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Longitudinal differentiation of agroeconomic risks linked to long-term climate changes: evidence from the European part of Russia

Diferenciación longitudinal de los riesgos agroeconómicos vinculados a los cambios climáticos a largo plazo: evidencia de la parte europea de Rusia

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Abstract
Agroeconomic risks result from climate changes and state of agriculture. The IPCC model of climate changes and the indicators of agricultural land value for economic activity, labour force, and economy diversification are compared for three groups of regions of the European part of Russia. It is established that the value of land is significant in all groups. The agroeconomic risks increase together with the intensity of the forecasted climate changes. Programs of agriculture development should take this evidence into account.
key words: climatic hazard, regional agriculture, risk geography

Resumen
Los riesgos agroeconómicos resultan del cambio climático y el estado de la agricultura. El modelo de cambio climático del IPCC y los indicadores del valor de la tierra agrícola para la actividad económica, la fuerza laboral y la diversificación de la economía se comparan para tres grupos de regiones de la parte europea de Rusia. Se establece que el valor de la tierra es significativo en todos los grupos. Los riesgos agroeconómicos aumentan junto con la intensidad de los cambios climáticos previstos. Los programas de desarrollo agrícola deberían tener en cuenta esta evidencia.
palabras clave: peligro climático, agricultura regional, geografía de riesgo

1. Introduction

Global climate changes that result from the human activity are thought to be one of the most important challenges of the modern society (Houghton, 2009). The economic aspects of this phenomenon can be really impressive (Nordhaus, 1994; Auffhammer, 2018; Tol, 2018), and achievements in the relevant studied were recognized by the 2018 Nobel Memorial Prize in Economic Sciences to W. D. Nordhaus. It is also known that

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agriculture is the industry most vulnerable to global climate changes (Delince et al., 2015; Zhang et al., 2017; Carter et al., 2018). However, the geographical patterns of agroeconomic risks are yet to be fully understood. Undoubtedly, these risks can be established for countries, but differences of their economical systems can "mask" some important regularities. In this case, it is promising to pay attention to the big countries that fulfill two conditions, namely stretching through several zones with different expected climate changes and consisting of administrative units, the agriculture of each of which is well characterized by the statistical data. The countries suitable for analysis are few, and one of them is Russia.

The European part of Russia (a traditionally recognized territory between the state border in the west, the Barents Sea in the north, the Urals in the east, and the Caucasus in the east) boasts well-developed, diversified, and high-productive agriculture if even facing some serious challenges (Nefedova, 2017; Cherednichenko et al., 2018; Fedotova et al., 2020). The activities include crop and vegetable production, animal husbandry, and the relevant food production. For instance, the Russian South is known as one of the world-important centre of wheat production, whereas milk production is typical for some areas in the north of this territory. In tIntergovernmental Panel on Climate Changehe long-term perspective, significant climate changes are forecasted for this territory (Intergovernmental Panel on Climate ChangeIPCC, 2014). The latter consists of relatively small administrative units (regions) with a different state of agriculture.

The objective of the present paper is to provide the preliminary evidence of longitudinal differentiation of agroeconomic risks linked to century-long climate changes in the light of the available statistical information. In the other words, this study seems to be the first step towards understanding geographical patterns of such risks on the national scale.

2. Methodology

Risk linked to global climate changes is a highly-complex idea (Jones, 2001; Preston et al., 2011; Xie et al., 2019; Javed et al., 2020; Toimil et al., 2020). Of big interest is the methodological template proposed by Carrao et al. (2016) who studied the global drought-related risks and dealt with three main constituents of the latter, namely hazard, exposure, and vulnerability. These constituents can be characterized with a set of indicators. Generally, the noted specialists demonstrated that risks are determined by the influence of the both natural factor and the socio-economic parameters of a given territory. In regard to the previous considerations, the agroeconomic risk examined in the present study is understood as a joint action of the forecasted long-term climate changes and the performance of the regional agriculture.

Eight Russian regions are selected for the present analysis (Table 1). These seem to be very representative to the south, the centre, and the north of the European part of the country, and the information on them permits interpretation of longitudinal differentiation.

The available models (IPCC, 2014) indicate that the intensity of long-term climate changes increases from the south to the north of the study territory (Figure 1). This is shown by the both pessimistic and optimistic scenarios, but the former is considered as representing the hazard more sharply (for the purposes of the present study, it is more important to understand the relative intensity of changes in the main geographical domains than the exact rate of the changes). The state of the agriculture is characterized with three indicators, namely PRO-AREA (the monetized volume of agricultural production from one agricultural land area unit), LAB-AREA (the number of agricultural workers dealing with one agricultural land area unit), and ENT-AREA (the number of agricultural enterprises working on one agricultural land area unit). Generally, these indicators suggest the value of agricultural land in regard to economic activity, labour force, and economy diversification, respectively. These indicators can be calculated for the selected regions with the statistical data provided by Rosstat; the "fresh" information characterize the state of the regional agriculture for 2017 (Rosstat, 2018). The original data used for

the purposes of the noted calculations include the knowledge of total agricultural land area of the selected regions, agricultural production converted from the national currency (RUR) to USD by the 2017-averahge exchange rate, the number of agricultural workers, and the number of agricultural enterprises.

Table 1

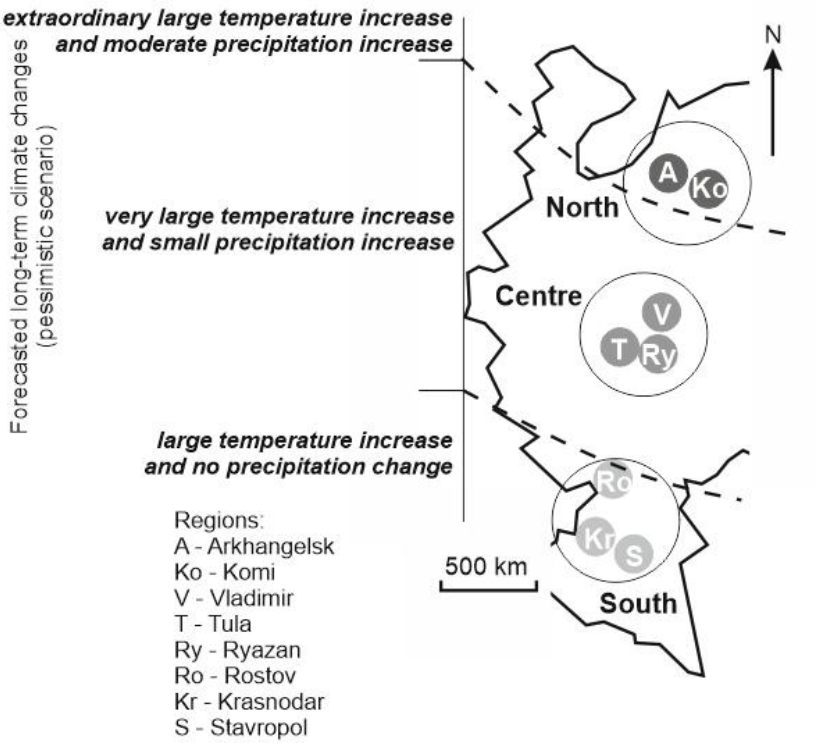
Basic characteristics of the analyzed regions.

Regions	Area, thousands sq km	Population, thousands	Regional contribution to national agroproduction, %%
South			
Rostov	101	4220.4	5
Krasnodar	75.5	5603.4	7.1
Stavropol	66.2	2800.7	3.7
Centre			
Tula	25.7	1491.8	1.1
Vladimir	29.1	1378.3	0.6
Ryazan	39.6	1121.5	1
North			
Arkhangelsk	589.9	1155	0.2
Komi	416.8	840.9	0.2

Source: Rosstat (2018).

Figure 1

Location of the selected regions on the study territory.



Source: compiled by authors.

The spatial gradient of the forecasted climate changes can be compared qualitatively to the indicators for the regions arranged in a south-north direction. Agroeconomic risks can be increased by the both higher intensity of climate changes and higher value of agricultural land. Two methodological notes should be given. First, the long-term climate changes will occur (as forecasted or differently) within a century. As it is (almost) impossible to forecast whether these will take synchronously across the study territory, it is presumed tentatively that the

gradient of these changes remains more or less constant, and it can be projected for the nowadays. Second, the proposed indicators seem to be important, but not only. Anyway, the idea of the present study is just to pose the question of within-country geography of agroeconomic risks on agenda, and, thus, these indicators seem to be enough: the tentative character of this study should be kept in mind.

3. Results

Each indicator demonstrates more or less significant differences between the selected regions (Table 2). Generally, the agricultural land is the most valuable in the Krasnodar Region of the Russian South, but it can be named as the least valuable in none region. For instance, the lowest PRO-AREA value is registered in the Arkhangelsk Region, but its ENT-AREA value is one of the biggest. This is a very interesting finding as it implies the absence of serious value loss by agricultural land moving from the "agriculture-friendly" south to the "agriculture-hostile" north.

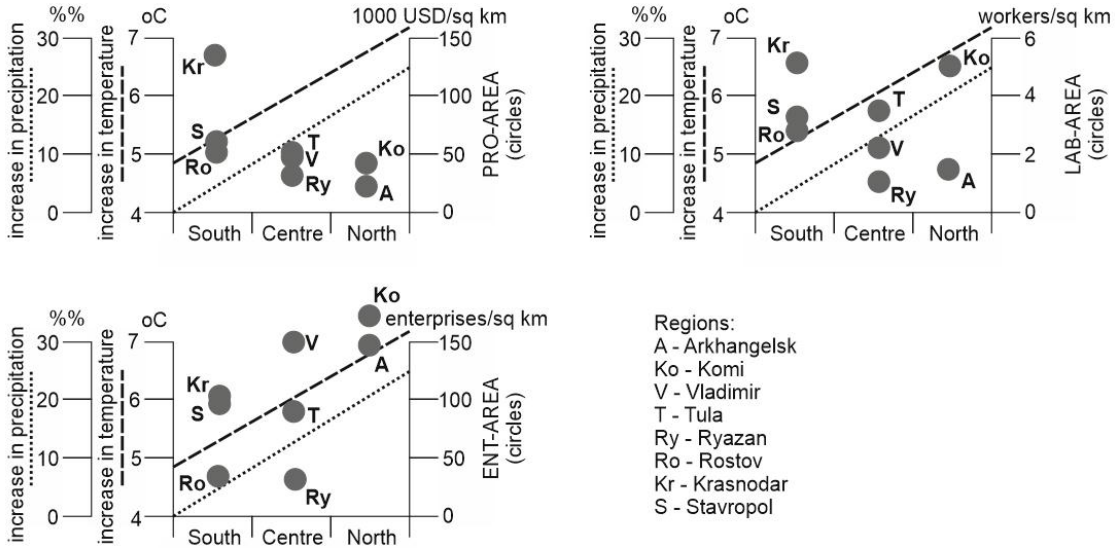
Table 2
Selected agroeconomic risk-related parameters of the analyzed regions.

Regions	PRO-AREA, 1000 USD/sq km	LAB-AREA,workers/sq km	ENT-AREA, enterprises/sq km
South			
Rostov	51.3	2.7	36.8
Krasnodar	132.9	5.2	102.6
Stavropol	55.7	3.4	92.8
Centre			
Tula	50.8	2.2	87.2
Vladimir	50	3.4	147.5
Ryazan	35.7	1.1	37.5
North			
Arkhangelsk	25.1	3.6	145.6
Komi	40.7	4.9	179.9

Source: compiled by authors

Gradients of the long-term climate changes and values of the indicators can be shown along the simplified longitudinal profiles (Figure 2). The intensity of temperature and precipitation change increases northwards, which contrasts the slight PRO-AREA decrease in this direction. The LAB-AREA decreases from the south to the centre, but it is impossible to judge about its significant change in the north. Finally, the ENT-AREA experiences increase: the maximum value is higher in the centre than in the south, and the values in the north are all high. Taken together, these results mean that the total value of agricultural land in the north of the European part of Russia is not less than in the south. The absence of clear loss in the value of agricultural land in the centre and the north means that the agroeconomic risks induced by the long-term climate changes are not minimized this way along the longitudinal profile. Moreover, the high values of the LAB-AREA indicator in Komi and the ENT-AREA in Komi, Arkhangelsk, and Vladimir mean that these regions are significantly exposed to climate change, which makes agroeconomic risks in them very high. Even if one would argue that the PRO-AREA indicator in the most essential, its decrease to the north appears to be too weak, especially in comparison to the forecasted intensity of precipitation changes (Figure 2).

Figure 2
Relationship of the analyzed parameters
on the simplified longitudinal profiles



Source: compiled by authors.

4. Discussion and conclusion

On the basis of the relative importance of the analyzed regions to the national agricultural production (Table 1), one would hypothesize that agriculture in the north of the European part of Russia is less "precious" to the country, and, thus, its perturbations by the climate changes do not lead to significant agroeconomic risks; and, vice versa, the outstanding importance of the southern regions induces higher risks. Taken into account the northward intensification of the forecasted climate changes, it would be also possible to assume the absence or, at least, the weakness of the longitudinal differentiation of agroeconomic risks on the study territory. However, the employed indicators mean that the value of agricultural land is significant as in the south, as in the centre and the north. If so, the economic determinant of differentiation appears to be absent, while the natural determinant is present. Although more detailed investigations with more climatic information and bigger number of indicators are necessary, the present study provides a tentative evidence of increase in agroeconomic risks from the south to the north of the European part of Russia following the spatial pattern of the forecasted climate changes.

The present study contributes to the growing, but still restricted number of works linking the issues of climate changes, risks, agriculture, and geography (e.g., Husnain et al., 2018; Robinson, 2018). The practical importance of the main finding of this study is as follows. First, agriculture development in Russia is regulated by state programs approved and realized on the both federal and regional levels. These programs should take into account agroeconomic risks linked to long-term climate changes and treat these correctly. Particularly, it is necessary to avoid a situation when agriculture of the Russian South will be addressed with more attention because of its higher total productivity than that of the northern part of the country where risks are really higher because of the more intense climate changes and the high value of agricultural land. Second, the methodology of agroeconomic risk calculations should be further developed and "deepened" in order to provide a solid scientific basis for the noted programs and the planned adaptation- and investment-related decisions. The present study is a tentative one, and its limitations are linked to the use of only selected, intuitively-proposed indicators, chiefly related to agriculture exposure. Its outcomes indicate on the geographical differentiation of

agroeconomic risks, but the interpretations are basically qualitative. Efforts to propose a more comprehensive and fully quantitative risk assessment methodology are necessary, although this requires joint work and finding consensus of dozens experts. This research has to be conducted in such big and geographically differentiated countries as Canada, Brazil, and the USA.

Conclusively, this study permits documenting the northward increase in the agroeconomic risks linked to the forecasted long-term climate changes in the European part of Russia. This longitudinal trend is caused by significantly stronger climate changes in the north that is not recompensed by any serious loss in the value of agricultural land. This finding stresses the urgency of future studies of geographical aspects of agroeconomic risks and also provides evidence for the state governance of risks related to climate changes.

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