeping accounting records in Economic Accounts for Agriculture (EAA). Ratios presented below are calculated based on the tables contained in the "Individual Report" and the "Standard Tables – ST" available in the FADN database. The farmer's land valuation (in force since 2009) was applied. Farms were classified according to Standard Output (SO) "2010" parameters. Taking into account the purpose of the study, outliers were excluded from the sample, so were those whose equity value was negative.

Table 16 presents a very general description of the study sample of private farms covered by the FADN system. It should be noted that their number varied, as some entities resigned from participation in the FADN system. The percentage of insured farms in the sample did not exceed 22% in the analyzed period. In 2015, only 19.5% of farmers purchased insurance policies. This may raise concerns, as the FADN sample includes, as a rule, entities oriented at commercial production, whose size exceeds economic size (ES) equivalent to EUR 2,000. The highest (i.e. PLN 99.9 thousand) average income from a family farm was generated in 2012, while the lowest such income (PLN 61.7 thousand) was generated in the analyzed period in 2009. High volatility of agricultural income results from significant fluctuations in prices (including: changes in prices of the agricultural product buy-in basket and the cumulative ratio of price scissors) and yields in Poland.

Table 16. General characteristics of the study sample

Year	Sample size	Percentage of farms covered with crop and livestock insurance (%)	Average income from a family farm (PLN)
2009	12,258	20.2%	61,709.37
2010	11,004	21.7%	84,284.26
2011	10,890	21.8%	93,183.23
2012	10,909	21.9%	99,936.02
2013	12,117	21.8%	89,809.81
2014	12,123	21.7%	80,285.14
2015	12,105	19.5%	72,522.50

Source: own calculations based on PL FADN data.

Tables 17-21 concern the income and financial situation (illustrated by means of several key financial ratios regarding profitability and debt) of the sample divided according to crop insurance coverage (payment of the insurance premium in a given year). Fur-

thermore, the significance of differences in distributions was evaluated for two independent samples using the non-parametric Mann–Whitney *U* test. Basic descriptive statistics are presented (mean, median, standard deviation, minimum and maximum).

A significant range (i.e. the difference between the maximum and the minimum) indicates a high volatility of income generated in the sub-samples in the analyzed years (Table 17). The highest range was observed for the sub-sample of farms that did not insure their crops (2013). Statistically significant ($p < 0.001$) differences in distributions were demonstrated for each year. This confirms the thesis that farms insuring their crops and livestock had a better income situation.

Table 17. Income from a family farm by crop and livestock insurance coverage

Item	Median	Mean	Standard deviation	Min.	Max.
2009					
NI	**29,972.66**	56,409.98	99,664.21	-330,196.55	2,619,734.93
I	**50,956.40**	82,645.81	133,696.47	-504,010.71	2,603,544.64
2010					
NI	**44,705.27**	76,135.71	115,226.97	-414,640.36	2,070,996.52
I	**74,806.23**	113,731.77	145,148.94	-865,978.32	1,897,493.87
2011					
NI	**48,578.47**	81,667.41	129,859.40	-321,715.42	3,923,017.46
I	**82,500.79**	134,448.22	172,017.32	-239,413.42	2,179,204.38
2012					
NI	**48,821.01**	84,923.40	134,206.99	-341,900.21	3,481,574.47
I	**95,412.55**	153,533.65	213,033.17	-194,755.09	3,688,377.90
2013					
NI	**46,388.85**	80,622.96	150,906.10	-242,820.24	7,257,978.58
I	**79,706.78**	122,820.49	158,197.27	-304,364.85	2,033,577.00
2014					
NI	**39,668.79**	71,388.66	129,617.82	-2,466,260.71	4,433,931.41
I	**68,636.38**	114,000.97	158,828.91	-390,082.65	2,402,871.16
2015					
NI	**37,472.44**	65,665.63	122,875.20	-534,564.56	5,321,236.74
I	**65,911.62**	100,895.84	139,885.83	-225,515.83	1,825,719.73

Note: I – a sub-sample of farms covered by insurance (an insurance policy was purchased in a given year), NI – a sub-sample of farms not covered by insurance (the farmer did not purchase a crop/livestock insurance policy); a median value in bold means a statistically significant difference in distributions for the above sub-samples of farms (p-value <0.001), no value of W-statistics for the Mann–Whitney *U* test was given.
Source: own calculations based on PL FADN data.

As indicated by the data presented in Tables 18 and 19, the group of farms covered by crop and livestock insurance demonstrated higher return on equity and assets[6] than entities not using this risk management tool (exception: the mean ROE in 2009). This is evidenced by the mean and median values as well as the Mann-Whitney *U* test results. In the sub-sample of farms in which no premium for the abovementioned insurance was paid, the ROE ratio was negative in 2009 and 2013-2015. Taking into account the analysis of measures of position (i.e. minimum and maximum), the study sub-samples included entities characterized by extremely low levels of equity, which

[6] In the case of private farms using accounting and record keeping solutions of the FADN system, return on assets (ROA) and return on equity (ROE), were calculated as the ratio of income from a family farm (SE420), less the cost of the farmer's and his family's labor input, to assets and equity, respectively (Smolik, 2016).

led to very high ROE values. Standard deviations, hence coefficients of variation, were higher for the viability of farms not covered by insurance. The sub-sample of entities purchasing crop and livestock insurance showed throughout the analyzed period lower empirical variation in viability between the analyzed years. In general, a better financial condition of farms insuring their crops and livestock is the resultant of numerous factors, though those related to the characteristics of their operators, primarily the age and vocational education, are also important (Pawłowska-Tyszko (ed.), 2016).

Table 18. ROE values by crop and livestock insurance coverage

Item	Median	Mean	Standard deviation	Min.	Max.
2009					
NI	**-2.98**	-2.40	19.24	-291.30	764.89
I	**1.58**	2.59	16.47	-75.98	339.73
2010					
NI	**0.27**	5.91	475.46	-121.77	44128.62
I	**2.79**	3.40	8.22	-32.82	126.58
2011					
NI	**0.40**	-0.70	113.07	-10380.61	218.17
I	**3.22**	4.11	9.57	-77.27	171.36
2012					
NI	**0.12**	0.24	11.40	-186.56	215.11
I	**3.96**	4.84	11.15	-50.03	287.68
2013					
NI	**-0.41**	-0.32	10.46	-302.20	118.38
I	**2.33**	2.90	9.78	-51.54	301.27
2014					
NI	**-1.34**	-1.30	12.39	-350.84	406.59
I	**1.32**	1.67	7.91	-141.92	91.98
2015					
NI	**-1.72**	-1.61	14.11	-114.21	1025.37
I	**0.92**	1.21	7.60	-52.15	186.36

The note and source as for Table 17.

Table 19. ROA values by crop and livestock insurance coverage

Item	Median	Mean	Standard deviation	Min.	Max.
2009					
NI	**-2.38**	-2.68	14.63	-291.30	146.55
I	**1.76**	1.83	11.57	-75.98	85.32
2010					
NI	**0.48**	0.59	10.04	-121.77	284.89
I	**2.79**	3.14	7.34	-32.82	126.58
2011					
NI	**0.56**	0.36	10.24	-252.52	218.17
I	**3**	.73	8.47	-77.27	171.36
2012					
NI	**0.33**	0.14	9.87	-186.56	135.95
I	**3.84**	4.38	9.93	-50.03	287.68
2013					
NI	**-0.23**	-0.37	9.52	-302.20	91.72
I	**2**	.66	9.07	-51.54	301.27
2014					
NI	**1.29**	-1.45	10.58	-227.87	406.59
I	**1.21**	1.40	6.50	-50.77	78.19
2015					
NI	**-1.63**	-1.79	9.49	-114.21	328.34
I	**0.85**	0.88	5.71	-30.70	50.61

The note and source as for Table 17.

Tables 20 and 21 show that significant variation (as illustrated by measures of position) can be seen also with respect to debt ratios. Analyzing the development of debt ratios (debt-to-equity and debt-to-assets), it should be noted that the excessively high percentage of liabilities in the financing of a farm leads to increased debt servicing costs. Although, there are numerous advantages of using leverage, especially at the stage of rapid growth of the farm, operators should take into account in their calculations the exposure to financial risk. The presented results confirm the hypothesis that farmers benefiting from subsidized crop insurance programs are characterized by higher debt than agricultural producers that do not participate in such public programs[7]. This hypothesis has been verified also in numerous foreign studies (Briggeman et al., 2009; Enjolras and Sentis, 2011; Brewer et al., 2012; Ifft et al., 2013). Analysis of the median value for the group of farms that do not insure their crops and livestock shows that half of the entities in this sub-sample did not have any liabilities. Furthermore, relatively low values of debt-to-equity and debt-to-assets ratios (means and medians <50%), even in the group of entities choosing insurance confirm the conservative strategy of shaping the capital structure on our family farms.

Table 20. Debt-to-equity ratios by crop and livestock insurance coverage

Item	Median	Mean	Standard deviation	Min.	Max.
2009					
NI	**2.52**	16.99	69.73	0.00	3,377.05
I	**8.01**	25.07	66.30	0.00	1,620.44
2010					
NI	**0.80**	0.59	10.04	-121.77	284.89
I	**3.55**	3.14	7.34	-32.82	126.58
2011					
NI	**0.29**	11.49	451.57	0.00	41,635.67
I	**3.57**	8.95	17.29	0.00	319.72
2012					
NI	**0.00**	6.91	28.45	0.00	1,856.59
I	**4.04**	10.24	19.07	0.00	263.14
2013					
NI	**0.00**	7.17	29.94	0.00	1,828.08
I	**3.85**	10.49	19.27	0.00	272.37
2014					
NI	**0.00**	6.74	32.96	0.00	2,143.73
I	**3.79**	14.45	206.64	0.00	10,565.52
2015					
NI	**0.00**	4.62	8.94	0.00	151.03
I	**3.88**	7.96	11.01	0.00	110.87

Note: negative capital – such farms would not be able to operate under commercial law regulations (the law of limited companies); however, to highlight the diversity of the FADN sample, such entities were not removed.
Other notes and the source as for Table 17.

[7] For example, Ifft et al. (2013) pointed out that the determination of the direction of dependence and causality between debt and insurance use is quite complex: did access to subsidized crop insurance programs (Federal Crop Insurance, FCI) make agricultural producers' debt greater or did farms in which the demand for borrowed capital increased treat insurance as enhancing their financial standing (after all the use of insurance improved the farm's credit scoring)? Ifft et al. (2013) believe that the mechanism of affecting debt by crop insurance depends on the type of the loan the farm is applying for. The results of studies by Enjolras and Sentis (2011) show that French high risk farms had insurance coverage. An explanation may be the many years of experience in risk management by these entities. What is more, French agroeconomists have recognized debt as one of the possible determinants of the demand for crop insurance.

Table 21. Debt-to-assets ratios by crop and livestock insurance coverage

Item	Median	Mean	Standard deviation	Min.	Max.
2009					
NI	**2.43**	9.15	14.72	0.00	238.19
I	**7.46**	13.89	20.10	0.00	314.57
2010					
NI	**0.78**	5.91	475.46	-121.77	44,128.62
I	**3.40**	3.40	8.22	-32.82	126.58
2011					
NI	**0.29**	4.80	8.39	0.00	99.76
I	**3.39**	6.70	9.03	0.00	76.17
2012					
NI	**0.00**	4.83	8.54	0.00	103.31
I	**3.77**	7.43	9.95	0.00	72.46
2013					
NI	**0.00**	4.82	8.95	0.00	111.77
I	**3.62**	7.59	10.27	0.00	70.02
2014					
NI	**0.00**	4.66	8.87	0.00	95.54
I	**3.66**	7.71	10.64	0.00	99.06
2015					
NI	**0.00**	6.28	18.30	-295.97	570.46
I	**3.74**	10.38	29.32	-1,020.22	340.85

The note and source as for Table 20.

6. Determinants of the demand for crop insurance – model approach

Mgr Justyna Herda-Kopańska

Polish farmers are obliged to insure at least 50% of the crop area to be entitled to direct support and disaster relief. Nonetheless, most farmers do not purchase crop insurance for various reasons. Table 22 presents a synthetic combination of motivators and deterrents guiding farmers considering the purchase of business insurance.

Logit and probit models can be used to analyze the factors affecting the purchase of crop insurance by farms. In this paper, we will first present the necessary theoretical introduction to this class of models, to pass on to our own studies.

There are a lot of qualitative economic and social phenomena. Both dependent and independent variables which describe such phenomena have a finite number of values. Typically, such phenomena are described by data from certain economic entities, such as farms, households, private enterprises, consumers. These entities have different options to choose from. For example, the farm can buy a new agricultural machine or not, a person without a job can seek it or not, the student can go to the university by car, public transport, bike or on foot. The choice of any of the available options depends on various factors that serve as explanatory variables. For instance, in the case of buying a flat, such factors can, undoubtedly, include the buyer's income or the price of the flat. Therefore, probit and logit models are used in order to determine the probability of making a specific decision by the economic entity, (Butryn and Fura, 2005).

Table 22. Motivators and deterrents guiding farmers considering the purchase of business insurance

Motivators	Deterrents
• coverage of damage caused by natural (climate) and production risks; • coverage of property damage risks, e.g. in case of fire or flood; • coverage of third-party liability borne by the farmer running agricultural business, which may adversely affect third parties and entail the obligation to pay damages by the farmer (sometimes in the form of an annuity) in case of an adverse random event; • coverage of damage caused by economic risks related to production processes and their effects, such as risks caused by random price and income volatility; • coverage of damage caused by institutional risks that affect, e.g. the farm's output; • lower uncertainty in farming and enhanced income stability; • enhanced agricultural producers' access to the financial sector, which makes them more credible not only for financial institutions but also for contractors – this definitely strengthens sustainable development mechanisms, ensuring the ability to meet both present and future needs; • on farms characterized by a high or medium development level, business insurance stimulates investment and enables systematic development; • the development of the farm lasts up to a certain point; then the farm stabilizes, which is possible with insurance coverage;	• unsustainable insurance solutions in the agricultural sector, as well as their connection with measures under the Common Agricultural Policy, the European Union and the introduction of high franchise and multiple-peril insurance solutions that restrict conscious risk management by farmers, which does not contribute to reducing their aversion to insurance; • farmers expect, first and foremost, the option of choosing coverage of those risks that significantly affect their income; • high, even prohibitive price of insurance against risks actually threatening a given farm; • 44.2% of farms generate most of their income from non-agricultural activity; it can, thus, be stated that a possible reduction in crop yields on these farms would not have a significant impact on their income, hence lower propensity to insure crops; • difficult socio-economic situation of the agricultural sector – farmers making economic choices, often resign from insurance coverage guided by the belief that they will not suffer damage and hence they do not need insurance; • farmers associate insurance more with the obligation to pay premiums than with the need to protect their property and crops against consequences of fortuitous events (compulsory insurance is the main reason for purchasing insurance policies); • very high share of the premium in the amount of indemnities, which translates into too expensive insurance and the fact that it is not commonly purchased; • considerable cost of insurance purchase;

Table 22 (cont.)

• on the least developed farms, economic, business insurance is mainly a tool for stabilizing farm income with which the farmer provides for his family; • business insurance in agriculture is an important factor strengthening the sustainable development of farms; • banks and other lending institutions require property to be insured; • insufficient information about a given product (crop insurance); • farmers do not feel at all that insurance they are offered is beneficial for them and provides real coverage; • the price of livestock insurance is too high; • significant diversification of production on farms and vertical integration of production processes (crop production and livestock production on one farm); • no impact of agricultural production output on domestic prices, and thus income earned by farmers, leads to the conclusion that in order for farmers' income to stabilize, it would be necessary to work out effective instruments stabilizing income itself and not safeguarding the production volume;	• limited insurance awareness of farmers – they do not try to make insurance companies develop insurance products tailored to the needs of their farms; • state aid in the event of a natural disaster – as farmers' can expect *ad hoc* state aid, they are less inclined to take out insurance; • unfavorable farm structure, dominated by non-commercial farms, i.e. ones that are to a large extent subsistence farms, as well as those whose operators seek work outside agriculture and do not treat the farm as the main source of their subsistence; • no funds to purchase insurance policies; • farmers are not familiar with the general insurance terms and conditions and are afraid that in the case of damage, they will receive no indemnities, or that these indemnities will be nominal; • no access to information about subsidized insurance and perpetual changes to the Act; • price volatility and a high share of direct payments in farmers' income; • fundamental differences in risk measurement from the point of view of farmers and that of insurance companies; insurance companies have to take into account a great deal of factors that make them set prices of insurance policies at a sufficiently high level which farmers usually find too high – these are e.g. the lack of independence of losses in agriculture, information asymmetry and high transaction costs;

Source: authors' own study, based on: A. Wicka (2011), Ubezpieczenia gospodarcze w rolnictwie w latach 2004-2010, "Roczniki Naukowe SERiA", nr 1; P. Kobus (2016), Determinanty poziomu ubezpieczeń rolniczych, "Studia i Prace WNEiZ US", nr 45/2; A. Kurdyś-Kujawska (2016), Ubezpieczenia gospodarcze jako czynnik zapewniający zrównoważony rozwój gospodarstw rolnych, "Prace Naukowe UE we Wrocławiu", nr 436; J. Pawłowska-Tyszko (2011), Ubezpieczenia majątkowe w rolnictwie polskim, "Zagadnienia Ekonomiki Rolnej", nr 1; M. Kaczała, K. Łyskawa (2010), Ubezpieczenia przedsiębiorstw/gospodarstw rolnych, [in:] ed. L. Gąsiorkiewicz, J. Monkiewicz, Ubezpieczenia w zarządzaniu ryzykiem przedsiębiorstwa (tom 2), Poltext, Warszawa; A. Wicka, E. Wojciechowska-Lipka (2009), Wspólna Polityka Rolna a ubezpieczenia gospodarcze w rolnictwie polskim, "Zeszyty Naukowe SGGW w Warszawie. Polityki Europejskie, Finanse i Marketing", nr 2 (51); A. Szymecka (2008), Ubezpieczenia gospodarcze jako instrument zarządzania ryzykiem w rolnictwie. Doświadczenia wybranych państw Unii Europejskiej, "Przegląd Prawa Rolnego", nr 2 (4).

Probit and logit models are mainly used to describe qualitative phenomena. In basic versions of these models, dichotomous variables are analyzed, whose variants are assigned values 1 or 0. Therefore, these models are also termed binomial models (Batóg and Wawrzyniak, 2005).

If y_i is 0 or 1 for the relevant variants of the qualitative variable, where i changes depending on the case, then (Batóg and Wawrzyniak, 2005):

$$P(y_i = 1) = p_i \text{ and } P(y_i = 0) = 1 - p_i$$

The probabilities formulated above are dependent variables that appear in the analyzed models. In the probit model, these probabilities correspond to the values of a cumulative distribution function of the standard normal distribution, whereas in the logit model, they correspond to the values of a cumulative distribution function of the logistic distribution. Therefore, these models take the following forms (Batóg and Wawrzyniak, 2005):

a) probit model:

$$p_i = \int_{-\infty}^{x_i^T \beta} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{t^2}{2}\right) dt$$

b) logit model:

$$p_i = \frac{1}{1+\exp\left(-x_i^T \beta\right)}$$

where:
x_i – values of explanatory variables for the different cases,
β – structural parameters.

Once the models have been estimated, then the theoretical values of variable Y are determined. This is done in accordance with the following rule (Batóg and Wawrzyniak, 2005):

$$\hat{y}_i = \begin{cases} 1, & \text{if } 0.5 < \hat{p}_i \leq 1 \\ 0, & \text{if } 0 \leq \hat{p}_i \leq 0.5 \end{cases}$$

Currently, logit models are widely used in banks to assess credit risk, as well as in enterprises to assess customer loyalty. They are also one of the tools used by actuaries to assess insurance risk and the chances of conversion and retention of insurance policies (de Jong and Heller, 2008).

Logit models are most often used "in modelling the risk of the analyzed entity being in a certain state" (Jackowska, 2011). Where a dependent variable is binary, i.e. when it informs whether the analyzed phenomenon occurs or not, then we are dealing with a binomial model (Jackowska, 2011).

The binomial logit model is used to describe the dichotomous quality variable Y depending on the value of exogenous variables $X_1, X_2, ..., X_k$ (quantitative or qualitative). The dependent variable is usually expressed by a 0/1 variable (Jackowska, 2011):

$$Y = \begin{cases} 1 & \text{event occurred} \\ 0 & \text{event did not occur} \end{cases}$$

The logit model is a special case of the generalized linear model (McCullagh and Nelder, 1989):

$$g(\mu) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k$$

where:
β_0 – intercept,
$\beta_1, \beta_2, \ldots, \beta_k$ – regression coefficients,
g – link function describing the link between the mean value of the dependent variable $\mu = E\left(Y \middle| X_1 = x_1, X_2 = x_2, ..., X_k = x_k\right)$ with a linear combination of predictors.

In the logit model $\mu = p = P(Y = 1|X_1 = x_1, X_2 = x_2, ..., X_k = x_k)$, and the link function, termed logit, has the following form (Jackowska, 2011):

$$g(p) = \text{logit}(p) = \ln\left(\frac{p}{1-p}\right)$$

The logit in negative for $p_i > 0.5$, and positive for $p_i < 0.5$ (Gruszczyński, 2012).

To sum up, the logit model can be written as follows (Jackowska, 2011):

$$p = P(Y = 1|X_1 = x_1, X_2 = x_2, ..., X_k = x_k) = \frac{\exp\left(\beta_0 + \sum_{i=1}^{k}\beta_i x_i\right)}{1 + \exp\left(\beta_0 + \sum_{i=1}^{k}\beta_i x_i\right)}$$

Typically, model parameters β_0, β_1, …, β_k are estimated using the method of maximum likelihood, by maximizing the logarithm of the likelihood function with respect to the model parameters using iterative numerical procedures (Jackowska, 2011).

Where the set of explanatory variables includes qualitative variables, these should be introduced to the model through dummy coding (Agresti, 2002). Where a variable consists of m variants, $m-1$ dummy variables are usually introduced. If in the group of study units, the values of all explanatory variables are zero, then such group is referred to as a reference group. It is arbitrarily determined when predictors are being dummy coded. A researcher dealing with coding can determine it by, e.g. selecting one of the following groups: the most numerous one, the lowest-risk one or the highest-risk risk. The reference group is used when interpreting model parameters (Jackowska, 2011).

Advantages of the logit model include the interpretability of parameters e^{β_i}. To this end, one should use the concept of odds, defined as ratio of the likelihood that an event will occur to the likelihood that an event will not occur. In the model presented above, the odds can be expressed as a function of explanatory variables (Jackowska, 2011):

$$\frac{p}{1-p} = \gamma(x_1, x_2, ..., x_k) = \exp\left(\beta_0 + \sum_{i=1}^{k}\beta_i x_i\right)$$

In the case of an intercept, value e^{β_0} is interpreted as the odds of the phenomenon to occur in the reference group (Jackowska, 2011).

The impact of an increase in the value of independent variables by $\Delta x_i (i = 1, 2, ..., k)$ on the odds of the phenomenon to occur can be determined by setting the odds ratio (Jackowska, 2011):

$$\psi(x_1, x_2, ..., x_k; \Delta x_1, \Delta x_2, ..., \Delta x_k) = \frac{\gamma(x_1 + \Delta x_1, x_2 + \Delta x_2, ..., x_k + \Delta x_k)}{\gamma(x_1, x_2, ..., x_k)} = \exp\left(\sum_{i=1}^{k}\beta_i \Delta x_i\right)$$

Where $X_i(i=1,2,...,k)$ is used as a dummy variable, then e^{β_i} is equal to the odds ratio for the group in which $X_i = 1$ and the group in which $X_i = 0$, with the other variables at a fixed level. If, however, this variable is used as a quantitative variable, then the odds ratio e^{β_i} informs how the odds will change if variable X_i increases by 1 unit with the other variables at a fixed level (Jackowska, 2011).

To verify the goodness of fit of the estimated model, one can use (Batóg and Wawrzyniak, 2005):

a) likelihood-ratio test – intended to verify the null hypothesis according to which all parameters of the model, with the exception of the intercept, are equal to zero; statistic of this test is expressed by the following formula:

$$\chi^2 = 2(\ln L_{UR} - \ln L_R)$$

where:

L_{UR} – the value of the likelihood function for the full model,

L_R – the value of the likelihood function for a model containing only the intercept (i.e. parameters described by explanatory variables are equal to zero),

and has a chi-squared distribution with the number of degrees of freedom equal to the number of explanatory variables in the model (without the intercept);

b) odds ratio – determined based on the contingency table of the case classification:

	$\hat{y}_i = 1$	$\hat{y}_i = 0$
$y_i = 1$	$n11$	$n10$
$y_i = 0$	$n01$	$n00$

in accordance with the following formula:

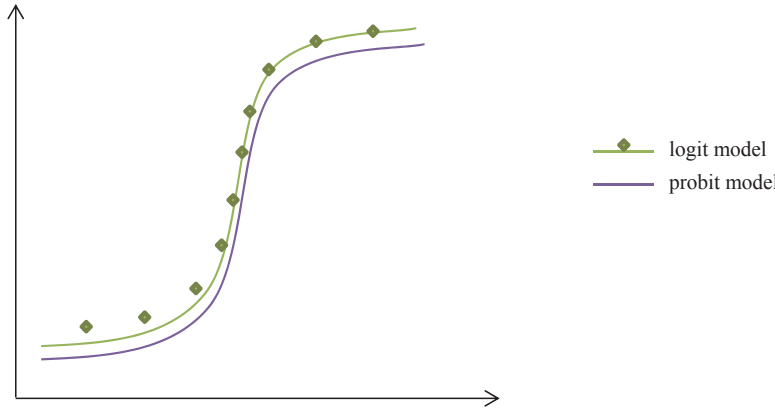
$$IS = \frac{n11 \cdot n00}{n01 \cdot n10}$$

where:

n_{ij} – the number of cases for which the actual value of the qualitative variable is i, and the theoretical value – j, $i, j = 0, 1$, whereby the greater IS value is than 1, the better classification the model gives.

The logit and probit models are similar to each other. What makes them differ is the specificity of the distribution of the random component in the model equation. The probit model is a regression model in which a cumulative distribution function of the standard normal distribution is the link function, whereas in the logit model, this function is served by a cumulative distribution function of the logistic distribution. These cumulative distribution functions are presented, in a simplified form, in Figure 16. They have a shape of "S-type curves". They are very similar to each other, except for the initial and final values, the so-called tails (Sielska and Pawłowska, 2016). Maddala (2008) believes that probit and logit models usually give similar results, and discrepancies may result from having large samples that provide enough observation for "tails".

Figure 16. Logit model vs probit model



Source: authors' own study, based on: A. Sielska, A. Pawłowska (2016), Szacowanie efektu oddziaływania polityki rolnej na wartość dodaną z wykorzystaniem propensity score matching, Monografie PW Nr 25, IERiGŻ, Warszawa.

The purpose of the authors' study was to identify factors affecting farmers' decisions as regards purchasing business insurance, and more specifically, crop insurance. The analysis covered 4,504 farms participating in the FADN agricultural accounting system. These farms kept agricultural accounting uninterruptedly throughout the study period, i.e. in 2009-2015.

The study began with specifying the vector of impact probability. For this purpose, logit models were used, with which the impact of all possible combinations from a set of 20 selected variables on a binary explanatory variable, denoting insurance purchase or lack of insurance, was estimated. The description of these 20 explanatory variables is presented in Table 23.

Estimation of logit models allowed for selecting, separately for each year, a set of predictors, i.e. features which enable forecasting the value of an explanatory variable. Table 24 presents the odds ratio values. It includes only statistically significant variables. The variables in bold are those whose increase in value (by one unit) increases the odds to purchase crop insurance by the farm, while those in italics decrease these odds.

Table 23. Description of explanatory variables

Name of the variable	Description
SN32*	Organic farming in accordance with the FADN typology (categories: yes; no; in conversion)[a]
SN39*	Less-favored areas in accordance with the FADN typology (categories: normal conditions, LFA but not mountain; mountain LFA)[b]
FADN REG*	Polish regions in accordance with the FADN typology (categories: Pomorze and Mazury; Wielkopolska and Śląsk; Mazowsze and Podlasie; Małopolska and Pogórze)[c]
NRWOJ*	Voivodeships in accordance with the FADN typology (categories: Dolnośląskie; Kujawsko-Pomorskie; Lubelskie; Lubuskie; Łódzkie; Małopolskie; Mazowieckie; Opolskie; Podkarpackie; Podlaskie; Pomorskie; Śląskie; Świętokrzyskie; Warmińsko-Mazurskie; Wielkopolskie; Zachodniopomorskie)[d]
TF14*	Agricultural type of the farm in accordance with the FADN typology (categories: cereal, oil and protein crops, various field crops combined, horticulture, vineyards, permanent crops; olives; various permanent crops combined; dairy cattle; rearing and fattening cattle; sheep and goats; pig and poultry, various crops, various livestock, mixed crops and livestock)[e]
TF8*	Agricultural type of the farm in accordance with the FADN typology (categories: field crops, horticulture, vineyards, permanent crops, dairy cows, herbivores, granivores, mixed)[f]
ES6*	Farm's economic size class in accordance with the FADN typology (categories: very small (EUR 2-8 thousand); small (EUR 8-25 thousand); medium-small (EUR 25-50 thousand); medium-large (EUR 50-100 thousand); large (EUR 100-500 thousand); very large (EUR over 500 thousand)[g]
ES9*	Farm's economic size class in accordance with the FADN typology (categories: very small (EUR 2-8 thousand); small (EUR 8-15 thousand); small (EUR 15-25 thousand); medium-small (EUR 25-50 thousand); medium-large (EUR 50-100 thousand); large (EUR 100-250 thousand); large (EUR 250-500 thousand); very large (EUR 500-1,000 thousand); very large (over EUR 1,000 thousand)[h]
D INW*	Investment subsidies (categories: yes; no)[i]
UAA6*	Utilized agricultural area classes in accordance with the FADN typology (categories: very small (less than 5 ha); small (5-10 ha); medium-small (10-20 ha); medium-large (20-30 ha); large (30-50 ha); very large (over 50 ha)[j]
SE131*	Total output (PLN)
SE025*	Utilized agricultural area (ha)
PROD OG NA 1 HA UR**	Total output per ha of utilized agricultural area (PLN/ha)
SE136*	Crop output per ha (PLN/ha)
WIEKROL*	Farmer's age (years)
WYKROL*	Farmer's education (categories: primary; vocational – non-agricultural; vocational – agricultural; secondary – non-agricultural; secondary – agricultural; higher – non-agricultural; higher – agricultural)[k]
DSGR*	Non-agricultural income (PLN)
DOCHZRGR*	Income from the family farm (PLN)
KREDDL SRED**	Average annual amount of long-term loans (PLN)
KREDKR SRED**	Average annual amount of short-term loans (PLN)

Symbols: * – variable name according to FADN, ** – variable name resulting from the authors' own calculations based on the FADN data.

[a] When interpreting logit models, the reference category is composed of farms that do not pursue organic farming. [b] When interpreting logit models, the reference category is composed of farms located in areas with normal farming conditions. [c] When interpreting logit models, the reference category is composed of farms located in Pomorze and Mazury. [d] When interpreting logit models, the reference category is composed of farms located in the Dolnośląskie Voivodeship. [e] When interpreting logit models, the reference category is composed of farms specializing in oil and protein cereal crops. [f] When interpreting logit models, the reference category is composed of farms specializing in field crops. [g] When interpreting logit models, the reference category is composed of farms with an economic size of EUR 2-8 thousand. [h] When interpreting logit models, the reference category is composed of farms with an economic size of EUR 2-8 thousand. [i] When interpreting logit models, the reference category is composed of farms which did not receive investment subsidies. [j] When interpreting logit models, the reference category is composed of farms with UAA of less than 5 ha. [k] When interpreting logit models, the reference category is composed of farms operated by farmers with primary education.

Source: authors' own study, based on: Z. Floriańczyk, D. Osuch, R. Płonka (2016), Wyniki standardowe 2015 uzyskane przez gospodarstwa rolne uczestniczące w Polskim FADN. Część I. Wyniki standardowe, IERiGŻ, Warszawa; A. Sielska, A. Pawłowska (2016), Szacowanie efektu oddziaływania polityki rolnej na wartość dodaną z wykorzystaniem propensity score matching, Monografie PW Nr 25, IERiGŻ, Warszawa.

Table 24. Odds ratio for the logit model (for the value of the explanatory variable) in 2009-2015

Explanatory variable	Odds ratio:						
	2009	2010	2011	2012	2013	2014	2015
Organic farming (used)	-	-	-	*0.465*	*0.332*	-	*0.240*
Organic farming (in conversion)	-	-	-	*0.291*	-	-	-
LFA, but not mountain	-	*0.661*	*0.665*	*0.662*	*0.670*	*0.674*	*0.692*
Region of Poland (Wielkopolska and Śląsk)	**1.963**	**2.203**	**2.320**	**1.563**	**2.192**	**2.195**	**2.983**
Region of Poland (Mazowsze and Podlasie)	-	-	*0.548*	*0.594*	*0.493*	-	-
Region of Poland (Małopolska and Pogórze)	*0.474*	*0.452*	*0.375*	*0.293*	*0.421*	-	-
Voivodeship (Kujawsko-Pomorskie)	**1.505**	**1.699**	-	**1.681**	-	**2.302**	**2.442**
Voivodeship (Lubelskie)	-	-	-	*0.495*	-	*0.604*	-
Voivodeship (Lubuskie)	-	**1.821**	-	-	**1.811**	**2.915**	**1.861**
Voivodeship (Mazowieckie)	-	*0.616*	-	*0.535*	-	-	-
Voivodeship (Śląskie)	**3.007**	**2.956**	**2.715**	**2.419**	**2.974**	-	-
Voivodeship (Wielkopolskie)	*0.597*	-	*0.650*	-	*0.703*	-	*0.579*
Specialization (TF14) (mixed field crops)	-	-	-	*0.731*	-	*0.625*	-
Specialization (TF14) (horticulture)	*0.200*	*0.178*	*0.235*	*0.134*	*0.129*	*0.050*	*0.117*
Specialization (TF14) (permanent crops)	*0.421*	*0.404*	*0.293*	*0.361*	*0.164*	*0.039*	*0.113*
Specialization (TF14) (dairying cattle)	*0.390*	*0.429*	*0.442*	*0.431*	*0.397*	*0.337*	*0.389*
Specialization (TF14) (rearing and fattening cattle)	-	-	-	*0.353*	-	*0.191*	*0.478*
Specialization (TF14) (pigs and poultry)	*0.559*	*0.528*	-	*0.531*	*0.583*	*0.534*	-
Specialization (TF14) (mixed crops)	*0.422*	*0.384*	*0.269*	*0.488*	*0.435*	*0.363*	-
Specialization (TF14) (mixed livestock)	*0.563*	*0.544*	*0.512*	*0.595*	-	*0.478*	*0.613*
Specialization (TF14) (mixed crops and livestock)	*0.724*	*0.649*	*0.650*	-	*0.676*	*0.589*	*0.718*
Economic size (ES6) large	-	-	*0.209*	-	-	-	-
Economic size (ES9) large	-	**2.291**	-	-	-	-	-
Investment subsidies (received)	-	-	-	-	**1.480**	-	-
Utilized agricultural area (medium-large)	**3.751**	**4.928**	-	-	-	-	**9.125**
Utilized agricultural area (large)	-	**5.228**	-	-	-	-	**12.642**
Utilized agricultural area (very large)	**4.545**	**6.456**	**3.564**	-	-	-	**14.296**
Total output	-	**1.000**	**1.000**	-	**1.000**	-	-
Total output per ha of the utilized agricultural area	-	-	*1.000*	-	-	-	-
Farmer's age	-	-	*0.991*	-	-	-	-
Farmer's education (vocational – non-agricultural)	-	-	*0.602*	-	-	-	-
Farmer's education (vocational – agricultural)	-	-	-	-	-	-	**1.941**
Farmer's education (secondary – non-agricultural)	-	-	-	-	**1.765**	-	-
Farmer's education (secondary – agricultural)	-	-	-	**1.650**	**1.868**	**1.679**	**1.913**
Farmer's education (higher – non-agricultural)	-	-	-	-	**2.036**	**2.195**	-
Farmer's education (higher – agricultural)	-	-	-	-	-	-	**2.044**
Income from the family farm	*1.000*	*1.000*	-	-	-	-	-
Average annual amount of long-term loans	**1.000**	-	-	-	-	**1.000**	-
Average annual amount of short-term loans	-	-	-	**1.000**	-	-	**1.000**

Source: authors' own study.

Based on data from 2009, the following variables were selected: region of Poland, voivodeship, farm specialization, utilized agricultural area class, income from the family farm and the average annual amount of long-term loans. Based on the developed model, it can be inferred that the odds to purchase crop insurance were almost two times higher in Wielkopolska and Śląsk and half-time lower in Małopolska and Pogórze than in Pomorze and Mazury. When the voivodeships are considered, the situation was as follows: farms located in the Kujawsko-Pomorskie and Śląskie Voivodeships had 1.5 times and three times, respectively, higher odds to purchase insurance than those located in the Dolnośląskie Voivodeship, while those located in the Wielkopolskie Voivodeship – by approx. 40% lower.

The type of specialization had a negative effect on the dependent variable. Farms specializing in horticultural crops had 80% lower odds to purchase crop insurance than those specializing in cereal, oil and protein crops. In the case of farms specializing in permanent crops, various crops and dairy cattle, these odds were also approx. 60% lower. For farms rearing pigs and poultry and for those specializing in rearing mixed livestock, the odds to purchase insurance were about 44% lower than for farms specializing in cereal, oil and protein crops. As regards farms specializing in mixed crops and livestock, the odds to purchase insurance decreased by 28%.

The odds to purchase insurance in 2009 were affected to the greatest extent by the class of utilized agricultural area. Farms classified according to their area as "medium-large" and "very large" had about four times and more than four-and-a-half times, respectively, higher odds to purchase insurance than "very small" farms. As regards variables that had a relatively small impact on the odds to purchase crop insurance, these were income from the family farm (negative impact) and average annual long-term loans (positive impact). In 2010, the same variables as in 2009 were recognized as significant (except for the average annual amount of long-term loans), as well as less-favored areas, economic size and total output. Based on the developed model, it can be inferred that the odds to purchase crop insurance were more than two times higher in Wielkopolska and Śląsk and more than half-time lower in Małopolska and Pogórze than in Pomorze and Mazury. In terms of voivodeships, these odds were almost two times higher in the Kujawsko-Pomorskie and Lubuskie Voivodeships and almost three times higher in the Śląskie Voivodeship compared to the reference category, namely the Dolnośląskie Voivodeship. For farms located in the Mazowieckie Voivodeship the odds to purchase crop insurance were 38% lower.

As in the previous year, the dependent variable was adversely affected by the type of specialization. Farms specializing in horticultural crops, permanent crops, various crops mixed and dairy farms had odds to purchase insurance at a similar level as in 2009. As regards farms rearing pigs and poultry and those rearing mixed livestock, the odds to purchase insurance were almost half-time lower than in the case of farms specializing in cereal, oil and protein crops. Farms specializing in mixed crops and livestock recorded a 35% drop in the odds to purchase insurance. The dependent variable was adversely affected also by the LFA variable. In the case of farms located in

non-mountain LFAs, the odds to purchase insurance were 34% lower than for those located in areas with normal farming conditions.

The economic size had a positive effect on the dependent variable. Large farms, i.e. those with an economic size in the range of EUR 100-250 thousand, had more than twice as high odds to purchase insurance than very small farms, i.e. those with an economic size of EUR 2-8 thousand. Alike in 2009, the odds to purchase crop insurance were affected most by the utilized agricultural area. Farms classified as "medium-large", "large" and "very large" had, respectively, almost five times, more than five times and almost six-and-a-half times higher odds to purchase insurance than those classified as "very small". Besides, a relatively small impact on the odds to purchase crop insurance was exerted by such variables as total output (positive impact) and income from the family farm (negative impact).

In 2011, the same variables as in 2010 were recognized as significant (with the exception of income from the family farm), as well as three others: total output per ha of utilized agricultural area and the age and education of the farmer operating the farm. Based on the developed model, it can be inferred that the odds to purchase crop insurance were more than two times higher in Wielkopolska and Śląsk than in Pomorze and Mazury. In Mazowsze and Podlasie as well as in Małopolska and Pogórze, these odds dropped by 45% and 62%, respectively. As regards the voivodeships, it can be observed that the odds to purchase insurance in the Śląskie Voivodeship were still almost three times higher than in the Dolnośląskie Voivodeship, albeit slightly lower than in the previous two years. Alike in 2009, farms located in the Wielkopolskie Voivodeship had 35% lower odds to purchase crop insurance in 2011.

As in previous years, the type of specialization had an adverse effect on the dependent variable. As for farms specializing in horticultural crops, permanent crops and mixed crops, the odds to purchase insurance decreased by 76%, 71% and 73%, respectively. On farms rearing dairy cattle and those rearing mixed livestock, the odds to purchase insurance were about 56% and 49% lower than on farms specializing in cereal, oil and protein crops. In the case of farms specializing in mixed crops and livestock the odds to purchase insurance were 35% lower. As in the previous year, the dependent variable was adversely affected also by the LFA variable. The odds to purchase insurance on farms located in non-mountain LFAs were at a similar level as in 2010. An adverse effect on the dependent variable was exerted also by the economic size. On large farms, i.e. those with an economic size in the range of EUR 100-500 thousand, the odds to purchase insurance were 79% lower than in the case of very small farms, i.e. those whose economic size was in the range of EUR 2-8 thousand.

The utilized agricultural area had the greatest positive effect on the dependent variable. On farms classified as "very large", i.e. those with a utilized agricultural area of more than 50 ha, the odds to purchase crop insurance were more than three-and-a-half times higher than in "very small" farms.

As regards education of the farmer operating the farm, the odds to purchase insurance were lower in the case of non-agricultural vocational education. Such farmers

demonstrated 40% lower odds to purchase insurance than farmers with primary education. The dependent variable was adversely affected also by the farmer's age. Each subsequent year resulted in an approx. 1% decline in the odds to purchase insurance. The odds to purchase crop insurance were also relatively inconsiderably affected by such variables as total output (positive impact) and total output per ha of utilized agricultural area (negative impact).

In 2012, the following variables materially affected the odds to purchase crop insurance: organic farming, less-favored areas, region of Poland, voivodeship, type of the farm's specialization, the farmer's education and the average annual amount of short-term loans. Based on the developed model, it can be inferred that the dependent variable was adversely affected by organic farming. Odds to purchase insurance were by 53% lower for farms pursuing organic farming than those in which organic farming was not practiced, whereas for farms in conversion, these odds were lower by 71%. As in the previous two years, the LFA variable affected the dependent variable to a similar adverse extent, i.e. the odds to purchase insurance in the case of farms located in non-mountain LFAs were 34% lower than in areas with normal farming conditions.

As regards regions of Poland, farms located in Wielkopolska and Śląsk had more than one-and-a-half times higher odds to purchase insurance than those located in Pomorze and Mazury. Farms located in Mazowsze and Podlasie as well as those located in Małopolska and Pogórze had odds to purchase crop insurance lower by 41% and 71%, respectively. In terms of voivodeships, a positive effect on the dependent variable was recorded in the Kujawsko-Pomorskie and Śląskie Voivodeships. In these voivodeships, the odds to purchase insurance were, respectively, over one-and-a-half times and almost two-and-a-half times higher than in the Dolnośląskie Voivodeship. As for farms located in the Lubelskie and Mazowieckie Voivodeships, these odds were approx. 50% lower.

As in the previous years, also 2012 saw adverse effects of the type of specialization on the dependent variable. Farms specializing in mixed field crops had 27% lower odds to purchase insurance than those specializing in cereal, oil and protein crops, whereas in the case of those specializing in mixed crops, permanent crops and horticultural crops, these odds were lower by 51%, 64% and 87%, respectively. For farms specializing in rearing dairy cattle, rearing and fattening cattle as well as rearing pigs and poultry, the odds to purchase insurance were lower by 57%, 65% and 47%, respectively. Farms rearing various livestock demonstrated 40% lower odds to purchase crop insurance. The odds to purchase insurance were 65% higher in the case of farmers with secondary agricultural education. Apart from this, a relatively small positive impact on the odds to purchase crop insurance was exerted by the average annual amount of short-term loans.

In 2013, the same variables as in 2012 were recognized as material (except for the average annual amount of short-term loans), as well as two others: investment subsidies and total output. Based on the developed model, it can be inferred that organic farming had an adverse effect on the dependent variable. Farmers pursuing organic farming had 67% lower odds to purchase crop insurance than those who did not prac-

tice such farming. As in 2010-2012, the dependent variable was adversely affected by the LFA variable also in 2013. Farms located in non-mountain LFAs has 33% lower odds to purchase crop insurance than those located in areas with normal farming conditions. As regards regions of Poland, the highest odds to purchase insurance were reported for farms located in Wielkopolska and Śląsk – more than two times higher than for farms situated in Pomorze and Mazury. Farms located in Mazowsze and Podlasie as well as those located in Małopolska and Pogórze had odds lower by 51% and 58%, respectively. As regards the voivodeships, the highest odds to purchase insurance were reported for farms located in the Śląskie and Lubuskie Voivodeships. Farms located in these voivodeships had, respectively, almost three times and almost two times higher odds to purchase insurance than farms in the Dolnośląskie Voivodeship. As regards farms located in the Wielkopolskie Voivodeship, the odds to purchase insurance were 30% higher.

As in the previous years, the type of specialization had an adverse effect on the dependent variable. In the case of farms specializing in horticultural crops, permanent crops and mixed crops, the odds to purchase insurance were lower by 87%, 84% and 56%, respectively. For farms rearing dairy cattle and those rearing pigs and poultry, the odds to purchase insurance were lower by 60% and 42%, respectively. In the case of farms specializing in mixed crops and livestock, the odds to purchase insurance were lower by 32%. Investment subsidies turned out to be another material variable. Farms that received such subsidies had 48% higher odds to purchase crop insurance than those that did not benefit from such support. Alike the previous year, the education of the farmer operating the farm was of significance. Secondary non-agricultural and agricultural as well as higher non-agricultural education were those categories that had a major impact on the odds to purchase insurance. Farmers with secondary non-agricultural and agricultural education had, respectively, 77% and 87% higher odds to purchase insurance than those with primary education. As regards farmers with higher non-agricultural education, these odds were more than two times higher. A relatively small positive impact on the odds to purchase crop insurance was exerted also by total production.

In 2014, the odds to purchase insurance depended on the following variables: less-favored areas, region of Poland, voivodeship, type of the farm's specialization, farmer's education and the average annual amount of long-term loans. As in 2010--2013, the dependent variable was adversely affected by the LFA variable also in 2014. The odds to purchase insurance on farms located in non-mountain LFAs were at a similar level as in 2013. The region of Poland had a positive impact on the dependent variable. Farms located in Wielkopolska and Śląsk had the odds to purchase insurance more than two times higher than those located in Pomorze and Mazury. As regards the voivodeships, the highest odds to purchase insurance were reported for farms located in the Kujawsko-Pomorskie and Lubuskie Voivodeships. Farms located in these voivodeships had, respectively, more than two times and almost three times higher odds to purchase insurance than farms in the Dolnośląskie Voivodeship. As for farms located in the Lubelskie Voivodeship, these odds were 40% lower. As in the previous years,

the type of the farm's specialization had a negative impact on the dependent variable. Specializing in mixed field crops and in mixed crops entailed the odds to purchase insurance lower by 37% and 64%, respectively, than specializing in cereals, oil and protein crops did. In the case of farms specializing in horticultural crops and permanent crops, these odds were lower by 95% and 96%, respectively. Lower odds to purchase insurance were reported also for farms rearing dairy cattle, rearing and fattening cattle, rearing pigs and poultry and those rearing mixed livestock – by 66%, 81%, 47% and 52%, respectively. In the case of farms specializing in mixed crops and livestock, the odds to purchase insurance were lower by 41%. As regards the farmer's age, the odds to purchase insurance were affected once again mainly by secondary agricultural and high non-agricultural education. Farmers with secondary agricultural education had 68% higher odds to purchase insurance than those having primary education. As regards farmers having higher non-agricultural education, these odds were more than two times higher. As in 2009, a relatively small positive impact on the odds to purchase crop insurance was exerted by the average annual amount of long-term loans.

In 2015, the same variables as in 2012 were recognized as material, and additionally the utilized agricultural area. Based on the developed model, it can be inferred that the dependent variable was adversely affected by organic farming. Farms pursuing organic farming had 76% lower odds to purchase insurance than those that did not practice such farming. As in 2010-2014, the dependent variable was adversely affected by the LFA variable also in 2015. In the case of farms located in non-mountain LFA, the odds to purchase insurance were 31% lower than for those located in areas with normal farming conditions. The region of Poland had once again a positive impact on the dependent variable. Farms located in Wielkopolska and Śląsk had almost three times higher odds to purchase crop insurance than those located in Pomorze and Mazury. This level of the odds to purchase insurance was the highest throughout the analyzed period. As regards the voivodeships, the highest odds to purchase insurance were reported for farms located in the Kujawsko-Pomorskie and Lubuskie Voivodeships. Farms located in these voivodeships had, respectively, almost two-and-a-half times and almost two times higher odds to purchase insurance than farms in the Dolnośląskie Voivodeship. As for farms located in the Wielkopolskie Voivodeship, these odds were lower by 42%.

As in the previous years, also 2015 saw adverse effects of the type of the farm's specialization on the dependent variable. Farms specializing in horticultural crops and permanent crops had approx. 88% lower odds to purchase insurance than those specializing in cereal, oil and protein crops, whereas in the case of farms rearing dairy cattle, rearing and fattening cattle and rearing various livestock, these odds were lower by 61%, 52% and 39%, respectively. As for farms specializing in mixed crops and livestock, the odds to purchase insurance were lower by 28%.As in 2009-2011, the odds to purchase crop insurance were determined primarily by the utilized agricultural area. This was also the variable that had the greatest impact on these odds throughout the analyzed period. Farms classified as "medium-large", "large" and "very large" had,

respectively, over nine times, more than twelve-and-a-half times and more than fourteen-and-a-half times higher odds to purchase insurance than farms classified as "very small". As in 2012-2014, the farmer's education had a positive effect on the dependent variable. However, in 2015, it was vocational, secondary and higher agricultural education that had material impact on the odds to purchase insurance. Farmers having such education had approximately two times higher odds to purchase insurance than those having primary education. Apart from this, a relatively small positive impact on the odds to purchase crop insurance was exerted, as in 2012, by the average annual amount of short-term loans.

7. Impact of the purchase of insurance on selected characteristics of family farms

Mgr Justyna Herda-Kopańska

The impact of the purchase of crop insurance by farms on selected factors can be examined using the propensity score matching (PSM) method. The purpose of this method is to create a control group that will include units as similar as possible to those in the experimental group. Units are matched based on the value of only one variable, i.e. propensity score. Therefore, the PSM method is treated as a tool to reduce the number of features/dimensions with which observations within the data set can be described. These dimensions are reduced to one synthetic indicator, sometimes referred to as propensity to participate in the intervention condition (Konarski and Kotnarowski, 2007).

The PSM method consists of three stages, shown in Figure 17. In the first of them, unknown values of propensity score should be estimated. To this end, a logistic regression model can be used. Then, the dependent variable is treated as being in the group affected by the stimulus, while the independent variables are characteristics that are supposed to affect the result, on the one hand, and the participation in a given activity, on the other. In the second stage, units are selected to the control group based on the calculated propensity score. This selection can be carried out in many ways. The nearest neighbor method is one of the simplest ones, and involves matching the most similar units, i.e. those with the closest propensity score. As a result of matching, a control group is formed. As assumed, this group must include all balanced observable variables used in the probability model. Therefore, the control group should be similar to the existing intervention group in terms of the selected set of characteristics. In the third stage, the effects are analyzed through comparison of the intervention group with the resulting control group (Trzciński, 2009).

Figure 17. Stages of the PSM method

Source: authors' own study.

The use of the PSM method is in principle relatively simple and intuitive. Each unit from the group taking part in the analyzed event (agricultural farms purchasing crop insurance) should be assigned at least one, the most similar unit from the non-participating group (farms that do not purchase crop insurance). The similarity is expressed in terms of the probability of participation in the event, estimated based on observable characteristics of the various units (farms). Selected units (farms) are included in the control group, the results of which can be compared with the results observed in the group of units (farms) participating in the event (purchasing crop insurance).

To apply the PSM method, one must have relevant data, which is a complex issue in this method that requires the following conditions to be observed (Trzciński, 2009):

1) in the estimated probability model there must be such a set of independent variables X that will make real the Conditional Independence Assumption (CIA);
2) some minimum requirements must be met with respect to the size of the intervention group and the control pool used in the formation of the control group;
3) data must be collected in a timely manner;
4) data must be collected in a standardized manner.

Once the set of variables is determined, one should proceed to estimating the propensity score. At this point, the estimation model must be chosen. There are different methods of estimating $P(X_i)$. In the literature, a logit model or a probit one are usually indicated, though, the former is more common (Konarski and Kotnarowski, 2007). Caliendo and Kopeinig (2005) point out that where the dependent variable is dichotomous (participation or lack of participation), both models give similar results. However, selection of a method for estimating the propensity score may be more difficult where the predicted event is a multiple treatment case, i.e. when the unit can choose between more than two options (participate or not). In this case, the multinominal logit model or the multinominal probit model should be used. The former requires more robust assumptions, which is why the probit model is sometimes recommended (Trzciński, 2009).

The third, indirect, way is the use of many logistic regression models. In such a case, subsequent regression models are created, taking into account all options available for the unit (farm). Unfortunately, this approach has two disadvantages (Trzciński, 2009):

1) as the number of possible options available to the unit increases, the number of models to be estimated grows disproportionately;
2) in each of the models, only two options are considered at the same time, thus the probability of participation in one of the two selected groups is estimated, despite the fact that there are more groups altogether; there is, thus, no holistic view of the intervention.

Then, once the propensity score is estimated, the appropriate technique of selection of units from the control pool to the control group should be chosen. To this end, at least several approaches, expressed in practice through different unit matching algorithms, may be used. Each of the techniques is available also in several variants. Such a large number of approaches makes selecting a control group difficult, which is why

the use of data included in the control pool is optimized at this stage. In practice, before the matching procedure is launched, the following three decisions should be made (Trzciński, 2009):

1) whether the once used unit from the control pool should be included in this pool once again while matching;
2) how many control units should be per beneficiary and, finally;
3) what matching method to apply.

Once the units are matched, one should verify whether the applied procedure allowed for obtaining balanced distributions of variables used in the model in the experimental group and in the control group. In general, the situation prior to the matching should be compared with the situation resulting from the application of the chosen control group selection algorithm. Thus, the experimental group is first compared with the entire control pool, i.e. with the whole group of available units that do not participate in the analyzed event. The next step is to compare the intervention group with the selected control group and assess the degree to which the initial differences between the units in the control pool and the units included in the experimental group are minimized. If the differences between the two groups are significant, then one should go back to the previous stages of the PSM method. One can go back to e.g. the stage when the matching algorithm is selected or even to the stage when the propensity score is estimated (Caliendo and Kopeinig, 2005).

The whole procedure ends with an analysis of the impact effect. In our case, it is an analysis of the impact of crop insurance purchase by farms on their selected characteristics, and thus economic and production categories.

The study was to show how the purchase of crop insurance by farms affects previously identified factors. The analysis was based on the same assumptions as for the logit study. The study covered 2015, and was performed using the propensity score matching method. First, the characteristics of the studied objects were balanced in such a way as to ensure their similar distribution in the group which was affected by a given determinant and in the unaffected group. Thus, the analysis was performed using a logit model, which helped select variables for the propensity score vector.

This was followed by estimation of crop insurance purchase by farms on identified quantitative variables, presented in Table 25. The bold font indicates statistically significant results at the significance level of $\alpha=0.05$, whereas results in italics are statistically insignificant at the same significance level. As can be seen, the results that were not statistically significant predominate, which resulted directly from high standard errors of the estimates. Nevertheless, assessment covered the impact of the purchase of crop insurance by farms on the identified variables.

Table 25. Results of estimating the impact of the purchase of crop insurance by farms on the identified quantitative variables (in 2015)

Identified quantitative variable	Estimation result
Total output (PLN)	**- 129,577.00**
Utilized agricultural area (ha)	*- 1.68*
Total output per ha of utilized agricultural area (PLN/ha)	*611.34*
Crop output per ha (PLN/ha)	*2,015.00*
Non-agricultural income (PLN)	*247.54*
Income from the family farm (PLN)	**- 20,101.00**
Average annual amount of long-term loans (PLN)	*- 21,200.00*
Average annual amount of short-term loans (PLN)	**- 6,965.60**

Source: authors' own study.

The results show that the average total output in the group of farms that purchased crop insurance, i.e. in the experimental group, was PLN 129,577 lower than in the control group. This result was statistically significant. In the case of the utilized agricultural area, the average area in the experimental group was 1.68 ha smaller than in the control group. However, this result was not statistically significant. As for output per ha of utilized agricultural area, its average volume in the group of farms that purchased crop insurance was PLN 611.34 per ha higher than in the control group. However, as regards the average crop output per ha, it was PLN 2,015 higher in the experimental group than in the control group. Neither result was statistically significant. In the case of income, the situation was as follows: in the group of farms that purchased crop insurance, the average non-agricultural income was PLN 247.54 higher than in the control group, while the average income from the family farm was PLN 20,101 lower. Only the latter result was statistically significant. As for the average annual amount of loans, the average amount of long-term loans was PLN 21,200 lower in the experimental group than in the control group, whereas the average annual amount of short-term loans was lower in the experimental group by PLN 6,965.60. Only the latter result was statistically significant.

8. Viability of the purchase of crop insurance by the farm's operator

Dr inż. Michał Soliwoda, dr inż. Joanna Pawłowska-Tyszko

The assessment of the impact of crop insurance on the financial condition of farms is of great importance, as the use of this risk management instrument is a specialized source of liquidity, which also stabilizes financial solvency (Barry et al., 2000; Mishra and Goodwin, 2006; Wang and Annan, 2016). Commercial insurance products are designed to secure assets and cash flows in the event of unfavorable phenomena (e.g. hail storm, severe drought).

The general assumptions of the model regarding the assessment of the viability of crop insurance purchase (in fact the gain from insurance) presented by Barry et al. (2000) are as follows:

- the probability of an event with adverse consequences for the agricultural producer is the same, whether he uses or not insurance or other liquid reserves;
- there is no problem of moral hazard, i.e. an insured farmer does not take action to increase the probability that a disastrous event will materialize (e.g. agrotechnical procedures carried out in an improper or negligent way);
- the farmer intends to provide liquidity in the event of an adverse event.

The farmer's decision regarding the purchase of insurance is the resultant of many variables, including: (1) the amount of the insurance premium, (2) liquid reserve, available even without the purchase of insurance, (3) the earnings rate of the liquid reserve, (4) the rate of return on funds invested in agricultural activity, in fact the profitability of agricultural production (i.e. income from a given activity/output value).

The decision model can be expressed using the following equation:

$$I = S(b-e) - P$$

where:

I – gain from insurance;

S – the amount of the necessary reserve;

P – annual insurance premium;

b – opportunity cost of the maintained reserve (e.g. rate of return, where specific funds are invested in agricultural production);

e – liquid reserve.

It clearly follows from the above formula that, with other constant variables, an increase in the premium directly deteriorates the viability of insurance purchase. The same results are caused by term e, whereas the effect of the growing profitability of a given crop is the opposite.

In accordance with the above equation, an agricultural producer operating in an economically rational manner:

- will purchase crop insurance if $I > 0$,
- will not purchase this instrument if $I < 0$,
- will make a neutral purchase decision if $I = 0$.

In practice, the above variables from the model expressed in the above equation, refer to the following economic and financial categories:
I – viability of insurance purchase (PLN/ha);
S – actual sum insured (yield x agricultural product price (PLN/ha);
P – annual insurance premium, calculated based on the insurance rate adopted for a given crop and risk factor(s) (PLN/ha);
b – profitability of production for a given crop (the ratio of subsidized or unsubsidized income to the crop output cost) (%);
e – annual interest on the deposit less capital gains tax (the so-called "Belka's tax") (%).

As noted by Barry et al. (2000), farms usually do not have an adequate level of liquid reserves to cover consequences of disastrous events. The insurance company can obtain such funds very quickly, using, e.g. its own funds or funds of the reinsurer, at a relatively low acquisition cost. While the insurance premium may be treated as a relatively "rigid" cash expense, often accounted for in the farm's cash flow plans, the role of indemnities in stabilizing the financial situation (in the case of insurable events) is very important. Consequences of many insurable events can significantly reduce the farm's ability to survive. Although the above model is simplified, it serves to assess the rationality of the agricultural producer's decision regarding the purchase of crop and livestock insurance.

Given the need to gather more detailed data at the level of production operations, and not the entire farm, the Agricultural Accountancy Department in the Polish Institute of Agricultural and Food Economics – National Research Institute developed a system for gathering data on agricultural products – Agrokoszty. The Agrokoszty system includes data concerning both crop and livestock production. In 2015, the studies covered spring barley, maize for grain, sweet lupine, fodder peas, soy and edible potatoes, while in 2013 – winter wheat, winter rye, winter oilseed rape, spring barley and pigs for fattening (Agrokoszty, 2017). **The Agrokoszty system is characterized by a high degree of unification and accurately determined standards and methodology used in it.** Table 26 presents the key categories used to assess viability.

Table 26. Key categories adopted for cost calculation in the Agrokoszty system

Category	Description
Output value	*Sum of the value of main products and by-products on the market*
Direct costs of crop production	*Seed and planting material, purchased fertilizers, plant protection agents, growth regulators, insurance of the analyzed crop, specialist costs*

Source: terminology of the Agrokoszty system (presented in detail in: Agrokoszty, Metodyka i zakres badań, 2017; Żekało (ed.), 2016, pp. 11-13; Skarżyńska, 2016, pp. 9-11).

It should be stressed that the Agrokoszty system also applied the structure of direct costs, used by the Polish FADN. The indirect costs of the farm were divided into two types: indirect actual costs (overheads, taxes and costs of external factors) and indirect estimated costs (i.e. depreciation). The Agrokoszty system records the farmer's own and hired labor input and costs, which is the basis for determining the labor intensity of various crops. Two income variants were adopted to assess viability of insurance decisions,

i.e. unsubsidized and subsidized agricultural income. Box 1 presents the calculation algorithm of the above surplus categories.

Box 1. Method of calculating the various categories of income for agricultural production

I		**Output value**
II	-	Indirect costs
III	=	**Direct surplus without subsidies**
IV	-	Actual indirect costs (except for the cost of external factors)
V	=	**Gross value added from operations**
VI	-	Estimated indirect costs – depreciation
VII	=	**Net value added from operations**
VIII	-	Cost of external factors
IX	=	**Unsubsidized operating income**
X	+	Subsidies
XI	=	**Operating income**

Source: Skarżyńska, Jabłoński 2016, p. 167.

The assessment of the viability of decisions regarding the purchase of insurance concerned the following crops (crop production):

- winter oilseed rape,
- winter wheat,
- maize for grain,
- sugar beets.

This selection of agricultural products resulted from the significant percentage of the area under these crops in the total sown area, as well as their great importance in the food economy.

Given that the model of Barry et al. (2006) is a tool accounting for the realities of American agriculture, it had to be adapted to the production constraints applicable to Polish private farms. Therefore, a number of assumptions used in the calculation of viability of crop insurance purchase were adopted, which include:

- due to the availability of data collected in the Agrokoszty system and those presented in publications (Skarżyńska, 2016; Żekało (ed.), 2016), the calculations concern data for 2015 only[8];
- the sum insured (actual) is the product of (1) yield (dt/ha), (obtained by farms in the target sample in the Agrokoszty system), and (2) the buy-in price of the product (PLN/ha);
- profitability of production was calculated as a ratio of operating income (in two variants: without and with subsidies) to the output value;
- interest rate on one-year deposits according to data of the National Bank of Poland (NBP) (NBP, 2017)[9], at the same time, accrued interest on deposits was reduced by capital gains tax at a rate of 19%;

[8] More detailed descriptions of the farm samples used in studies regarding the cost and profitability of agricultural products are available in publications by Skarżyńska (Skarżyńska, 2016) and Żekało (Żekało (red.), 2016).

[9] The average interest rate on agreements denominated in PLN from the "sector of family farms and non-commercial institutions operating for farms" was analyzed. The interest rate applied to "deposits with original maturity" of up to 2 years, inclusive, and was reported according to the balance at the end of the month (NBP, 2017).

- minimum and maximum rates provided for in the rationale to the draft act on amending the act on crop and livestock insurance were used (RCL, 2016)[10];
- maximum sums insured were provided for in the implementing act to the amended Act on subsidized crop and livestock insurance (Regulation of the Minister of Agriculture and Rural Development of 27 November 2015...);
- the level of integral franchise for risk group I was set at 10%, and for group II – at 25%;
- regulations regarding the determination of the maximum state subsidy to crop insurance premiums were compliant with Article 1(1)(a) of the Act of 24 April 2015 on amending the Act on crop and livestock insurance (Journal of Laws of 2015, item 892)[11].

Calculations of insurance purchase viability are presented according to a uniform scheme (Table 27). It should be noted that these calculations are based on data from one year, made for the target sample of farms in the Agrokoszty system. Therefore, the results of the calculations should not be extrapolated on the general population of farms specializing e.g. in winter oilseed rape production. A significant range between the maximum and minimum insurance rates for given crops is noteworthy, which also translates into significant dispersion of the levels of the viability of insurance purchase. Viability of the purchase of oilseed rape insurance (for risk group I and unsubsidized income) can serve here as good example.

All viability calculations presented in this study regard the purchase of crop insurance in the case of both subsidized premiums and, purely hypothetical, those not subsidized by the state (Table 27). It should be presumed that subsidizing insurance premiums increases significantly the viability of the purchase of this risk management tool.

Due to unfavorable conditions for growing maize for grain (in 2015), the profitability of its production (taking into account only unsubsidized income) was negative and amounted to -3.3% (Table 27). The purchase crop insurance would be viable only in the case of subsidized income (except for group II, the maximum rate). The inviability of insurance purchase is confirmed even by calculations for subsidized rates (except for the above-mentioned exceptions).

[10] It should be noted that the mean values or medians of insurance rates used in agriculture are not generally available. In the mentioned rationale (available online), only the range, i.e. the difference between the maximum and the minimum, was presented. The range, however, is a very simplified measure of distribution variation (the simplest absolute measure of dispersion), compared to, e.g. standard deviation, variance, mean absolute deviation or coefficient of variation. The information value of the range refers to the indication of the empirical area of the variability of a given characteristic.

[11] "2. The subsidies amount to : (1) up to 65% of the premium for insurance of crops referred to in Article 3(1)(1), if the insurance tariff rates specified by insurance companies do not exceed: (a) in the case of insurance of crops of cereals, maize, spring oilseed rape, agrimony, potatoes and sugar beets – 3.5% of the sum insured for crops; in the case of splitting risks, the sum insured for a given crop applies to all risks, (b) in the case of insurance of winter oilseed rape, ground vegetables, hops, tobacco, fruit trees and shrubs, strawberries and legumes – 5% of the sum insured; in the case of splitting risks, the sum insured for a given crop applies to all risks"

Table 27. Calculation of the viability of the purchase of winter oilseed rape crop insurance

Category	Winter oilseed rape	Winter wheat	Maize for grain	Sugar beets
Sum insured [PLN/ha]	4,952.99	4,272.48	3,835.61	6,097.52
yield [dt/ha]	34.60	64.50	63.20	533.00
buy-in price [PLN/dt]	143.15	66.24	60.69	11.44
Unsubsidized income to output ratio	23.6%	27.3%	-3.3%	6.4%
unsubsidized income [PLN/ha]	1,171.00	1,169.00	-128.00	389.00
output [PLN/ha]	4,956.00	4,275.00	3,833.00	6,102.00
Subsidized income to output ratio	40.1%	46.4%	17.9%	54.9%
subsidized income [PLN/ha]	1,988.00	1,984.00	687.00	3,348.00
Interest on the deposit [%]	1.62%	1.62%	1.62%	1.62%
Annul insurance premium Group I (min.) [PLN/ha]	179.30	154.66	38.36	60.98
Annul insurance premium Group I (max.) [PLN/ha]	643.89	555.42	191.78	365.85
Annul insurance premium Group II (min.) [PLN/ha]	99.06	85.45	76.71	121.95
Annul insurance premium Group II (max.) [PLN/ha]	742.95	640.87	652.05	914.63
Maximum sum insured [PLN/ha]	10,550.00	14,000.00	10,300.00	11,430.00
Insurance rate [%]				
Group I (min.)	3.6%	3.6%	1.0%	1.0%
Group I (max.)	13.0%	13.0%	5.0%	6.0%
Group II (min.)	2.0%	2.0%	2.0%	2.0%
Group II (max.)	15.0%	15.0%	17.0%	15.0%
Franchise [%]				
Group I	10%	10%	10%	10%
Group II	25%	25%	25%	25%
Viability of the purchase of insurance unsubsidized by the state [PLN/ha]*				
Viability of the purchase of unsubsidized* insurance Group I (min.)	801.75	834.52	**-209.56**	199.97
Viability of the purchase of unsubsidized insurance Group I (max.)	337.16	433.76	**-362.98**	**-104.91**
Viability of the purchase of unsubsidized insurance Group II (min.)	718.48	738.87	**-219.38**	95.50
Viability of the purchase of unsubsidized insurance Group II (max.)	74.59	183.45	**-794.72**	**-697.18**
Viability of the purchase of subsidized insurance Group I (min.)	1,536.60	1,567.59	524.44	2,861.11
Viability of the purchase of subsidized insurance Group I (max.)	1,072.01	1,166.83	371.02	2,556.23
Viability of the purchase of subsidized insurance Group II (min.)	1,330.86	1,349.76	392.29	2,313.12
Viability of the purchase of subsidized insurance Group II (max.)	686.97	794.34	**-183.06**	1,520.44
Maximum subsidy amount of up to 3.5-5% of the sum insured [PLN/ha]**	160.97	97.20	87.26	138.72
65% crop insurance premium				
to the annual insurance premium Group I (min.) [PLN/ha]	116.54	100.53	24.93	39.63
to the annual insurance premium Group I (max.) [PLN/ha]	418.53	361.02	124.66	237.80
to the annual insurance premium Group II (min.) [PLN/ha]	64.39	55.54	49.86	79.27
to the annual insurance premium Group II (max.) [PLN/ha]	482.92	416.57	423.83	594.51
Actual premium paid by the farmer [PLN/ha]				
Group I (min.)	62.75	57.46	13.42	21.34
Group I (max.)	482.92	458.22	104.52	227.13
Group II (min.)	34.67	29.91	26.85	42.68
Group II (max.)	581.98	543.67	564.79	775.91

Table 27 (cont.)

Viability of the purchase of state-subsidized insurance [PLN/ha]				
Viability of the purchase of unsubsidized insurance Group I (min.)	918.29	931.72	**-184.63**	239.60
Viability of the purchase of unsubsidized insurance Group I (max.)	498.13	530.96	**-275.72**	33.81
Viability of the purchase of unsubsidized insurance Group II (min.)	782.87	794.42	**-169.52**	174.77
Viability of the purchase of unsubsidized insurance Group II (max.)	235.56	280.65	**-707.46**	**-558.46**
Viability of the purchase of subsidized insurance Group I (min.)	1,653.14	1664.79	549.37	2,900.74
Viability of the purchase of subsidized insurance Group I (max.)	1,232.98	1,264.03	458.28	2,694.95
Viability of the purchase of subsidized insurance Group II (min.)	1,395.24	1,405.30	442.15	2,392.39
Viability of the purchase of subsidized insurance Group II (max.)	847.94	891.54	**-95.80**	1,659.16

Note: Group I (winter oilseed rape, winter wheat) – hail, overwintering losses, spring frosts (G Usp Pw), Group I (maize for grain, sugar beets) – hail, spring frosts (G Pw); Group II – drought; * unsubsidized income; in case of inviability of insurance purchase the values were marked; ** maximum subsidy rate of up to 3.5-5% of the sum insured [PLN/ha] – 5% rate for winter oilseed rape, and 3.5% for other crops (presented in this table); in case of inviability of insurance purchase the values were written in bold and red.
Source: own calculations based on data from sets of calculations for winter oilseed rape (Żekało, 2016, pp. 43-49), winter wheat (Czułowska, 2016, pp. 22-28), maize for grain (Skarżyńska 2016, pp. 37-46) and sugar beets (Abramczuk, 2016, pp. 50-56).

In the case of sugar beet production, whose profitability is very strongly dependent on the degree of its subsidization, insurance purchase was inviable in the case of:

- maximum rates, groups I and II (unsubsidized income) – without state subsidies to insurance premiums;
- maximum rates, but only for group II (unsubsidized income) – accounting for state subsidies to crop insurance.

Table 28. Differences between the viability of subsidized crop insurance and unsubsidized crop insurance

Item	Winter oilseed rape	Winter wheat	Maize for corn	Sugar beet
Difference in the viability of purchase of unsubsidized insurance Group I (min.)	116.54	97.20	24.93	39.63
Difference in the viability of purchase of unsubsidized insurance Group I (max.)	160.97	97.20	87.26	138.72
Difference in the viability of purchase of unsubsidized insurance Group II (min.)	64.39	55.54	49.86	79.27
Difference in the viability of purchase of unsubsidized insurance Group II (max.)	160.97	97.20	87.26	138.72
Difference in the viability of purchase of subsidized insurance Group I (min.)	116.54	97.20	24.93	39.63
Difference in the viability of purchase of subsidized insurance Group I (max.)	160.97	97.20	87.26	138.72
Difference in the viability of purchase of subsidized insurance Group II (min.)	64.39	55.54	49.86	79.27
Difference in the viability of purchase of subsidized insurance Group II (max.)	160.97	97.20	87.26	138.72

Source: authors' own calculations.

Table 28 shows the calculated differences between the viability of crop insurance purchase with (1) a state subsidy to the premium and (2) without a subsidy. A particularly advantageous situation (from the perspective of the agricultural producer)

can be observed as regards winter oilseed rape (risk group II) in the case of insurance premiums set as maximum ones on the market. Subsidies to insurance premiums slightly improve the viability of insurance purchase with respect to fodder crops (e.g. maize for grain). It should be noted that the differences relate only to one-year data, and the sum insured is the product of the price and yield, hence highly volatile categories.

It should be noted that operating income does not account for costs of one's own inputs. Taking into account the **labor input of the farmer and his family**[12] makes the calculation of the viability of the purchase of crop insurance more transparent, bearing in mind the organizational form of farms prevailing in Poland (i.e. private farms). Table 29 presents the results of the calculation of the viability of purchase of insurance for selected crops, against operating income less the cost of the farmer's and his family's labor input. Considering such income resulted in the following changes (compared to the above calculation presented in Tables 27-28):

- purchase of winter oilseed rape crop insurance (group II, maximum rate, without state subsidies to the premium) would be inviable;
- even with the above-mentioned change in the methodology, the purchase of winter wheat crop insurance still remains inviable;
- the purchase of insurance of maize for grain was inviable in most of the options;
- furthermore, the purchase of sugar beet crop insurance would be inviable at the maximum (subsidized) rate, for group II.

Table 29. Calculation of the viability of insurance purchase for selected crops, accounting for operating income, less the costs of the farmer's and his family's labor input

Item	Winter oilseed rape	Winter wheat	Maize for grain	Sugar beet
Unsubsidized income [PLN/ha]	1,171	1,169	-128	389
Subsidised income [PLN/ha]	1,988	1,984	687	3,348
Farmer's and his family's labor input [hour/ha]	7.9	8.6	8.3	13.7
Hourly wage [PLN/hour]	14.73	14.73	14.73	14.73
Cost of the farmer's and his family's labor input [PLN/ha]	116.37	126.68	122.26	201.80
Unsubsidized income less the cost of the farmer's and his family's labor input [PLN/ha]	1,054.63	1,042.32	-250.26	187.20
Subsidized income less the cost of the farmer's and his family's labor input [PLN/ha]	1,871.63	1,857.32	564.74	3,146.20
Viability of the purchase of (unsubsidized) insurance [PLN/ha]				
Viability of the purchase of unsubsidized insurance Group I (min.)	697.08	720.58	**-319.67**	18.48
Viability of the purchase of unsubsidized insurance Group I (max.)	232.49	319.82	**-473.09**	**-286.40**
Viability of the purchase of unsubsidized insurance Group II (min.)	631.26	643.92	**-311.14**	**-55.74**

[12] The cost of the farmer's and his family labor input is the product of labor inputs (spent in the production process related to specific operations and transparently recorded in the Agrokoszty system) and the normative rate (determined based on the average wage in the entire national economy in a given year – based on data of the Central Statistical Office). It is assumed that "a full-time agricultural worker works 2,120 hours per year". In 2015, the thus calculated hourly wage was PLN 14.73 (Skarżyńska, 2016, p. 18).

Table 29 (cont.)

Viability of the purchase of unsubsidized insurance Group II (max.)	**-12.63**	88.50	**-886.48**	**-848.42**
Viability of the purchase of subsidized insurance Group I (min.)	1,431.93	1,453.65	414.33	2,679.62
Viability of the purchase of subsidized insurance Group I (max.)	967.34	1,052.89	260.91	2,374.75
Viability of the purchase of subsidized insurance Group II (min.)	1,243.63	1,254.81	300.53	2,161.88
Viability of the purchase of subsidized insurance Group II (max.)	599.74	699.39	**-274.81**	1,369.20
Viability of the purchase of state-subsidized insurance [PLN/ha]				
Viability of the purchase of unsubsidized insurance Group I (min.)	813.62	817.78	**-294.73**	58.11
Viability of the purchase of unsubsidized insurance Group I (max.)	393.46	417.02	**-385.83**	**-147.68**
Viability of the purchase of unsubsidized insurance Group II (min.)	695.64	699.46	**-261.27**	23.53
Viability of the purchase of unsubsidized insurance Group II (max.)	148.34	185.70	**-799.22**	**-709.70**
Viability of the purchase of subsidized insurance Group I (min.)	1,548.48	1,550.85	439.26	2,719.26
Viability of the purchase of subsidized insurance Group I (max.)	1,128.32	1,150.09	348.17	2,513.47
Viability of the purchase of subsidized insurance Group II (min.)	1,308.02	1,310.35	350.39	2,241.15
Viability of the purchase of subsidized insurance Group II (max.)	760.72	796.59	**-187.55**	1,507.92

Source: authors' own calculations, based on data on farmer's own labor inputs (Abramczuk, 2016; Czułowska, 2016; Skarżyńska, 2016; Żekało, 2016).

9. Determinants of the demand for crop insurance, factors motivating to purchase such insurance and factors discouraging from this – results of empirical studies

Dr inż. Joanna Pawłowska-Tyszko, dr inż. Michał Soliwoda

Insurance is only one of the instruments to manage risk by a farmer, and its choice should be based on actual needs identified, where it is impossible to find another way to protect against losses. Szumlicz indicates four elements affecting insurance needs: the need to provide the farm with additional insurance coverage, belief in the rational use of the available insurance offer, foresight making the farm inclined to pro-insurance behavior and the good financial condition of the farm (Szumlicz, 2007). In Poland, crop and livestock insurance can be divided into two groups: compulsory (or quasi-compulsory) insurance subsidized by the state and voluntary insurance. Numerous studies show that farmers use insurance to a small extent, which may be the result of their poor income situation. Wicka notes that insurance policies are purchased to a limited extent mainly due to their high price (Wicka, 2008). On the other hand, Stempel's studies show that as the acreage of farms grows, the number of farmers purchasing insurance increases, as shown by the relationship between the farm's area and the level of insurance coverage (Stempel, 2010).

The authors' study covered both farms which purchased subsidized crop insurance in 2015 and those which were not insured at this period. This assumption was adopted deliberately, as the authors' main intention was to find out the opinions about the operation of the current subsidized insurance system presented by two groups of farmers, having different attitudes to crop insurance.

The diagnostic survey was addressed to farmers who operated family farms (private farms) in all voivodeships in Poland. The farms covered by the study participated in the Polish FADN system. The selection of farms to be analyzed should be considered arbitrary (expert)[13], and the subjective selection criteria include:

- entities specialized in crop production, i.e. they represented the production type "field crops" (1 in the TF8 classification) or "mixed cropping" (61 in the TF14 classification);
- in the case of the "insured farms" sample, these entities purchased crop insurance in 2015 and in the previous year;
- farms from given the sub-samples in a given voivodeship were not adjacent to each other (they were not located in the same gmina);
- the size of the sub-sample composed of insured farms was 43, while that of the sub-sample of uninsured farms was 77; this reflects to a certain extent the percentage of farms purchasing insurance in the population of commercial farms (Polish FADN).

[13] Expert (arbitrary) selection is used, e.g. in pilot studies, in which preferences regarding the use of new public or social policy tools can be tested. This justifies the use of this type of selection to assess farmers' preferences relating to the existing system of subsidized crop and livestock insurance. Nevertheless, taking into account the above specific characteristics for farm selection to the sample, the conclusions from the conducted studies do not allow us to generalize them at the level of the population of commercial farms in Poland.

Accordingly, the study covered a total of 120 farms. The research material was collected using two separately structured survey questionnaires, addressed to the two of the above-mentioned groups of farms operated by farmers who:

1. Did not purchase subsidized crop insurance in 2015. The questionnaire addressed to them contained 5 questions, mainly semi-open ones, with a few suggested answers and an option to provide one's own replies as well, or open ones, to enable the respondents to express their opinions and comments.
2. Purchased subsidized crop insurance. The questionnaire addressed to this group of farms contained 5 questions as well, both closed and semi-open, in which the respondents had the opportunity to complete chosen answers with their own opinions, comments and suggestions.

The survey was conducted by an interviewer (FADN coordinator) by phone or in person, which made the clarification of any doubts raised by the surveyed farmers easier. The questions concerned, for example:

- familiarity with the act on subsidized insurance,
- reasons for resignation from state-subsidized insurance and motivators to purchase such insurance,
- opinion about the farmer's deductible,
- directions of changes in the subsidized insurance system,
- intention to purchase subsidized insurance policies for subsequent years.

The collected source material was subjected to a comparative analysis and presented in a tabular and descriptive form. The results were presented separately for the group of farms insuring their crops in 2015 and for farms that did not purchase subsidized crop insurance in 2015, which was necessitated by the different questions addressed to these groups. Income from the family farm and the UAA were the main criteria for the division of the analyzed farms, which were divided by the median into two groups (below and above the median).

1. On farms that did not take out state-subsidized insurance, the median for income from a family farm was PLN 146,100, and for UAA – 51.4 ha of UAA,
2. On farms that took out state-subsidized insurance, the median for income from a family farm was PLN 156,500, and for UAA – 91.6 ha of UAA.

Table 30 presents descriptive statistics for the basic production categories (i.e. acreage, share of agricultural land leased), economic categories (income from a family farm, assets and total output) and financial categories (e.g. total asset debt, equity debt) characterizing farms, as well as socio-demographic characteristics of their operators (i.e. age, higher education). Table 31 contains two basic measures of distribution variation (i.e. range and coefficient of variation, CV) for the above-mentioned variables. Table 32 presents the results of statistical verification of the hypothesis about the difference in distributions, performed using the Mann–Whitney *U* test.

The acreage of farms run by the respondents was characterized by a significant diversity. Taking into account the values of central measures, the average farm in the insureds' sub-sample had an area of 111.5 ha of UAA, while half of the farms had an area

of at least 91.6 ha of UAA. In the group of uninsured farms, the average acreage was definitely lower (90.5 ha of UAA), with a median of 51.4 ha. This indicates a distribution with right-sided asymmetry. Higher income from the family farm (average: PLN 224.4 thousand, median: PLN 156.5 thousand) was generated by farms which paid the insurance premium. In the sample of uninsured farms, the average income from the family farm amounted to PLN 153.1 thousand (median: PLN 146.1 thousand). Taking into account the values of the coefficient of variation (CV), i.e. the ratio of the standard deviation to the arithmetic mean, the distribution variation for the sub-sample of insured farms was higher for income from the family farm (96.1%) than for the farm area (59.1%). In the sub-sample of insured farms, a significant range (i.e. the difference between the maximum and the minimum) of income from the family farm was recorded (almost PLN 1,065 thousand). In the group of uninsured farms, the differentiation in income from the family farm was lower, as confirmed by the coefficient of variation (69.1%), as well as the range (PLN 671.8 thousand). There were no considerable and statistically significant differences in the percentage of agricultural land leased in the total UAA, although in the case of uninsured farms, the use of agricultural land leased was more frequent (uninsured farms, mean and median of 35.7 and 29.6%, respectively, while in the case of the insured ones – 32.4% and 26.2%, respectively).

A comparison of descriptive statistics for total output and assets generally confirms the regularities regarding the distribution of income from the family farm. In general, the sub-sample of insured farms, compared to those that did not purchase subsidized insurance, included entities with a significant total output and assets of a greater value.

Taking into account the specificity of selecting farms for the sample, the relationship between purchasing crop insurance and asset and equity debt was not confirmed. The literature on the subject, mainly Anglo–American publications, indicated that farms participating in subsidized insurance programs, mainly those relating to crops, were more indebted than uninsured entities (Enjolaras and Sentis, 2011, Ifft et al., 2013, Santaremo et al., 2016).The average asset debt in the case of insured farms was 9.9% (median: 7.0%), while in the group of uninsured farms, this debt was slightly lower (mean: 8.1%, median: 5.6%). A similar relationship was recorded with respect to equity debt. This can be explained by the combined use of several farm selection criteria as well as the limited sizes of the sub-samples.

In both analyzed sub-samples, the average age of the operator of the farm was very similar (insured – 48.8 years, uninsured – 47.2 years); however, in the sample of uninsured farms, the median was higher than the mean (50 years), which indicates a distribution with left-sided asymmetry for the variable "farmer's age". Taking into account the measures of distribution variation (Table 2), the farmer's age was characterized by similar empirical variation.

It should be noted that as much as 23.1% of operators of insured farms had higher education. Slightly less, i.e. 18.6%, of operators of farms which did not purchase crop insurance held a university degree. This may indicate that the skills gained when studying facilitate making decisions on crop insurance purchase.

Table 30. General characteristics of insured and uninsured farms in the survey sample (PLN, %)

Farm characteristic	Insured (N=43)					Uninsured (N=77)				
	$\bar{x}$	SD	Me	Min	Max	$\bar{x}$	SD	Me	Min	Max
UAA (ha)	111.5	65.9	**91.6**	23.8	367.0	90.5	51.4	**71.0**	50.1	290.3
Income from the family farm (PLN)	224,403.28	215,620.36	156,489.90	-105,753.00	958,913.00	163,113.53	113,007.80	141,639.89	16,028.28	687,868.00
Total output (PLN)	543,578.63	420,215.93	**388,723.90**	202,552.51	2,224,941.00	363,983.16	212,601.48	**319,812.00**	50,420.00	1,101,468.00
Share of leased land (%)	32.4	27.4	26.2	0.0	84.7	35.7	29.0	29.6	0.0	100.0
Total assets (PLN)	3,848,663.95	2,991,779.28	**3,407,165.00**	532,511.00	18,436,316.00	2,796,211.14	2,232,715.66	**2,186,390.00**	313,988.00	9,739,784.00
Asset debt (%)	8.1	10.5	5.6	0.0	53.1	9.9	9.8	7.0	0.0	39.3
Equity debt (%)	10.9	19.0	6.0	0.0	113.2	12.5	14.2	7.5	0.0	64.7
Farmer's age (years)*	48.8	9.2	50.0	27.0	67.0	47.2	8.9	46.0	28.0	64.0
Higher education (%)	23.1	42.7	-	-	-	18.6	39.4	-	-	-

Note: $\bar{x}$ – mean, SD – standard deviation, Me – median, * 4 respondents in the sub-sample of uninsured farms did not specify their age, hence in the case of the statistical description of this category, the sub-sample included only 39 farms; values of medians for variables in the case of which the Mann–Whithey *U* test confirmed significant, at the typically adopted level, distribution variation, were given in bold font (Table 32).
Source: own studies.

Table 31. Measures of distribution variation with respect to the variables characterizing the study sub-samples

Farm characteristic	Insured (N=43)		Uninsured (N=77)	
	Spread	CV (%)	Spread	CV (%)
Utilized agricultural area (ha, %)	343.3	59.1	240.2	56.8
Income from the family farm (PLN, %)	1,064,666.0	96.1	671,839.7	69.3
Total output (PLN, %)	2,022,388.5	77.3	1,051,048.0	58.4
Share of leased land (%)	0.8	84.6	1.0	81.2
Total assets (PLN, %)	17,903,805.0	77.7	9,425,796.0	79.8
Asset debt (%)	0.5	129.7	0.4	99.0
Equity debt (%)	1.1	174.1	0.6	113.5
Farmer's age (years, %)*	40.0	18.8	36.0	19.0
Higher education (1-yes, no-0, %)	1.0	185.0	1.0	211.6

Source: authors' own studies.

Table 32. Results of the statistical verification of distribution variations, performed using the Mann–Whitney *U* test

Variable	W statistics, p-value
Utilized agricultural area (ha, %)	W = 1,244, **p-value = 0.02449**
Income from the family farm	W = 1,345, p-value = 0.08977
Total output (PLN)	W = 1,040, **p-value = 0.0007631**
Share of leased land (%)	W = 1,723, p-value = 0.7129
Total assets (PLN)	W = 1,011, **p-value = 0.0004242**
Asset debt (%)	W = 1,840, p-value = 0.3093
Equity debt (%)	W = 1,840, p-value = 0.3093
Farmer's (years)*	W = 1,321,5, p-value = 0.2937
Higher education (1-yes, 0-no)	W = 1,430, p-value = 0.07089

Source: authors' own studies.

The results of the studies into crop state-subsidized insurance for farms which did not purchase this type of insurance in 2015 were presented broken down into two income groups (farms with smaller and farms with higher income, below and above, respectively, PLN 146.1 thousand) and two area groups (with a smaller and larger area, below and above, respectively, 51.4 ha) by the median, and for the whole sample of farms under study.

The farmers declared that they knew the Act on subsidized crop and livestock insurance to varying extents. About 70% of the farmers declared that they knew the Act, almost 29% of them had heard something about it and only slightly more than 1% of them did not know it at all (Table 33). Similar results were obtained for the surveyed area and income groups. From about 76% to over 79% of the surveyed farmers who did not purchase crop insurance in 2015, earning income above PLN 146.1 thousand and having farms larger than 51.4 hectares of UAA, declared that they knew the whole Act. However, it should be emphasized that farms earning lower income and

having smaller areas also demonstrate good familiarity with the Act (over 60% of respondents), which proves that it is not unawareness of legal regulations that was the reason for not purchasing insurance. This argument is often emphasized in numerous studies on insurance.

Table 33. Familiarity with the Act on crop and livestock insurance (%)

Item	By income from the family farm		By UAA		Total
	Lower income	Higher income	Smaller area	Larger area	
Yes	64.1	76.3	60.5	79.5	70.1
No	0.0	2.6	2.6	0.0	1.3
To a small extent	23.7	33.3	36.8	20.5	28.6

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

The studies showed that over 58% of the farmers declared that they had purchased, before 2015, state-subsidized agricultural crop insurance policies, over 32% of them had never purchased such insurance, and about 9% of the farmers did not remember if they had ever purchased such insurance (Table 34). Insurance policies were purchased before 2015 by farms earning higher income (approx. 64% of the respondents) and having larger areas (over 69% of the respondents). It should be noted that despite the declared familiarity with the Act, over 32% of the farmers never purchased this insurance; these were mostly farms with lower income – less than PLN 146.1 thousand (42.1% of the respondents), and smaller areas – below 51.4 ha of UAA (36.8% of the respondents). A specific relationship can, thus, be seen between the farm's area and income and the situation as regards insurance coverage. It can be assumed that the amount of income and the volume of agricultural output limited by the farm's area can be some of the factors affecting the purchase of an insurance policy. It seems reasonable, however, to identify other reasons limiting the purchase of such policies, which is presented further in the study.

Table 34. Declared purchase of a state-subsidized insurance policy before 2015

Item	By income from the family farm		By UAA		Total
	Lower income	Higher income	Smaller area	Larger area	
Yes	52,6	64.1	47.4	69.2	58.4
No	42.1	23.1	36.8	28.2	32.5
To a small extent	5.3	12.8	15.8	2.6	9,1

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

Almost 38% of the farmers in the surveyed population indicated that the main reason for abandoning insurance purchase was its price, which, according to the respondents, made this insurance inviable (Table 35). Another reason was the loss adjustment by insurance companies, as almost 17% of the respondents claimed that this was done in an unreliable and unfair manner. Almost 12% of the respondents indicated other reasons, in particular: insufficient budgetary funds allocated for subsidies (used up to the cap) (45% of responses); bundled offer not adapted to the farmer's needs (no drought risk in the bundle) (11% of responses); no option to insure all crops (11% of responses); lack of funds during the contracting period, and later no limit on subsidies

(22% of the responses) and an insufficient number of insurance companies whose offers could be compared to choose the most advantageous one (11% of responses). Only slightly more than 5% of the farmers did not re-insure their crops because they coped with decreased yields on their own (e.g. by diversifying their business – 45% of responses). The analyses showed that an excessively high policy price and unreliable loss adjustment were the main reasons for abandoning insurance by farmers earning income above PLN 146.1 thousand and operating farms with the UAA of over 51.4 ha (Table 35). It should be noted that farmers earning higher income and operating farms with a larger UAA tend to declare the use of other ways to mitigate farm risks much more frequently.

Table 35. Reasons for abandoning the purchase of subsidized crop insurance by farms which purchased subsidized insurance policies before 2015 (%)

Item	By income from the family farm		By UAA		Total
	Lower income	Higher income	Smaller area	Larger area	
Policies were too expensive/it was inviable for me	31,6	43.6	34.2	41.0	37.7
Loss adjustment was unreliable/unfair	10.5	23.1	7.9	25.6	16.9
I cope with decreased yields on my own, which is faster and cheaper	2.6	7.7	2.6	7.7	5.2
Other reason	15.8	7.7	7.9	15.4	11.7

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

The surveyed farmers expect certain changes to the system, which in their opinion may make them re-purchase subsidized crop insurance, thus increasing their prevalence (Table 36). When asked what should be changed to make them purchase subsidized crop insurance, more than 58% of the respondents pointed to unreliable and unfair loss adjustment by insurance companies. This is indicated by both farmers operating high- and low-income farms, as well as farmers operating farms with a smaller and larger UAA. The prevalence of insurance may be enhanced by a lower price of the insurance policy, as indicated by around 30% of the respondents. This argument is indicated slightly more often by farmers operating larger farms (approx. 31%) and earning higher income (approx. 33%). Only 18% of the farmers expect higher rates of premium subsidies; these are mainly farmers whose income is below PLN 146.1 thousand (about 26% of the responses) and those operating smaller farms, below 51.4 ha of UAA (about 34% of the farms). Over 35% of the surveyed farmers pointed to other factors affecting their willingness to re-purchase subsidized insurance. These were, starting with those most frequently indicated: an option to purchase single risk insurance (44.4% of the responses); more flexible multiple-peril insurance coverage (40.7% of the responses); higher cap on budgetary subsidies allocated for a given year (22.2% of the responses); stability of the provisions contained in the Budget Act (14.8% of the responses) and an option to insure selected crops and purchase coverage for selected risk groups (11.1% of the responses). It should be noted that the farms earning lower

income would purchase insurance if multiple-peril insurance coverage was more flexible (46.6% of the responses) and the purchase of single risk insurance was possible (38.9% of the responses), which may imply that the current offer does not meet their needs and that policies offered in the current form are expensive. The farms earning higher income indicated mainly the too low cap on subsidies allocated for premiums (50% of the responses) and the need to make multiple-peril insurance more flexible (33% of the responses).

Table 36. Changes that would make farmers, as they indicate, purchase crop insurance (%)

Item	By income from the family farm		By the UAA		Total
	Lower income	Higher income	Smaller area	Larger area	
the subsidy should be higher	26.3	10.3	34.2	2.6	18.2
the total price of the policies/insurance premium should be lower	26.3	33.3	28.9	30.8	29.9
insurance companies should perform loss adjustment in a fair and reliable manner	57.9	59.0	57.9	59.0	58.4
other	52.6	17.9	18.4	51.3	35.1

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

The surveyed farmers were also requested to answer the question what the crop and livestock insurance system in Poland should look like in their opinion. Although this question was optional, almost half (49.4%) of the surveyed farmers answered it, as presented in Table 37. The table includes only five of the most common postulates (presented in the order corresponding to the number of responses). Over 24% of farmers in the surveyed population indicate that the worst drawback of the current solutions in the area of crop and livestock insurance, which should be changed, is the too low cap on the subsidy for the insurance premium. The farmers declared that despite their intention to purchase insurance, they did not enter into insurance contracts because there were not sufficient budgetary funds for the subsidies. On the other hand, they pointed out that the conclusion of an unsubsidized insurance contract was associated with high costs, often exceeding the farm's budget for such purposes. The studies show that almost 19% of the respondents expect lower insurance premiums and introducing maximum rates for given risk groups, set by the state, and not by insurance companies. Over 16% of the respondents would accept the introduction of an insurance obligation, pointing out that this could hopefully lead to a drop in the prices of insurance policies. About 11% of the surveyed farmers point out to too frequent changes in the insurance system, which make it difficult to understand by farmers, who also perceive it as unstable. These factors discourage them from entering into insurance contracts. Therefore, farmers expect simplification of the statutory provisions,

which should be understandable for all interested parties (especially for the farmer). Simplification of the provision is expected by over 5% of the surveyed farmers. About 8% of the respondents draw attention to the problem of drought risk in insurance, which remains unresolved at the moment. In this regard they point out the lack of an insurance offer covering this risk, hence the inability to take out insurance against this risk through subsidized insurance or very high costs of drought insurance. They expect the expansion of local meteorological stations to monitor drought and other climate-related events in a given area. This can imply that they expect indexed insurance.

Table 37. Changes to the Polish crop and livestock insurance system expected by the surveyed farmers (%)

Item	Total
Higher subsidy ceiling	24.3
Lower insurance premiums/max. premium rates set by the state, not by insurance companies	18.9
The system should be compulsory	16.2
The system should be stable (no frequent statutory changes)	10.8
Opportunity to take out insurance against drought risk/ the premium adapted to drought risk	8.1
The system should be simplified	5.4

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

The results of the surveys carried out among farmers who insure their crops show that they choose to purchase subsidized crop insurance mainly due to concerns about their crops and high weather risk aversion (Table 38). Over 79% of the surveyed farmers indicate these factors as the main reasons for entering into an insurance contract. These farms are dominated by ones earning income of more than PLN 156.5 thousand and using over 91.6 ha of UAA. This means that larger area farms with larger output volume demonstrate greater propensity to insure their crops and thus secure their income. What is more, these farms earn higher income which, on the one hand, may indicate their greater capability to purchase the policy and, on the other, their greater financial stability. Over 29% of the respondents want to safely benefit from direct payments, and thus fulfil the statutory obligation to insure at least 50% of crops. This factor is indicated mainly by larger farms, using over 91.6 ha of UAA (over 20% of the respondents). It is difficult, however, to assess whether farmers who want to safely use direct payments are afraid of fines for non-compliance with the obligation, as it follows from informal conversations with these farmers that the current fine of EUR 2 for the lack of an insurance policy is not high. Thus, they are often willing to pay it, because the price of the insurance policy is disproportionately high compared to the amount of the fine. According to the farmers what prompts them to conclude an insurance contract is limiting the amount of *ad hoc* aid to half of its rate in the absence of insurance at the time a natural disaster. The survey revealed that about 16% of the surveyed farmers believe that the existing premiums are at a reasonable level and do not discourage them from purchasing insurance. A similar percentage of the respondents (around 16%) indicate that the purchase of insurance was caused by their tense financial situation which does not allow them to generate losses. Only 4.5% of the re-

spondents asked about the reason for insurance purchase indicated the administrative requirements of the agencies/banks with which they cooperate as well as a limited number of other risk management instruments that meet their needs. Only slightly more than 2% of the farms pointed out to other factors, e.g. the amount of indemnities received after the occurrence of a random event.

Table 38. Factors encouraging farmers to purchase state-subsidized crop insurance (%)

Item	By income from the family farm		By UAA		Total
	Lower income	Higher income	Smaller area	Larger area	
Insurance premiums are at a reasonable level	9.1	6.8	11.4	4.5	15.9
I do not want to risk, as there are a lot of threats, especially those related to weather	34.1	45.5	36.4	43.2	79.5
My financial situation is tense and I am concerned about further losses	9.1	9.1	9.1	6.8	15.9
This was required by the bank and/or the Agricultural Property Agency	2.3	2.3	2.3	2.3	4.5
I was to safely benefit from direct payments	13.6	13.6	9.1	20.5	29.5
There are few risk management instruments	2.3	2.3	0.0	4.5	4.5
Other (specify)	0.0	2.3	0.0	2.3	2.3

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

The analysis of the results presented in Table 40 shows what elements should be improved in the Act on subsidized crop and livestock insurance, so that farmers could continue to purchase them. These are: reliability and fairness of loss adjustment (over 68% of the surveyed farmers); adapting the insurance offer to the conditions prevailing in a given region and, first of all, to the farm (almost 48% of the respondents); maintaining or increasing the current level of the premium subsidy (about 36% of the farmers). Over 11% of the surveyed farmers indicate the need to increase the number of insurance companies offering state-subsidized insurance, and 20% of the respondents mention other factors such as: higher subsidy ceilings, an opportunity to select risks to be included in a multiple-peril insurance policy, lowering loss thresholds conditioning the payment of indemnities, extending the period of insurance contracting. The data contained in Table 39 show that the income amount and the area of the farm do not differentiate the farmers' opinions on suggested statutory changes.

Table 39. Elements that need to be improved so that farmers continue to purchase state-subsidized crop insurance

Item	By income from the family farm		By UAA		Total
	Lower income	Higher income	Smaller area	Larger area	
Premium subsidies should be higher or should remain at the present level	20.5	15.9	20.5	15.9	36.4
Insurance companies should better adapt their offers to the needs of specific farms	27.3	22.7	25.0	22.7	47.7
Insurance companies should perform loss adjustment in a fair and reliable manner	34.1	31.8	29.5	38.6	68.2
There should be more insurance companies	4.5	6.8	9.1	2.3	11.4
Other (specify)	4.5	15.9	9.1	11.4	20.5

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

The information contained in Table 40 indicates that farmers who purchased subsidized crop insurance declared that they also held commercial policies. Almost 55% of the surveyed farmers purchased this type of insurance, and about 45% did not have such coverage. It should be noted that the farms with lower income purchased commercial policies more often (about 30%) than the farms earning higher income (25% of the respondents), but these differences were not so profound (27.6% of the farms with lower income vs 27.0% of the farms with higher income). UAA did not determine the purchase of commercial insurance. Therefore, the farm's income and area are not determinants of the purchase of commercial insurance. These are other factors, not covered by this study. It can be assumed, however, that such other factors may include the exhausted limit of funds for subsidies or the absence of subsidized insurance for selected groups of insured risk and specific crops that are not covered by the Act on subsidized crop and livestock insurance.

Table 40. Commercial property insurance policies held by farms purchasing state-subsidized insurance

Item	By income from the family farm		By UA		Total
	Lower income	Higher income	Smaller area	Larger area	
yes	27.6	27.0	27.3	27.3	54.6
no	20.5	25.0	22.7	22.7	45.5

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

The farmers were also asked about their opinion on the deductible. This issue is extremely important because insurance companies claim that it should be higher, while farmers emphasize that it is already too high. The respondents' opinions can be, thus,

valuable guidance for those working on changes to the system in this respect. Table 41 shows that half of the farmers, especially those having smaller farms (27.3% of the respondents) and earning lower income (29.5% of the respondents), find the current deductible to be too high. Slightly over 27% of the farmers find it adequate, but it should be emphasized that this opinion is expressed mainly by the farmers operating larger farms (almost 27% of the respondents) and earning higher income (about 18% of the surveyed farmers).

Table 41. Opinion on the farmer's deductible

Item	By income from the family farm		By UAA		Total
	Lower income	Higher income	Smaller area	Larger area	
Adequate	9.1	18.2	4.5	22.7	27.3
Too high	27.3	22.7	29.5	20.5	50.0
I have not considered this	13.6	9.1	15.9	6.8	22.7

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

The intention to purchase insurance for the subsequent year declared by the farmers who insured their crops in 2015 proves that this instrument is needed. Almost 89% of the surveyed farmers declared their intention to purchase this insurance for the subsequent year (Table 42). This intention is declared by both small and large farms, whereby this intention is more common among farms earning higher income (50% of the respondents) and farms with UAA of over 91.6 ha (about 48% of the respondents). Only a small group of the surveyed farmers (11.4%) declared that they would not purchase insurance in the subsequent year. These were mainly owners of smaller farms (9.1% of the respondents) and those earning lower income (11.4% of the respondents). This may be due to the inadequacy of the current system to the needs of economically weaker farmers and those operating smaller-area farms. This may be evidenced by their comments concerning the level of the farmer's deductible (a significantly higher percentage of smaller-area farms and those earning lower income express their dissatisfaction in this regard than in the case of larger farms) or their declarations as regards change to the subsidy rate and adapting insurance companies' offers to the needs of specific farms (a significantly higher percentage of smaller-area farms and those earning lower income express their dissatisfaction in this respect than in the case of larger farms).

Table 42. Farmers' declarations as regards their intention to purchase insurance for the subsequent insurance year (%)

Item	By income from the family farm		By the UAA		Total
	Lower income	Higher income	Smaller area	Larger area	
yes	38.6%	50.0%	40.9%	47.7%	88.6%
no	11.4%	0.0%	9.1%	2.3%	11.4%

Source: authors' own study based on a survey carried out among farms covered by the FADN system.

Conclusions

1. The expected utility (EU) theory/hypothesis indicates that the purchase of insurance may be of interest primarily to farmers with risk aversion. It should be, however, added at this point that the demand for insurance is strongly determined by the intensification of adverse selection and moral hazard in the market as well as the level of surcharges demanded by insurance companies. Of course, this demand shows negative price elasticity, but it is characterized by positive income elasticity. Besides the EU, other concepts are developed to describe the functioning of traditional insurance. These include, first and foremost, the prospect theory (PT). It strongly emphasizes a different perception of gains and losses and the importance of subjective weighing of the probability of their occurrence. Loss aversion is the key component of the prospect theory. One thing, however, is certain: loss aversion and risk aversion are not as common among farmers as it is generally assumed. Therefore, it is extremely difficult to generate significant demand for insurance without its heavy subsidization, which holds true particularly for multiple-peril insurance. The prospect theory implies, for instance, that farmers can treat insurance purchase as a sort of investment, thus spending their own funds for this purpose can be considered as an undisputed sunk cost, while receiving indemnities is perceived as uncertain future revenue. Other farmers try to embed the purchase of insurance coverage in a comprehensive farm and family risk management system. Economic psychologists and behavioral financiers provide a huge number of surprising observations of the behavior of people considering the purchase of an insurance policy. It is, therefore, very difficult to formulate clear policy recommendations with respect to future decisions as regards insurance purchase by farmers, even if such insurance is subsidized. In Poland, the problem is extremely complicated by the fact that we do not know farmers' preferences regarding risk and losses. Extensive and systematic studies are, therefore, needed. In general, such studies are very difficult from the methodological and computational perspective. To this end, need to be supported through the state budget so that interdisciplinary teams of high-class specialists can be created and operate, accumulating experience and knowledge. The burden of exploration should focus on holistic risk management in agriculture, and not only on insurance and its subsiding.
2. A comprehensive approach to risk management in agriculture can contribute to the modernization of this sector. Access to financial services – including agricultural insurance and other risk financing instruments, such as savings or loans – can help farmers implement more efficient technologies and provide them with the opportunity to start a new production cycle after a natural disaster. Agricultural insurance should be promoted and subsidized, but only if basic services in the area of agricultural infrastructure are provided – availability of inputs and effective marketing channels for the sale of agricultural products. Such insurances can also be part of the strategy of adapting agriculture to climate change. It follows from a review of agri-insurance programs that it should take the form of public-private partner-

ships (PPPs). The level of premium subsidies should be based on actuarially sound risk calculations and the surcharges demanded by insurance companies should be acceptable for farmers and taxpayers.

3. Based on performed analyses it can be concluded that considerable changes have taken place as regards subsidized crop and livestock insurance implemented in Polish agriculture since 2005, whose main purpose was to make purchasing insurance more widespread. In 2008, this insurance became, as required by statutory provisions, compulsory, whereby the insurance obligation applies to only 50% of crops owned. However, this obligation is not satisfied by about 80% of farms. Experience gained so far in its implementation indicates the need for further changes, as the biggest problem still remains its prevalence, especially as regards: the scope and type of covered risk, as the problem of drought risk is still only partially solved; stabilization of the level of the premium subsidy; increasing the limit of premium subsidies. Increasing this limit can translate into a significant increase in its prevalence.
4. Studies presented in the literature and statistics on agricultural insurance indicate the following factors that limit the purchase of insurance policies:
   - as regards demand: unstable and insufficient amount of the premium subsidy, subsidy limits too low to the needs identified in the analyzed period, high cost of a single policy, high farmer's deductible;
   - as regards supply: too low tariff rates which qualify for subsidies, high indemnities payable by insurance companies (integral franchise), a high loss ratio recorded with respect to crop insurance, high risk of agricultural activity, frequent changes to legal provisions, which necessitates the preparation of new general insurance conditions, hence delays in the provision of services.
5. The income situation of farms purchasing crop and livestock insurance, compared to that of farms that do not use this instrument, was much better in the analyzed period. In turn, farms whose operators purchased insurance policies were characterized by higher returns on assets and equity. Entities whose operators paid the insurance premium were characterized by significantly higher debt-to-equity and debt-to-asset ratios. The relationship between farms' debt and their use of insurance coverage needs to be further explored (taking into account the direction and effects over time). This is important from the perspective of identifying the capital needs of family farms, as well as developing more precise methods of assessing the creditworthiness of these entities.
6. An analysis performed using a logit model allows for concluding that the purchase of crop insurance by farms in the analyzed period, i.e. in 2009-2015, was adversely affected primarily by the type of the farm's specialization. Farms specializing in horticultural crops, permanent crops, mixed crops, rearing dairy cattle, rearing pigs and poultry and those rearing mixed livestock, as well as farms specializing in mixed crops and livestock, were characterized by lower odds to purchase crop insurance than farms specializing in cereal, oil and protein crops. Farming on less-favored areas had also an adverse impact on the purchase of crop insurance by

farms. A positive impact in this respect was exerted by utilized agricultural area. Larger farms had higher odds to purchase insurance. Positive effects were also attributed to the education of the farmer operating the farm. However, this was the case only in the second half of the analyzed period, when higher odds to purchase insurance by farmers with secondary agricultural education were recorded. As for the region of Poland, the highest odds to purchase crop insurance were recorded for farms located in Wielkopolska and Śląsk. At the level of voivodeships, the highest odds to purchase crop insurance were recorded for farms located in the following voivodeships: Kujawsko-Pomorskie, Lubuskie and Śląskie.

7. Based on a study performed using the PSM method, it can be concluded that the purchase of crop insurance by farms did not have a significant impact on the acreage of the utilized agricultural area. It was slightly smaller than on farms which did not take out such insurance. The purchase of crop insurance had a significant and considerable impact on the total output (its value was almost PLN 130 thousand lower than on uninsured farms); income from the family farm (which was more than PLN 20 thousand lower) and the average annual amount of short-term loans (which was almost PLN 7 thousand lower). The impact on the remaining identified variables was not statistically significant.
8. The agricultural producer's decision regarding the purchase of crop insurance depends on numerous factors related to the parameters of offered insurance (mainly the insurance rate and, to a lesser extent, the franchise level, the bonus/malus system). The presented method of assessing the viability of crop insurance purchase is based on the microeconomic concept of the opportunity cost (considered from the perspective of the agricultural producer). The presented simulation examples show that determinants related to the economic situation on agricultural markets may possibly have an impact on the farmer's decision to purchase crop insurance or abandon this service. These are primarily the buying-in price of the agricultural product and the yield volume, whose levels are subject to significant fluctuations in dynamic terms, as the product of these two categories, i.e. the actual sum insured, is limited by law (e.g. regulations of the Minister of Agriculture and Rural Development). The following postulate can be made: the selection of a bundle of risk factors in a multiple-peril insurance policy should reflect the farmer's actual needs for instruments providing coverage against the most severe factors typical of a given crop. The requirement of an integral franchise in the crop insurance system may raise certain doubts and even resistance among agricultural producers. Although farmers complain about this instrument, it enables insurance companies to eliminate minor damage and, above all, inhibit moral hazard. Thus, the amount of the insurance premium may be maintained at a higher level than in the absence of a contractual clause. The presented simulation examples show that the state's participation in the subsidized crop insurance system increases the viability of insurance purchase ("gain" from it). This is particularly important in the case of insurance against drought risk, as well as at relatively high insurance rates. The results of the calculation of the viability of

crop insurance depend to a large extent on the method of determining surplus categories. For example, when unsubsidized operating income was assumed, insurance of maize for grain turned out to be inviable. When this calculation accounts for operating income less the cost of the farmer's and his family's labor input, there is a significant decrease in the viability of the purchase of insurance of crops characterized by relatively high labor intensity (e.g. sugar beets). There is also an increase in the number of inviable calculation options for the purchase of insurance of maize for grain. Although the presented calculation examples are based on numerous assumptions, the cost-effectiveness criterion adopted in the decision-making model relates strictly to the economic rationality category. It is worth considering the analysis of the farmer's decision in a 2-3 year horizon (using lagged variables) and taking into account the amount of received indemnities. It would be necessary to confront the applied model with the decision-making rules applied by farmers themselves when considering the purchase of insurance.

9. Analysis of the group of uninsured farms shows that over 70% of farmers declare that they are familiar with the Act on subsidized crop and livestock insurance, which means that it is not unfamiliarity with the law that makes farmers not insure their crops, as frequently emphasized in numerous studies on this subject. Farmers that have never decided to purchase insurance despite their familiarity with the law operate mostly farms earning lower income, with UAA of less than 51.4 ha. Therefore, the purchase of an insurance policy can depend, *inter alia*, on the income level and the output volume, limited by the farm's area.
10. An analysis of farms holding crop insurance policies shows that the basic reasons that prompted farmers to purchase subsidized insurance include their intention to comply with the statutory obligation to insure 50% of crops and concerns about the future of their farms. Such declarations were made by 79% of farms, especially those with larger UAA (about 43% of the respondents) and higher income (about 45%). This means that larger farms with a greater output volume tend to be more inclined to insure their crops, and thus secure their income. The decision to purchase an insurance policy may also be due to a possible reduction in the amount of *ad hoc* aid to half of its rate in the absence of insurance at the time a natural disaster occurs. This decision is hardly ever motivated by the amount of the fine for the lack of insurance. This may imply that higher fines could induce some farmers to conclude an insurance contract.
11. Insured and uninsured farmers show some differences as regards changes they expect in the current agricultural insurance system. The former mentioned mainly: the reliability and fairness of loss adjustment, adaptation of the insurance offer to the region's constraints, and, above all, the needs of the specific farm, maintaining the current level of premium subsidies or its increase and increasing the number of insurance companies offering state-subsidized insurance. The latter emphasized the need to: increase annual subsidy limits, set insurance premiums at a lower level, introduce compulsory insurance, reduce the frequency of amendments to the Act, regulate the drought risk problem in the Act (lower costs, higher subsidies) and simplify statutory provisions.

References

1. Abramczuk Ł. (2016), *Buraki cukrowe*, [in:] *Produkcja, koszty i dochody z wybranych produktów rolniczych w latach 2014-2015 (wyniki rachunku symulacyjnego)* (ed. M. Żekało), IERiGŻ-PIB, Warszawa.
2. Ackert F.L., Deaves R. (2012), *Understanding Behavioral Finance*, Cengage, India.
3. Act of 19 December 2008 on amendment to the Act on freedom of economic activity and certain other (Journal of Laws 2009 No.18 item 97).
4. Act of 2 December 1958 on property and personal insurance (Journal of Laws 1958 No.72 item 357).
5. Act of 20 September 1984 on property and personal insurance (Journal of Laws 1984 No.45 item 242).
6. Act of 22 May 2003 on obligatory insurance by the Insurance Guarantee and on the Polish Motor Insurance Bureau (Journal of Laws 2003 No.124 item 1152).
7. Act of 24 April 2015 on amendment to the Act on crop and livestock insurance (Journal of Laws 2015 item 892).
8. Act of 25 July 2008 on amendment to the Act on crop and livestock and the Act on the national producer registration system, register of farms and register of applications for payment (Journal of Laws 2008 No.145 item 918).
9. Act of 25 March 2011 on limiting administrative barriers for citizens and entrepreneurs (Journal of Laws No.106. item 622).
10. Act of 27 April 2006 on amendment to the Act on crop and livestock insurance subsidies (Journal of Laws 2006 No. 120 item 825).
11. Act of 28 July 1990 on insurance activity (Journal of Laws 1990 No.59 item 344).
12. Act of 28 March 1952 on state insurance (Journal of Laws 1952 No. 20, item 130).
13. Act of 7 July 2005 on crop and livestock insurance (Journal of Laws 2005 No.150 item 1249 as amended, Journal of Laws of 2015 item 577, 892, 1844).
14. Act of 7 March 2007 on amendment to the Act on crop and livestock insurance subsidies and certain other acts (Journal of Laws 2007 item 49 item 328).
15. Agresti A. (2002), *Categorical Data Analysis*, John Wiley & Sons, New Jersey.
16. Agrokoszty (2017), *Metodyka i zakres badań,* http://www.agrokoszty.pl/index.php?id=43.
17. Agrokoszty (2017), *System Zbierania Danych o Produktach Rolniczych*, http://www.agrokoszty.pl/index.php?id=19.
18. *Applied Risk Management in Agriculture* (2010), D.L. Hoag (ed.), CRC Press, Boca Raton, London, New York.
19. Arrow K.J. (1979), *Eseje z teorii ryzyka*, tran. B. Samojlik, PWN, Warszawa.
20. Babcock A.B. (2015), *Using cumulative prospect theory to explain anomalous crop insurance*, American Journal of Agricultural Economics, vol. 97, no. 5.
21. Barnett B., Barrett Ch.B., Skees J.R. (2008)*, Poverty Traps and Index-Based Risk Transfer Products,* World Development Vol. 36, No. 10.
22. Barry P.J, Ellinger P.N., Hopkin J.A., Baker C.B. (2000), *Financial Management in Agriculture* (Sixth Edition), Interstate Publishers, Danville, Illinois.

23. Batóg B., Wawrzyniak K. (2005), *Modele probitowe i logitowe jako podstawa systemu diagnoz na przykładzie sektorów Warszawskiej Giełdy Papierów Wartościowych*, Zeszyty Naukowe Uniwersytetu Szczecińskiego, nr 415, Prace Katedry Ekonometrii i Statystyki, nr 16.
24. Binswanger H.P. (1981), *Attitudes toward Risk: Theoretical Implications of an Experiment in Rural India*, The Economic Journal, vol. 91.
25. Bocquého G., Jacquet F., Reynaud A. (2014), *Expected utility or prospect theory maximisers? Assessing farmers' risk behaviour from field-experiment data*, European Review of Agricultural Economics, vol. 41, no. 1.
26. Breusted G., Larson D. (2006), *Mutual Crop Insurance and Moral Hazard: The Case of Mexican Fondos*. Paper presented at the annual meeting of the International Association of Agricultural Economists.
27. Brewer B.E., Wilson C.A., Featherstone A.M., Harris J.M., Erickson K., Hallahan, C. (2012), *Measuring the financial health of U.S. production agriculture*, Journal of the ASFMRA.
28. Briggeman B.C., Towe C.A., Morehart M.J., (2009), *Credit constraints: Their existence, determinants, and implications for US farm and nonfarm sole proprietorships*, American Journal of Agricultural Economics, 91(1).
29. Budget Act for 2005-2015.
30. Butryn B., Fura M. (2005), *Wyznaczanie prawdopodobieństwa podjęcia decyzji z użyciem modelu probitowego i logitowego*, Badania Operacyjne i Decyzje, nr 2.
31. Caliendo M., Kopeinig S. (2005), *Some Practical Guidance for the Implementation of Propensity Score Matching*, German Institute for Economic Research IZA, Berlin.
32. Cantillon R. (1938), *Essai sur la nature du commerce en general*, ed. and tran. Zawadzki W., *Ogólne rozważania nad naturalnymi prawami handlu*, Szkoła Główna Handlowa w Warszawie – Skład Główny „Biblioteka Polska", Warszawa.
33. Coate S. (1995), *Altruism, the Samaritan's Dilemma, and Government Policy Transfer,* American Economic Journal 85 (1).
34. Coble H.K., Knight O.T., Pope D.R., Willims R.J. (1996), *Modeling Farm-Level Crop Insurance Demand with Panel Data*, American Journal of Agricultural Economics, vol. 78.
35. COM (2013), *An EU Strategy on adaptation to climate change, Communication from the Commission to the European Parliament*, *the Council, the European Economic and Social Committee and the Committee of the Regions*, COM(2013) 216 final, Brussels 16.04.2013.
36. Commission Regulation (EC) No 1857/2006 of 15 December 2006 on the application of Articles 87 and 88 of the Treaty to State aid to small and medium-sized enterprises active in the production of agricultural products and amending Regulation (EC) No 70/2001.
37. Cummins J.D., Mahul O. (2009), *Catastrophe Risk Financing in Developing Countries: Principles for Public Intervention*, Washington, DC: World Bank.

38. Cutler M.D., Zeckhauser R. (2004), *Extending the Theory of Meet the Practice of Insurance*, [in:] Litan R., Herring R. (ed.), Brookings-Warton Papers on Financial Services.
39. Czarny E. (2006), *Mikroekonomia*, Polskie Wydawnictwo Ekonomiczne, Warszawa.
40. Czułowska M. (2016), *Pszenica ozima* [in:] *Produkcja, koszty i dochody z wybranych produktów rolniczych w latach 2014-2015 (wyniki rachunku symulacyjnego)* (ed. M. Żekało), IERiGŻ-PIB, Warszawa.
41. Dhami S. (2017), The Foundations of Behavioral Economic Analysis, Oxford University Press, Oxford, New York.
42. Döring T. (2015), *Öffentliche Finanzen und Verhaltensökonomik. Zur Psychologie budgetwirksamen Staatstätigkeit*, Springer Gabler, Wiesbaden.
43. Du X., Feng H., Hennessy A.D. (2017), *Rationality of Choices in Subsidized Crop Insurance Markets,* American Journal of Agricultural Economics, vol. 99, no. 3.
44. EEA (2008), *Impacts of Europe's changing climate – 2008 indicator-based assessment*, Report No 4/2008.
45. Enjolras G., Sentis P. (2011), *Crop insurance policies and purchases in France*, Agricultural Economics, 42 (2011).
46. Falkowski A., Zaleśkiewicz T. (ed.) (2012), *Psychologia poznawcza w praktyce. Ekonomia, biznes, polityka,* Wydawnictwo Naukowe PWN, Warszawa.
47. Floriańczyk Z., Osuch D., Płonka R. (2016), *Wyniki standardowe 2015 uzyskane przez gospodarstwa rolne uczestniczące w Polskim FADN. Część I. Wyniki standardowe*, IERiGŻ, Warszawa.
48. Fritsch M. (2014), *Marktversagen und Wirtschaftspolitik.* Mikroökonomische *Grundlagen Staatlichen Handelns*, Vollständing überarbeitete Auflage 9, Verlag Franz Vahlen, München.
49. Goodwin K.B. (2011), *Problems with Market Insurance in Agriculture*, American Journal of Agricultural Economics, vol. 83, no. 3.
50. Goodwin K.B., Smith H.V. (1995), *The Economics of Crop Insurance and Disaster Relief*, AEI Press, Washington DC.
51. Goodwin K.B., Smith H.V. (2013), *What Harm is Done by subsidizing Crop Insurance?*, American Journal of Agricultural Economics, vol. 95, no. 2.
52. Góral J. (ed.) (2016), *Subsydia a ekonomika, finanse i dochody gospodarstw rolniczych (2)*, IERiGŻ-PIB, Monografie Programu Wieloletniego 2015-2019, Warszawa 2016.
53. Gruszczyński M. (2012), *Modele zmiennych jakościowych dwumianowych*, [in:] Gruszczyński M. (ed.), *Mikroekonometria. Modele i metody analizy danych indywidualnych*, Wolters Kluwer Polska, Warszawa.
54. Handschke J., Monkiewicz J. (ed.) (2010), *Ubezpieczenia. Podręcznik Akademicki,* Poltext, Warszawa.
55. Hardaker B.J. (2000), *Some issues in dealing with risk in agriculture*, Working Paper Series in Agricultural and resource Economics, nr 3. University of New England, Armidale.

56. Hardaker B.J., Gudbrand L., Anderson R.J., Huirne M.B.R. (2015), *Coping with Risk in Agriculture*, 3rd Edition, Applied Decision Analysis, CABI, Wallingford, Boston.
57. Hazell P., Pomareda C., Valdes A. (1986), *Crop Insurance for Agricultural Development*. *Issues and Experience*, The Johns Hopkins University Press, Baltimore and London.
58. Hazell P.B.R. (1992), *The Appropriate Role of Agricultural Insurance in Lower Income Countries*. Journal of International Development 4 (6).
59. Horowitz J. K., Lichtenberg E. (1993), *Insurance, Moral Hazard, and Chemical Use in Agriculture*, American Journal of Agricultural Economics 75 (4).
60. Ifft J., Kuethe T., Morehart M. (2013), *Farm Debt Use by Farms with Crop Insurance. Choices.* Quarter 3. http://www.choicesmagazine.org/choices-magazine/theme- articles/current-issues-in-risk-management-and-us-agricultural-policy/farm-debt-use-by-farms-with-crop-insurance (10.06.2017).
61. *Impacts of Europe's changing climate. An indicator – based assessment*, EEA Report, No. 2/2004.
62. *IPCC (Intergovernmental Panel for Climate Change,* (2007). IPCC Fourth Assessment Report. Geneva.
63. Jackowska B. (2011), Efekty interakcji między zmiennymi objaśniającymi w modelu logitowym w analizie zróżnicowania ryzyka zgonu, Przegląd Statystyczny, tom 58, zeszyt 1-2.
64. James P.C., Nair R. (2009), *A Study of Yield-Based Crop Insurance in India: A Performance Review. Agricultural Insurance Company of India*: New Delhi.
65. Janowicz-Lomott M., Łyskawa K. (2016), *Funkcjonowanie dotowanych ubezpieczeń upraw w Polsce*, Wiadomości ubezpieczeniowe 2/2016, PIU, Warszawa.
66. Jensen M.C., Meckling W.H. (1976), *Theory of the firm: Managerial behavior, agency costs and ownership structure*, Journal of Financial Economics, vol. 3, no. 4, 1976.
67. Jerzak M.A., Czyżewski A. (2006), *Ekonomiczne uwarunkowania wykorzystania rynkowych narzędzi stabilizacji cen i zarządzania ryzykiem w rolnictwie*, Wydawnictwo Akademii Rolniczej w Poznaniu.
68. Jong P., Heller G.Z. (2008), *Generalized Linear Models for Insurance Data*, Cambridge University Press, Cambridge.
69. Kaczała M., Łyskawa K. (2010), *Ubezpieczenia przedsiębiorstw /gospodarstw rolnych*, [in:] ed. Gąsiorkiewicz L., Monkiewicz J., *Ubezpieczenia w zarządzaniu ryzykiem przedsiębiorstwa (tom 2)*, Poltext, Warszawa.
70. Klimowski C. (2002), *Istota, skutki i zarządzanie ryzykiem katastroficznym w rolnictwie polskim*, Wyd. IERGŻ, Warszawa.
71. Kłoczko-Gajewska A., Sulewski P. (2009), *Postawy rolników wobec ryzyka i sposoby jego ograniczania*, Roczniki Nauk Rolniczych, SERIA G, T. 96, Z.1, 2009.
72. Knight F.H. (1921), *Risk, Uncertainty and Profit*, Schaffner &Marx, Boston, http://www.econlib.org/library/Knight/knRUP.html.

73. Kobus P. (2013), *Ryzyko występujące w produkcji roślinnej, metody jego pomiaru*, [in:] Wicka A. (ed.) Czynniki i możliwości ograniczania ryzyka w produkcji roślinnej poprzez ubezpieczenia, Wydawnictwo SGGW, Warszawa.
74. Kobus P. (2016), *Determinanty poziomu ubezpieczeń rolniczych*, Studia i Prace WNEiZ US, nr 45/2.
75. Konarski R., Kotnarowski M. (2007), *Zastosowanie metody propensity score matching w ewaluacji ex-post*, [in:] ed. Haber A., *Ewaluacja ex-post. Teoria i praktyka badawcza*, Polska Agencja Rozwoju Przedsiębiorczości, Warszawa.
76. Kowalewski E., Ziemiak M. (2013), *Stan prawny ubezpieczeń obowiązkowych w Polsce, Polska Izba Ubezpieczeń*, Warszawa
77. Kulawik J. (ed.) (2014), *Dopłaty bezpośrednie i dotacje budżetowe a finanse oraz funkcjonowanie gospodarstw i przedsiębiorstw rolniczych (4)*, IERiGŻ-PIB, Warszawa.
78. Kunreuther C.H., Pauly V.M., McMorrow S. (2013), *Insurance & Behavioral Economics. Improving Decisions in the Most Misunderstood Industry*, Cambridge University Press, New York.
79. Kurdyś-Kujawska A. (2016), *Ubezpieczenia gospodarcze jako czynnik zapewniający zrównoważony rozwój gospodarstw rolnych*, Prace Naukowe UE we Wrocławiu, nr 436.
80. Lange O. (1967), *Optymalne decyzje. Zasady programowania*, wyd. 2 popr., PWN, Warszawa.
81. Lipińska I. (2012), *Z problematyki ubezpieczeń upraw rolnych i zwierząt gospodarskich*, Przegląd Prawa Rolnego Nr 2(11), Warszawa.
82. Maddala G.S. (2008), *Ekonometria*, Wydawnictwo Naukowe PWN, Warszawa.
83. Mahul O., Skees J.R. (2007), *Managing Agricultural Risk at the Country Level: The Case of Index-Based Livestock Insurance in Mongolia*, World Bank Policy Research Working Paper 4325, Washington, DC.
84. Mahul O., Stutley Ch.J. (2010), *Government Support to Agricultural Insurance Challenges and Options for Developing Countries,* The Word Bank, Washington.
85. McCullagh P., Nelder J.A. (1989), *Generalized Linear Models*, Chapman & Hall, London.
86. Minc B. (1997), *Systemy ekonomiczne*, t.2, PWN, Warszawa.
87. Mishra A.K., Goodwin B.K. (2006), *Revenue insurance purchase decisions of farmers,* Applied Economics, 2006, 38.
88. NBP (2017), *Statystyka i sprawozdawczość. Nowa statystyka stóp procentowych.* https://www.nbp.pl/home.aspx?f=/statystyka/pieniezna_i_bankowa/oprocentowanie_n.html (6.06.2017).
89. Orlicka J. (2006), *O kontrowersjach wokół ustawy o dopłatach do ubezpieczeń upraw rolnych i zwierząt gospodarskich*, Ustawodawstwo i Orzecznictwo, nr 1.
90. Pawłowska-Tyszko J. (2011), *Ubezpieczenia majątkowe w rolnictwie polskim*, Zagadnienia Ekonomiki Rolnej, nr 1.

91. Pearcy J., Smith H. (2015), *The Tangled Web of Agricultural Insurance: Evaluating the Impacts of Government Policy*, Journal of Agricultural and Resource Economics, vol. 40, no. 1.
92. Piet L., Bougherara D. (2016), *The impact of farmers' risk preferences on the design of an individual yield crop insurance*, INR, Paris.
93. PZU (2017), *Ogólne warunki ubezpieczenia upraw ustalone uchwałą z dnia 28 czerwca 2007 r. ze zmianami ustalonymi uchwałą nr UZ/10/2011 Zarządu PZU SA z dnia 7 stycznia 2011 r. oraz uchwałą nr UZ/55/2012 Zarządu PZU SA z dnia 17 lutego 2012 r*. https://www.pzu.pl/c/document_library/get_file?uuid=744a48f5-029a-4835-9e66-39f66b894378&groupId=10172.
94. RCL (2016), *Uzasadnienie: Projekt ustawy o zmianie ustawy o ubezpieczeniach upraw rolnych i zwierząt gospodarskich.* https://legislacja.rcl.gov.pl/docs//2/12281402/12334151/12334152/dokument209144.pdf.
95. Regulation of the Council of Ministers of 14 February 1963 on obligatory insurance of crops (Journal of Laws No. 57, item 261).
96. Regulation of the Council of Ministers of 23 October 1956 on organization and financing of activities to prevent fire damage and damage to the livestock population (Journal of Laws No. 49, item 217).
97. Regulation of the Council of Ministers of 24 November 1956 on obligatory insurance of crops against hailstorms and floods (Journal of Laws No. 57, item 262).
98. Regulation of the Minister of Agriculture and Rural Development of 27 November 2015 on maximum sums insured for respective agricultural crops and livestock for 2016 (Journal of Laws of 2015 No. 0 item 2003).
99. Rejda E.G., McNamara J.M. (2017), *Principles of Risk Management and Insurance*, Thirteenth Edition, Pearson, London, New York.
100. Rembisz W. (2009), *Instrumenty rynku rolnego*, Vizja Press & IT , Warszawa.
101. Ronka-Chmielowiec W. (2002), *Ryzyko jako przedmiot ubezpieczenia*, [in:] Ronka-Chmielowiec W. (ed.) *Ubezpieczenia. Rynek i ryzyko*, PWE, Warszawa.
102. Rynek ubezpieczeń. Dane za okres 2006-2016. KNF
103. Rządowy projekt ustawy o zmianie ustawy o ubezpieczeniach upraw rolnych i zwierząt gospodarskich (2016). http://www.sejm.gov.pl/sejm8.nsf/agent.xsp?symbol=RPL&Id=RM-10-19-16.
104. Santeramo F.G., Goodwin B.K., Adinolfi F., Capitanio F. (2016*), Farmer Participation, Entry and Exit Decisions in the Italian Crop Insurance Programme*, Journal of Agricultural Economics, Vol. 67, No. 3.
105. Schmitz A., Moss B.Ch., Schmitz G.T., Furten W.W., Schmitz C.H. (2010), *Agricultural policy, Agribusiness and Rent-Seeking Behaviour*, University of Toronto Press, Toronto, Buffalo, London.
106. Serra T., Goodwin K.B., Featherstone M.A. (2003), *Modeling changes in the U.S. demand for crop insurance during the 1990s*, Agricultural Finance Review, vol. 63, no. 2.

107. Shaik E.A., Coble H.K., Knight O.T., Baquet E.A., Patrick F.G. (2008), *Crop Insurance and Yield Insurance Demand: A Subjective Probability Approach*, Journal of Agricultural and Applied Economics, vol. 40, no. 3.
108. Sherrick J.B., Barry J.P., Ellinger N.P., Schnitkey D.G. (2004), *Factors Influencing Farmers Crop Insurance Decisions*, American Journal of Agricultural Economics, vol. 86, no. 1.
109. Siamwalla A., Valdes A. (1986), *Should Crop Insurance be Subsidized?" In Crop Insurance for Agricultural Development*, ed. P. B. R. Hazell, C. Pomareda, A. Valdes. Baltimore MD: Johns Hopkins University Press.
110. Sielska A., Pawłowska A. (2016), *Szacowanie efektu oddziaływania polityki rolnej na wartość dodaną z wykorzystaniem propensity score matching*, Monografie Programu Wieloletniego 2015-2019, Nr 25, IERiGŻ, Warszawa.
111. Skarżyńska A. (2016). *Wyniki ekonomiczne wybranych produktów rolniczych w 2015 roku*. IERiGŻ-PIB, Warszawa.
112. Skarżyńska A., Jabłoński K (2016), *Koszty jednostkowe i dochody wybranych produktów w 2014 roku – wyniki badań w systemie Agrokoszty*, Zagadnienia Ekonomiki Rolnej, nr 2(347).
113. Smith H.V. (2011), *Premium Payments. Why Crop Insurance Costs Too Much*, American Enterprise Institute, Washington DC.
114. Smith H.V., Glauber W.J. (2012), *Agricultural Insurance in Developed Countries: Where Have We Been and Where Are We Going?*, „Applied Economic Perspectives and Policy", vol. 34, no. 3.
115. Smith H.V., Glauber W.J., Dismukes R. (2016), *Rent dissipation in the US Agricultural Insurance Industry*, IFPRI, Washington D.C.
116. Smith H.V., Watts A.M. (2009), *Index Based Agricultural Insurance in Developing Countries*, Report prepared for the Bell and Melina Gates Foundation.
117. Smith V.H., Goodwin B.K. (1996), *Crop Insurance, Moral Hazard, and Agricultural Chemical Use,* American Journal of Agricultural Economics 78 (May).
118. Smolik A. (develop.) (2016), *Jak rozumieć zawartość Raportu Indywidualnego Gospodarstwa Rolnego (wersja 2015*), IERIGŻ-PIB, Warszawa. http://fadn.pl/wpcontent/uploads/2017/01/Jak_rozumiec_zawartosc_publikacji_Raport_Indywidualny2015.pdf (10.06.2017).
119. Snowdon B., Vane H., Wynarczyk P. (1998), *Współczesne nurty teorii makroekonomii*, Wydawnictwo Naukowe PWN, Warszawa.
120. Soliwoda M. (2016), *Crop and livestock insurance in Poland reconsidered: challenges from the perspective of agricultural policy*. Paper presented at 156th EAAE Seminar "Prospects for agricultural insurance in Europe", Wageningen UR, the Netherlands, October, 3-4, 2016. http://ageconsearch.tind.io/record/249991/files/Soliwoda%20%20PL%20EAAE%20Seminar%20Wageningen_full%20paper%208.10.2016.pdf.

121. Soliwoda M., Herda-Kopańska J., Gorzelak A., Pawłowska-Tyszko J. (2016), *Instrumenty zarządzania ryzykiem w rolnictwie - rozwiązania krajowe i międzynarodowe*, Monografie Programu Wieloletniego 2015-2019, nr 35, IERiGŻ-PIB, Warszawa.
122. Sprawozdania z wykonania ustawy budżetowej 2006-2016.
123. Sproul T., Michaud P.C. (2017), *Heterogenity in loss aversion: evidence from field elicitations*, Agricultural Finance Review, vol. 77, no. 1.
124. Stempel R. (2010), *Ubezpieczenia rolne w gospodarstwach rolników indywidualnych Polski północnej*, Wiadomości Ubezpieczeniowe 2/2010, Warszawa.
125. Stigler J.G. (1971), *The theory of economic regulation*, Bell Journal of Economics and Management Science, vol. 2, no. 1.
126. Stiglitz E.J., Rosengard K.J. (2015), *Economics of the Public Sector, fourth edition*, W.W. Norton & Company, Inc, New York, London.
127. Stroiński E. (2006), *Ubezpieczenia majątkowe i osobowe w rolnictwie*, Wydawnictwo Akademii Finansów, Warszawa.
128. Szumlicz T. (2007), *Ubezpieczenia*, [in:] *Diagnoza społeczna 2007. Warunki i jakość życia Polaków*, Warszawa.
129. Szymecka A. (2008), *Ubezpieczenia gospodarcze jako instrument zarządzania ryzykiem w rolnictwie. Doświadczenia wybranych państw Unii Europejskiej*, Przegląd Prawa Rolnego, nr 2 (4).
130. Śmiglak-Krajewska M. (2014), *Sposoby ograniczania ryzyka w gospodarstwach rolnych z terenu województwa kujawsko-pomorskiego*, Roczniki Naukowe Ekonomii Rolnictwa i Rozwoju Obszarów Wiejskich, t.101, z.4., Warszawa.
131. Thünen J.H. (1910), *Der isolierte Staat in Beziehung auf Landwirtschauft und Nationalökonomie*, Verlag von Gustav Fischer, Jena.
132. Trzciński R. (2009), *Wykorzystanie techniki propensity score matching w badaniach ewaluacyjnych*, Polska Agencja Rozwoju Przedsiębiorczości, Warszawa.
133. Uzasadnienie Projektu ustawy o ubezpieczeniach upraw i zwierząt gospodarskich z 2015 roku (druk 3247), http://www.sejm.gov.pl (access: 05-06-2017).
134. Varangis P., Larson D.J., Anderson J. (2002), *Agricultural Markets and Risks: Management of the Latter, Not the Former*, World Bank Policy Research Working Paper 2793, Washington, DC.
135. Velandia M., Rejesus M.R., Knight O.T., Sherrick J.B. (2009), *Factors Affecting Farmers' Utilization of Agricultural Risk Management Tools: The Case of Crop Insurance, Forward Contracting and Spreeding Sales*, Journal of Agricultural and Applied Economics, vol. 41, no. 1.
136. Wang Y., Annan F. (2016), *On the Demand for Federal Crop Insurance. Selected Paper prepared for presentation at the 2015 Agricultural & Applied Economics Association and Western Agricultural Economics Association Annual Meeting*, Boston, Massachusetts, July 31-August 2, http://ageconsearch.umn.edu /record/235250/files/2016AAEA.pdf

137. Wicka A. (2008), *Ubezpieczenia rolnicze źródłem osiągania przewagi konkurencyjnej gospodarstw rolnych*, Roczniki Naukowe Seria, tom X, Zeszyt 1, Warszawa-Poznań-Lublin.
138. Wicka A. (2011), *Ubezpieczenia gospodarcze w rolnictwie w latach 2004-2010*, Roczniki Naukowe SERiA, nr 1.
139. Wicka A., Wojciechowska-Lipka E. (2009), *Wspólna Polityka Rolna a ubezpieczenia gospodarcze w rolnictwie polskim*, Zeszyty Naukowe SGGW w Warszawie. Polityki Europejskie, Finanse i Marketing, nr 2 (51).
140. Wilkinson N., Klaes M. (2012), *An Introduction to Behavioral Economics*, 2nd Edition, Palgrave Macmillen, New York.
141. Willett A.H. (1901), *The Economic Theory of Risk and Insurance, Studies of History*, Economics and Public Law, vol. XIV, no. 2, The Columbia University Press, New York.
142. Williams C.A., Smith M.L., Young P.C. (2002), *Zarządzanie ryzykiem a ubezpieczenia*, Wydawnictwo Naukowe PWN, Warszawa.
143. Williamson O.E. (2002), *The theory of the firm as governance structure: from choice to contract*, The Journal of Economic Perspectives 16 (3).
144. World Bank (2010), *Managing Agricultural Production Risks: Innovations in Developing Countries*. Report 32727, Agriculture and Rural Development Department, Washington, DC.
145. Woś A. (1996), *Prognoza przekształceń strukturalnych polskiego rolnictwa do 2020*, IERiGŻ, Warszawa.
146. Wright B.D., Hewitt J.A. (1994), *All Risk Crop Insurance: Lessons from Theory and Practice." In Economics of Agricultural Crop Insurance: Theory and Evidence,* ed. Darell L. Hueth and W. Hartley Furtan. Boston: Kluwer.
147. Zaleśkiewicz T. (2012), *Psychologia ekonomiczna*, Wydawnictwo Naukowe PWN, Warszawa.
148. Zweifel P., Eisen R. (2012), *Insurance Economics*, Springer-Verlag, Berlin, Heidelberg.
149. Żekało M. (2016), *Produkcja, koszty i dochody z wybranych produktów rolniczych w latach 2014-2015 (wyniki rachunku symulacyjnego)*, IERiGŻ-PIB, Warszawa.
150. Żekało M. (2016), *Rzepak ozimy*, [in:] *Produkcja, koszty i dochody z wybranych produktów rolniczych w latach 2014-2015 (wyniki rachunku symulacyjnego)*, (ed. M. Żekało), IERiGŻ-PIB, Warszawa.

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Print run: 250 copies, 8.87 publisher`s sheets
Printing and binding: ZAPOL Sobczyk Spółka Jawna