Agricultural Insurance and Bounded Rationality

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Abstract

Bounded rationality influences the individuals making decisions. Rationality of decisions is limited by the complexity of the decision problem, the cognitive limitations of decision makers, and the time available to make the decision. One specific case of this situation is decision on the agricultural insurance. The success of agricultural activity is highly dependent on environmental influences in the region. These risks can destroy entire harvest or exterminate a whole herd of livestock. The Czech Republic, through the Support and Guarantee Fund for Farmers and Forestry, provides farmers and forest managers with a contribution to cover the costs of the payment of insurance against unforeseen damage for already several years by which it affects decision-making about insurance. The article discusses the rationality of decision on the agricultural insurance using decision model under risk.

Keywords

Decision-making, agricultural insurance, claim, alternative, payoff, risk.

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Introduction

The modern theory of economic decision-making assumes that rational decision-making is based on maximizing the expected utility, which means that one would have to be equipped with unlimited knowledge, information, time and ability to process these data. The possible impact of emotions on decision-making is generally ignored by this theory. However, the expected utility theory in its original form included the idea that persons generated their wealth based on the pain and the joy that it will bring them.

Bechara and Damasio (2005) examined the hypothesis of somatic markers, which assigns each decision some subsequent emotional experience, which allows us rapidly eliminate unfavourable alternatives. Therefore, they proposed a neuronal model of economic decision-making in which emotions are seen as the major factor in decision-making. They further proved that rational decision-making is influenced by previous emotional processing. It causes a situation whereby the human factor rarely behaves as homo economicus, maximizing utility. Using the somatic marker hypothesis, it has also been proved that people often base their judgement on hunches, feelings and subjective assessments of consequences (Loewenstein et al., 2001). Exact economic models usually do not take into consideration these emotional factors and do not use them in their theories.

One of the first who dealt with the theory of rational decision-making is Simon (1955, 1972). He arrived at a conclusion that, objectively, rational decision-making is not realistic because of excessive demands on the cognitive capacity of decision-makers for whom it is too difficult to handle the complete set of information or who has only partial information about decision-making alternatives. He admits that in such a case it is difficult to choose the alternative that maximizes the expected utility. As a solution, he offers the use of models, the finding of acceptable solutions and possible replacement of the optimization criteria with criteria of satisfactory performance. According to Stigler (1961), one can deal with incomplete information using Theories of the allocation of resources. What falls into this category is, for example, the Sequential sampling theory, which deals with issues like: should I decide now or wait until I gather more information? This problem is addressed by comparing incremental costs of the extension of the sample with an expected gain, i.e. with regard to how the potential decision improves.

Rubinstein (1988) uses in his work the Allais paradox that deals with human behaviour during the decision-making process when, while actual choices are made by individual decision-makers, there is a conflict with the prediction according to the expected utility theory. Decision-making is based on similarity relations on the probability and prize spaces. Rubinstein points out certain characteristics of decision-making schemes used to determine the preferences of decision-making alternatives and also supports the idea of Herbert Simon in his work: "There is an urgent need to expand the established body of economics analysis... to encompass the procedural aspects of decision-making."

However, some authors, for example von Neumann and Morgenstern (1944), approach the expected utility theory while understanding the decision-maker to be a rational economic entity who is trying to choose the alternative with the highest expected value or utility. This traditional understanding of economic decision-making, however, is undermined by the Prospect Theory which describes decision-making based on the implementation of possible losses or profits, not the final outcome, so the decision-maker selects decisions which, however, may not be optimal (Tversky and Kahneman, 1981; 1974). This theory, however, achieves different results for optimistic and pessimistic decision-makers and it has been proven that optimistic decision-makers make better decisions (Abramson et al., 1978).

An appropriate way of modelling of the decision-making process and the analysis of the consequences of bounded rationality is the use of decision-making models, models of games against the nature (Smith, 2004; Rubinstein, 1998; Tversky and Kahneman, 1981; Kahneman and Tversky, 2000). Tversky and Kahneman also deal with the influence of the framing effect of the decision-maker's view of a problem. Rydval et al. (2014; 2012) discuss the limited rationality through the framing effect and its impact on the loss of information and information asymmetry in the market environment. They define the framing effect as a set of expectations and opinions of entities involved in the given decision-making process where there are elements of bounded rationality.

The decision-making in the agricultural insurance is very complicated task because it needs to estimate many parameters. Some results of these topics can be found for instance in Špička and Vilhem (2012), Liu et al. (2016) or Šturcová (2013). This article discusses the rationality of decision-making concerning the agricultural insurance using decision-making models under risk. The paper is organised as follows: the first part consists of a description of the decision-making model, the second part shows its practical application to the agricultural insurance, the third part analyses results of the mathematical model and human approach based on bounded rationality.

Materials and methods

Model of decision-making under risk

The aim of the decision-making model under risk is to help a decision-maker to select one of his strategies – alternatives that are available. The alternatives effect depends on possible future states of nature and is expressed as payoffs associated with each alternative /state of nature combination. The future result of a selected alternative depends also on the probabilities with which the states of nature are realized (Pratt et al., 1964; Bonini et al., 1997). The general format of a decision model under risk is provided in Table 1.

		States of nature			
		S_1	S_2	.....	S_n
Alternatives	A_1	v_{11}	v_{12}	.....	v_{1n}
	A_2	v_{21}	v_{22}	.....	v_{2n}
	.....	.....	.....	.....	.....
	A_m	v_{m1}	v_{m2}	.....	v_{m3}
Probabilities		p_1	p_2	.....	p_n

Source: own processing

Table 1: Decision-making table

where

- A_i is the i-th alternative, $i = 1, ..., m$,
- S_j is the j-th state of nature, $j = 1, ..., n$,
- v_{ij} is the payoff of alternative A_i and state of nature S_j combination, and
- p_j is probability of state of nature S_j.

The selection of the best alternative is the goal of the decision-making model. The appropriated alternative is specified according to a decision-making criterion typically the maximisation of the output. So we will suppose hereafter that the best alternative maximises the payoffs value. A commonly used criterion is the Expected Monetary Value Criterion (EMV); the alternative is selected if it has the maximal mean value of the payoffs (1).

$$EMV_i = \sum_{j=1}^{n} p_j v_{ij} \quad i = 1,...,m$$
$$A_I\!: \quad EMV_I = \max_{i=1,...,m} EMV_i \qquad (1)$$

Another approach is the estimation of the fitness of the alternatives depending on the analysis of their dominance. The simplest case of dominance is the outcome dominance, defined as follows: alternative A is dominant over alternative B if A always gives at least as good a result as does B, $\min_{j=1,\dots,n} v_{Aj} \geq \max_{j=1,\dots,n} v_{Bj}$. It is the strongest form of dominance.

Event dominance is the second form of dominance. Alternative A is dominant over alternative B if A always gives better result as does B, $v_{Aj} \geq v_{Bj}$ $j = 1,\dots,n$.

An interesting case of dominance of decision alternatives is the canonical first-order stochastic dominance which is defined as follows: alternative A has a first-order stochastic dominance over alternative B if, for the required outcome x. A gives at least as high probability of receiving at least x as does B, and for some x, A gives a higher probability of receiving at least x, $P(v_A \geq x) \geq P(v_B \geq x)$. It is the weakest form of dominance but it describes an overall behaviour of alternatives from the point of view of the outcome. It can be graphically displayed as a graph of cumulative probability $P(v_A \geq x)$ which is called a risk profile (Pratt et al., 1964; Bonini et al., 1997).

Data

To build the models, data of one of the largest Czech insurance companies providing agricultural insurance were used. Generally, the livestock insurance covers almost 80 % of the livestock and crop insurance covers about 60 % (SZIF, 2014). In this paper, only active insurance policies for the period 2010 - 2015 and to them related insured events from the area of insurance of animals, crops and forests were processed. For the analysis almost 10.000 records of annual policies were used.

Table 2 contains information on the distribution of individual types of damage in this sense, their average premium and the average insurance settlement for each group of damages.

From the values listed in Table 2, it is clear that in the event that the client decides “To get insured” but will not have any damage, he or she will have, as a consequence of this decision, the average costs given by the sum of premium in the amount of CZK 61,222. The biggest costs will be incurred in a situation when the state of nature “Small claim” will be sustained since the average small claim accounts for only less than 24% of the average premium. In “Medium claim”, it's already almost 73%. At the same time, from Table 2 it ensues that, in the event of “High claim”, we can cover damages at twice the amount than we have pay as a premium.

In the case that the client decides “Not to get insured” and there is “No claim”, the client has no costs but, in the opposite extreme case, the client can sustain a loss of more than CZK 0.5 million (not receiving insurance settlement). Any damage will probably have to be covered only using the client's own funds.

Results and discussion

Analysis of the best decision in problem of agricultural insurance

To select an optimal decision, a decision-making model was put together, in which there are two alternatives for a decision. We assume that the decision-maker chooses the alternative either “To get insured” or “Not to get insured”. The impact of both of the decisions depends on the future, on whether an insured event occurs or not.

Individual states of nature are formed by states of the insured event. Insured events were divided

Type of damage		No claim	Small claim	Medium claim	High claim
Interpretation		No insurance settlement	Insurance settlement at maximum 1/2 of the premium	Insurance settlement from 1/2 of the premium up to the premium	Insurance settlement higher than the premium
Representation (%)		91.33	2.78	2.13	3.76
Premium (CZK)	Min	360	1 676	1 063	500
	Avg	61 222	373 898	491 751	265 210
	Max	2 888 988	5 700 051	6 141 176	2 041 188
Average insurance settlement (CZK)	Min	0	759	768	800
	Avg	0	89 685	356 870	553 142
	Max	0	2 593 651	3 622 259	6 871 716

Source: own processing

Table 2: Distribution of damages according to the premium of individual clients and their premium and damages.

into four categories, namely: "No claim"; "Small claim"; "Medium claim" and "High claim". A small claim is such whose insurance settlement does not exceed half of the premium paid by a specific client. The amount of insurance settlement in a medium claim is in the interval from half of the premium to the whole premium in a specific client and the amount of insurance settlement in case of a high claim exceeds the value of the given premium.

The decision-making table contains individual payoffs for combinations of decision alternatives and states of nature. In this case, the payoffs are determined based on the difference between costs associated with the payment/non-payment of premium and the paid/unpaid insurance settlement. The actual amount of damage/claim is not necessary to take into consideration because payoffs for each state of nature would be changed in both alternatives by an equal value. If the decision-maker is insured, the payoff is equal to the difference between the insurance settlement and paid premium. If the decision-maker is not insured, the payoff is equal to the loss of the expected but not received insurance settlement.

The decision-making model is shown in Table 3 where the average payoffs are set out as well as objective probabilities of each of the state of nature (the risk vector) that have been determined based on the occurrence of damages in the previous years. It is most likely (91.33%) that the client will not sustain any damage and unlikely (3.76%) that the client will sustain high claim.

The best alternative

Payoffs of individual alternative of decisions move in the following intervals:

To get insured:

$$v_1 \in \langle d_1, h_1 \rangle = \langle \min_{j=1,2} v_{1j}, \max_{j=1,2} v_{1j} \rangle$$
$$= \langle -284{,}213;\ \ 287{,}932 \rangle$$

Not to get insured:

$$v_2 \in \langle d_2, h_2 \rangle = \langle \min_{j=1,2} v_{2j}, \max_{j=1,2} v_{2j} \rangle$$
$$= \langle -553{,}142;\ \ 0 \rangle$$

The final payoffs in this decision-making situation may therefore be in the range of values:

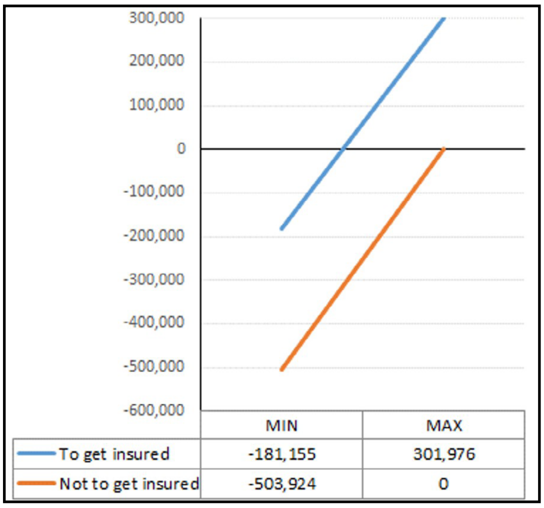
$$v \in \langle D, H \rangle = \langle \min_{j=1,2} \min_{j=1,2} v_{ij}, \max_{j=1,2} \max_{j=1,2} v_{ij} \rangle$$
$$= \langle -553{,}142; 287{,}932 \rangle$$

Decisions about the best alternative may be made based on the EMV. The alternative with the maximum value of the EMV is chosen if the payoffs are of the profitable type. In the first alternative, the decision-maker can expect a payoff in the amount of CZK -55,865 while in the "Not to get insured" alternative, the expected payoff amounts to CZK -30,881. According to this method and the information set out in Table 3, the client should therefore not get insured, the best alternative is the "Not to get insured".

The alternatives were further analysed and evaluated by the outcome dominance, event dominance and stochastic dominance.

Outcome dominance

This is the strongest form of dominance. In order to be able to exclude one of the decision-making alternative, it would be necessary for the dominant alternative to have each payoff better than or at least as good as payoff of the dominated alternative.



Source: own processing

Figure 1: Outcome dominance.

(in CZK)	No claim	Small claim	Medium claim	High claim	EMV
To get insured	-61,222	-284,213	-134,881	287,932	-55,865
Not to get insured	0	-89,685	-356,870	-553,142	-30,881
Probability of the occurrence	91.33 %	2.78 %	2.13 %	3.76 %	

Source: own processing

Table 3: Decision-making model and EMV criterion.

According to Figure 1, there is no dominance among the alternatives depending on the payoffs since the worst payoff of the "To get insured" alternative is not better than or as good as the best payoff of the "Not to get insured" alternative.

Event dominance

This is a weaker form of dominance since it is sufficient if the dominant alternative provides for each state of nature a payoff better or as good as the dominated alternative. From Figure 2, it is evident that between individual alternatives of the decision "To get insured" and "Not to get insured" there is again no dominance depending on the states of nature. However, what is important is the progress of payoffs of individual alternatives, which shows the distribution of payoffs for individual states of nature. It can be stated that for the case of a medium and high claims, it is more beneficial for the client to have insurance since without insurance the client could sustain a loss ranging from more than CZK 350,000 to more than CZK 550,000 (Table 3). In the case of a small or even no claim, the opposite is true. The client will sustain lower costs in case of a decision “Not to get insured” - the amount of premium would indeed have exceeded the insurance settlement.

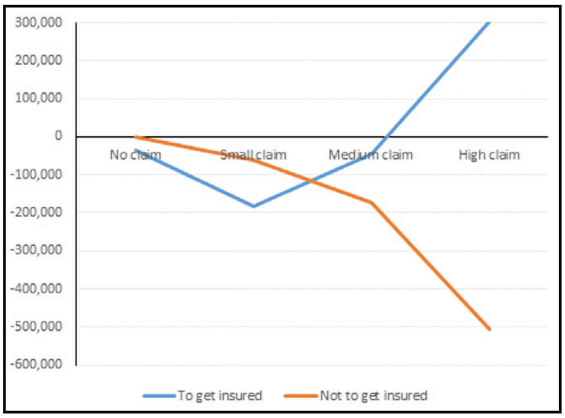


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Figure 2: Event dominance.

Stochastic dominance

This is the weakest and the most complex form of dominance, which analyses the cumulative probability of achieving the required amount of payoff. From the data presented in Table 3, it is possible to construct the risk profile - a graph of cumulative probabilities, which shows the comprehensive view of the probability of achieving a certain level of payoffs by individual alternatives.

From Figure 3, it is clear that no alternative dominates based on stochastic dominance. There is a 97% probability that if the client is insured, he or she will sustain a loss of more than CZK 134,000. And there is an almost zero probability that the client would be paid the insurance settlement for the damage that would be twice the value of the premium the client paid. On the other hand, if the client does not get insured, he or she risks a big loss but the probability of this loss drops rapidly to zero. It is true that the client may sustain a loss of more than CZK 0.5 million with the probability of 96% but, at the same time, with 91% probability he or she will not sustain any damage.

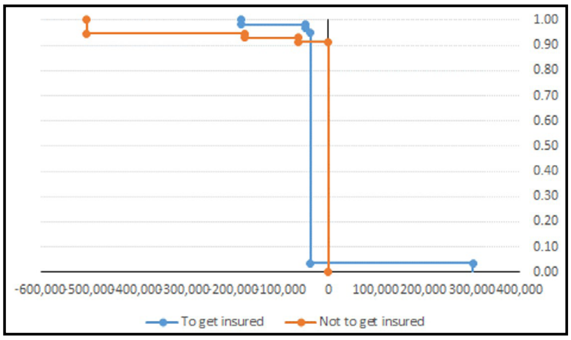

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Figure 3: Stochastic dominance.

Discussion

A rational decision-maker is able to choose the best alternative after a decision-making process based on all available information according to the selected criteria. In the case of the decision under risk, the best alternative is selected according to the EMV criterion. The proposed model shows as the best alternative “Not to get insured” although the both expected payoffs are negative.

In the case of the alternative "Not to get insured", however, even the actual payoffs is non-positive. Either the damage does not occur and the payoff is zero - premium is not paid, or some damage occurs and the decision-maker is forced to pay it using his or her own funds (which is modelled as the amount of a not received insurance settlement). In the case of the alternative “To get insured”, the results are negative, the decision-maker sustains a loss because the premium is higher than the supply, only in case of a high claim the payoff is positive, the decision-maker gets considerable funds to cover it.

The question is, why do decision-makers get insured then? From the emotional standpoint, the decision “To get insured” is easily justifiable by a fear of a high loss. The analysis of the stochastic dominance, however, shows that this situation has a very small probability. On the other hand, the event dominance analysis shows a significant advantage of the alternative "To get insured" in the state of nature "High claim". This view is the basis for decision-making of the risk aversion decision-maker. Additionally, the decision-maker has incomplete information on the possible occurrence of the uncertain states of nature.

Considering the actual amount of damages, payoffs of individual alternatives for a specific amount of damages were further reduced by this amount – the entire behaviour of the payoffs would thus be even more moved towards negative values. The decision-maker should then choose a "Not to get insured" alternative even more. However, due to the size of the potential loss, the decision-maker is not able to rationally process the information about the probability of the occurrence of an adverse event and the respective payoff and chooses the "To get insured" alternative. It is a manifestation of the paradigm of bounded rationality. The irrational choice of alternative "To get insured" is also supported by the effect of subsidies provided by the Support and Guarantee Fund for Farmers and Forestry (PGRLF, 2016) which reduces the insurance costs by 30 - 50% of the premium paid, however the decision model with 40 % discount showed similar results as original one. The psychological effect of this relatively high subsidy moves the decision-making closer to the "To get insured" alternative. Therefore the total premium paid slightly increases in agricultural insurance (Špička and Vilhelm, 2012).

Conclusion

The result of this article is to confirm the existence of bounded rationality in agricultural insurance in the Czech Republic since the clients, according to the results of EMV and based on individual analyses, should not get insured. Bounded rationality seems to originate here due to insufficient information on payments in the insurance industry, excessive complexity related to the selection of the best solution and, of course, due to the fear of an impending loss. It seems to be financially more acceptable to clients to pay regular but smaller amounts than to pay eventually a one-time but a very high amount of money.

The decision-making about agricultural insurance is discussed by Liu et al. (2016) and Šturcová (2013). Both authors show that the cost of agricultural insurance and probability of damage occurrence are important factors in the decision process whether to get insured or not.

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