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PROBABILITY OF THE INSURED EVENT OCCURRENCE IN THE INDEX INSURANCE OF CROPS

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Abstract

On the basis of the classical multirisk insurance the comparative analysis led and index insurance of a harvest of crops, authors have drawn a conclusion on prevalence in the Russian practice of traditional multirisk model over more available, from the economic point of view, index agroinsurance, owing to imperfection of the existing standard and legal base and also lack of the state support (index agroinsurance unlike classical model of multirisk insurance). Modification of a traditional method of calculation of probability of a loss occurrence at index insurance of productivity of crops is offered. The author's modified technique assumes calculation of probability of a loss occurrence not on the basis of the number of years, and on the basis of data on crop acreage that in turn, allows to receive more representative results reflecting not only the fact of emergence of an insured event, but also its scales. Approbation of the traditional and modified index approach to determination of probability of a loss occurrence has shown that the author's modified technique allows to consider more correctly the statistical frequency of a loss occurrence and also crop acreage on a climatic microzone on which the insured event for the considered period took place, providing thereby correct accounting of a difference in the crop structure of sown areas.

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Keywords: Agricultural insurance, index insurance, crop yield insurance, insurance event.

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1. Introduction

The procedure for determining the probability of an insured event is one of the key procedures both in insurance in general and in agricultural insurance particularly: it largely determines the amount of the insurance premium paid by the insured to the insurer, on which the economic attractiveness of agricultural insurance for all its participants depends.

In the world practice, there are two main models of agricultural insurance in relation to crop yields:

1) classical multi - risk insurance, supposing determination of fact of offensive of accident insured on the basis of data of certain producer of agricultural produce;

2) index insurance, providing for ascertaining of the fact of occurrence of insured event on the basis of the values independently calculated index (in particular, in such as there may be regional indexes of productivity or variety of "weather" indexes).

The conceptual differences of index insurance from the classical model are:

- no restrictions on the value of the franchise (for the classical model of insurance is characterized by the establishment of a mandatory (by law) or recommended (at the level of associations of insurers) the value of the franchise);
- the independence of determining the occurrence of the insured event (it is fixed on the basis of independent organizations that are not a direct party to the insurance relationship);
- lower cost of insurance products is compared to the traditional model of insurance in connection with a reduction in costs of the insurer.

In the context of historically conditioned features of the formation of the legislative framework at the national level at the moment in Russia is definitely the predominant multi risk schema is a traditional model of crop insurance of agricultural crops, involving the simultaneous insurance of the totality of risks enshrined in law (actually their list is exhaustive) for which a normative set of a fixed amount deductible of 30%.

In the specialized scientific literature some aspects of this model of insurance from the mathematical point of view and computer modelling is discussed by Miranda & Vedenov (2001), Banks (2004), Grossi & Kunreuther (2005), Goodwin & Vado (2007), Garrido & Zilberman (2008), Chichilnisky (2009), Mahul & Stutley (2010), Smith & Glauber (2012), Si-nan (2008) etc.

In scientific literature the problems of index insurance in the Russian market, including from the standpoint of mathematical and computer modelling, is considered in works of Turyansky, Charykova, Chogut, & Grishina (2007), Sannikova (2009), Shumilina & Zhichkin (2010), Bizhdov (2014), Shcherbakov (2014), Efimov & Tupikov (2015), Prokopyeva (2017), etc.

Also, scientific articles by Menkhaus, Yakunina, & Phillips (2001) are devoted to the study of the price discovery for agricultural goods in the context of different (alternative) trading institutions using the methods of experimental economics.

Index agricultural insurance in our country is used only in a few cases, although in comparison from an economic point of view to traditional multirisk model insurance it is much more affordable for agricultural producers. Low degree of dissemination of the index insurance is largely due to the

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imperfection of the existing legal framework, as well as a complete lack of state support in contrast to the classical model of multi-risk crop insurance.

2. Problem Statement

The traditional use of index insurance of crop yields provides for the following calculation logic:

1) calculate the average yield of a crop for a specific territory (as a rule, a municipal area) for each year ($\overline{y_{r_i}}$):

$\overline{y_{r_i}} = \frac{\sum y_{r_i} * c_{r_i}}{\sum c_{r_i}}$, (1)

y_{r_i} – the yield of crops in the year on each individual field relating to the territory under consideration;

c_{r_i} – sown area of crops in the year on each individual field relating to the territory under consideration;

2) calculation of the average historical yield of crops for specific areas ($\overline{Y_{r_i}}$):

$\overline{Y_{r_i}} = \frac{\sum_{i=1}^{n} \overline{y_{r_i}}}{n}$, (2)

n is the number of years over which is calculated the average historical yield;

2) determining the value of the franchise (F) is performed individually for each policyholder, both in absolute and relative terms;

3) determination of the insured sum (IS), also produced individually for each policyholder;

4) calculate the average actual yield of crops for the year in which the insurance is made ($\overline{y_{r_{n+1}}}$):

$\overline{y_{r_{n+1}}} = \frac{\sum y_{r_{n+1}} * c_{r_{n+1}}}{\sum c_{r_{n+1}}}$, (3)

$y_{r_{n+1}}$ – the actual yield of crops in a year in which the insurance on each individual field relating to the territory under consideration;

$c_{r_{n+1}}$ – the actual sown area of crops in the year in which the insurance on each individual field relating to the territory under consideration;

5) comparison of average historical yield of crops for specific areas ($\overline{Y_{r_i}}$) with average actual yields of crops for the year in which the insurance ($\overline{y_{r_{n+1}}}$):

- if $\overline{y_{r_{n+1}}} \geq \overline{Y_{r_i}} - F$, the insured event does not occur, and the amount of the insurance indemnity is equal to 0
- if $\overline{y_{r_{n+1}}} < \overline{Y_{r_i}} - F$, there is an accident, and the amount of insurance compensation (IC) is determined by the formula:

$IC = IS * IL$, (4)

IL – the insurance loss is determined by the formula:

$IL = \frac{\overline{Y_{r_i}} - \overline{y_{r_{n+1}}}}{\overline{Y_{r_i}}} - F$, (5)

F – the deductible defined in the share unit, wherein:

- if $\frac{\overline{Y_{r_i}} - \overline{y_{r_{n+1}}}}{\overline{Y_{r_i}}} \leq F$, то ILwill be equal to 0 (so, $IC = 0$);
- if $\frac{\overline{Y_{r_i}} - \overline{y_{r_{n+1}}}}{\overline{Y_{r_i}}} > F$, то $IL > 0$ ($IC > 0$).

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Under this approach, determining the probability of occurrence of the insured event P_{IE} is as follows:$P_{IE} = \frac{n_{IE}}{n}$, (6)

n_{IE} – the number of years in which observed occurrence of the insurance event.

Unfortunately, in Russian practice there is a situation when the traditional approach is used in index insurance is not applicable due to the very nature of the initial statistical data which are published by the Federal state statistics service, in particular:

- for certain types of crops detailed statistics on productivity is not maintained (e.g., official statistics are not separately distinguished rank, chickpea, mung bean: data are collected together; there is no detail for individual types of lentils: red, green, yellow, etc.);
- the original time series may have "gaps", due to the fact that in some years one or the other crop is not cultivated in the municipal area;
- the original length of the time series on the yield of crops in a particular area, for objective reasons, may be significantly less than the recommended (in particular, the world Bank recommends the use of average data yield for 30 years).

In addition, the current method does not take into account changes in cropping patterns occurring from year to year, which are used to calculate the average crop yields, i.e. each year the average yield is calculated for different acreage.

3. Research Questions

In this regard, it is expedient modification of the calculation of the probability of occurrence of an insured event involving the presence of the following features compared with conventional method:

1) the calculation of the average yield of agricultural crops and average historical yield of crops are based on historical data, not on any particular territory (municipal district), and in General climatic microzones ($\overline{y_{m_i}}$ и $\overline{Y_{m_i}}$) i.e., the insured event under similar logic occurs if $\overline{y_{m_{n+1}}} < \overline{Y_{m_i}} - F$;

2) the determination of the amount of the insured sum (IS) according to the standardized algorithm:

$IS = \overline{Y_{m_i}} * c_{p_{n+1}} * \overline{MP}$, (7)

$c_{p_{n+1}}$ – projected sown area of crops the insured (the agricultural producers);

(MP) – the average market price of crops is calculated over n years, as defined by the formula:

$\overline{MP} = \frac{\sum_i^n MP_i}{n}$, (8)

3) determining the probability of occurrence of the insured event is subject to the acreage of agricultural crops, i.e. this takes into account not only the fact of occurrence of the insured event, but that the sown area in which it took place:

$P_{IE} = \frac{\sum_{i=1}^n c_{IE_i}}{\sum_{i=1}^n c_i}$, (9)

where c (IE_i) – sown area of agricultural crops according to the climatic zone where took place the insurance event during the period under review;

c_i – sown area of agricultural crops according to the climatic zone during the period under review.

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Thus, the proposed method of calculating estimates of the probability of occurrence of the insured event involves the calculation of this indicator is not based on the number of years, and on the basis of data on the sown area of agricultural crops. In our opinion, in the case of short time series (statistical data on crop yields and areas sown to crops in the context of municipalities published 2012) this approach allows you to get much more representative results, reflecting not just the fact of occurrence of the insurance event, but also its scope.

4. Purpose of the Study

The purpose of this study is to develop an alternative algorithm to evaluate the probability of occurrence of the insured event in index insurance of crops, on the one hand, allowing to carry out such calculations on the basis of the existing information base (statistical data collected and published by Federal state statistics service), and, on the other hand, gives the possibility to properly take into account the extent of the insured event (in the framework of the traditional approach, all the insurance cases are recognized as a priori), as well as to solve the problem of short time series, characterized by the presence of "gaps" is not due to systematic cultivation of crops on territories of municipal areas.

5. Research Methods

The study was performed using economic-statistical methods of structural dynamic analysis, primarily with the use of the relative statistical indicators (variables).

Testing of traditional and modified index approach was carried out on the example of OP Marksovsky “Novopokrovskoe”, LTD Marksovsky district of the Saratov region, as a test crop was spring barley selected.

Table 01. The Average yield of spring barley in Marksovsky district of the Saratov region in 2012-2017, kg/ha] (Federal state statistics service of the Russian Federation, 2018)

Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Yield level	3,1	5,5	14,3	5,6	18,9	19,6

The average historical yield for crops (kg/ha), calculated on the basis of data available in the public domain, is:

$$\overline{Y_{r_i}} = \frac{3,1+5,5+14,3+5,6+18,9+19,6}{6} = 11,2.$$

Let the deductible is 25% (F=0,25).

In 2018, the sown area of spring barley in the OP Marksovsky “Novopokrovskoe”, LTD made up 503 ha projected crop amounted to 12 t/ha (1.2 t/ha) and the expected selling price of commodity products – 600 rubles/kg (or 6000 RUR/t), i.e., the sum insured was 3621600 RUB (IS=1,2*503*6000=3621600). Due to the fact that the final statistics on actual yields of spring barley in Marksovsky district of the Saratov region will be published only in the first half of 2019, to determine the probability of occurrence of the insured event only on the basis of available historical data (table 2).

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Table 02. Calculation of the number of times of occurrence of the insured event at the level of the franchise, equal to 25% in 2012-2017 (for example, the yield of spring barley in Marksovsky district of the Saratov region)

Year	2012	2013	2014	2015	2016	2017
IL	0,4724	0,2575	0	0,2485	0	0
The fact of the insured event	Yes	Yes	Not	yes	Not	Not

The table shows that n_IE=3 (for a given level of the deductible, the insured event occurred in 2012, 2013 and 2015), i.e

$P_{IE} = 0{,}5$ ($P_{IE} = \frac{3}{6} = 0{,}5$).

In total in territory of the Saratov region allocated 7 climatic micro-watersheds, while Marksovsky district is in the Northern left-Bank microzone, which in addition also included Balakovo, Dukhovnitsky, Ivanteevka and Pugachev areas (data on yields and sown areas of spring barley for this zone are presented in tables 3 and 4).

Table 03. The Average yield of spring barley in the Northern left-Bank zone of the Saratov region, 2012-2017, kg/ha] (Federal state statistics service of the Russian Federation, 2018)

Year	2012	2013	2014	2015	2016	2017
Balakovsky area	5,6	8,6	15,3	6,2	18,7	19,2
Dukhovnitsky area	7,0	9,3	12,4	7,5	16,3	15,5
Ivanteevskiy area	11,2	9,6	15,3	9,5	14,6	19,1
Pugachev area	8,3	7,7	12,5	4,5	15,6	21,3

Table 04. Acreage of spring barley in the Northern left-Bank zone of the Saratov region, 2012-2017, ha (Federal state statistics service of the Russian Federation, 2018)

Year	2012	2013	2014	2015	2016	2017
Balakovsky area	18361,5	14917,0	15372,5	19962,5	14934,5	13327,0
Dukhovnitsky area	12652,0	13848,0	14067,0	16596,0	12378,0	8711,0
Ivanteevskiy area	13667,0	15075,0	22315,0	25225,0	24153,0	19121,0
Marksovsky area	14632,0	9928,0	6455,0	11294,0	8885,	12374,0
Pugachev area	20637,0	20794,0	9253,0	11392,	8993,0	12680,0

The average yield of spring barley is calculated taking into account the amount of acreage in the Northern left-Bank zone is presented in table 5.

Table 05. Average yield of spring barley in the Northern left-Bank zone of the Saratov region, 2012-2017, kg/ha

Year	2012	2013	2014	2015	2016	2017
Yield (for the micro zone)	7,0	8,3	14,2	7,1	16,5	19,2

The average historical yield in the Northern left-Bank zone $\overline{Y_{m_t}}$ for the reporting period is 12.0 C/ha.

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To ensure the comparability of results obtained using different methodologies, the deductible must be the same (F=0,25), however, the value of the sum insured in this case will be different: it will be 3802680 RUB (IS=1,2*503*6300=3802680) due to the difference in yield of spring barley (in this case it is numerically equal), and the average price of realization (in the calculation of the insurance sum it is calculated on the basis of average prices for 2012-2017). The calculation of the number of times of occurrence of the insured event on the yield of spring barley in the Northern left-Bank zone, the value of the insurance loss and the acreage of spring barley, which was the occurrence of the insured event are presented in tables 6, 7 and 8.

Table 06. The Fact of occurrence of the insurance event at the level of the franchise, equal to 25% in 2012-2017 (for example, the yield of spring barley in the Northern left-Bank zone of the Saratov region)

Year	2012	2013	2014	2015	2016	2017
Balakovsky area	Yes	Yes	Not	Yes	Not	Not
Dukhovnitsky area	Yes	Not	Not	Yes	Not	Not
Ivanteevskiy area	Not	Not	Not	Not	Not	Not
Marksovsky area	Yes	Yes	Not	Yes	Not	Not
Pugachev area	Yes	Yes	Not	Yes	Not	Not

Table 07. Calculation of the amount of insurance loss at a deductible level of 25% in 2012-2017 (for example, the yield of spring barley in the Northern left- Bank microzone of the Saratov region)

Year	2012	2013	2014	2015	2016	2017
Balakovsky area	0,2850	0,0359	0	0,2352	0	0
Dukhovnitsky area	0,1688	0	0	0,1273	0	0
Ivanteevskiy area	0	0	0	0	0	0
Marksovsky area	0,4926	0,2933	0	0,2850	0	0
Pugachev area	0,0608	0,1107	0	0,3764	0	0

Table 08. Calculation of the insured loss when the level of the franchise, equal to 25% in 2012-2017 (for example, the yield of spring barley in the Northern left-Bank zone of the Saratov region)

Year	2012	2013	2014	2015	2016	2017
Balakovsky area	18361,5	14917,0	0	19962,5	0	0
Dukhovnitsky area	12652,0	0	0	16596,0	0	0
Ivanteevskiy area	0	0	0	0	0	0
Marksovsky area	14632,0	9928,0	0	11294,0	0	0
Pugachev area	20637,0	20794,0	0	11392,	0	0

Given the acreage of spring barley, which had insured event occurs, the probability of its occurrence is

$P_{IE} = 0{,}3873$ ($P_{IE} = \frac{171166}{442000} = 0{,}3873$)

i.e. the result differs significantly from the result obtained based on the use of traditional methods (0,50).

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6. Findings

The results indicate an extremely high level of probability of occurrence of the insured event, questioning the very need for yield insurance of the crop in the area. For a given probability of occurrence of the insured event the value of the insurance rate will be very high, which makes insurance of yield of crops economically feasible for agricultural producers, while the decline in the value of the insurance rate is unreasonably high risks shall be assumed by the insurer.

It seems to us that the result is largely due to a very small length of the time series, where each new observation has a major impact on the probability of occurrence of the insured event. In this regard, it is advisable to conduct calculation of probability of insured event for insurance of crop yields given the climatic micro-watersheds.

7. Conclusion

The calculation of the probability of occurrence of insured event for insurance of crop yields using the modified method, involving calculations for the municipal area, and in General, the climatic zone, of which it is part, allows to obtain a more accurate and representative results by using a larger array of source statistics, largely solving the problem of "short" time series. In addition, the proposed approach to the definition of probability of approach of an insurance case allows to correctly take into account not just the statistical frequency of its occurrence (number of years in which observed occurrence of the insurance event), and scope (acreage of the analyzed crops in General, climatic micro-zone where took place the insurance event during the period under review). This ensures correct accounting for the difference in the structure of sown areas of crops, the occurrence of which is objectively due to the current weather conditions and the structure of crop rotation.

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