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Risks in agriculture and opportunities of their integrated evaluation

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Abstract

Agriculture is a unique sector because of its dependence on the climate and biological variables. Therefore, in agriculture it is vital to identify and evaluate risks to be sure that decisions made on the farm will bring positive results. Scientific literature describes a lot of risk evaluation methods. However it is not easy to see which methods should be used in the agricultural sector. This article describes the main types of risk in agriculture, their features and their relevance with respect to scientific theories. Secondly, it introduces the most popular risk evaluation methods and their potential use in agriculture and finally presents a logical framework of integrated risk evaluation.

Keywords: Agricultural risk, risk types, risk evaluation methods, integrated evaluation;

1. Introduction

Agricultural business organizations and farmers are more likely to face risks than other business sectors owing to the fact that agricultural products and services are related to natural processes, biological assets, and plant and animal diseases. Agriculture is highly exposed to adverse natural events, such as insect damage or poor weather conditions, which have a negative impact on the production. In the future, climate change may lead to a further increase in the economic costs of major climatic disasters. Therefore farmers have to develop risk management strategies to cope with those adverse events and sometimes to use government assistance. Hence in agriculture it is extremely important to evaluate and manage agricultural risks and to select the best management methods.

Integrated risk assessment helps to identify more than one risk and leads to greater decision-making efficiency. As mentioned above, agriculture is a very specific industry because of its dependence on the weather and climate. In scientific literature, individual risk assessment is widely analyzed while integrated risk assessment is usually limited to integration of two risks and it is mainly used in the banking sector.

Scientific problem: what kind of risks can integrated approach be applied to and how those risks affect the economic decision-making process on farms.

Aim: to identify the types of risks that have the greatest impact on agriculture and to analyze the possibilities to create an integrated risk assessment model.

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Tasks:

1. to identify the main types of agricultural risks and the circumstances of their occurrence;
2. to reveal their relevance with respect to scientific theories;
3. to analyze risk evaluation methods and their specific features;
4. to create a logical framework for integrated risk evaluation in agriculture.

Research methods: the theoretical risks analysis is based on common scientific research methods: generalization and comparative analysis. The techniques of deduction, induction, modeling and synthesis are used to create a logical framework for the integrated risk assessment model.

2. Risks in Agriculture

Risks in agriculture have been a matter of worldwide concern since 1933, when the risk analysis framework was oulined by Knight (2002). The analysis of literature in the field of agricultural risk (Halter, 1971; Dillon, 1971, Hardaker, 2004; Landanyi, 2003) shows that it is difficult to evaluate and manage risks in agriculture. Agricultural enterprises have to cope with large numbers of uncertainties. Agricultural economics literature describes a number studies on estimating farmer risk preferences (Gomez-Limon *et al*., 2003; Isik, Khanna, 2003; Toledo, Engler, 2008) and provides models to understand how a farmer decides among a set of random choices (Hardaker *et al*., 2004; Bradshaw, 2004). In general, all those studies focus on a limited set of risk sources pick out several measurable and non-measurable risk factors from the analysis. To this effect, measuring the importance of different risk sources, which influence farmers' decisions, and constructing management tools to assist the decision-making process have received less adequate attention in the literature.

According to Baquet *et al*. (1997), there are five distinct risk factors in agriculture: production risk, marketing risk, credit risk, personal risk, and environmental risk. Whereas Hardaker et al (2004) expand this list with political and business risks. Thus each of those risks play a role in the farmer decision-making process and therefore it is crucial to evaluate and measure risks in agriculture in a competent way.

Risk management may be split into a number of steps that should be taken in a routine and cyclic way by each organization. Those steps are outlined by Hardarker et al (2004), who argue that risk evaluation is a key step.

First, it is important to define risk. Scientific literature offers many different definitions. According to Rockett (1999), the concept of risk is rather broad and it is often confused with such concepts as harm, danger, threat or uncertainty. Others argue that risk is an event or its outcome probability. Risk includes both potential benefit and potential loss. Jasanoff (1998) supports the opinion of Hardarker et al (2004) and considers that the concept of risk analysis is the most important step in the decision-making process that can help to pursue profitable activities.

Aleknevičienė (2005) argues that people usually take risk in anticipation of better results. According to the author, market activities are aimed at earning maximum profits and gaining the largest market share, thus the main goal is clearly to win. On the other hand there is a desire to prevent the likelihood of failure or to minimize it. Consequently, this paper will interpret the concept of risk as a possibility to suffer financial losses.

The paper provides analysis of the main risk types in agriculture and reveals their relation to different scientific theories (Figure 1).

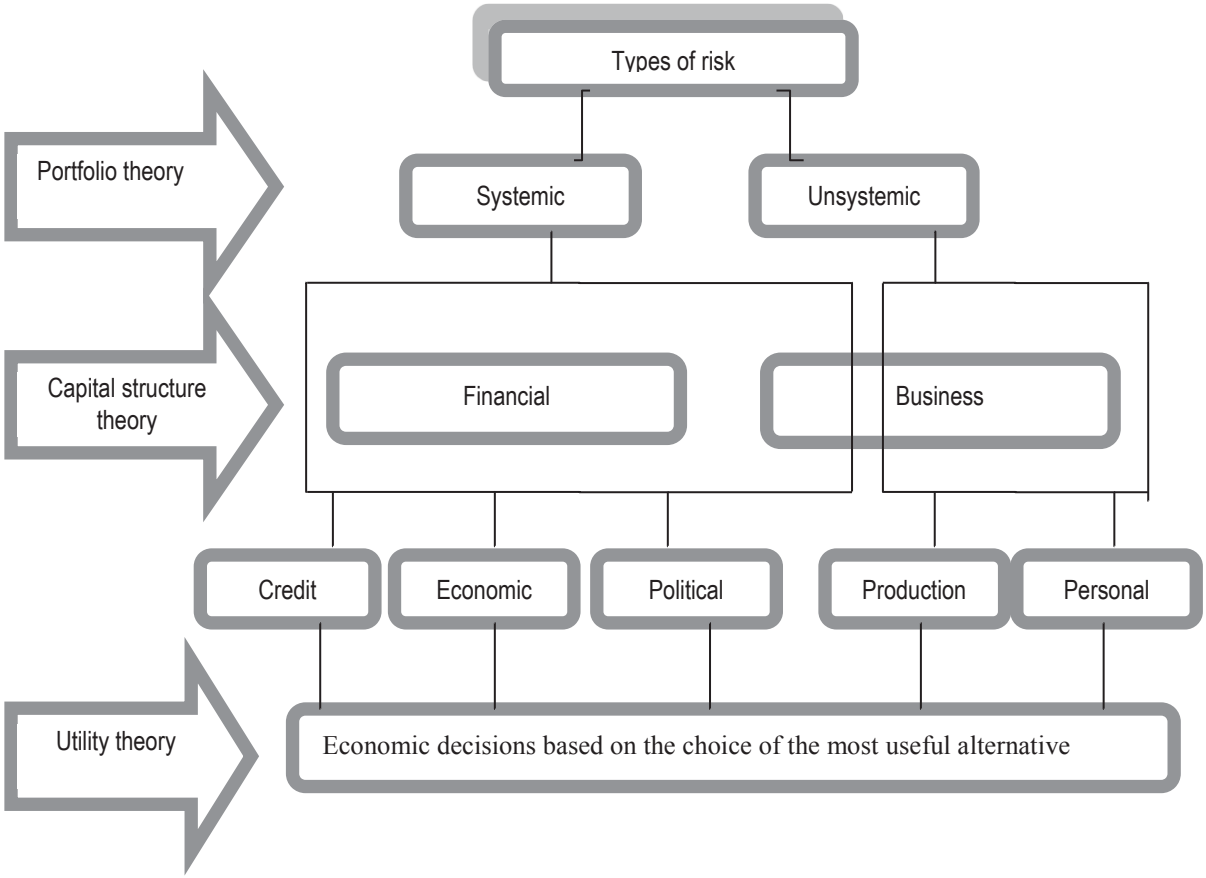

Figure 1. Risk types in agriculture and their relation to economic and finance theories

According Popescu and Visinescu (2009), the theory of business finance starts with Modigliani and Miller's capital irrelevance proposition. Before them, there was no generally accepted theory of capital structure. Modigliani and Miller start by assuming that a firm has a particular set of expected cash flows. When the firm chooses a certain proportion of debt and equity to finance its assets, it merely divides the cash flows among its investors. According to Modigliani and Miller's capital structure theory, there are two types of risk: systemic and unsystemic. Systemic risk is defined as risk inherent to the entire market or the entire market segment while unsystemic risk is company or industry specific risk that is inherent in each investment. Usually unsystemic risk can be reduced by means of appropriate diversification.

Credit, economic and political risks are attributed to systemic risk, since they are faced by all businesses, while production and personal risks are regarded as unsystemic risk. Production risk in agriculture is characterized by high specificity and the dependence on natural conditions. Meanwhile personal risk is part of unsystemic risks because all decisions made in a farm or agri-business are inevitably linked to the specific properties of this sector.

Risk assessment is closely related not only to the above-mentioned finance theory, but also to economic utility theory. According to Girdzijauskas and Štreimikienė (2007), the most important subject of market relations is the consumer, because the desires and economic opportunities of the consumer shape the demand for goods and services, which stimulate the supply. Market participants seek to satisfy their own interests or try to achieve maximum benefits which may be expressed as utility or profit. The economic utility theory deals with the consumer behavior. According to Just, Peterson (2003), the utility theory has been analyzed in agricultural literature at least since 1970. In economics, utility is perceived as a real or imaginary product, which meets human needs. Risky decisions are based on the utility theory.

The utility theory provides standard economic models, which show how decisions are made. The assumption of the theory says that human needs are basically stable and they do not change depending on the context. Individuals have limited resources to achieve maximum satisfaction and they constantly have to make choices of how to use their resources. They have two alternatives and they decide which is better before they make their choice (Hedesström, 2006).

According to the aforesaid theory, users always want more benefits rather than less, i.e. the consumer is interested in minimizing costs and maximizing benefits. According to Cather (2010), the utility theory is an integral part of risk and attitudes towards it. Scientists claim that people tend to choose a less risky alternative if the same level of performance can be obtained in the future. Thus, risk aversion strategy may explain many decisions of consumers from investing to gambling.

Initially, economists defined the decision-making process as the choice of a profitable alternative based on a certain set of economic parameters. In 1738, the Dutch mathematician D. Bernoulli created the expected utility theory, which showed how to use mathematical calculations to assess the benefits associated with one of the numerous alternative solutions (Cacho, Bywater and Bywater, and Dillon, 1999).

In 1954, L.Savage suggested the theory of rational decision making under uncertainty. The keynote of this theory is that a decision maker must first calculate the probabilities of the potential outcomes and their results. The decision maker chooses the alternative that offers the highest utility (Samuelson, Zeckhauer, 1988).

The analysis of the above researches leads to a conclusion that all utility-related theories emphasize the underlying principle: a decision maker always chooses the alternative that offers the biggest benefit. Therefore, integrated risk assessment in agriculture will help to choose an optimal alternative and to come up with the most advantageous solutions.

The analysis of agricultural economics literature (Hardarker et al., 2004; Patrick, 1992; Dickson, 1996; Johnson, 2008; Adams, 2008; Dao et al., 2004) pointed out the main risk types in agriculture, their features, and the key factors (Table 1).

Table 1. Risk types in agriculture and their features

Risk type	Features	Key factors
Production	Risk occurs because agriculture is affected by many uncontrollable events that are often related to the weather, including excessive or insufficient rainfall, extreme temperatures, hail, insects, and diseases. Technology plays a key role in the production risk in farming. A rapid introduction of new crop varieties and production techniques often offers a potential for improved efficiency, but may at times yield poor results, particularly in the short term. In contrast, the threat of obsolescence exists with certain practices (for example, using machinery for which parts are no longer available), which creates another, and different, kind of risk.	Natural conditions; biological and environmental hazards; technological level; natural disaster; demand; policy decisions
Credit	This type of risk occurs when the borrower fails to make payments as agreed. Agricultural production is characterized by seasonality, which may influence the specific circumstances of the settlements and the cash flow distribution in a certain period.	Legal transactions; partner's willingness to settle the debt; partner's financial status
Personal	This type of risk may result from such events as death, divorce, injury, or poor health of the participants in the firm. Furthermore, the changing objectives of individuals involved in the farming enterprise may have significant effects on the long run performance of the operation.	Personal experience; education and competence; attitude to risk; personal goals; health condition
Political	This risk results from changes in policies and regulations that affect agriculture. This type of risk generally arises from changes in policies affecting the disposal of animal manure, restrictions in conservation practices or land use, or changes in income tax policy, credit policy or subsidizing policies.	Environmental regulations; political events; business regulation; environmental protection; food safety
Economic	This type of risk is related to trade transactions and the capability of the participants to honor their obligations under certain conditions in the country. This risk reflects the country's economic risk indicators.	Control of exchange rate; tax policy; price controls, market fluctuations

Table 1 shows that although the sources of agricultural risks differ, they are ultimately related to each other. Once the risks and their features are analyzed, it is possible to determine their interaction. Farmers decide the kind of crop

they are going to produce depending on the market situation, the price levels, the national policies, the climate, and the location of the land. Whereas the personal opinion and expectations of the farmers undoubtedly play a central role in any decision-making process. Thus it can be concluded that the production risk is related to economic, political and personal risks. The economic risk depends on the political situation in the country and also on the existing legislation and regulations. The credit risk depends on regulation that is part of the political risk and on the general economic situation of the country. Consequently, in the processes of the analysis, evaluation or management of agricultural risks it is difficult to isolate different types of risk because risks influence each other and interact.

3. Methods of Risk Evaluation in Agriculture

In scientific literature risk evaluation contains many different quantitative and qualitative models. According to Braendeland, Refsdal, Stolen (2010), qualitative risk modeling techniques are focused on the causes and consequences, while the quantitative techniques concentrate on event probability calculations.

The risk evaluation methods in agriculture are the same as in other sectors. As mentioned before, agriculture is a specific sector because of its close relation to the nature. The analysis of literature (Rasche, 2001; Ahmed et al., 2007; Bandyopadhyay et al., 1999; Dimitrakopoulos et al., 2010) pointed out the main risk evaluation methods used for agricultural risk evaluation. The results of this analysis are given in Table 2.

Table 2. Risk methods for assessing risks in agriculture

Method	Risk type				
	Personal	Production	Economic	Political	Financial
What if?: a hazard analysis method that determines what can go wrong and judges the likelihood and severity of the occurrence of such situations.	□	□		□	
Fuzzy matrix: a mathematical algorithm to predict the future performance.			□	□	
Scenario analysis: a method of analyzing "bad" to "good" variations of circumstances and comparing them with the most probable situation or the base case.	□	□	□	□	□
Event tree analysis (ETA): a logical model to determine how an unexpected event could take place.	□		□	□	□
Fault tree analysis (FTA): a diagram that shows the logical relationships between errors of the subsystems and the components.	□		□	□	□
Delfi technique: a method based on a variety of expert opinion. There is a special questionnaire to interview experts.			□	□	
Monte-Carlo simulation: a method where computer simulations of the future are developed and the expected rate of return and risk indexes are obtained.			□		□
Cost-benefit analysis (CBA): this method weighs the potential costs and the expected profitability. It uses the time value of money.			□	□	□
Risk-at-value (VAR): the VaR method is a statistical method to measures potential losses, which a business entity will incur over time with a certain probability.				□	□
Variation-covariation method: this method uses massive historical data and usually it is highly adaptive.			□	□	□

Table 2 shows that agricultural economics literature presents several methods to estimate farmer risk preferences, however most of the methods evaluate only one risk type, e.g. financial, personal, economic or political. Thus it is difficult to choose an efficient evaluation method since quantitative methods usually require massive statistical data, special techniques and knowledge and it takes quite a lot of time to calculate the result. Meanwhile the qualitative methods highly depend on knowledge and experience or the decision-maker.

All those studies mostly focus on a limited set of risk sources, and only few researchers, such us Su, Zhao, Zhang, Li, Deng (2011) seek to use one evaluation model to evaluate several risks at the same time. The author considers that a single integrated model for evaluation of agricultural risks would be very practical due to the

following reasons: with risks in agriculture being interrelated, a single integrated model would make it possible to evaluate situation very quickly; it is vital that risk evaluation takes into account not only statistical and quantitative data but also the circumstances, i.e. qualitative data; if a single model is used rather than multiple models, the decisions will be timely, fast, and efficient.

4. Integrated Risk Evaluation in Agriculture

After the risk evaluation models are analyzed, it can be concluded that an integrated evaluation method is the most appropriate choice in risk evaluation in agriculture as it can help to see risks holistically. Figure 2 provides an illustrated logical scheme of the integrated risk evaluation method.

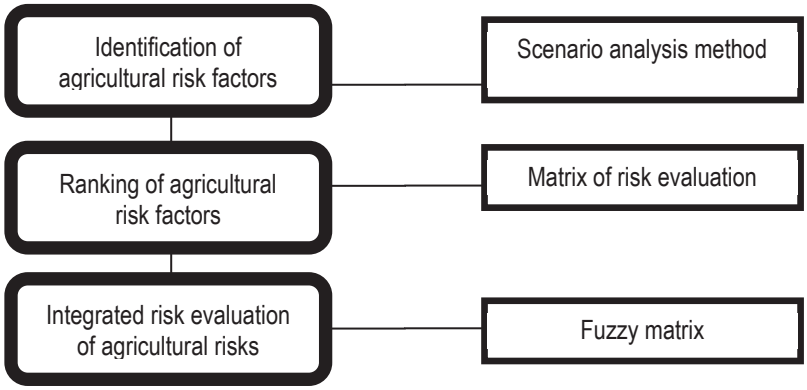

Figure 2. Logic framework of integrated agricultural risk evaluation

The first step in integrated risk evaluation in agriculture is to identify the risk factors. The previously identified risk types, i.e. the credit, economic, political, production and personal risks can be modeled using the scenario analysis method.

This method is rather complex: it helps to look at the key factors that multiply the number of rough scenarios. On top of that, this method can include not only quantitative but also qualitative data analysis. It usually analyzes three situations: “Best case”, “Worst case” and “Most likely case”. The scenario analysis is a method, which is broadly used in decision-making. It is based on the assumption that future events cannot be predicted with certainty. Each option provides information whenever the predictions turn out to be true. A critical step of the analysis is the identification of the key factors and the compression of the scenarios. The success of this method of analysis largely depends on the technical and methodological expertise of those involved, as well as the quality of the data used. In this case, the accuracy of the method depends on the farmer’s judgment. Thus a farmer can use this method to identify the risk and its factor that poses the greatest threat to the success of the farm.

Once factors are identified, they are put in the risk evaluation matrix using the likelihood and consequence scale. Depending on the factors in the matrix, they can be grouped based on expert opinion or estimating probabilities or forecasts derived from historical data.

Scientists Su, Zhao, Zhang, Li, Deng (2011) suggest that the matrix in Table 3 should be used for risk ranking.

Table 3. Risk ranking matrix

Probability of risk occurrence	Risk category			
	I	II	III	IV
	Catastrophic	Critical	Low	Insignificant
(A) Frequent	**1A**	**2A**	**3A**	**4A**
(B) Likely	**1B**	**2B**	**3B**	**4B**

(C) Occasional	**1C**	**2C**	**3C**	**4C**
(D) Seldom	**1D**	**2D**	**3D**	**4D**
(E) Unlikely	**1E**	**2E**	**3E**	**4E**

Risk index	Risk level
1A, 1B, 1C, 1D, 2A, 2B, 2C, 3A	High
1E, 2D, 3B, 3C, 4A	Medium
2E, 3D, 3E, 4B, 4C, 4D, 4E	Low

Table 3 shows that the risk ranking matrix consists of two parts: probability rating and risk category. Each part contains a scale. The two scales are placed in a matrix formation, and the cells of the matrix are assigned relative levels of risk severity.

The third phase of agricultural risk evaluation uses the fuzzy matrix method. The data are taken from the previous stage of the risk assessment model. The matrix is made by taking into account the agricultural risk factors, their occurrence, and their number.

Fuzzy metrics helps determine the categories of risk a farmer will be facing: high, medium or low. Depending on their experience and risk understanding, farmers decide whether the risk should be managed or not. This logical framework helps farmers to exclude formidable factors, their probabilities and expected effects, so it is easy to identify the most problematic areas on the farm and to make the most reasonable decisions.

Conclusions

1. Market activities are aimed at earning maximum profits and gaining the greatest market share. On the other hand there is a desire to prevent the likelihood of failure or to minimize it. Therefore risk can be defined as the possibility of suffering financial losses.

2. The main risk types in agriculture include personal, production, economic, political, and credit risks. Those agricultural risks have different sources but nevertheless they are also related to each other. Following the analysis of the risks and their features, it is possible to identify their interaction. Farmers decide which kind of crop to produce depending on the market situation, the price level, the national policies, the climate and the location of their land, and last but not least the personal opinion and expectations of the farmers. Production risks are related to economic, political and personal risks. Economic risks arise from the political situation in the country and various regulations. Credit risks are associated with regulation that is part of the political risk and with the general economic situation in the country. Therefore, in attempt to analyze risks in agriculture and to evaluate or manage them, it is difficult to separate different types of risk because risks affect each other and interact.

3. Several quantitative and qualitative methods are used in risk evaluation: What if? Variation-covariation method, Risk-at-value, Cost-benefit analysis, Monte-Carlo simulation, Delfi technique, Fuzzy matrix, Scenario Analysis, Event tree analysis, and Fault tree analysis. One and the same method can be used to evaluate several types of risks.

4. There are several reasons why an integrated risk assessment model would be very productive in agricultural risk evaluation: risks in agriculture are interrelated and thus a single integrated model will make it possible to evaluate the situation very quickly; in risk evaluation it is important to take into account not only statistical, quantitative data but also the circumstances, i.e. qualitative data; if a single model is used rather than multiple models, the decisions will be timely, fast, and efficient

5. Integrated risk evaluation in agriculture should be conducted in several stages: first, agricultural risk factors should be identified using the scenario analysis method, second, those factors must be ranked using the risk evaluation matrix, and finally all the data should be put together in a fuzzy matrix.

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