ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 67 140 Number 6, 2019

HOW CHANGE IN INDUSTRY MIX CAN IMPROVE THE FINANCIAL PERFORMANCE OF REGIONAL ECONOMIES: EVIDENCE FROM THE PORTFOLIO APPROACH

Marina Malkina[1]

[1] Center of Macro and Microeconomics, Institute of Economics and Entrepreneurship, Lobachevsky State University of Nizhni Novgorod, 23 Prospekt Gagarina, 603950 Nizhni Novgorod, Russia

To link to this article: https://doi.org/10.11118/actaun201967061561
Received: 3. 6. 2019, Accepted: 6. 9. 2019

To cite this article: MALKINA MARINA. 2019. How Change in Industry Mix Can Improve the Financial Performance of Regional Economies: Evidence from the Portfolio Approach. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 67(6): 1561–1575.

Abstract

The aim of the study is to adapt the portfolio approach to optimization of the industrial structures of regional economies and to assess its results. The research is based on data of the Russian regions and federal districts in 2004–2016. The ratio of a balanced financial result to gross regional product referred to as financial return, and its volatility, called financial risk, were used as target parameters of regional economies. The application of the portfolio approach allowed us to evaluate financial return and risk in the regions and districts and decompose them by industries. Further, we solved three optimization problems: maximization of financial return at a given risk level, minimization of risk at a given return level, maximization of the Arrow-Pratt risk aversion utility function, and assessed their gains. As a result, we found that all three optimizations were often accompanied by a certain re-specialization of regional economies, rather than an increase in the degree of their diversification, although in the regions the situation was significantly different. For the federal districts, we identified a cross-regional effect that neutralized financial volatility, which can be used in re-specialization of regions within districts. Ultimately, the features and limitations of the application of the portfolio approach to the management of industrial structures of regional economies were discussed.

Keywords: industrial structure of economy, financial return, financial risk, portfolio approach, optimization, economic diversification, specialization

INTRODUCTION

Any economic system seeks to improve its efficiency. Obviously, the achievement of this goal is connected with the management of the industrial structure of economy. This raises the question of which industry shifts are effective. To answer it, first we need to choose a key performance indicator or a group of indicators that characterize the state of the regional or national economy and at the same time can be disaggregated by industries.

In many previous studies, gross domestic product or employment were used as key performance indicators, and economic stability was assessed through the volatility of their growth rates. In our study, the role of such an indicator is assigned to another parameter – the ratio of the net financial result to the gross domestic or regional product (GDP or GRP), hereinafter referred to as financial return. The financial result reflects both the current financial condition of enterprises in a country or region and the sufficiency of financial resources for its subsequent development. Applying in our analysis a relative indicator of the financial result rather than an absolute one enables us to obtain stationary time series, to separate volatility from the trend and eliminate systemic risk. Our approach implies that the level of financial instability in a region or country, hereinafter referred to as financial risk, is measured by means of the intertemporal standard deviation or variance of financial return. In addition, financial return and financial risk can be easily disaggregated by industry, which allows for the use of the portfolio approach.

Literature Overview

The portfolio approach was originally developed by H. Markowitz (1959) and W. Sharpe (1970) for evaluation of the investment portfolio properties, such as return and risk, and subsequent effective management of its structure. Later, some researchers proposed to extend this approach to the assessment of instability of the economic system as a whole and its particular spheres. In this case, the economy of a certain country or region is considered as a portfolio in which industries play the role of generators of both return and risk.

In this context, we should mention the pioneering works by M. Conroy (1974, 1975), who applied the portfolio approach to assess the volatility of regional economies and to determine the contributions made to it by various sectors and their interconnections. Following him, other researchers used this approach for the sectoral decomposition of GDP or employment volatility (Barth *et al.*, 1975; Kurre and Woodruff III, 1995; Trendle, 2006; Chiang, 2009; Ezcurra, 2011; Kluge, 2018). Another group of authors adapted the portfolio approach to the analysis of tax systems and their characteristics (Garrett, 2006; Seegert, 2017), as well as to the assessment of mutual influence of international trade partners (Jansen *et al.*, 2016). Simultaneously, a number of scholars launched a discussion about the peculiarities and limitations of the use of the portfolio approach in new areas (see overview in: Dissart, 2003).

Another direction of expanding the portfolio approach in the study of economic systems was the determination of the relationship between the degree of diversification or specialization of the economy and its level of stability (Siegel *et al.*, 1995; Fu *et al.*, 2010). Some authors have revealed a positive effect of regional economy diversification on economic stability. For example, Deller and Watson (2016) evidenced it within their analysis of the US states in 2005–2012; however, the researchers also found that US states followed diverse spatial patterns. Mikheeva (2017), examining the Russian regions in 2000–2014, confirmed the hypothesis that diversification can provide a stable but low growth in employment and industrial production. On the contrary, highly specialized regional economies showed a more pronounced, but unstable growth of these economic indicators. Simultaneously, some scholars emphasized that measurement of the degree of economic diversification is scale sensitive, while the estimation of instability based on time series can cause robustness problem (Wagner, 2010; Chen, 2019).

The portfolio approach was also applied to determine the relationship between economic growth and instability of regional economies (Chandra, 2002). A number of researchers derived the convex-type growth-instability frontiers (Chandra, 2003; Bigerna, 2013), which confirmed the suitability of the portfolio approach for the analysis of the efficiency of economic structures. Other researchers advanced this tool and suggested optimization of the industrial structure of the economy to increase its stability (Hafner, 2016). In addition, the portfolio approach was employed in the analysis of the cointegration of a number of economic indicators in the cycle (Park and Hewings, 2012). Cointegration testing is important when research is based on a series of collinear indicators. However, in our current study, this problem does not yet matter, since we use a generalized measure of economic performance.

When optimizing the industrial structure of the economy, we have to choose an adequate objective function. In our study, we use three objective functions in determining the optimal structure of portfolio: maximization of financial return, minimization of financial risk, and maximization of utility. In this context, the discussion on the choice of a utility function with different investor's attitude to risk and types of indifference curves (Elton *et al.*, 2013) is also of interest.

Finally, we should refer to a number of our own works, where the portfolio approach has already been used to assess and decompose the risk level of tax systems (Malkina and Balakin, 2015; Malkina, 2017), as well as to analyze the volatility of financial return in Russia and its regions (Malkina, 2018a, 2018b).

The current study is dedicated to the application of the portfolio approach to optimize the industrial structures of the Russian regions and federal districts under various objective functions and built-in constraints. We also intend to find out how this optimization is related to the change in the degree of diversification (specialization) of regional economies.

MATERIALS AND METHODS

Our research is based on official data provided by the Federal State Statistics Service of the Russian Federation on 82 constituent entities of Russia (hereinafter referred to as regions), considered separately and combined into 8 federal districts, for 2004–2016. Chechen Republic was excluded from the analysis due to the incompleteness of statistical data on this region for the period under consideration. The data used for analysis covers the net financial result and the GRP of the regions and federal districts with the breakdown by 11 main types of economic activity (hereinafter referred to as industries), as per the All-Russian Classification of Economic Activities-2001.

These industries are: A – Agriculture, hunting and forestry; B – Fishing, fish farming; C – Mining and quarrying; D – Manufacturing; E – Electricity, gas and water supply; F – Construction; G – Wholesale and retail trade, repair; I – Transport and communications; J – Financial intermediation; K – Real estate, renting and business activities; Other – other industries including: H – Hotels and restaurants; P – Public administration and defense; M – Education; N – Health and social work; O – Other community, social and personal service activities.

The methodology presented below is a combination of the Markowitz portfolio approach (Markowitz, 1959), the Shorrocks' variance decomposition by factor components (Shorrocks, 1982) and traditional economic and mathematical models.

The ratio of the net financial result (F_i) to GRP (Y_i), that is, the financial return of each i-th region $i = \overrightarrow{1,N}$, can be decomposed into the contribution of all k-th industries $k = \overrightarrow{1,K}$:

$$f_i = \frac{F_i}{Y_i} = \sum_{k=1}^{K} \alpha_{ik} \times f_{ik}, \qquad (1)$$

where

$\alpha_{ik} = Y_{ik}/Y_i$ – the share of k-th industry in the total GRP of i-th region,

$f_{ik} = F_{ik}/Y_{ik}$ – the financial return of this industry.

According to the portfolio approach, the volatility of the financial return, that is, financial risk in each i-th region, can be measured by its inter-temporal variance (σ_i^2) and further decomposed into the sum of covariances in all k-th industries representing their contribution to its volatility (θ_{ik}):

$$\sigma_i^2 = \frac{1}{n} \sum_{t=1}^{T} (f_{it} - f_i)^2, \qquad (2)$$

$$\sigma_i^2 = \sum_{k=1}^{K} \theta_{ik} = \sum_{k=1}^{K} Cov_t(\alpha_{ik} \times f_{ik}; f_i), \qquad (3)$$

where

$f_i = \sum_{t=1}^{T} F_{it} / \sum_{t=1}^{T} Y_{it}$ – the annual average of the financial return in i-th region, and $t = \overrightarrow{1,T}$ is the serial number of the year.

Further decomposition of financial risk generated in each k-th industry allows to divide it into the intra-industry (within), i.e. θ_W, and inter-industry (between), i.e. θ_B, components:

$$\theta_{ik} = \underbrace{Var(\alpha_{ik} \times f_{ik})}_{\theta_W} + \underbrace{\sum_{l=1, l \neq k}^{L} Cov_t(\alpha_{ik} \times f_{ik}; \alpha_{il} \times f_{il})}_{\theta_B}, \qquad (4)$$

where "l" is an industry different to the "k" industry.

The latter formula is slightly different from the traditional formula of the portfolio approach, where the shares of industries are considered constant and, therefore, can be extracted from variance and covariance equations:

$$\theta_{ik}{*} = \underbrace{\alpha_{ik}{}^2 \times \sigma_{ik}{}^2}_{\theta_W} + \underbrace{\sum_{l=1, l \neq k}^{L} \alpha_{ik} \times \alpha_{il} \times Cov_t(f_{ik}; f_{il})}_{\theta_B}. \qquad (5)$$

It is evident that the financial risk assessed under the average annual industrial structure

$$\sigma_i{*}^2 = \sum_{k=1}^{K} \theta_{ik}{*}$$

differs from its actual value obtained with the changeable industrial structure (σ_i^2). Indeed, we get $\sigma_i{*}^2 > \sigma_i^2$, when the deviations on average are towards the optimal industrial structure of the region and vice versa.

Comparing the industry's contribution to financial returns and financial risk in itself indicates the direction of optimizing the industrial structure of the regional economy. For precise optimization with different objective functions, we have developed three optimization models for the regional level.

The first optimization model determines the industrial structure of the regional economy, under which the maximum financial return is achieved at a given level of financial risk. By the later, we understand the risk under the average industrial structure over the past periods of time. The second optimization model seeks the industrial structure of the regional economy, under which the minimum risk is achieved at a given (average in the past) level of financial return. The third optimization model is created to find the maximum of the Arrow-Pratt utility function, taking into account the chosen level of risk aversion (in our case β = 1.5). For all three models, the economic structure was imposed restrictions on the change in the industries' shares within the historically specified range, that is, between its minimum and maximum levels during the period under consideration. We were guided by the fact that the industrial structure of a certain economy is connected with available resources, demand for products, and intra-regional and inter-regional relations.

The three above models are presented below:

$$\begin{cases} f(\alpha_{ik}) \to \max; \\ \min\{\alpha_{ikt}\} \le \alpha_{ik}; \\ \alpha_{ik} \le \max\{\alpha_{ikt}\}; \\ \sum_{k=1}^{K} \alpha_{ik} = 1; \\ \sigma^2(\alpha_{ik}) = \sigma^2(\bar{\alpha}_{ik}) \end{cases} \quad (6)$$

$$\begin{cases} \sigma^2(\alpha_{ik}) \to \min; \\ \min\{\alpha_{ikt}\} \le \alpha_{ik}; \\ \alpha_{ik} \le \max\{\alpha_{ikt}\}; \\ \sum_{k=1}^{K} \alpha_{ik} = 1; \\ f(\alpha_{ik}) = f(\bar{\alpha}). \end{cases} \quad (7)$$

$$\begin{cases} U(\alpha_{ik}) = f(\alpha_{ik}) - \frac{\beta}{2}\sigma^2(\alpha_{ik}) \to \max; \\ \min\{\alpha_{ikt}\} \le \alpha_{ik}; \\ \alpha_{ik} \le \max\{\alpha_{ikt}\}; \\ \sum_{k=1}^{K} \alpha_{ik} = 1; \end{cases} \quad (8)$$

At the aggregated level of federal districts, the approaches to optimization were slightly modified. In the federal district, each industry of each region is considered as a contributor to the total financial return and financial risk of this district. The contribution of each regional industry to financial risk can be divided into 4 components on two grounds: intra/inter-industry, intra/inter-regional. In other words, both interactions within and between industries and interactions within and between regions influence the federal district's financial risk. In this case, the optimization of the industrial structure of the district involves the redistribution of activity not only within regions between industries but also within industries between regions, which can imply a change in the regional specialization.

For districts, as well as for regions, our models are static. The shares of the regions in the district GRP are fixed and equal to the average shares for the past period. The shares of industries in the district GRP are also fixed and correspond to the average shares in the period under review. This means that our models do not deal with faster growth of some regional economies or certain industries, as well as with general changes in the regional and industrial structures of the district economy. The models are intended only to redistribute regional activity between industries and industrial activity between regions.

They are presented below:

$$\begin{cases} f(\alpha_{ik}) \to \max; \\ \min\{\alpha_{ikt}\} \le \alpha_{ik}; \\ \alpha_{ik} \le \max\{\alpha_{ikt}\}; \\ \sum_{k=1}^{K} \alpha_{ik} = \bar{\alpha}_i; \\ \sum_{i=1}^{N} a_{ik} = \bar{\alpha}_k; \\ \sigma^2(\alpha_{ik}) = \sigma^2(\bar{\alpha}_{ik}) \end{cases} \quad (9)$$

$$\begin{cases} \sigma^2(\alpha_{ik}) \to \min; \\ \min\{\alpha_{ikt}\} \le \alpha_{ik}; \\ \alpha_{ik} \le \max\{\alpha_{ikt}\}; \\ \sum_{k=1}^{K} \alpha_{ik} = \bar{\alpha}_i; \\ \sum_{i=1}^{N} \alpha_{ik} = \bar{\alpha}_k; \\ f(\alpha_{ik}) = f(\bar{\alpha}_{ik}). \end{cases} \quad (10)$$

$$\begin{cases} U(\alpha_{ik}) = \\ = f(\alpha_{ik}) - \frac{\beta}{2}\sigma^2(\alpha_{ik}) \to \max; \\ \min\{\alpha_{ikt}\} \le \alpha_{ik}; \\ \alpha_{ik} \le \max\{\alpha_{ikt}\}; \\ \sum_{k=1}^{K} \alpha_{ik} = \bar{\alpha}_i; \\ \sum_{i=1}^{N} \alpha_{ik} = \bar{\alpha}_k. \end{cases} \quad (11)$$

It should be noted that the optimization at the district level can worsen the value of the objective function of some regions.

Then we investigated the connection of three optimizations of regional industrial structures with changes in the degree of diversification of regional economies. This degree was assessed by means of the structural similarity index (SSI), where the industrial structure of the national economy served as a benchmark:

$$SSI_i = 1 - \sqrt{\sum_{k=1}^{K} (\alpha_{ik} - \alpha_k)^2}. \quad (12)$$

The application of the above technique allowed us to obtain new results for the Russian regions and federal districts.

RESULTS

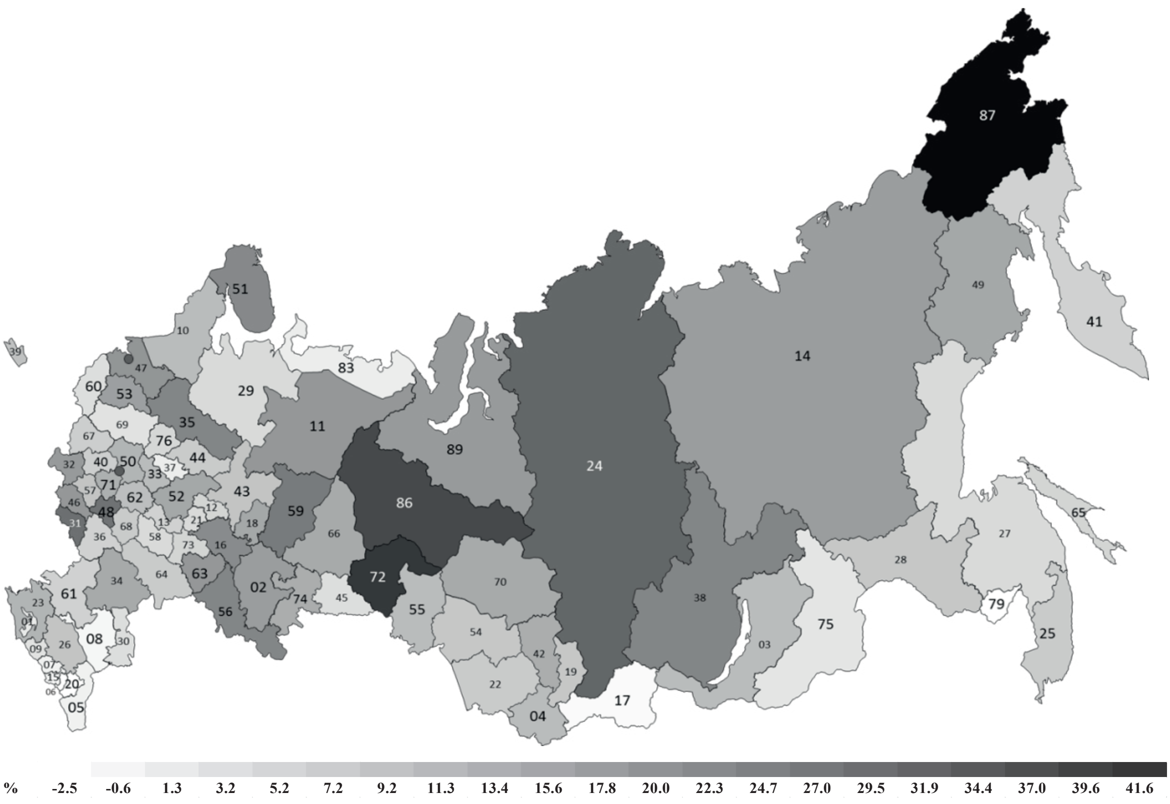
The average financial return of the Russian regions in 2004–2016, evaluated by means of formula 1, is presented on the map of Russian regions in Fig. 1. Here we can observe a significant gap in the financial return of Russian regions, which ranges from -2.5% in Jewish Autonomous Region (a subject of the Far Eastern Federal District, whose administrative code is 79) to +41.6% in Chukotka Autonomous Region (also belonging to the Far Eastern Federal district, code 87). While the country average financial return is 14.9%, it's interregional GRP-weighted standard deviation amounts to 8.95%. The marked regional differences in financial return of regional economies are largely due to dissimilarities in their industrial structure. Indeed, the country average financial return in Mining (sector C) is 31.9%, with its inter-regional standard deviation of 337.4%. In Financial intermediation (sector J), financial return is even higher and reaches 78%, while the standard deviation is lower, amounting to 57%. In contrast, the sectors of Agriculture (A), Construction (F) and Other Activities (O) show the worst profitability in the reporting period, where their country average financial returns are only 5.5%, 3.9% and -0.0%, respectively.

Financial risk of regional economies, assessed and disaggregated with use of formulas 2 and 3, is presented on the map of Russian regions in Fig. 2. Its regional value varies even more than value of return: from 1.2% in Mari El Republic (Volga Federal District, code 12) to 114.8% in Chukotka Autonomous Region. While the national average financial risk is 4.5%, its interregional standard deviation reaches 5.6%.

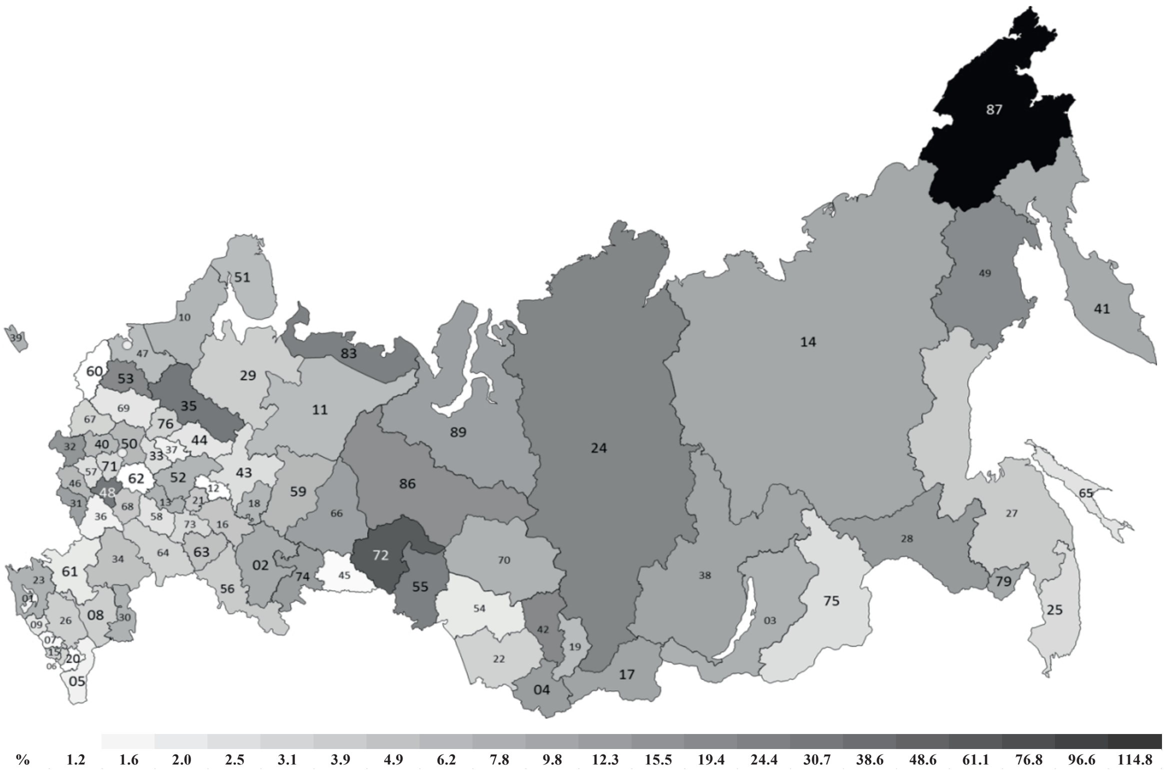
In Fig. 3, we can observe a positive and moderate correlation between financial return and financial risk in Russian regions, which is fully consistent with the conventional theory.

Obviously, financial risk, similarly to financial return, depends on the industrial structure of regional economies. More precisely, the contribution of industries to overall regional risk depends on their shares in the GRP, their inherent risk, and covariances of their financial return with the returns in other sectors (see formulas 4 and 5). It is the latter factor that actualizes the importance of the degree of diversification or specialization of the economy for its financial stability.

According to our calculations, the greatest internal risk is peculiar to sector B – Fishing (where its average country value is 10.6%), followed by sectors E – Electricity and I – Transport (6.5% in each), D – Manufacturing and G – Trade (6.4% in each). The smallest internal risk is observed in sector A – Agriculture (1.6%). However, in some particular regions, the situation is significantly different. The financial return covariances vary greatly across regions. Nation-wide, the lowest covariance of



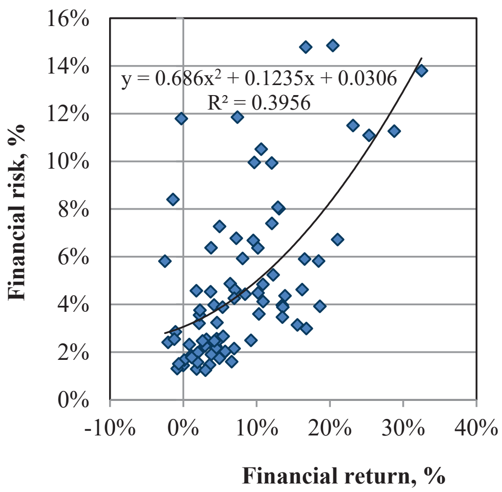
1: *Average financial return in Russian regions in 2004–2016*
Note: Hereinafter, subjects of the Russian Federation are designated by administrative codes
Source: The author's own calculations based on data provided by Russian Federation Federal State Statistics Service, RFSSS



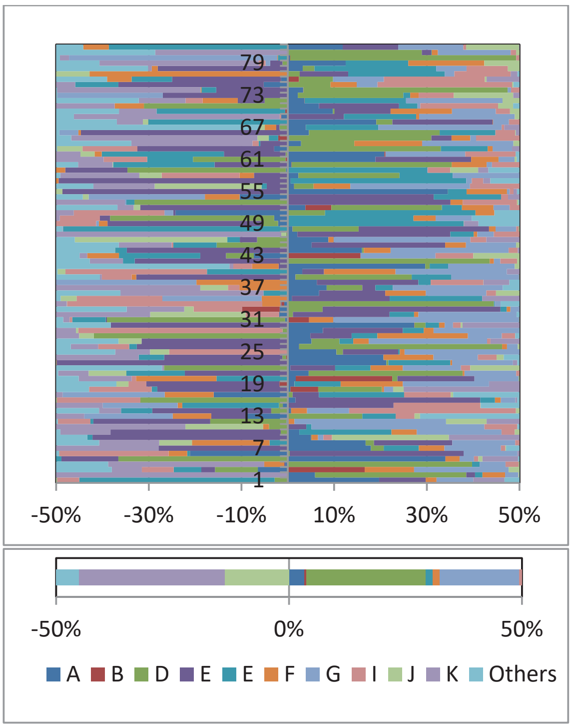
2: *Financial risk in Russian regions in 2004–2016*
Source: The author's own calculations based on data provided by Russian Federation Federal State Statistics Service, RFSSS

financial return with other sectors is observed in Agriculture, while the highest covariance is intrinsic to Fishing and Manufacturing.

Before proceeding with the optimization of industrial structures, we should pay special attention to the differences between each industry's contributions to financial return and financial risk.

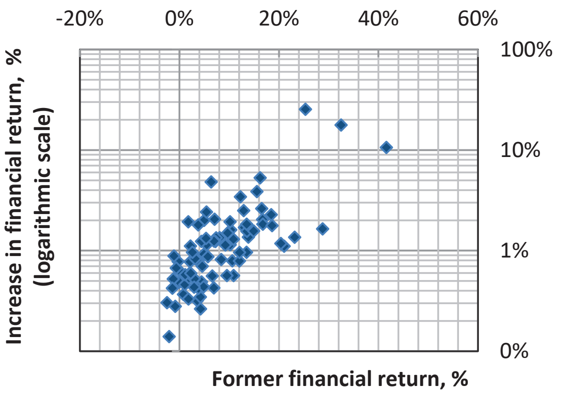


3: *The relationship between risk and return of regional economies, 2004–2016 (excluding outlier – Chukotka Autonomous Okrug)*
Source: The author's own calculations based on data provided by RFSSS

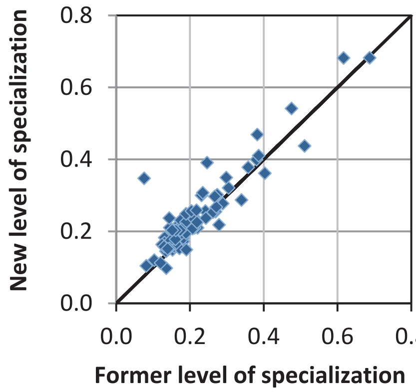


4: *Difference between financial return and financial risk in various industries of the Russian regions and the country as a whole*
Source: The author's own calculations based on data provided by RFSSS

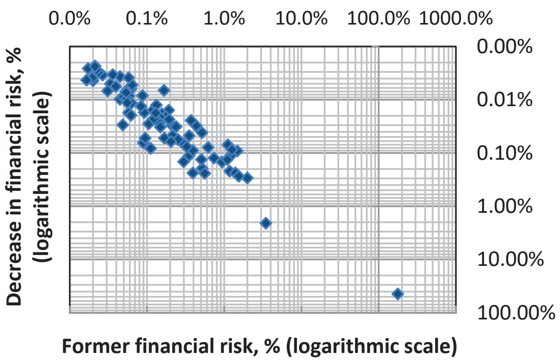
Fig. 4 presents these deviations for all sectors of 82 regions (they are shown by multi-colored narrow stripes at the top of the diagram) and for the country as a whole (shown by a wide strip below it). The gaps preliminary indicate the direction of optimizing industrial structures: for industries located on the right side of the chart, the share should be increased, and for industries on the left side it should be reduced. The longer the strip length, the greater the effect of a change in the share of the corresponding industry.



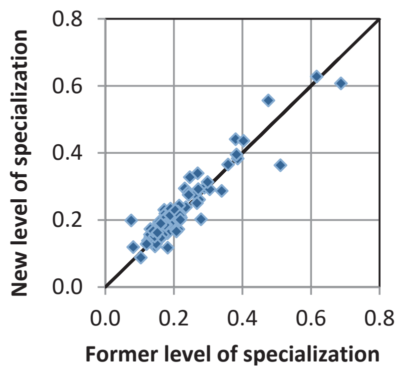
5: *The results of optimization of the industrial structures of regional economies-I*
Source: The author's own calculations based on data provided by Russian Federation Federal State Statistics Service, RFSSS



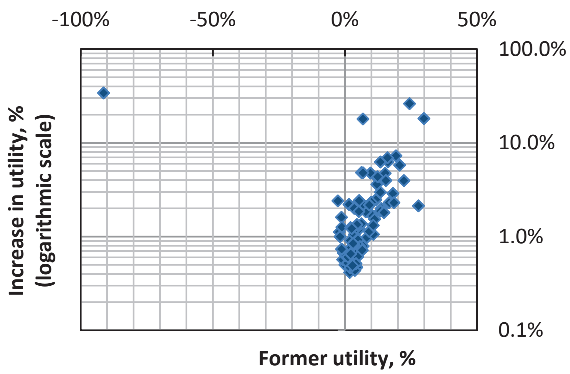
6: *The changes in specialization of regional economies under optimization-I*
Source: The author's own calculations based on data provided by Russian Federation Federal State Statistics Service, RFSSS



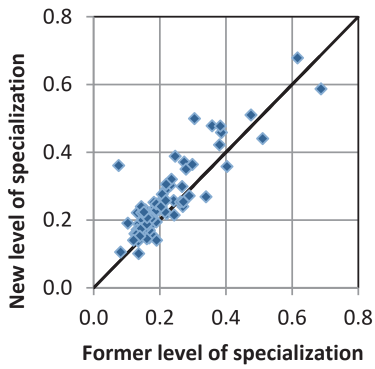
7: *The results of optimization of the industrial structures of regional economies-II*
Source: The author's own calculations based on data provided by RFSSS



8: *The changes in specialization of regional economies under optimization-II*
Source: The author's own calculations based on data provided by RFSSS



9: *The results of optimization of the industrial structures of regional economies-III*
Source: The author's own calculations based on data provided by RFSSS



10: *The changes in specialization of regional economies under optimization-III*
Source: The author's own calculations based on data provided by RFSSS

Further, based on three models, described by formulas 6, 7, 8, we calculated optimal industrial structures of all Russian regions. The generalized results of these calculations are presented on Figs. 5 and 6 (for model I: maximization of return under built-in constraints), Figs. 7 and 8 (for model II: minimization of risk), and Figs. 9 and 10 (for model III: maximization of Arrow-Pratt utility function).

Figs. 5, 7 and 9 demonstrate the relationship between the former levels of financial return, risk and utility and their changes after optimization of the economic structures in all 82 Russian regions. It is evident that in regions with a higher level of financial return and utility, the probability of their further increase is larger on average. At the same time, regions with a higher level of risk have, on average, greater potential to reduce it. However, the situation in the Russian regions varies greatly, and the correlations between the examined parameters are medium in strength. The outliers on the figures are visible, and the most conspicuous of them are the values of Chukotka Autonomous Okrug.

Figs. 6, 8, and 10 show the effects of three portfolio optimizations on the specialization level of regional economies, assessed by the structural similarity index (SSI, formula 12). Comparison of these levels before and after optimizations led us to somewhat unexpected results.

Optimization-I showed that in most regions (61 out of 82) the growth of financial return was accompanied by an increase in economic specialization, which is quite consistent with the conventional economic patterns. In particular, the optimization results indicated the need for a deeper specialization: in Agriculture – a number of agrarian territories (e.g., Kabardino-Balkan Republic, Republic of Dagestan, Tambov Oblast); in Fishing and fish farming – Kamchatka Krai, currently specializing in this industry; in Mining and quarrying – the regions that are already leaders in the industry (Yamalo-Nenets and Khanty-Mansi Autonomous Okrugs), as well as the regions with an increased share of it in the industrial structure (Republics of Tatarstan and Bashkortostan, Kaliningrad Oblast, Krasnoyarsk Krai). It should also be noted that in the overwhelming majority of regions (64 out of 82) the maximization of financial return was accompanied by an increase in the share of Manufacturing in GRP, and in 51 regions – an increase in the share of Mining and/or Trade. At the same time, the solution of the problem of the return maximization indicated the need to reduce the share of social sectors and public administration in all regions except Republic of Ingushetia, as well as to decrease the share of Real estate sector in 62 out of 82 regions. However, this finding is driven by the goal of maximizing financial return. Obviously, this is not the only goal that regional governments have to pursue; they should also be guided by social, infrastructure and other goals.

At the same time, in 21 regions, an increase in financial return was accompanied by an increase in the degree of economic diversification. An example of it is the Novosibirsk Oblast, where the degree of diversification is already one of the highest in the country.

After optimization, the average financial return increased to a greater extent (by 2.12 p.p. against 0.94 p.p. on average) in those regions where the level of specialization grew rather than fell. In particular, the top ten leaders by the financial return growth (with an average of 7.86%) include only those regions where the level of economic specialization has increased (on average by 63.8%, according to the SSI). Meanwhile, the presence of individual features of regional economies still does not allow us to extend to them some general conclusions.

Optimization-II showed that in most regions risk minimization was also accompanied by an increase in economic specialization, although the number of such regions (53) was less compared to optimization-I. The opposite change in the specialization and risk level does not correspond to the generally accepted patterns. However, the impact of risk reduction on the industrial structure of regional economies turned out to be somewhat different from the effect of the return maximization. Thus, in most regions, an increase in the share of Agriculture (54 against 46 in optimization-I) and/or Trade (56 against 51) was recommended. Another distinctive result of this optimization was a significant increase in the number of regions in which the share of Construction (45 versus 25), Transport and communications (43 versus 34), social services and public administration (32 versus 1), as well as Fishing industry (47 versus 31) should grow. At the same time, the risk minimization led to a decrease in the number of regions for which the share of Mining and/or Manufacturing was recommended to enlarge (the number of such regions decreased by 22 and 38, respectively, compared to the return maximization).

Another surprising result is that both optimizations have more often led to a unidirectional change in the shares of industries than to multidirectional ones. The Pearson linear correlation coefficient for changes in the shares of regions after two optimizations turned out to be positive and equal to 0.331, and the Spearman's rank correlation coefficient was 0.314. This finding also does not fully match one of the general economic concepts, which establishes a direct dependency between profitability and risk. Meanwhile, for absolute values of return and risk, a direct relationship is still observed (for the initial state and three optimizations, the Pearson correlation between the regional portfolio return and risk ranges in 0.551–0.566). The observed discrepancy in two findings is due to the fact that optimization does not take into account the absolute values of risk and return, but their marginal values.

Finally, according to optimization III, the maximization of the utility function leads to a higher level of specialization in most regions. Only in 16 regions, this goal is achieved under the growing economic diversification. This means that diversification, when it is understood as the diversity of industries, is not in itself a prerequisite for the sustainable development of regional economies. On the contrary, to achieve this goal, an optimal trade-off between diversification and specialization should be found.

Optimization of the utility function demonstrated the need for a predominant increase in the share of Manufacturing (in 65 out of 82 regions) and Mining (in 57 regions). Moreover, not only the number of regions where this is recommended but also the average share of these industries in the regional economies has grown, compared to optimizations I and II. The number of regions in which Agriculture has to grow turned out to be more than under optimization-I (+2), but less than under optimization-II (-6). However, the share of Agriculture in GRP of the Russian regions should be less on average (compared to other two optimizations). For Financial intermediation (sector J), the result was the opposite to the result for Agriculture. The proportion of sector J is recommended to increase on average, and the number of regions where it should occur (41) is less than under optimization-I (-2) and more than under optimization-II (+3). This conclusion is quite logical, since the average return in Financial intermediation is significantly higher than in Agriculture (78% vs. 5.5% on average in 2004–2016). At the same time, Agriculture contributes negatively to the overall risk due to the negative covariances of its financial return with returns in other industries.

We also revealed a very weak inverse relationship between the initial degree of diversification of regional economies and its change under optimizations I, II and III (Pearson coefficients are -0.236, -0.267 and -0.210, but not robust due to the outliers).

Now we can examine in detail the changes in the industrial structure of some regions for which the most impressive results were obtained. They are: Moscow, Karachay-Cherkess Republic, Tyumen Oblast and Chukotka Autonomous Okrug (see Tab. I).

Moscow (the subject of the Central Federal District and the capital of Russia) is one of the most profitable Russian regions. Its financial return is 70% higher than the national average, and it ranks 9th in Russia by financial risk. Meanwhile, as our results show, financial return in Moscow can be doubled through the change in the industrial structure of its economy, while the reduction of financial risk is rather problematic. All three optimization models indicate the need to increase the share of Wholesale and retail trade, repair (sector G) in its economy, to substantially reduce the share of Real estate activities (K) and slightly decrease the share of Manufacturing (D). In addition, the optimizations of return and risk leads to opposite conclusions regarding the direction of change in the share of Transport and communication (I) and Other industries, which include the social sphere and public administration. Apparently, in this case, the utility function should be taken into account.

Karachay-Cherkess Republic (the subject of the North Caucasian Federal District) is one of the poorest agricultural regions located in the southern part of Russia. Both return and risk in the region are small. The problem of maximization of financial return is solved here by an increase in the share of Agriculture (A), Manufacturing (D) and Trade (G). However, the minimization of risk, on the contrary, requires a reduction in the share of Manufacturing (D) and Trade (G), while the shares of Construction (F) and social sphere and public administration in the GRP should increase. The results of the utility function optimization for this region turned out to be closer to the results of the financial return maximization.

Tyumen Oblast (located in the Ural Federal District) is one of the richest Russian regions. It is characterized by an increased level of financial return and risk and the highest degree of economic diversification. However, the optimization models have shown that there are large reserves in the region to further increase financial return (it can be raised by 17.7 percentage points, that is, by 54.5% of the achieved level), to reduce risk (by 6.7 p.p, or 36.9%) and to maximize the utility function (by 18.2 p.p., or 60.7%). Some results for this region turned out to be unexpected, in particular, the need for a significant increase in the share of Mining to reduce financial risk and increase in the share of Manufacturing to enlarge financial return. To maximize the utility function, the shares of both industries in GRP should be increased. In addition, the maximization of return in Tyumen Oblast was accompanied by an increase in the Real Estate industry's share in GRP, while minimization of risk required its reduction.

Chukotka Autonomous Okrug (located in the Far Eastern Federal District) is the most unbalanced Russian region and it is ranked 7th by the level of economic specialization (after some predominantly mining areas and Tuva Republic, where agriculture prevails). Chukotka is the absolute leader in the country by both the financial return (which amounted to 41.6% in 2004–2016) and financial risk (σ = 133.1%). The most profitable industry in this region is Mining, although it is also a source of significant risk. However, the greatest risk in this region was generated by Trade, whose contribution to portfolio financial risk was 10.7 times greater than its contribution to portfolio financial return. Therefore, all three optimizations led to reduction in the share of Trade and increase in the share

I: *The results of three optimizations of industrial structures in some Russian regions, %*

Condition	f	σ	U	Average share of industry in GRP										
				A	B	C	D	E	F	G	I	J	K	Other
Moscow (Central Federal District)														
Actual	25.3	10.9	24.5	0.1	0.0	0.0	12.9	3.3	3.9	35.7	9.0	1.6	20.8	12.6
Optimization-I	50.7	10.9	49.8	0.0	0.0	0.0	11.8	4.1	2.6	44.7	10.3	2.9	14.8	8.8
Optimization-II	25.3	9.8	24.6	0.1	0.0	0.0	11.5	2.3	3.0	44.7	8.2	1.1	14.8	14.3
Optimization-III	51.6	11.4	50.7	0.0	0.0	0.0	11.5	3.1	2.6	44.7	10.3	4.1	14.8	8.8
Karachay-Cherkess Republic (North Caucasian Federal District)														
Actual	1.1	3.0	1.0	22.0	0.0	1.7	13.5	5.8	7.9	11.6	4.9	0.2	5.2	27.2
Optimization-I	1.5	3.0	1.5	25.0	0.0	2.3	18.4	3.2	5.4	17.2	3.4	0.2	3.8	21.2
Optimization-II	1.1	1.6	1.1	20.0	0.0	2.2	11.1	3.2	8.9	9.2	6.0	0.0	8.0	31.4
Optimization-III	1.6	2.0	1.5	25.0	0.0	2.3	18.4	3.2	5.5	17.2	3.4	0.0	3.8	21.2
Tyumen Region (Ural Federal District)														
Actual	32.5	18.6	29.9	4.8	0.0	7.9	21.2	3.0	7.1	22.2	11.8	0.5	11.6	9.9
Optimization-I	50.2	18.6	47.6	3.8	0.0	2.6	47.6	1.4	3.2	13.9	17.2	0.9	3.9	5.5
Optimization-II	32.5	11.8	31.5	6.2	0.0	14.4	20.4	3.8	7.7	5.2	17.2	0.9	18.6	5.5
Optimization-III	49.8	15.4	48.1	3.8	0.0	11.3	47.6	1.4	3.2	5.2	17.2	0.9	3.9	5.5
Chukotka Autonomous Okrug (Far Eastern Federal District)														
Actual	41.6	133.1	-91.3	1.4	1.1	37.4	0.6	12.8	7.9	6.7	5.3	0.0	2.0	24.7
Optimization-I	52.2	133.1	-80.7	3.9	0.1	50.1	0.2	9.2	3.8	6.2	6.7	0.0	1.1	18.7
Optimization-II	41.6	115.2	-58.0	3.9	4.3	40.3	0.2	9.2	7.6	4.5	10.2	0.0	1.1	18.7
Optimization-III	49.0	119.0	-57.3	3.9	4.2	50.1	0.2	9.2	3.8	4.5	4.3	0.0	1.1	18.7

Note. Hereinafter: f – financial return; σ – financial risk; U – value of utility function.
Source: The author's own calculations based on data provided by Russian Federation Federal State Statistics Service, RFSSS (http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/en/main/)

of Mining in the region's GRP. Meanwhile, they also indicated that the production of low-profit Manufacturing, Electric power, gas and water supply and Real estate industries should also be reduced in the region.

Further, we assessed the financial return, risk, and utility of all 8 federal districts of Russia and implemented the optimization of their industrial structures using formulas 9–10. We supposed that the scales of all regional economies, as well as the scales of all industries in the district are constant. Meanwhile, a redistribution of activity between industries in the regions may increase the total financial return in the district, reduce its risk, or increase its utility.

Financial return of the district's economy is calculated as the GRP-weighted average return of its constituent regions. Financial risk in the district represents the sum of the internal risks of their constituent regions and the inter-regional risks (intra-industry and inter-industry) calculated as the covariance of their financial returns. When the inter-regional component of financial risk is positive, the district risk exceeds the average risk of its regions, and vice versa. In our case, the financial risk of each of the 8 districts (measured by the standard deviation of financial return) turned out to be lower than the GRP-weighted average risk of its constituent regions. This indicated that the inter-regional risk component was negative.

The maximum deviation of the district's risk level over the average risk of its constituent regions was observed in the Ural Federal District (it was -62.14%), the minimum – in the Central Federal District (-3.35%). In addition, in the Central District, only 2 out of the 19 regions (namely, Moscow and Moscow Oblast) showed the financial risk higher than in the district as a whole. In the Volga Federal District, on the contrary, only in 1 region out of 13 (namely, in Mari El Republic) the regional risk was lower than the district risk. At the same time, the financial return of this region was 4 times lower than the district average return.

The original state and the results of three optimizations of the districts' industrial structures are presented in Tab. II. They indicate that redistribution of industrial activity within and between regions leads to the greatest increase

II: *The results of three optimizations of industrial structures of the Russian federal districts, %*

Federal districts	Actual			Optimization-1			Optimization-2			Optimization-3		
	f	*σ*	*U*	*f*	*σ*	*U*	*f*	*σ*	*U*	*f*	*σ*	*U*
Central	18.96	7.65	18.52	33.57	7.65	33.13	18.96	7.38	18.55	33.57	7.64	33.13
Northwestern	14.15	3.74	14.04	15.60	3.74	15.50	14.15	3.01	14.08	15.78	4.10	15.65
Southern	6.63	2.99	6.56	7.29	2.99	7.22	6.63	2.65	6.58	7.39	3.12	7.32
North Caucasian	1.76	1.30	1.75	2.47	1.30	2.46	1.76	1.16	1.75	2.47	1.28	2.46
Volga	12.06	1.83	12.04	12.97	1.83	12.94	12.06	1.40	12.05	12.97	1.56	12.95
Ural	19.73	4.42	19.58	22.03	4.42	21.88	19.73	3.15	19.66	22.07	4.12	21.94
Siberian	12.16	3.86	12.05	13.96	3.86	13.85	12.16	3.39	12.07	13.98	3.83	13.87
Far Eastern	6.17	4.00	6.05	7.84	4.00	7.72	6.17	3.33	6.09	7.94	4.43	7.80

Source: The author's own calculations based on data provided by Russian Federation Federal State Statistics Service

in financial return in the Central Federal District (by 14.62 percentage points, or 77.1% to the base level), when the smallest – in the Volga Federal District (by 0.91 p.p., or 7.54%). The greatest risk reduction is possible in the Ural Federal District (-1.28 p.p., or -28.88%), while the lowest – in the Central Federal District (-0.27 п.п., -3.47%). The Central District is the absolute leader in maximization of the utility function (+78.94%). The North Caucasus Federal District is ranked second (+40.54%), but this is more likely due to its lowest initial utility level among other districts.

Fig. 11 shows, as an example, the required changes in the industrial structures of the constituent regions of the Central Federal District, based on the results of three optimizations.

DISCUSSION

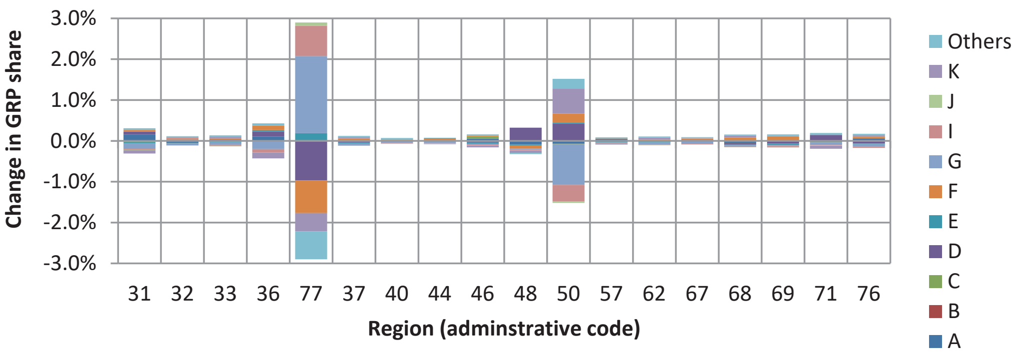
The obtained results have a certain scientific value. First of all, they continue and develop the discussion about the possibility of using the portfolio approach to optimize the industrial structure of the economy, which was considered in the Introduction.

Our results showed that both an increase in financial return and a decrease in financial risk can entail not only the redistribution of economic activity between industries, but also an increase in the degree of economic specialization of the regions. This contradicts to the findings by Kluge (2018) who confirmed the positive impact of diversification on economic stability. At the same time, they support some studies that revealed the positive impact of multiply regional specializations on employment growth rates and their stability, while economic diversification have contributed to stability, but not to economic growth (Hong and Xiao, 2016).

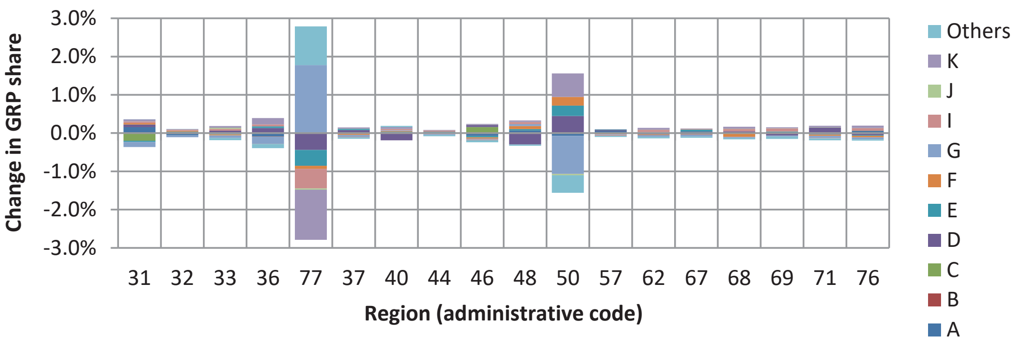
Whereas the direct relationship of financial return with economic specialization is generally accepted, the inverse dependency between financial risk and economic specialization requires special justification. We explain this collision by the fact that portfolio theory focuses not so much on the diversity of portfolio instruments, but on the reverse covariance of their returns (Malkina, 2018a). For regional portfolios consisting of industries, this finding is of particular importance. At the same time, the pointed discord is also due to the fact that in the conventional portfolio theory, which deals with securities, the homogeneous financial instruments are used in different portfolios. For regional industries portfolios, these properties are not preserved. The same industry varies greatly in different regions. Moreover, optimization models for regional portfolios are sensitive to the degree of industries disaggregation. But even deeper disaggregation (up to the separation of the production of specific goods) will not allow for the homogeneity of the subsectors of the regions, since ultimately the enterprises of these sectors will differ. This means that the conclusions and recommendations regarding a particular region may not be applicable to another region and to their totality. However, on average, they reflect the state of a particular country, and this is also valuable.

In addition, an insufficient number of observations in the time series may violate the requirements of the portfolio theory. The reason for this is the limited statistical data of Russia and its short market history. It should also be borne in mind that the results of portfolio optimization, even obtained under conventional application of the portfolio theory, are of limited use due to the non-repeatability of shocks. This can be fully attributed to the optimization of industries portfolios of regions or countries.

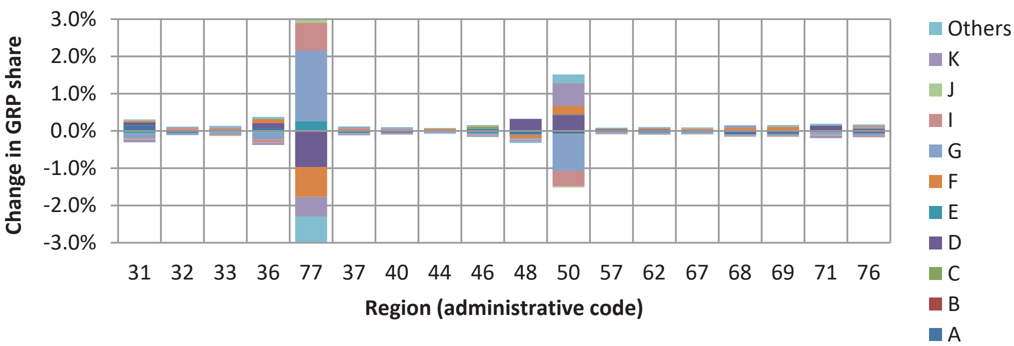
The choice of the utility function should be estimated separately. We did not set ourselves the task of evaluating the properties of various utility functions and making a reasonable choice among them. We just applied the most common utility function with the built-in property of risk aversion, the level of which is determined by the Arrow-Pratt coefficient value. However, the use of this function led us to the surprising conclusion about its negative



a) Optimization-I



b) Optimization-II



c) Optimization-III

11: *Required changes in the industrial structure of the Central federal district economy according to three optimizations: a) maximization of the financial return; b) minimization of the financial risk; c) maximization of the financial utility function*
Note: The subjects of the Central Federal District (regions) are designated by their administrative codes: 31 – Belgorod Oblast; 32 – Bryansk Oblast; 33 – Vladimir Oblast; 36 – Voronezh Oblast; 77 – Moscow; 37 – Ivanovo Oblast; 40 – Kaluga Oblast; 44 – Kostroma Oblast; 46 – Kursk Oblast; 48 – Lipetsk Oblast; 50 – Moscow Oblast; 57 – Oryol Oblast; 62 – Ryazan Oblast; 67 – Smolensk Oblast; 68 – Tambov Oblast; 69 – Tver Oblast; 71 – Tula Oblast; 76 – Yaroslavl Oblast. The industries (A, B, C, etc.) are labeled in accordance with their codes specified earlier.
Source: The author's own calculations based on data provided by the Russian Federation Federal State Statistics Service (http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/en/main/)

value for the actual portfolios of 10 of the 82 regions. Among them, Chukotka Autonomous Okrug demonstrated an unprecedentedly negative level of this utility, which was due to the high volatility of financial return in this mining-dominated region. After optimization, the situation improved, but the negative utility remained in 6 regions. The very existence of negative utility may raise the question of the need to find a more adequate utility function, which at the same time would take into account the marginal effects of return and risk. But since we do not matter the absolute utility values, but only their relative changes and make comparisons among regions, the selected function has completely coped with this task.

In our model, we optimize financial return relative to risk. Of course, the financial performance of the region is very important for its sustainable development. But financial stability is not the only goal of regional development. Other important goals of economic policy are: maintaining social stability, improving infrastructure, innovative development, access to world markets, etc. Therefore, recommendations for changes in the industrial structure should be estimated not only from the standpoint of the achievement of the chosen goal but also adjusted to capture other policy objectives. We already wrote about this in the Results when the return-maximization model indicated the need to reduce the social sector and public administration in almost all regions. The dependence of the industrial structure of the economy on available resources and the interconnectedness of industries also need to be taken into account. We wrote about this in Materials and Methods. In our models, we partially circumvented this problem by setting restrictions on changes in the shares of industries.

Our models are static. With regard to the regions, they do not involve the future growth of the regional economies. With regard to the districts, they do not suggest the growth of industries and changes in the overall industrial structure. The proposed models can be advanced in future by substantiating both the growth rates of individual regions and industries, and the range of their changes. Probably, when determining the maximum and minimum share of a particular industry, it is necessary to take into account their dependence not so much on the past as on the current state. Indeed, it is very problematic to drastically increase or decrease the share of some industry in some region in the short run, which is also emphasized by Siegel *et al.* (1995). Regional optimization models are more likely designed to adapt the economy in the long run, but should also unclose the path to new states. The creation of a dynamic portfolio model that meets the emergence of new shocks requires upgrading the methodology and enhancing the predictive power of the model.

Another limitation of our models is that optimization within federal districts does not necessarily mean optimization within regions. For some regions, the key indicators have even worsened, albeit the number of such regions was rather small. To maintain a balance of interests of the subjects of the Russian Federation, additional internal restrictions should be introduced into the model.

Finally, the search for effective tools for managing changes in the industrial structure remains an important practical problem. Thus, optimization results are likely to play an indicative role; they point to the sectors requiring priority support to be provided by regional governments. At the district or country level, they also indicate which regions should be maintained in which direction, but do not say anything about effective tools for this support.

The search for solutions to these problems may become the subject of future theoretical and methodological studies based on the construction of more sophisticated models, which should lead to more accurate conclusions for the economy of Russia and its regions.

CONCLUSION

Using the portfolio approach, we evaluated the financial return and financial risk of the Russian regions and federal districts in 2004–2016 and decomposed it by 11 enlarged economic activities referred to as industries. The solution of three optimization problems allowed us to determine the optimal industrial structures in the regions and federal districts where the maximum financial return, minimum financial risk, and maximum risk-aversion utility function were achieved under built-in restrictions on the change in the share of industries in the gross regional product. At the regional level, the optimization models assumed the redistribution of activity between industries; at the level of federal district, they suggested the redistribution of industrial activity between regions. The obtained assessments of changes in financial return, risk and utility moderately correlated with their base levels in the regions. Maximization of return and utility in most regions was accompanied by an increase in the level of specialization, and minimization of risk also led to an increase in specialization, but in fewer cases. In other words, the solution of the three optimization problems was more likely accompanied by re-specialization of the regions than by an increase in the degree of their economies diversification. This implies that the pronounced characteristics of industries (higher return/lower risk), as well as the reverse covariance of their financial returns with returns in other industries, are more important for reducing the risk of a portfolio than just its diversity. The results of optimizations are also sensitive to the selected constraints and the type of utility function. More accurate results can be obtained with deeper theoretical and methodological approaches, and ways to improve them are determined in the Discussion. In general, our findings suggest an effective redistribution of regional activity and the need for state support for individual industries in certain regions and their clusters.

Acknowledgements

The reported study was funded by RFBR according to the research project No. 19-010-00716, “Development of methodology and non-traditional methods for assessing financial instability”.

REFERENCES

BARTH, J., KRAFT, J. and WEST, P. 1975. A portfolio theoretical approach to industrial diversification and regional employment. *Journal of Regional Science*, 15(1): 9–15.

BIGERNA, S. 2013. The regional growth-instability frontier in Italy. *Atlantic Economic Journal*, 41(4): 463–464.

CHANDRA, S. 2002. A test of the regional growth-instability frontier using state data. *Land Economics*, 78(3): 442–462.

CHANDRA, S. 2003. Regional economy size and the growth-instability frontier: evidence from Europe. *Journal of Regional Science*, 43(1): 95–122.

CONROY, M. E. 1974. Alternative strategies for regional industrial diversification. *Journal of Regional Science*, 14(1): 31–46.

CONROY, M. E. 1975. The concept and measurement of regional industrial diversification. *Southern Economic Journal*, 41(3): 492–505.

CHEN, J. 2019. Geographical Scale, Industrial Diversity, and Regional Economic Stability. *Growth and Change*, 50(2): 609–633.

CHIANG, S. 2009. The effects of industrial diversification on regional unemployment in Taiwan: is the portfolio theory applicable? *The Annals of Regional Science*, 43: 947.

DELLER, S., WATSON, P. 2016. Spatial variations in the relationship between economic diversity and stability. *Applied Economics Letters*, 23(7): 520–525.

DISSART, J.-C. 2003. Regional economic diversity and regional economic stability: research results and agenda. *International regional science review*, 26(4): 423–446.

ELTON, E. J., GRUBER, M. J., BROWN, S. J. and GOETZMANN, W. N. 2013. *Modern portfolio theory and investment analysis*. 9th Edition. Wiley.

EZCURRA, R. 2011. Unemployment volatility and regional specialization in the European Union. *Regional Studies*, 45(8): 1121–1137.

FU, S., DONG, X. and CHAI, G. 2010. Industry specialization, diversification, churning, and unemployment in Chinese cities. *China Economic Review*, 21: 508–520.

GARRETT, T. A. 2006. *Evaluating state tax revenue variability: a portfolio approach*. Working Papers of Federal Reserve Bank of St. Louis, 2006, No. 2006-008. [Online]. Available at: https://s3.amazonaws.com/real.stlouisfed.org/wp/2006/2006-008.pdf [Accessed: 2018, January 17].

HAFNER, K. A. 2016. Regional industrial diversification: evidence from German gross value added. *Review of Regional Research*, 36(2): 169–193.

HONG, S. and XIAO, Y. 2016. The Influence of Multiple Specializations on Economic Performance in U.S. Metropolitan Areas. *Sustainability*, 8(9): 963.

JANSEN, M., LENNON, C. and PIERMARTINI, R. 2016. Income volatility: whom you trade with matters. *Review of World Economics*, 152(1): 127–146.

KLUGE, J. 2018. Sectoral diversification as insurance against economic instability. *Journal of Regional Science,* 58(1): 204–223.

KURRE, J. A. and WOODRUFF III, C. H. 1995. Regional economic fluctuations: portfolio variance and industrial instability across metro areas. *The review of regional studies*, 25(2): 159–186.

MALKINA, M. 2017. Influence of the industrial structure of economy on the risk level of Russian regions' tax systems. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, 65(6): 2025–2035.

MALKINA, M. Y. 2018a. Contribution of regions and their sectors to the financial instability of the Russian economy. [in Russian: Vklad regionov i otraslej v finansovuyu nestabil'nost' rossijskoj ehkonomiki]. *Terra Economicus,* 16(3): 118–130.

MALKINA, M. Y. 2018b. Instability of financial return of regional economies and its determinants. [in Russian: Nestabil'nost' finansovoj dohodnosti regional'nyh ehkonomik i ee determinanty]. *Spatial Economics/Prostranstvennaya ehkonomika*, 3: 88–114.

MALKINA, M. Y. and BALAKIN, R. V. 2015. Correlation Assessment of Tax System Risk and Profitability in the Russian Regions [in Russian: Ocenka vzaimosvyazi riska i dohodnosti nalogovoj sistemy v regionah Rossii]. *Economy of Region/Ekonomika regiona*, 3: 241–255.

MIKHEEVA, N. N. 2017. Diversification of Regional Economic Structure as Growth Strategy: Pros and Cons. *Regional Research of Russia*, 7(4): 303–310.

MARKOWITZ, H. M. 1959. *Portfolio Selection: Efficient Diversification of In-vestments*. Chicago, IL: Cowles Foundation for Economic Analysis.

PARK, Y. and HEWINGS, G. J. D. 2012. Does Industry Mix Matter in Regional Business Cycles? *Studies in Regional Science*, 42: 39–60.

SEEGERT, N. 2017. *Optimal tax portfolios: An estimation of Government Tax Revenue Minimum-Variance Frontiers*. [Online]. Available at: http://www-personal.umich.edu/~seegert/papers/OptimalTaxPortfolios_Seegert.pdf [Accessed: 2018, January 17].

SHARPE, W. F. 1970. *Portfolio Theory and Capital Markets*. New York, NY: McGraw-Hill.

SHORROCKS, A. 1982. Inequality Decomposition by Factor Components. *Econometrica*, 50(1): 193–211.

SIEGEL, P. B., JOHNSON, T. G. and ALWANG, J. 1995. Regional economic diversity and diversification. *Growth and Change*, 26(2): 261–284.

TRENDLE, B. 2006. Regional economic instability: The role of industrial diversification and spatial spillovers. *The Annals of Regional Science*, 40(4): 767–778.

WAGNER, J. E. 2000. Regional Economic Diversity: Action, Concept, or State of Confusion. *Journal of Regional Analysis and Policy*, 30(2): 1–22.

Contact information

Marina Malkina: mmuri@yandex.ru