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The effects of weather risks on micro-regional agricultural insurance premiums in Hungary

This paper examines the effects of territorial differentiation of damage to wheat, maize, barley, sunflower and rapeseed production caused by drought and heavy rain. Our study evaluated the differences between LAU1 micro-regions in Hungary in the effects of the weather on agricultural production and found that there are extremely high differences in the probabilities of damage occurring. Therefore the design of agricultural insurance products should be based on different absolute deductibles and different insurance premiums for micro-regions. Furthermore, we found that within a micro-region individual producers face a very high diversity of risks which implies that in the long term only a *bonus-malus* system developed for individual agricultural producers can mitigate different risks, and that this can be the basis of a well performing risk management system that is suitable for a wide risk community.

Keywords: weather risks, micro-regions, insurance premiums, crop yields

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Introduction

The role of insurance in management of risk in agricultural production has long been the centre of attention for researchers and policy makers. Agricultural insurance products were first offered by private companies approximately two hundred years ago, initially in Europe and then in the United States (Smith and Glauber, 2012), and these followed different development paths during the progress of the two agricultural insurance markets (Székely and Pálinkás, 2009). The development of these markets has required an increasing role of government due to the persistence of moral hazard, adverse selection and systemic risks problems in agricultural production. Today, almost 90 per cent of the global agricultural premium of about USD 20 billion is collected in high-income countries where agricultural insurance products are heavily subsidised by governments (Mahul and Stutley, 2010).

The Hungarian agricultural insurance market has experienced major changes during the last decade (Kemény *et al.*, 2012a). A new agricultural insurance system based on two pillars started to operate from 2012. The first pillar is the continuation of the National Disaster Fund but with two important changes: the participation of farmers is compulsory above a certain farm size and there is a stricter control of the damage compensation. The second pillar focuses on the expansion of the agricultural insurance market by introducing insurance fee support for farmers who contract insurance policies for hail, fire, storm and winter frost damage as well as for drought, heavy rain and spring frost, which previously were not insurable risks. The insurance premiums are calculated for actual insurance products based on country level variables, except for hail risk where different variations of the (LAU1) micro-regional insurance premium calculation procedure are applied. The outcome of these country level insurance premiums for different weather risks is the formation of very heterogeneous risks communities, and this does not permit the sustainable operation of an agricultural insurance system.

Many studies in the Hungarian agricultural economics literature (e.g. Csete, 2004; Pesti *et al.*, 2004) emphasise the importance of exploring the effects of micro-regional weather impacts on variations in the yield of agricultural crops but do so without having conducted any empirical investigations since the political and economic changes of 1989. Empirical observations suggest that the main weather risk factors vary widely among macro-regions as well as among micro-regions, implying the need for a more detailed examination of the effects of the weather on crop yields. Therefore the objective of this study is to estimate the optimal insurance premiums for the stakeholders of the Hungarian agricultural insurance market, based on micro-regional weather conditions. These should take into account the willingness to pay of farmers, the financial capacities of insurance companies and the governmental budget resources.

The structure of the article is as follows. The next section presents the theoretical and empirical background of the paper, and this is followed by a description of the methodology and data used to achieve the research objectives. The penultimate section contains the results of our calculations and the final section concludes with six policy implications.

Theoretical background

The estimation of insurance premiums is based on two primary principles of risk management. On the one hand, an equitable insurance system is characterised in the long term by the parity of the total insurance premium and the expected value of the damage incurred. On the other, farmers' decisions are characterised by a risk aversion attitude in the long term, implying that they are disposed to pay higher insurance premiums than the compensation value of their crop damage for assuring incomes from their farm operations. If these conditions are valid the insurance premium covers the compensation for damage incurred while the extra charge attributable to the risk aversion attitude of farmers covers the earnings and costs of insurance companies (Zweifel and Eisen, 2012).

However these principles do not always apply in the short term. Before introducing a comprehensive insurance product covering drought, heavy rain and spring frost risks the insurance premium system should take into account the following essential conditions: (i) the insurance premium should be set at an acceptable level for producers; (ii) the damage compensation should not overload insurance companies even in years with high rates of damage; (iii) the insurance premium for every crop should cover the costs of insurance at least at national level even if this objective cannot be achieved for every micro-region; (iv) the insurance premium system should not be too complex and there must not be exaggerated differences between producers' insurance premiums (Kemény *et al.*, 2012b).

The *acceptable level of insurance premiums for farmers* (i) is considered to be 2-3 per cent of the output. Even considering the maximum of allowed governmental support of insurance premiums (65 per cent) in the European Union, the total insurance premium paid by farmers complemented by the governmental insurance premium support cannot exceed 5 per cent of the farm output of insured product due to the low willingness to pay of farmers for insurance (Kemény *et al.*, 2010).

That *damage compensation should not overload insurance companies* even in years with high rates of damage (ii) is a fundamental condition for insurance companies providing risk management products for Hungarian agriculture as they have suffered losses in five of the last six years. This makes it even harder to solve the optimisation problem of calculating acceptable insurance premiums for farmers and insurance companies while taking into account the low willingness to pay of farmers for agricultural insurance and the fact that agricultural insurance companies exhausted their reserves in previous years, which prevents them from accepting further losses in their agricultural insurance operations. An acceptable solution for both farmers and agricultural insurance companies can be achieved only with governmental support for agricultural insurance premiums.

The condition *the insurance premium for every crop should cover the costs of insurance* (iii) states that there are not preferred crops where the total insurance premium collected from farmers complemented by governmental support is lower than the damage compensation paid by insurance companies. This implies the differentiation of insurance premiums for different crops.

The condition *the insurance premium system in a micro-region should cover the damage compensation, not be too complex and there must not be exaggerated differences between producers' insurance premiums* (iv) defines the need for a transparent and clear agricultural risk management insurance system. Such a system would have less than ten insurance premium categories and in a micro-region all crops would fall into the same category. Moreover in every micro-region the collected insurance premiums should cover the damage compensation, which implies that the farmers are using crop rotation in the case of insurable crops. To overcome inverse selection in the risk community in a micro-region it is imperative to not have exaggerated differences between producers' insurance premium rates.

Methodology

We applied the linear programming method to solve the multi-conditional optimisation problem when calculating micro regional level insurance premiums. The model is formulated according to the description of Bakos (2000). Matrix (1) represents a set of scenarios $V = \{V_1, V_2, ..., V_m\}$ and a set of attributes $C = \{C_1, C_2, ..., C_n\}$, where c_{ij} is the value of future *i* of scenario *j*.

$$\begin{array}{ccccc} & V_1 & V_2 & \dots & V_n \\ C_1 & c_{11} & c_{12} & \dots & c_{1n} \\ C_2 & c_{21} & c_{22} & \dots & c_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ C_m & c_{m1} & c_{m2} & \dots & c_{mn} \end{array} \qquad (1)$$

The c_{ij} values of the matrix are normalised; every row is transformed to values between zero and one. The rows of the transformed matrix contain a set of usable parameters $U = \{U_1, U_2, ..., U_n\}$ making possible the comparability of the variables (2).

$$\begin{array}{ccccc} & V_1 & V_2 & \dots & V_n \\ U_1 & u_{11} & u_{12} & \dots & u_{1n} \\ U_2 & u_{21} & u_{22} & \dots & u_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ U_m & u_{m1} & u_{m2} & \dots & u_{mn} \end{array} \qquad (2)$$

Depending on which values of attributes are preferred, lower (3) or higher (4) values of u_{ij} are calculated with the formula:

$$u_{ij} = \frac{c_{ij} - c_{i\,\min}}{c_{i\,\max} - c_{i\,\min}} \qquad \text{(lower is preferred)} \qquad (3)$$

or

$$u_{ij} = \frac{c_{i\,\max} - c_{ij}}{c_{i\,\max} - c_{i\,\min}} \qquad \text{(higher is preferred)} \qquad (4)$$

The *p* vector contains the values of weighting parameters defined by decision maker and the sum of these values is one (5).

$$\sum\nolimits_{i=1}^{m} p_i = 1 \qquad (5)$$

The weighting parameters are values between zero and one, which are used to express the importance of usable parameters for selecting the most favourable solution (6).

$$z = Opt_{j=1}^{n} \sum\nolimits_{i=1}^{m} p_i u_{ij} \qquad (6)$$

Owing to the gradual introduction of the limiting conditions described in the previous section, in our case the insurance premium optimisation matrixes have the following forms:

$$\begin{array}{ccccc} & V_1 & V_2 & \dots & V_n \\ C_1 & c_{11} & c_{12} & \dots & c_{1n} \\ C_2 & 0 & c_{22} & \dots & c_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ C_m & 0 & 0 & \dots & c_{mn} \end{array} \qquad \begin{array}{ccccc} & V_1 & V_2 & \dots & V_n \\ U_1 & u_{11} & u_{12} & \dots & u_{1n} \\ U_2 & 0 & u_{22} & \dots & u_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ U_m & 0 & 0 & \dots & u_{mn} \end{array} \qquad (7)$$

The four conditions presented above were introduced gradually according to their importance, obtaining the minimum values of insurance premium sums in the *C* triangle matrix and the elements of the transformed *U* matrix (7).

These matrixes are multiplied by the *p* column vector, which contains the weighting factors attributed by decision maker, thus providing different scenarios, among these Z which represents the optimal scenario.

Micro-regional yield loss values were calculated from Hungarian Statistical Office data for the period 2003-2009 collected from about 7,000 farms operating as companies. The yield loss is estimated in each of 173 LAU1 micro-regions in Hungary (i.e. all micro-regions except Budapest) as a difference from the weighted average of the micro-regional crop yield in the analysed period. The weights (*p* vector) are the utilised agricultural area of farms in the sample from a micro-region. When the yield loss for a crop (wheat, maize, barley, sunflower, rapeseed, grape and apple) exceeds a certain threshold in a micro-region, the farmers in that micro-region are entitled to compensation. We evaluated the compensation value in every micro-region as a product of yield loss of a certain crop and its average producer price.

Micro-regional meteorological data were interpolated from over 100 automatic weather station records provided by the Hungarian Meteorological Service for the same period (2003-2009). Applying conditions of meteorological variation to define yield loss made it possible to identify all-risk yield losses caused by weather risks. Those yield losses that satisfy certain meteorological conditions are considered to be damage eligible for compensation. *Drought* is considered for wheat, winter barley, maize, sunflower and rapeseed production when there is a lower yield than the defined threshold and the total rainfall is less than 10 mm in at least one month between March and September. *Heavy rain* risk is considered for wheat, winter barley, maize, sunflower and rapeseed production when the yield is lower than the defined threshold and in at least one month between March and September the average rainfall is higher than 80 mm.

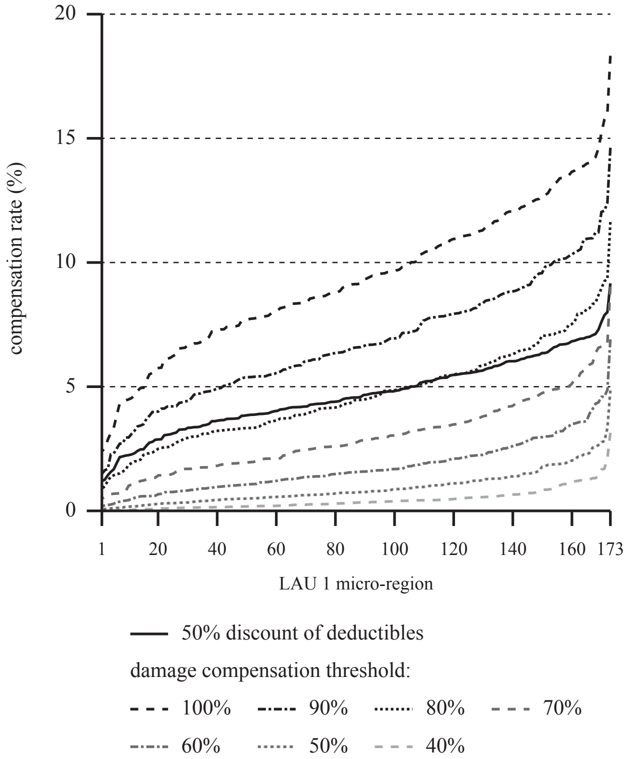
Results

When calculating optimised insurance premiums that take into account micro-regional differences we adhered to the two principles of risk management identified by Zweifel and Eisen (2012), described above. Since our intention was to reconcile conflicting conditions when calculating optimised insurance premiums, as a first step we present here the effects of each of our four conditions on the rate of damage compensation and then we gradually introduce these conditions for solving our linear programming problem. In the second stage, optimised insurance premium results are presented based on three scenarios according to different deductible rates.

The relationship between damage compensation rates and the defined conditions

Damage compensation rates for when condition (i) is considered are presented in Figure 1. The damage compensation rate is calculated as a share of damage value and insurance value in the 173 micro-regions based on yearly average output, when the deductible rate is gradually increased from 0 to 60 per cent (this means that the damage compensation threshold is decreased gradually by 10 per cent from 100 per cent to 40 per cent).

Figure 1: Crop damage compensation rates of Hungarian LAU1 micro-regions for different damage compensation thresholds or a 50% discount of deductibles as an average of the period 2003-2009.



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There are major differences among the damage compensation rates of micro-regions. In the best performing micro-region, in the case of a 100 per cent damage compensation threshold the justified insurance premium is 2.5 per cent of average output while in the worst performing micro-region it is 18 per cent. This figure shows that if we wish to have acceptable insurance premiums for all farmers it is necessary to reduce the discount or the absolute value of deductibles. We can have an acceptable insurance premium rate at 70 per cent damage compensation threshold, where in the worst performing micro-region the insurance premium rate is below 10 per cent. The same acceptable insurance premium rates can be attained at 60, 50 and 40 per cent of the deductible threshold.

If the insurance product fulfils condition (ii), i.e. that even in a year with heavy damage such as 2003 there are no losses in the insurance system of insured products, the results presented in Figure 2 are obtained.

In years with heavy damage almost 50 per cent of output is lost, which implies very high insurance premiums for 100 per cent compensation. In this case the insurance premiums should be set at around 40 per cent, which is unacceptable for farmers if we take into account their willingness to pay is around 5-6 per cent. This problem can be solved in two ways. One possibility is to reduce the damage compensation threshold to 50 or 40 per cent, which means that only those farmers whose output decrease was higher than 50 or 60 per cent receive any compensation. The other possibility is to increase the discount of deductibles to 80 per cent.

For a crop producer the option of a damage compensation threshold set at 50 per cent seems more plausible than the option of a discount of damage set at 80 per cent.

Figure 2: Crop damage compensation rates of Hungarian LAU1 micro-regions for different damage compensation thresholds or an 80% discount of deductibles in 2003.

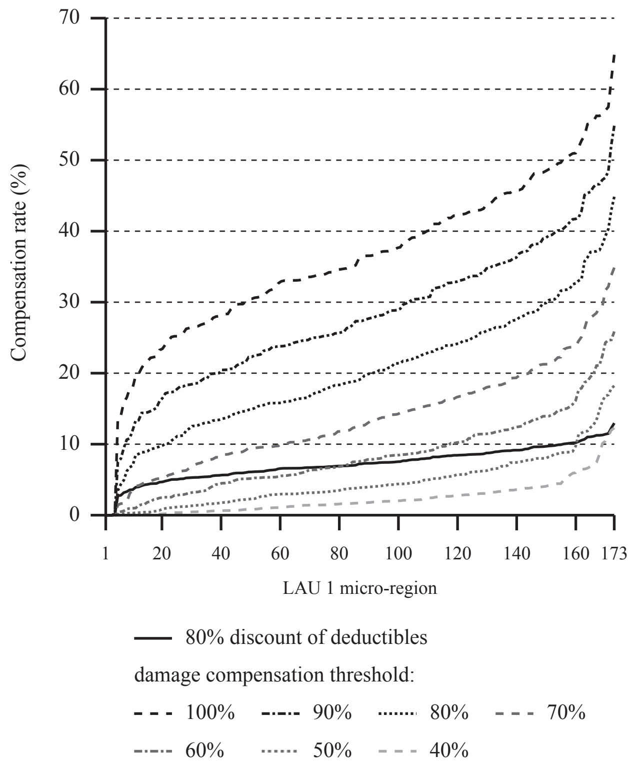

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Figure 3: Crop damage compensation rates of Hungarian LAU1 micro-regions for different crops as an average of the period 2003-2009, using a damage compensation threshold of 50 per cent rate of deductibles.

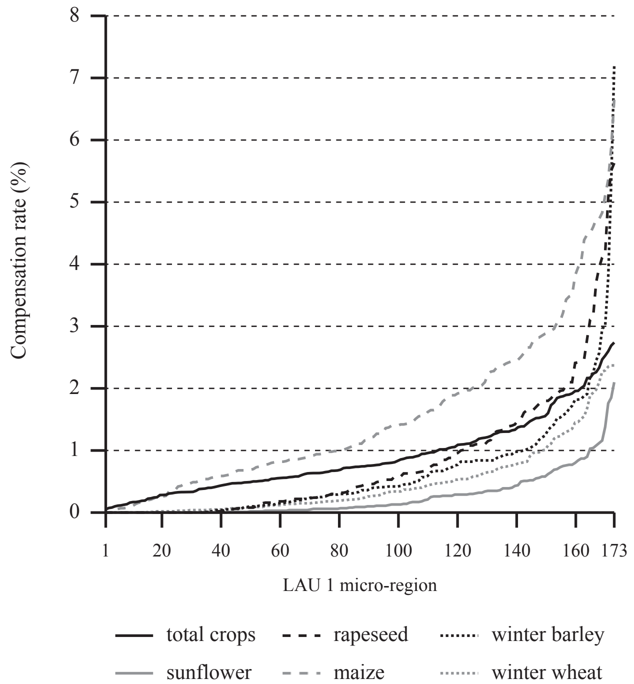

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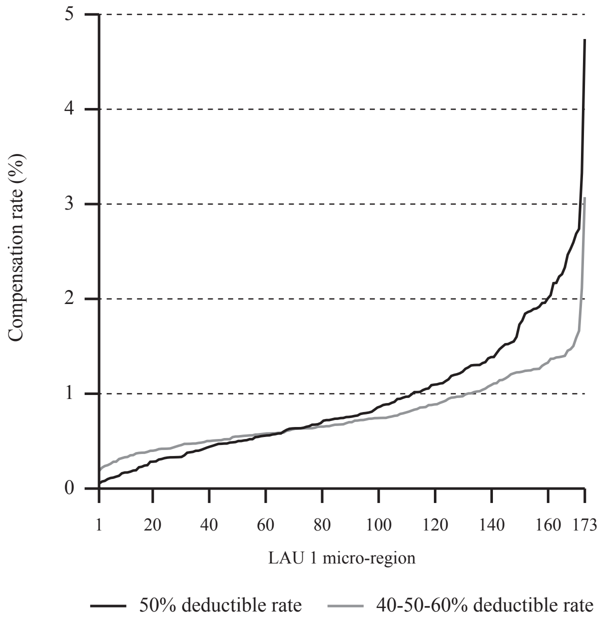
Figure 4: Crop damage compensation rates of Hungarian LAU1 micro-regions as an average of the period 2003-2009, using 50 per cent and 40-50-60 per cent rates of absolute deductibles.



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Condition (iii) is to have, at least at national level, an insurance system where the insurance premiums cover all damage incurred. This can be attained by applying highly differentiated insurance premiums for different crops (Figure 3).

For sunflower, with the most favourable damage compensation rates, where in the micro-region with the highest damage of 50 per cent, the insurance premiums can be set around 1 per cent of the farms' sunflower output value. However for maize, with most unfavourable damage compensation rates, for 30 per cent of farmers the insurance premiums can be set at the 2 per cent level, while in the case of most farms exposed to weather risks the insurance premiums should be set at 7 per cent of the maize output value.

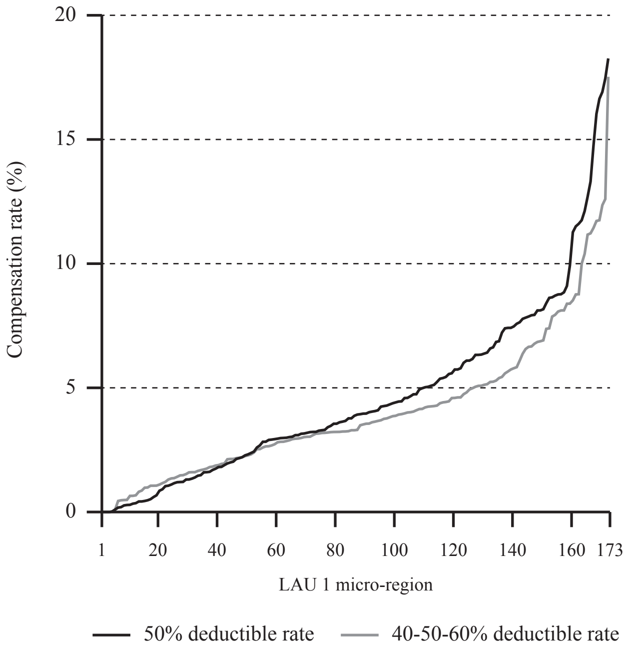
Condition (iv) contains the clauses of insurance premium calculation at micro-regional level: on the one hand the coverage of damage incurred by insurance premiums collected in the micro-region and on the other hand to not have exaggerated differences among insurance premiums paid by different farmers in the micro-region.

The micro-regions are classified according to their damage compensation threshold records averaged over seven years in three categories: the micro-regions characterised by the highest damage are connected to 40 per cent, the micro-regions with medium damage to 50 per cent and the micro-regions when the least damage are connected to a 60 per cent yield threshold.

By applying differentiated 40-50-60 per cent absolute deductible rates according to the risk exposure of a micro-region, more homogeneous insurance premium rates can be obtained compared to general valid average 50 per cent absolute deductible rate (Figure 4).

The same situation arises in the years with heavy damage, for example in 2003 the differentiation of micro-regions according to their risk exposure makes it possible to set lower insurance premiums for most of the farms (Figure 5).

Figure 5: Crop damage compensation rates of Hungarian LAU1 micro-regions in 2003, using 50 per cent and 40-50-60 per cent rates of absolute deductibles.



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Optimisation of insurance premiums by gradual introduction of conditions

Introducing gradually the four conditions presented in the previous section and referring to our principle that the insurance premiums should cover damage compensation we developed three scenarios.

In scenario A we consider conditions (i) and (ii), which imply that the damage threshold is set at 50 per cent, the discount of deductibles is 10 per cent, the same insurance premium rates are applied for all crops, the damage compensation rate is set at 75 per cent of the average values for 2003-2009, and even in the case of years with high levels of damage compensation this cannot exceed 110 per cent.

Insurance premium rates for drought and heavy rain should be set threefold higher (see Kemény *et al.*, 2012b) for all farmers, micro-regions and crops considering condition (ii) to avoid serious damage by insurance companies when extreme weather conditions cause a drastic fall of farm output (Table 1 column 2).

Applying a flat 3.6% insurance premium rate for compensating insurance companies because of years with extreme crop damage contributes to increasing their profits. This scenario can be applied only in the case of introducing a new insurance premium system followed by increasing the damage threshold or reducing the insurance premium rates. Scenario A does not satisfy our expectations as there are big differences in damage compensation rates among different field crops (Table 2) and there is a high redistribution of insurance premiums among different micro-regions (Figure 6).

In scenario B condition (iii), which does not allow cross financing of insurance premiums between different crops, is considered together with conditions (i) and (ii). In this scenario the conditions of scenario A are complemented with the condition that the same damage compensation rate is applied to every crop. The difference between sunflower, with the least damage, and maize, with the most damage, is fivefold and the insurance premium of maize remains at an acceptable level (Table 1 column 3).

Scenario B allows us to calculate acceptable insurance premiums which handle the situation of years with extreme

Table 1: Insurance premium rates for drought and heavy rain insurance for five crops, when cross financing of insurance premiums between different crops is allowed or not allowed.

Crop	Insurance premium rate (%)	
	Allowed	Not allowed
Rapeseed	3.6	3.2
Maize	3.6	5.6
Sunflower	3.6	1.1
Winter wheat	3.6	1.7
Winter barley	3.6	2.7

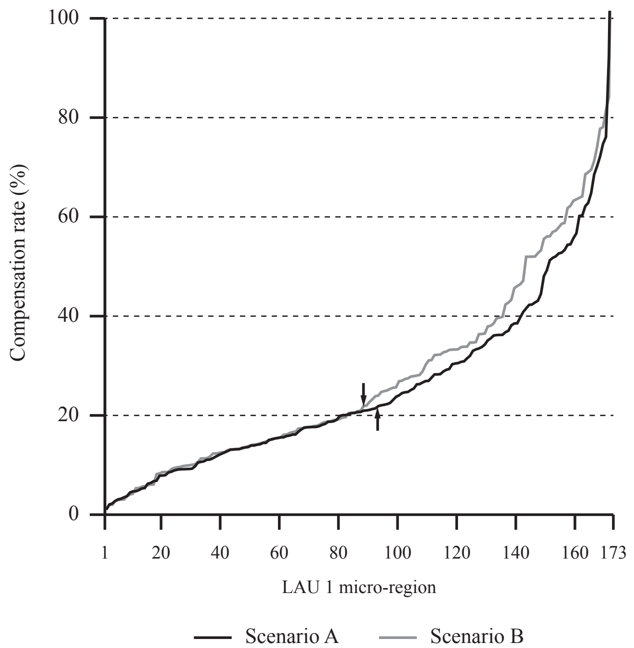
Source: own data

Table 2: Crop damage compensation rates (per cent) for drought and heavy rain insurance for five crops for the period 2003-2009 under scenario A.

	2003	2004	2005	2006	2007	2008	2009
Rapeseed	301.4	0.5	0.5	0.0	36.1	0.0	22.1
Maize	100.7	0.0	1.2	0.1	132.8	0.5	14.5
Sunflower	25.4	0.0	1.9	0.0	13.4	0.0	9.1
Winter wheat	63.8	0.0	0.3	0.0	9.9	0.0	4.7
Winter barley	109.5	0.0	5.2	0.0	25.1	0.0	14.6
Total damage compensation rate	110.0	0.1	1.1	0.1	61.6	0.2	10.7

Source: own data

Figure 6: Crop damage compensation rates of Hungarian LAU1 micro-regions for scenarios A, i.e. taking into account conditions (i) and (ii), B, i.e. taking into account also condition (iii).



Values for micro-region 173 are 132% (scenario A) and 129% (scenario B)
Parity with the average damage compensation rate is indicated thus: upward arrow: scenario A; downward arrow: scenario B
Source: own composition

damage. The insurance premiums are financing the damage compensation in the case of different crops (Table 3), thus the first three conditions are held, but the problem of redistribution of insurance premiums among micro-regions remain unsolved (Figure 6). Furthermore in half of the micro-regions the insurance premiums are higher than in scenario A.

Table 3: Crop damage compensation rates (per cent) for drought and heavy rain insurance for five crops for the period 2003-2009 under scenario B.

	2003	2004	2005	2006	2007	2008	2009
Rapeseed	334.1	0.5	0.5	0.0	36.3	0.0	22.1
Maize	63.8	0.0	0.6	0.2	75.7	0.3	8.4
Sunflower	83.4	0.0	5.5	0.0	39.6	0.0	27.0
Winter wheat	133.0	0.0	0.6	0.0	18.7	0.0	8.7
Winter barley	146.3	0.0	6.3	0.0	30.1	0.0	17.6
Total damage compensation rate	110.0	0.1	1.1	0.1	61.6	0.2	10.7

Source: own data

We managed without any difficulties the inclusion of the first three conditions in our linear programming model. But solving the problem of redistribution of insurance premiums among micro-regions (condition iv) cannot be performed in the same way as we have 173 micro-regions, five crops and ten insurance premium rate categories, which results in an over-identification model. Consequently we grouped the micro-regions into six categories according to their exposure to risk (Table 4): in the first two categories, which are the least exposed to risk, the farmers are compensated when their output decreases below 60 per cent of the average output in the micro-region. In the third and fourth categories, namely those with medium exposure to risk, farmers are compensated after their output decreases by 50 per cent, while in the last two categories of micro-regions, where the exposure to risk is the highest, farmers are compensated when their output falls below 40 per cent of the average output of the micro-region.

In scenario C there are six categories of micro-regions with three output thresholds. The risk exposure of the six categories of micro-regions is increasing from the first to the sixth category. The insurance premium rates vary among categories of micro-regions and crop products (Table 4), and consequently the insurance premium rate is lower and the output threshold is higher in micro-regions and crop products with lower exposure to risk.

The inclusion of micro-regions in different categories according to their exposure to risk and the differentiation of insurance premium rates within the category of micro-regions led to improved results: in years with heavy crop damage excessive compensation is avoided, the redistribution of insurance premium is reduced to an acceptable level and the problem of redistribution of insurance premiums between micro-regions are considered (Table 5).

Table 4: Output threshold levels and crop insurance premium rates for drought and heavy rain insurance in six micro-region categories.

	1	2	3	4	5	6
Output thresholds	60%	60%	50%	50%	40%	40%
Rapeseed	2.0	4.0	3.0	3.5	3.5	3.5
Maize	4.0	6.0	4.0	4.5	4.5	6.0
Sunflower	0.8	2.0	0.8	1.0	1.0	1.0
Winter wheat	1.0	1.5	0.8	1.5	1.5	1.5
Winter barley	2.5	2.5	2.5	2.5	2.5	2.5

Source: own data

Table 5: Crop damage compensation rates for drought and heavy rain insurance for five crops in six micro-region categories as an average of the period 2003-2009 under scenario C.

	1	2	3	4	5	6	Average
Rapeseed	14.0	19.0	21.3	20.2	19.9	20.5	19.6
Maize	23.1	31.7	20.2	26.3	20.6	34.5	25.5
Sunflower	15.5	14.3	14.9	20.6	16.1	19.3	17.5
Winter wheat	20.7	21.5	22.3	23.1	12.8	24.6	20.9
Winter barley	21.6	25.0	16.4	12.8	16.4	23.0	21.0
Total damage compensation rate				23.8			

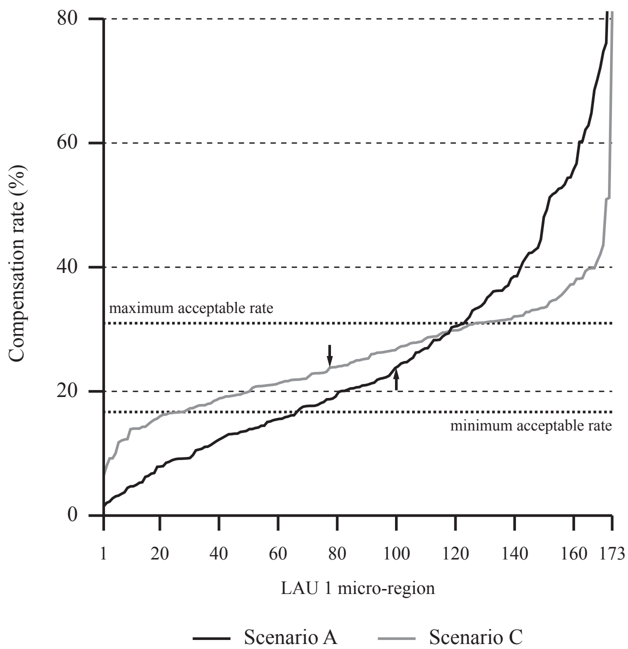
Source: own data

The insurance premiums optimised in scenario C are lower than in scenario A (Figure 7), namely in the majority of micro-regions the insurance premiums remain in an acceptable zone. Furthermore in this last scenario the redistribution of insurance premiums among micro-regions is solved in an acceptable manner (see Kemény *et al*., 2012b).

Discussion

This study investigates the spatial distribution of natural risks and their effects on the yield variations in Hungarian crop production. The conflicting conditions presented cannot be entirely taken into consideration at the same time when insurance premiums are calculated. There are only solutions

Figure 7: Crop damage compensation rates of Hungarian LAU1 micro-regions for scenarios A, i.e. taking into account conditions (i) and (ii), and C, i.e. taking into account all four conditions.



Parity with the average damage compensation rate is indicated thus: upward arrow: scenario A; downward arrow: scenario C
Source: own composition

which are approaching the perfect insurance premium system. In addition to an insurance premium system optimised to the interests of stakeholders 'strategies to enhance knowledge and trust are needed to ensure that farm managers are able to utilize insurance products for readjusting their production decisions and improving their performance' (Spörri *et al.*, 2012, p.12).

The calculation of the insurance premiums is based on all-risk yield loss and consequently the calculation of premiums according to every type of risk is very difficult due to methodological problems. Therefore the settlement of insurance premiums should be carried out with extreme caution taking into account the actuarially fair insurance premium rate, the willingness to pay for insurance of farmers (Chambers, 2007) and the opinions of experts.

Our theoretical expectation was that the size of the multirisk insurance system payments required to cover the costs and the profits of insurance companies would not have a considerable influence on the output and income levels of crop producing farms at the macro level. However the performance of the multi-risk insurance system is beyond question because the macro-level income of producers suffering damage is increased. According to our model estimations, during the years with heavy adverse weather conditions 24-35 per cent of farmers can suffer crop damage and their income can increase due to contracting multi-risk insurance by 26 per cent in the case of operational profit and 36 per cent in the case of profit before tax.

The micro-level performance of the multi-risk insurance system is not clear. The damage caused by the insurable risks (drought, heavy rain) reduces the income per production value by 15 per cent in the case of 30 per cent of farmers suffering damage, while the compensation for damage is higher than 8 per cent only in the case of 10 per cent of farmers with damage due to the high absolute value of deductibles.

The policy implications of these findings, which in the long term will allow an enlargement of the risk community and the reduction of exposure to risks, as well as a reduction in government expenditure and a certain level of profitability of insurance companies, are the following:

1. The introduction of the agricultural insurance scheme presented here, in addition to the interests of agricultural producers and insurance companies, is also in the government interest because setting up this insurance structure allows agricultural producers to cut their financial losses, which in turn reduces the pressures on producers and at the same time on the state damage mitigating fund.
2. Successful operation of this agricultural insurance scheme can be achieved only if the risk community grows to a suitable size. Therefore government support is needed for a rapid expansion of the risk community to this size. This can be achieved by means of an insurance premium subsidy, other allowances granted for farmers with insurance contracts, or even administrative regulations that specify a certain level of insurance engagement.
3. Enhanced risk coverage offers the possibility of better protection against risks for every financing organisation. Thus banks financing agricultural crop production and integrators can reduce credit rescheduling and the risks of non-payment caused by adverse weather conditions if they oblige agricultural producers to take out the all-risks crop insurance that is available on the market.
4. Government monitoring of agricultural insurance companies and market processes is required to prevent the increase of insurance premiums above the market equilibrium premium level due to government stimulation of the spreading of agricultural insurance. Nevertheless the likelihood of charging extra insurance premiums because of the insurance fee subsidy is very low based on the experience of the last ten years which is characterised by a very low insurance damage rate.
5. The introduction of the insurance scheme presented in this study can be performed only with high insurance premiums and a high value of deductibles which would be expected to yield lower loss ratios for insurance companies, but after the spreading of this insurance scheme among farmers the loss ratio should gradually decline to 75 per cent. This should be achieved by decreasing the absolute value of deductibles instead of reducing the insurance premiums. In this way an increased level of protection of farmers can be achieved by agricultural insurance, which reduces the risk of a drastic decrease in farmers' profit before tax caused by adverse weather conditions
6. The high range of yields in micro-regions indicates large differences in crop output in Hungarian agriculture within the same micro-region. Since the technological losses cannot be perfectly separated from losses caused by adverse weather conditions it is not sufficient to classify micro-regions according their risk characteristics except in the short term, i.e. the year of introducing the insurance scheme. In the long term insurance premiums should be based on the individual records of loss ratios in the case of every crop producer, developing a *bonus-malus* insurance premium system. This insurance scheme can adequately handle the extent of the differences in country-wide and micro-regional level risks due to the differences in natural endowments and the production skills of farmers. In this case, in a micro-region with a high loss ratio a farmer producing in favourable microclimatic conditions and/or with excellent production skills can obtain an insurance contract for her/his crop production at a lower insurance premium, while in a micro-region with a low loss ratio a poorly performing farmer should accept higher insurance premiums according to her/his higher loss ratio compared to the average micro-regional loss ratio.

In conclusion, insurance in agriculture is becoming an essential risk management tool for farmers to handle unexpected effects of different shocks. The introduction in Hungary of multi-risk yield insurance based on macro-regional and micro-regional differentiated damage thresholds, as well as on macro-regional and micro-regional differentiated insurance premiums, will help to preserve the standard of living of those who depend on farming, strengthen the viability of farm businesses, and provide an environment which supports investment in the farming sector. The introduction of micro-regional optimised insurance premiums will lead to wider risk communities in agricultural production and a sustainable agricultural insurance system.

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