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RISK OF AGRICULTURAL PRODUCTION IN RUSSIAN OREL REGION

Marián Tóth, Vladislav Matveev, Andrea Boháčiková

ABSTRACT

The paper evaluates the risk of agricultural farms in Russian Orel region by using the modified Markowitz portfolio theory. We analyse individual farm data of agricultural animal and crop production with respect to yield, price and revenue agricultural risk. Farms included in the analyses represent four organizational legal forms and the range of agricultural products produced by these farms is wide. Therefore the research focused on the grain and milk production only. Over the period 2010 to 2014 the effects of Russian ban on import of agricultural products from EU can be observed in form of increased price level of individual commodity prices. Risk and return are negatively related and investors are comparing the risk with profitability. The same stands for farmers. They select the type of production based on expected return. The result show that the systemic yield, price and revenue risk of grain production is higher when compared to milk production. This is due the nature of animal and crop production. Climate and weather risk has much lower effect on animal production when compared to crop production. Therefore the overall risk of crop production is higher. But farmers consider the risk not isolated but in relation to profitability. The profitability of crop production is higher as in Orel region more than 90% of agricultural production is not animal related and farms are profitable with and also without subsidies. Our empirical study shows that in case of equal expected profitability animal production is more profitable for the farmer as it is linked to lower yield, price and revenue risk.

Keywords: Markowitz; profitability; risk; production; price; yield

INTRODUCTION

In the last years the agro-industrial complex of the Russian Federation faces serious restructuring, namely the transformation into an independent sector of the economy. These changes are due to a number of macroeconomic factors, such as: reduction of oil prices, depreciation of the national currency, the growth of the consumer price index, a ban on the import of consumer goods and raw materials, increase in the refinancing rate and many other effects of economic and political sanctions on Russian economy. Generaly in many transition economies agricultural production is adapting to domestic demand influenced by the lower purchasing power of population and by changes that occurred in the structure of consumption and in consumer behaviour of the population **(Michalski, 2015)**. Crop and also milk production is changing due to globalization **(Mura et al., 2012)**. Milk production exports increases and country competitiveness in exporting milk changes over time **(Mura, 2011)**. One of the reason are also changes in the consumption and consumer preferences **(Kubicová and Habánová, 2012)**.

All the changes in Russian economy contribute to a series of macro-economic structural changes in agriculture, such as:

- Providing food security by reducing dependence on imported goods and services;
- Increasing profitability and efficiency of agrarian sector of the economy, by means of increasing the volume of production and sales of agricultural products;
- Improving the quality of products, due to the modernization (machinery and technology);
- Reducing the dependence of the Russian economy on raw materials industry and the influx of capital in other areas of production, including agriculture;
- Increasing level of state support of agricultural producers;
- Implementation of the results of science and research in production, processing and storage of agricultural products.

Each of the presented changes can improve the agricultural economy and the Russian economy as a whole. However, success of each of these factors is only possible in the complex of all the others.

One of the aspect which influences the success of a farm is the risk management. Farms are generally affected by various types of risks. In the paper we focus on the risk of Russian agricultural farms engaged in primary production in Orel region.

Risk generally refers to deviation of the evaluated indicator, and its level depends on the volatility over a certain period. Risk in agriculture has been a matter of worldwide concern since 1933, when the concept of risk analysis had been introduced **(Hardaker et al., 2004)**. Agriculture is a sector facing particularly large risks, resulting mainly from natural factors outside the control of farmers. The sources of risks, that are relevant in agriculture have different characteristics, and can be classified in very different ways **(Huirne et al., 2000; Holzman and Jorgensen, 2001)**. Production or yield risk occurs because agriculture is affected by many uncontrollable events that are often related to weather, including excessive or insufficient rainfall, extreme temperatures, hail, insects, and diseases **(Miller et al.,**

2004). For crops, common causes of yield risk include weather events (drought, excess moisture, hail, freeze and flooding), crop pests and disease. Livestock production losses are much less frequent than crop production losses, and tend to be due to disease outbreaks, weather-related perils or predators. Production risk is likely to grow, due to climate change and globalisation **(Kahn and Zaks, 2009; Heymann, 2007)**. Price risk refers to variability in output and input prices. Variability in fuel prices and in fertilizer prices appear to be the main components of input price variability in crop production, partly because fuel and fertilizer amount to most of the input costs in conventional agriculture, and partly because, as commodities themselves, they are subject to price fluctuations. This variability is expected to increase, in line with increased volatility of energy prices. In the livestock sector, input costs amount predominantly to feed costs **(Kimura et al., 2010)**. Output price risk arises due to the biological lag inherent in agricultural production. During this period, output prices may change dramatically in response to shocks in supply and demand. This may put farmers in a difficult situation if commodity prices decrease drastically during the production and marketing cycle, as observed also during the food commodity price spike in 2007/2008. Price and production risk are two important components of revenue risk. Unpredictable variations in farm revenues can reduce the ability of farm businesses to invest in order to improve productivity and profitability, and consequently affect the future economic welfare of those working in agriculture.

Direct sources of risk not only for Russian agriculture are the climate change, price fluctuations and foreign exchange markets, the violation of the organization of technological operations, negative epidemiological situation and many other factors.

Within this concept, there are many different approaches for assessing the impact of risk on the activities of the organization. Talking about the systematic risk which refers to the general level and not individual or farm level the concept of diversification is applied. One of them is the Markowitz portfolio theory. Its essence lies in the fact that the risk is a standard measurement of the medium-dispersion model and the standard deviation of return on the company's shares **(Markowitz, 1952)**.

The risk analysis of agriculture, using the Markowitz approach or Single index model, has been applied to a number of studies. They mainly focused on the certain part of agriculture production, for example, **Peterson and Leuthold (1987)** used the portfolio approach to examine the cattle feeding problem, **Sanchirico et al., (2005)** use portfolio theory to develop optimal management of fisheries, **Gempesaw et al., (1988)** applied the model to Delaware farm sector market portfolio or in more recent study **Libbin et al., (2004)** applied the Markowitz portfolio model directly to a series of New Mexico farms and many other studies could be mentioned.

This paper is the extension of our previous study **(Tóth et al., 2014)** and we focus on the study of yield, price, and revenue risk. The main purpose is to evaluate the above-mentioned risks of Russian agricultural farms in the Orel region over the period 2010 – 2014. We use the alternative approach based on the Markowitz portfolio theory.

MATERIAL AND METHODOLOGY

The data used for the analysis are individual data of agricultural farms of Orel Region (Russia) for the period 2010 – 2014. Orel region is located in western part of Russian federation with total area of 24 700 km^2. Farms included four organizational and legal forms: agricultural cooperatives, partnerships, limited liability companies and joint stock companies. Since the range of agricultural products produced by these farms is wide, the selection criterion was the obligatory presence of the product in all years. We focus on grain and milk production only.

The modified Markowitz portfolio theory approach was used to assess the agricultural enterprises of Orel region (Russia), namely to assess the yield risk, price risk and revenue risk in the Orel region of farm i. Yield risk is measuring the volatility of tons over the observed period. Price risk is focusing on the volatility of prices of the agricultural commodity. Revenue risk combines the production with prices and measures the volatility of the revenue from hectare (grain) or head (milk).

$$Yield^{\,i} = \frac{Production\ output}{Sowing\ area\ (or\ livestock\ animals)}$$

$$Price^{\,i} = \frac{Revenues\ from\ sales}{Production\ output}$$

$$Revenue^{\,i} = Yield * Price$$

The modified Markowitz portfolio theory approach was used to estimate the total yield, price, revenue risk. The calculation is based on the average value EX of the evaluated indicator X (Yield, Price, Revenue) of individual farm i:

$$EX_i = \sum_{i=1}^{t} X_i \cdot d_i$$

Where Xi is indicator of farm "i", di is a weight of Xi over the observed period (5 years, di = 0.20), t is number of years in observed period, i, j are individual farms. The individual risk of each farm (σ_i) is calculated using the standard deviation.

$$\sigma_i = \sqrt{\sum_{i=1}^{t} (X_i - EX_i)^2 \cdot d_i}$$

Where σi is standard deviation of the individual indicator X (individual farm risk), Xi is individual farm indicator, EXi is average individual farm indicator.

The portfolio risk (σ_p) is determined by three variables: weight of the individual farm in portfolio (wi), standard deviation of individual risk (σi), and covariance, relation between the Xi and Xj (σij). To take into account market portfolio of all agriculture farms, the weight wi of each farm is determined by farm market share on the specific market in Orel Region. The covariance represents the relationship between returns and Σ covariance matrix. The portfolio risk is then measured according to eq. for σ_p.

$$\sigma_{ij} = \frac{1}{n} \sum_{i=1}^{n} (X_i - EX_i)(X_j - EX_j)$$

$$\Sigma = \begin{bmatrix} \sigma_{11}\,\sigma_{12} & \sigma_{13} & \dots & \sigma_{1k} \\ \sigma_{21}\,\sigma_{22} & \sigma_{23} & \dots & \sigma_{2k} \\ \sigma_{31}\,\sigma_{32} & \sigma_{33} & \dots & \sigma_{3k} \\ & \cdots & & \\ \sigma_{k1}\,\sigma_{k2} & \sigma_{k3} & \dots & \sigma_{kk} \end{bmatrix}$$

$$\sigma_p = \sqrt{\sum_{i=1}^{n} w_i^2 \cdot \sigma_i^2 + \sum_{i=1}^{n} \sum_{j=1}^{n} w_i \cdot w_j \cdot \sigma_{ij}}$$

Where wi is an individual weight of i-farm in a portfolio and n is number of farms.

The expected portfolio yield, price and revenue is estimated by the multiplication of k x 1 vector of individual weight of farm in portfolio (w) and k x 1 vector of corresponding individual expected indicator (the sum of multiplication of each farm´s expected X and its share in the market).

$$EX_p = \sum_{i=1}^{n} EX_i \cdot w_i$$

Where EXp is expected portfolio yield, price and revenue and EXi is the average yield, price and revenue of individual farm. Finally to compare the relative extent of the risk coefficient of variation was used.

$$CV_p = \frac{\sigma_p}{EX_p}$$

Markowitz portfolio theory has several assumptions describing the behaviour of rational investor. The paper does not focus on the investment choice and decision making process of investor, as well as the efficient frontier modelling, but uses the theory as a tool to collect individual farms into common portfolio for risk assessment. Therefore the non-compliance of the assumptions of theory is not considered to have a negative effect on the results.

RESULTS AND DISCUSSION

Agro-industrial complex of the Russian Federation is a complex economic structure whose primary purpose is the production, storage, transportation and marketing of agricultural products. It consists of three units:

- Organizations involved in the production of capital goods (fixed assets, raw materials, etc.), required for the production of agricultural products;
- Organizations that are directly involved in agricultural production (production of livestock and crop production);
- Processing organization.

The main part of risk is linked to farms directly involved in the production of goods, as they are facing a variety of climatic and economic risks. Therefore, research of agricultural risks should be carried out on the example of such a farms. Table 1 shows the dynamics of the financial performance of farms in the Orel region.

The table 1 reflects the decrease in the number of farms and the relative stable share of profitable farms with an average of 76.8% in the analyzed period. Financial indicators show the increase in average profitability and also the ability to generate profit without subsidies in last three years. One of the reason for the increase in 2014 is the ban on agricultural imports from EU and other countries. The structure of agricultural production in Orel region is presented in Table 2. Agricultural crop production in Orel region is focused on grain and sugar beet production. These two crops amount to 90% of the total agricultural production. Animal production is less than 10% and it is dominated by milk production. For our analysis we selected grain and milk production with the aim to compare risk and profit of crop and animal production in Russian Orel region.

Table 1 The dynamics of financial performance of farms in Orel region.

Indicators	**Years**				
	2010	**2011**	**2012**	**2013**	**2014**
Farms	214	186	197	171	173
- Out of them profitable	151	148	157	123	140
Share of profitable on all, %	71	80	80	72	81
Return on costs, %	11.8	15.9	25.5	14.2	23.9
Net profit margin(profit/assets), %	5.0	10.1	17.7	10.4	19.1
Net profit margin without subsidies, %	(7.3)	(3.0)	8.9	0.6	11.8

Source: Territorial body of the Federal State Statistics Service of the Orel region.

Table 2 Structure of agricultural production Orel Region, %.

Types of products	**2010**	**2011**	**2012**	**2013**	**2014**
Grain	55.40	40.50	43.88	47.24	57.33
Beet sugar	31.68	50.10	46.80	44.65	34.98
Sunflower seeds	0.57	1.88	1.57	2.03	1.81
Potatoes	0.67	1.05	1.91	1.30	1.21
Vegetables	0.18	0.18	0.13	0.14	0.12
Fruits and berries	0.07	0.03	0.07	0.03	0.06
Cattle and poultry	2.32	1.41	1.31	1.20	1.42
Milk	6.04	4.00	3.61	2.88	2.54
Eggs	1.83	0.59	0.51	0.45	0.45
Wool	0.13	0.15	0.10	0.07	0.04
Honey	1.11	0.12	0.10	0.02	0.04

Source: Territorial body of the Federal State Statistics Service of the Orel region.

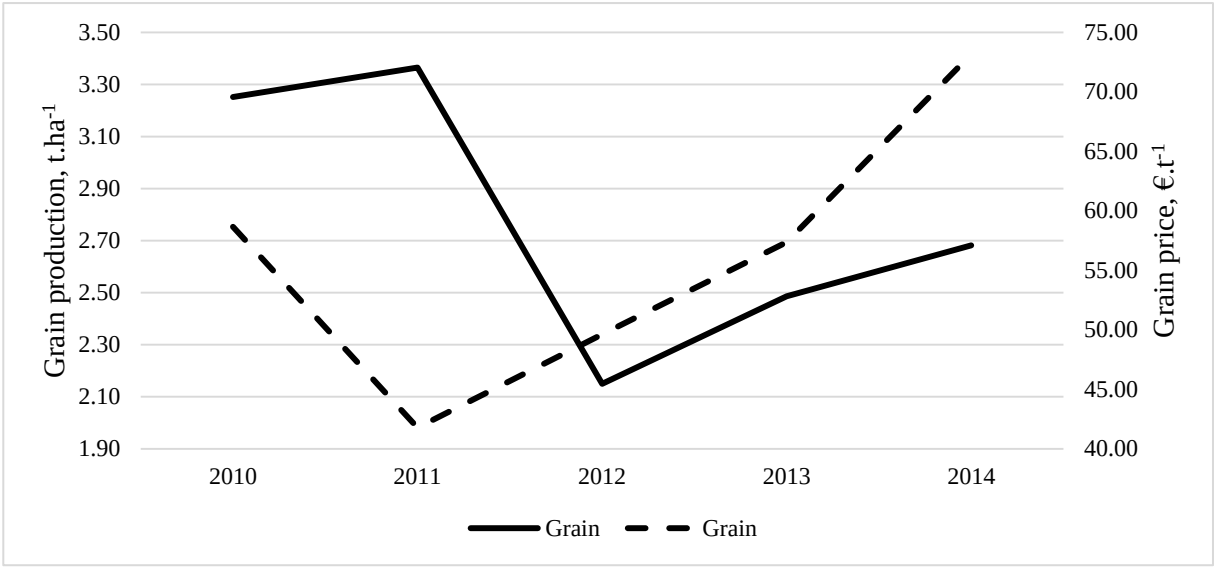

Figure 1 Grain production and price in Orel region.
Source: own processing.

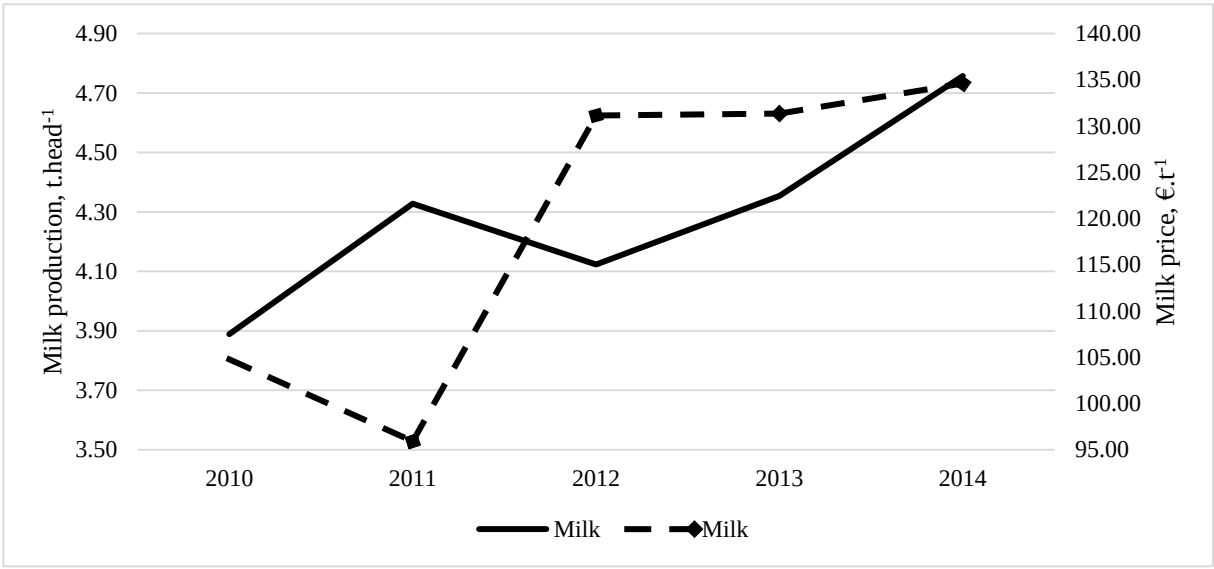

Figure 2 Milk production and price in Orel region.
Source: own processing.

Risk of Russian farms in Orel region

To assess the risks of farms in the Orel region we selected farms operating in each year of the observed period producing grain or milk in each year (2010 – 2014). We included 40 farms in the calculation of grain related risk and 32 farms in the calculation of milk related risk.

The average price and yield developments of grain and milk in Orel region are in figure 1 and 2. Both types of production are volatile with respect to ton per ha, ton per head and with respect the price. For the price we can see an increase in case of milk and grain from 2013 to 2014. Year 2014 was in Russia specific for the ban on agricultural imports from EU and Russian farms were benefitting in form of higher prices of agricultural commodities.

The differences in risk between milk and grain production were reflecting the individual changes in yields, prices and were cumulated by the Markowitz portfolio theory. The results measure the volatility on the level of systematic risk.

Direct calculation of each type of the risk using the Markowitz portfolio theory was performed in ton per hectare in case of grain and in tons per head in case of milk (Table 3). The methodology decreases the individual farm risk to the level of systematic or so called market risk. Based on the results it is possible to compare the yield, price and revenue risk between crop (represented by grain) production and animal (represented by milk production) production in the Orel region. The yield risk of grain in Orel region was measured by the volatility per hectare (Table 3). The average yield in ton was 2.87ton per ha with risk 0.56 ton per ha in the whole Orel region. Milk production is less risky with the results 4.21 ton per head and risk 0.44 ton per head. The best indicator to evaluate the relative size of the risk is variation coefficient. We can conclude that the risk of grain yield was 19.5% while the

Table 3 Risks of farms in the Orel region (Russia).

Risk type		Grain	Number of farms	Milk	Number of farms
Yield risk	Average yield	2.87		4.21	
(in tons/ha or tons/head)	Risk	0.56	40	0.44	32
	Variation coefficient	0.195		0.105	
Price risk	Average price	56.03		119.03	
(in €/ton)	Risk	10.09	40	17.79	32
	Variation coefficient	0.180		0.149	
Revenue risk	Average revenue	160.06		494.63	
(in €/ha or €/head)	Risk	39.72	40	94.55	32
	Variation coefficient	0.248		0.191	

Source: own processing.

risk of milk production 10.5% over the observed period. This is due the nature of animal and crop production. Climate and weather risk has much lower effect on animal production when compared to crop production.

Price risk was measured as the volatility of grain and milk price over the observed period not in individual farm but in the whole Orel region represented by 40 or 32 farms respectively. Grain price fluctuations were higher when compared to milk price. Measured in absolute measures the price risk of grain was 10.09€ per ton with the average 56.03€ per ton. So the relative volatility of grain price was 18% while the relative price volatility of milk was only 14.9%.

The revenue risk covers the volatility of production and price risk. Generally the revenue risk is lower as the sum of yield and price risk as in many cases the correlation is negative. In years of low yields the price is increasing and vice versa. Based on our results we can conclude that crop revenues are more volatile when compared to animal revenues. Grain revenue relative risk was 24.8% over the observed period in Orel region. Milk revenues are less volatile. Measured by variation coefficient the risk was 19.1% in the observed period.

CONCLUSION

Agricultural production is linked to risk. Some of the risks are common with other sectors in the economy and some are unique. Climate and weather related risk have a strong effect on agricultural production. In the paper we focused on the differences in risk between crop and animal production in Orel region over the period 2010-2014. Based on our results we can conclude that the Russian ban on agricultural imports from EU and other countries in 2014 had a positive effect on price development of grain and milk. Prices increased and farmers profitability also. There are differences in relative power of risk between crop production represented by grain and animal production represented by milk. Based on individual data we compared the yield, price and revenue risk in the whole Orel region. We can conclude that grain production is linked to higher yield, price and revenue risk when compared to milk production. Farmers same like investors are not evaluating risk individually. Risk and return are negatively related and investors are comparing the risk with profitability. The same stands for farmers. They select the type of production based on expected return. But the risk is hard to be evaluated individually. Our empirical study shows that in case of equal expected profitability animal production is more profitable for the farmer as it is linked to lower yield, price and revenue risk.

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Contact address:

Ing. Marián Tóth, PhD., Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Finance, Tr. A. Hlinku 2, 94976 Nitra, Slovakia, E-mail: marian.toth@uniag.sk.

Ing. Vladislav Matveev, Orel State Agrarian University, Russia, E-mail: vvmatveev@list.ru.

Ing. Andrea Boháčiková, PhD., Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Finance, Tr. A. Hlinku 2, 94976 Nitra, Slovakia, E-mail: andreapiterkova@gmail.com.