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Kirill G. Sorokozherdyev ✉, *Evgeniy A. Efimov*
Peter the Great St. Petersburg Polytechnic University, Saint Petersburg, Russian Federation

THE INFLUENCE OF THE REGIONAL SECTORAL STRUCTURE ON THE SOCIO-ECONOMIC DEVELOPMENT OF A REGION[1]

Abstract. The socio-economic development of regions and countries is an important research issue. Thus, it is necessary to identify those areas that can serve as sources of economic growth and the basis for the well-being of the population. This study aims to determine the most important sectors of the economy of a region that can contribute to its socio-economic development. For this research, the Arkhangelsk region was taken as one of the typical Russian regions that have neither significant reserves of hydrocarbons nor any large industrial complexes. In this regard, the question of possible origins of economic growth seems especially relevant. To this end, an autoregressive distributed lag model (ADL-model) was developed, which is based on quarterly data on the socio-economic development of the Arkhangelsk region for the period 2004–2019. The obtained three equations reflect the dynamics of regional socio-economic development. The study showed that the greatest influence on the socio-economic development of the region is exerted by such industries as mining, construction, and manufacturing sectors. The study can become the basis for forecasting and modelling the socio-economic development of the Arkhangelsk region in the short and medium-term. It also can be helpful for analysing the effectiveness of measures aimed at stimulating those or other industries of the region. The model can be used in developing a regional development strategy.

Keywords: regional economic development, regional sectoral structure, regional GDP structure, mining sector, sector of wholesale and retail trade, sector of manufacturing, sector of construction, agricultural sector, ADL model, Arkhangelsk region

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ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

К. Г. Сорокожердьев ✉, *Е. А. Ефимов*
Санкт-Петербургский политехнический университет Петра Великого, г. Санкт-Петербург, Российская Федерация

Влияние отраслевой структуры на социально-экономическое развитие региона

Аннотация. Поиск источников экономического роста и повышения благосостояния населения является предметом многочисленных исследований социально-экономического развития регионов. Цель данного исследования — определить важнейшие отрасли экономики региона, которые могут способствовать его социально-экономическому развитию. Архангельская область была выбрана в качестве объекта анализа как типичный регион России, в котором нет значительных запасов углеводородов, крупных промышленных комплексов, а значит, поиск возможных источников экономического роста особенно актуален. Авторами разработана модель авторегрессии и распределенного лага (ADL-модель) для анализа квартальных данных о социально-экономическом развитии Архангельской области за период 2004–2019 гг. Полученные три уравнения отражают динамику регионального социально-экономического развития. Исследование показало, что горнодобывающая, строительная и обрабатывающая отрасли оказывают наибольшее влияние на социально-экономическое развитие региона. Полученные результаты могут быть использованы для прогнозирования и моделирования социально-экономического развития Архангельской области в краткосрочной и среднесрочной перспективе, а также для изучения эффективности мер, направленных на стимулирование различных региональных отраслей. Представленная модель в дальнейшем может быть применена при разработке стратегии регионального развития.

Ключевые слова: региональное экономическое развитие, региональная отраслевая структура, региональная структура ВВП, горнодобывающая отрасль, оптово-розничная торговля, обрабатывающая промышленность, строительная отрасль, сельское хозяйство, ADL-модель, Архангельская область

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Introduction

The presented research analyses the socio-economic development of the Arkhangelsk region. The research topic is relevant since economic growth is a long-term development goal of any region. The topic of economic growth has gained particular importance considering many negative events in international economics that occurred in the last decade. In this regard, it is important to identify some possible factors contributing to the development of the region, the growth of the welfare of its inhabitants. Having determined the main growth points of the regional economy, it is possible to create a long-term strategy for the socio-economic development of the region, which will take into account the current features of economic relations.

The initial scientific hypothesis of this study is that the economic performance of some sectors of the regional economy should significantly affect the dynamics of its socio-economic development. As of now, this problem is quite acute for many Russian regions, especially if it is difficult to single out some backbone industry that contributes to the development of the entire region. As a rule, in such regions there are no serious sources of raw materials and minerals, a relatively high unemployment rate, while the agricultural sector and some small-scale industrial production form the basis of the economy. In such regions, the question of possible sources of further development is particularly urgent.

The work is concentrated around a dynamic econometric model that was developed to describe and analyse the economic development of the Arkhangelsk region. The model consists of three equations, it is a regression model with a distributed lag, where the socio-economic development factors of the region are the contributions of the main regional economic sectors to the gross regional product (GRP). As a result, it is possible to assess the role of a particular industry in the regional socio-economic development. The effect of stimulating measures of one or another regional branch can be estimated with the equations. So, the socio-economic indicators for the region and ultimately the quality of life of the population can be both analysed and managed. The Arkhangelsk

region was chosen as an object of analysis because it is a typical Russian region. While it has some peculiarities, the region has neither vast oil and gas reserves, nor financial centres or heavily industrialised areas. Accordingly, the question of possible growth points for the regional economy is very relevant. The subject of research is the socio-economic development of the Arkhangelsk region.

The study examined the current dynamics of the socio-economic development of the region using the quarterly data for all the studied indicators for the period 2003–2019.

The purpose of the research is to analyse the role of regional segments of the sectoral structure in the socio-economic development of the Arkhangelsk region. To achieve this goal, the following tasks were accomplished:

— conducting a general overview of the socio-economic situation of the region;

— analysing the contribution of various sectors to GRP;

— creating an autoregressive distributed lag model (ADL-model) reflecting the impact of regional sectors on socio-economic development;

— identifying the most significant segments of the regional economy for socio-economic development.

To solve the aforementioned problems, we used Gretl software package for econometric modelling. The application of the software can be explained by the following points. Firstly, it is a free, fairly convenient, and versatile package for performing econometric calculations. Secondly, Gretl provides an opportunity to "feel" all the details and subtleties of the studied methods when they are implemented based on the corresponding vector-matrix relationships, which gives more opportunities for data analysis.

The ADL-approach was proposed to study the dynamics of the socio-economic development of the region. We see this approach as optimal in terms of applicability and flexibility, as it takes into account the lags in the dynamics of macroeconomic processes. The approach makes it possible to apply an understandable mechanism of the least squares method, which would imply the possible inter-period influences of various industries on regional socio-economic development. At the same time, the model is also not overly complicated, the resulting equations can clearly indicate the importance of certain sectors of the regional economy for the development of the region as a whole. The novelty of this approach lies in the choice of indicators of socio-economic development and the factors influencing it. The use of other methods and approaches is also possible if they are compatible with the logic of this study. In particular, a simple regression can be used, however, its result may turn out to be somewhat rougher in comparison with the real dynamics in the region. Since the study touches upon the aspect of socio-economic development, typical variables characterising not only the economic component, but also the social one were taken as the resulting indicators. At the same time, the number of resulting variables, in our opinion, is quite reasonable. One of the resulting indicators reflects the macroeconomic aspect, another reflects the micro level, and the third reflects the social aspect.

Analysis of research in this field. Analysis of modern research demonstrates that many scholars examine various aspects of regional economic growth and development. Alongside with the conceptual studies on economic growth and development, other works can be classified according to the growth factor and taken into the analysis.

The conceptual research is presented by books of Pike et al. (2006), Gigliotti et al. (2018), Raudino and Raudino (2016), and Acemoglu (2008). These researchers disclose the development process as a multi-purpose one including many aspects such as sustainability and environmental safety. Besides, the problem of sustainability and sustainable development is touched upon in other works (Nijkamp & Vreeker, 2000; De Sousa Fragoso, 2015; Gigliotti et al., 2018; Shahraki, 2019). For instance, Nijkamp and Vreeker (2000) developed a model for selecting the optimal development scenario for the region. Thus, with the help of a multidimensional indicator system, it is possible to distinguish the most appropriate regional development strategy. The study of Shahraki (2019) highlights the importance of the technological factors in the development of cities and territories.

Many researchers have focused on such factors as human capital (Gennaioli et al., 2011) and innovations (Cooke & Leydesdorff, 2006; Lagendijk & Cornford, 2000). These works analyse the relationship of regional development with investment in research and development (R&D), the number of researchers, intangible assets, patent payments, and know-how. The importance of the educational sphere for the regional development is explained by Gennaioli et al. (2013). The book of Vermeulen (2017) presents a fundamental research of the role of knowledge networks in various sectors of the European economy. Fleisher et al. (2010) have shown a significant effect of human capital on the development of Chinese regions, whereas the effect is depending on the geographic location of the region. Gordon and McCann (2005) analysed the innovative activities of British companies,

concluding that innovation patterns depend on the region. So, the work studies only the innovative factor of regional economic growth.

The influence of small businesses on regional development is disclosed in many works. For instance, in the study of Freshwater et al. (2019), the role of small and medium-sized companies in the socio-economic development of the region is analysed. Many studies are also based on the factor of entrepreneurship, small and medium business. González-Pernía and Peña-Legazkue (2015) examined the role of export-oriented small-businesses in the regional development in Spain. Dejardin and Fritsch (2011) investigated the influence on regional economic growth of newly created businesses. The work of Bashir et al. (2014) revealed the positive role of self-employment as the factor of regional economic growth. Kasseeah (2016) as well as Wennekers and Thurik (1999) linked economic growth with entrepreneurial activity. The latter has proven to be one of the factors of the regional economic development. Audretsch and Keilbach (2004) once again considered the entrepreneurial activity as a factor providing for knowledge spillovers and, hence, stimulating economic growth. The work of Malecki (1993) is more concentrated on the entrepreneurship phenomenon and analyses it profoundly again regarding this factor to be important for regional development. In the study by Dahlstrand (2007), regional development is considered as a process that can be catalysed by technology-based newly created companies in the region. These technological start-ups are becoming growth-points for disseminating technology and managerial expertise especially in the major regions. The importance of entrepreneurial activity for job creation is analysed by Baptista et al. (2008) for some Portuguese regions. The newly-created businesses have proven to be sources of new jobs and economic growth, although with a time-lag. Again entrepreneurial activity was analysed in the study of Noseleit (2013), but the author proves that economic growth can be obtained only with a combination of entrepreneurial activity and factors of production that have to be reallocated between the sectors. The importance of entrepreneurship is also stated in the research of Andreeva et al. (2016), but here the authors proved the hypothesis that economic growth in the country and in the region is determined not by large companies, but by many small innovative companies.

Some studies relate to the impact on global economic development processes (Coe et al., 2004; Scott & Storper, 2007). Some scholars associate regional economic development with social capital (Iyer et al., 2005), and in some works, growth is linked with the problem of income inequality (Seligson & Kuznets, 2019). The work of Gallup et al. (1999) studies the location of a region as the main factor of economic development. Several studies touch upon the relationship between the environment and economic growth (Mäler, 2013; Green & Studies, 2012). Some works are testing relatively new concepts and creating new trends in regional development. In particular, the work of Ross et al. (2016) explores the advantages and disadvantages of the formation of the so-called megaregions, agglomerations of large cities, and adjacent territories.

Crespo-Cuaresma et al. (2011) analysed the regional development factors using the quantile approach, where differences in the influence of individual growth factors are monitored based on regression analysis. The work of Caliendo et al. (2018) considers aggregate economic activity as a derivative of the activity of various sectors of the economy. This research is somewhat similar to the present study.

There are numerous Russian-language publications on the examined topic (Nizhegorodtsev & Arkhipova, 2009; Ashkhotov, 2013; Nikolaev & Makhotaeva, 2016; Aivazian et al., 2016; Ryumina & Anikina, 2007; Efimova & Gritsenko, 2021; Mikhailov & Sarkisyan, 2003). In particular, the study of Nizhegorodtsev and Arkhipova (2009) classifies the regions of the Russian Federation according to the sources of economic growth: labour, capital, institutions, R&D. The article by Ashkhotov (2013) explores the relationship between the per capita value of GRP and the shares of the extractive and manufacturing sectors of the economy in various regions. The author comes to the conclusion that it is the manufacturing sector that makes the main contribution to per capita GRP. The work of Nikolaev and Makhotaeva (2016) examines interregional interactions as sources of economic development of territories, highlights the increase in the number of people employed in the economy as a significant factor contributing to economic development. According to Aivazian et al. (2016), the Russian regions are divided into different areas of specialisation, including industry, agriculture, etc. In this study, as well as in the study of Nizhegorodtsev and Arkhipova (2009), the cluster analysis tool is used. Cluster analysis is also used in the research of Ryumina and Anikina (2007), where the endowment of the region with raw materials is taken as a special source of economic growth. The authors identify two main ways to achieve high economic growth — the one based on resources and the innovation-based. The

article by Efimova and Gritsenko (2021) examines the role of the extractive sector in regional economic growth on the example of some territories of the Russian Federation and Canada, some parallels are drawn. Mikhailov and Sarkisyan (2003) analysed various aspects of industrial and investment activity in the region as factors of economic growth. Based on the obtained regression models, the corresponding conclusions were obtained.

The economic and geographical position of the region. Arkhangelsk region has a favourable economic and geographical position. It is located in the north of the East European Plain, in geographic coordinates between 60.5 and 70 degrees North latitude. It is washed by the White, Barents and Kara Seas. Modern Arkhangelsk is not only the largest seaport in the North, since the Northern Sea Route passes through it, but also a transport hub connected with other regions of Russia by air, rail and road. The main type of transport is rail, although there are several airports located in the region. The region traditionally exports various products mainly related to its forest resources to the countries of near and far abroad.

The Arkhangelsk region is a region of the forest industry, the fishing industry, modern shipbuilding, and also Russian cosmonautics.

More than 24 thousand enterprises and organisations of all forms of ownership and management are registered in the region.

Regional economic development is based on the most traditional sectors like forestry and construction industry. Also, the developed infrastructure of commercial ports, including the Arkhangelsk Sea Port, the northern gateway to Russia, plays a significant role. The port provides a substantial part of freight traffic in this region.

The climate of the region is temperate continental, marine in the northwest, subarctic in the northeast, that is, there are cool summers and long cold winters. The territory of the region is a vast plain with a weak slope towards the White and Barents Seas.

Arkhangelsk region has significant forest resources. The area covered by forest is 22.3 million hectares. The total stock of wood is more than 2,500 million m³. Coniferous species (pine, spruce) prevail in the composition of the forest fund (80 %), deciduous species (birch, aspen) are about 20 %.

The area is rich in minerals. The efforts of geological prospectors in the Arkhangelsk region created a powerful raw material base for the development of oil and gas production and processing in the Nenets Autonomous District, which is a part of the region. The only diamondiferous province in Europe has been opened in the Arkhangelsk region. The minerals mined in the region are diamonds, lead, zinc, silver, coal, bauxite, gypsum.

The main component of socio-economic development in the research is GRP. The indicator is taken in the model as the variable Y_2. The region is successfully developing showing good dynamics. This can be evidenced by the steady growth of GRP (Figure 1) over the past 16 years, excluding crises that have occurred during this time. Figure 1 shows the quarterly dynamics of GRP.

The share of agriculture from 2005 to 2019 decreased from 5.5 % to 3.5 %. Relatively low values of this indicator are primarily associated with the geographical location of the region. Despite some objective difficulties, the regional government sees potential in the development of the agricultural industry: from 2012 to 2019, the volume of state support for the agricultural sector amounted to almost 6 bln. roubles.

In particular, investment projects in dairy farming are being actively implemented in the region: over the past five years, 22 livestock facilities for 6,000 cattle places have been commissioned. This will increase the annual milk production by about 10 %. Support is also provided to enterprises whose activities contribute to import substitution in the fields of vegetable growing and beef cattle breeding.

Mineral extraction (Figure 2) is the main source of GRP in the Arkhangelsk region, amounting to 30 % in 2019. Arkhangelsk region ranks second in the country in accounted reserves of diamonds, which make up about 20 % of the total Russian. A work financed by both attracted and own funds of the extraction industry is being carried out to search and evaluate deposits of diamonds, gold, and bauxites. The federal budget also funds the prospecting for diamonds and evaluation work on fresh groundwater in the region.

One of the most developed industries of the Arkhangelsk region is forestry, woodworking, and pulp and paper industry. The machine-building industry is the second largest, next to the forestry. The share of manufacturing in the GRP structure during the period from 2005 to 2019 decreased by about 5 % and amounted to 14 %.

The Arkhangelsk region is one of the leading forestry centres in Russia. The largest chemical and mechanical wood processing facilities are located here. The region provides a third of the Russian pulp and cardboard volumes, up to 8 % of lumber, and up to 11 % of paper. Due to its convenient geographical location, the timber industry of the region is engaged primarily in export activities. The lumber is exported to 80 countries. Among

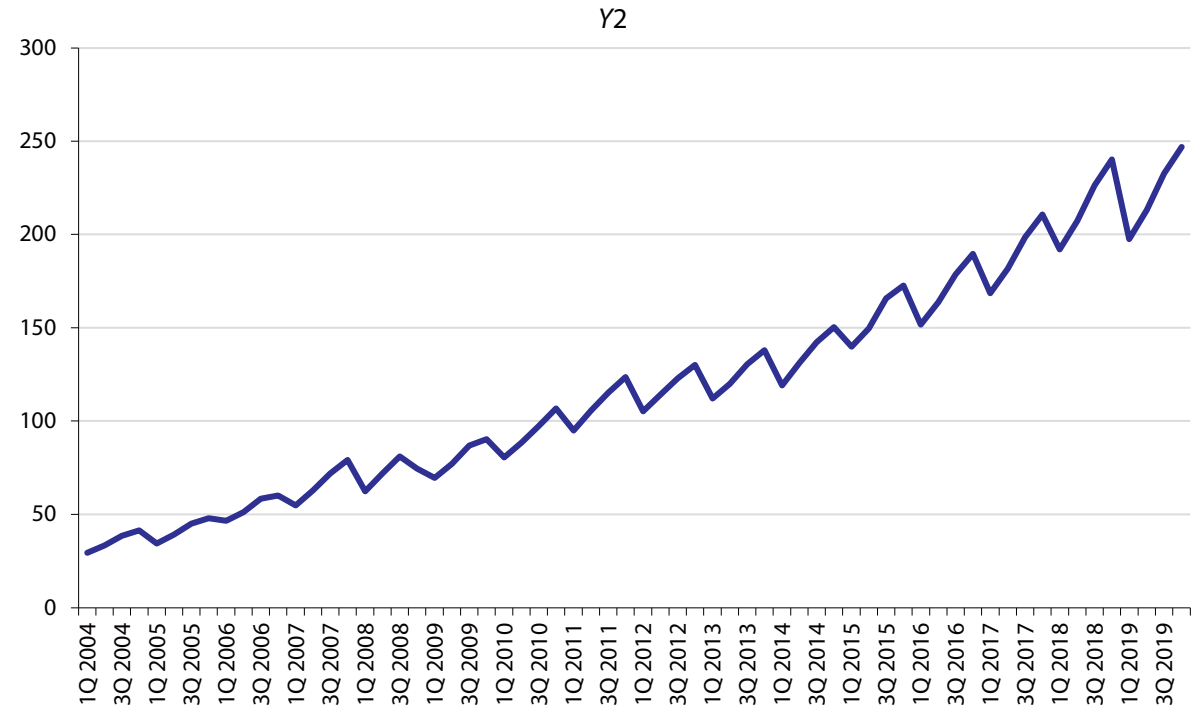

Fig. 1. *GRP of the Arkhangelsk region, bln. roubles (quarterly data) (source: Obtained using Gretl software based on the official statistics. Retrieved from: https://29.rosstat.gov.ru)*

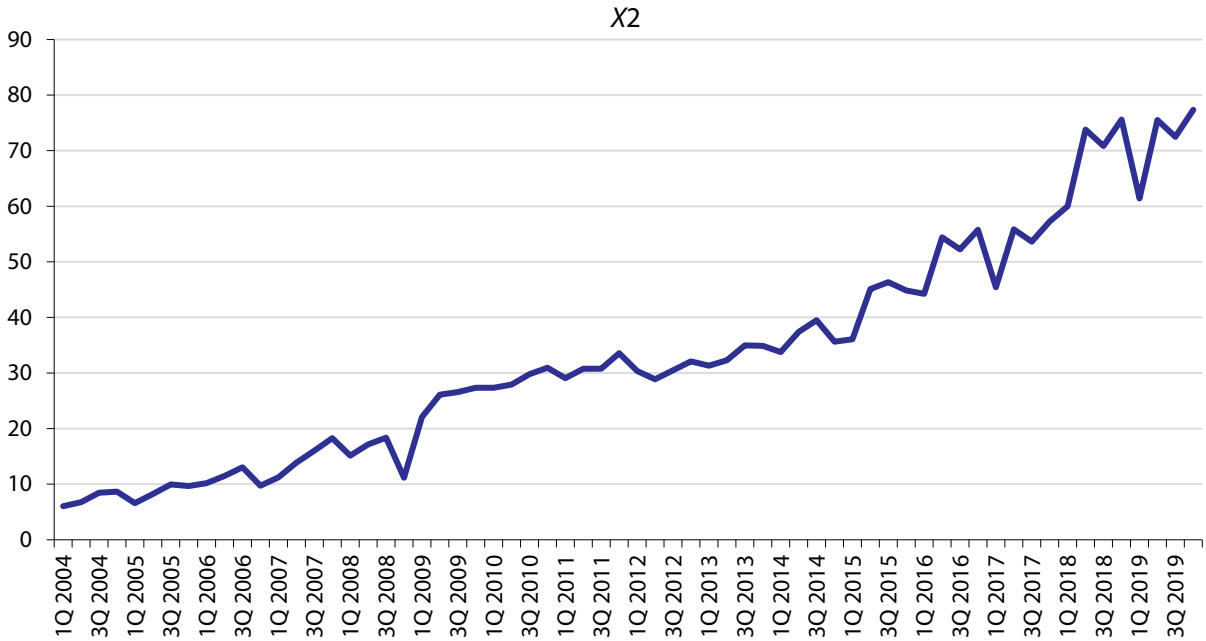

Fig. 2. *GRP created by the mining industry in the Arkhangelsk region, bln. roubles (quarterly data) (source: Obtained using Gretl software based on the official statistics. Retrieved from: https://29.rosstat.gov.ru)*

the importers are Germany, France, Poland, Italy, Belgium, Great Britain, the Netherlands, China, Azerbaijan, Egypt. Below is a graph of the manufacturing dynamics in the Arkhangelsk region (Figure 3).

The region is in the middle of the list of the regions in the Northwestern Federal District in terms of housing construction. The construction of 1,547 buildings and structures was launched in 2019. 1,360 buildings were built for residential use. In terms of money, the contribution of the sector to GRP amounted to 41 bln. roubles, which is 9 % higher as of 2018.

During the analysed period, the construction sector generated stable cash flows to the regional budget, therefore, in relative terms, the share of the sector in the regional GRP remained constant and amounted to about 7 %. Below is a graph of regional construction sector dynamics for the examined period (Figure 4).

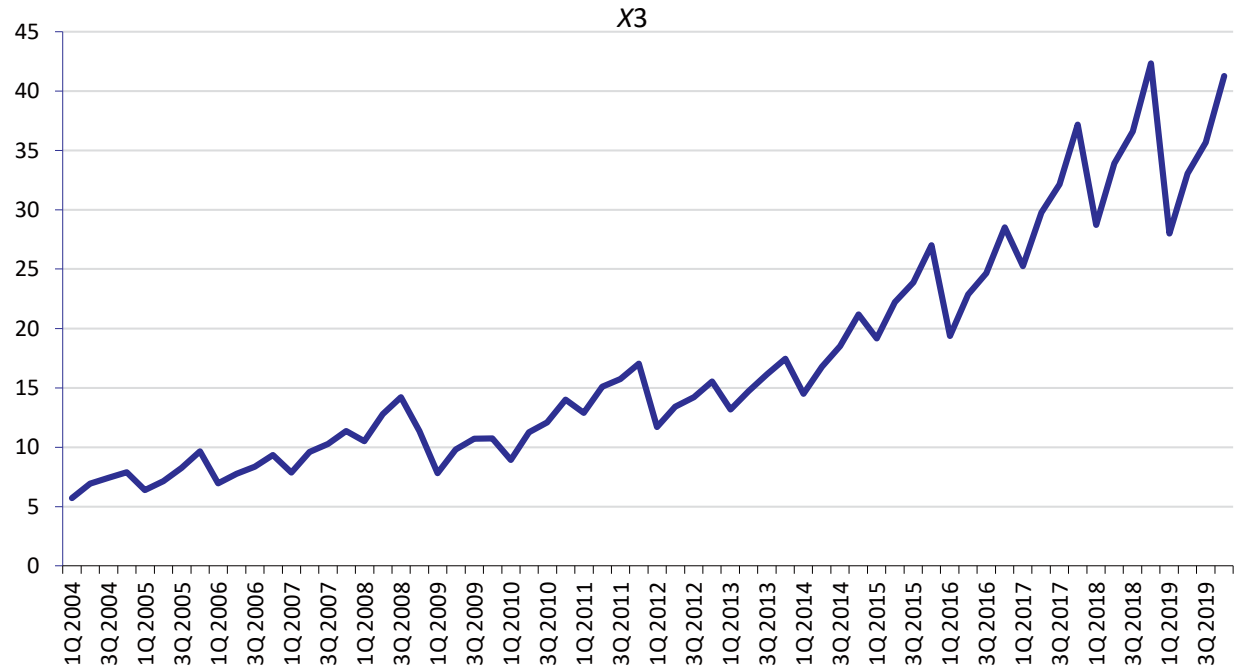

Fig. 3. *GRP created by manufacturing of the Arkhangelsk region, bln. roubles (quarterly data) (source: Obtained using Gretl software based on the official statistics. Retrieved from: https://29.rosstat.gov.ru)*

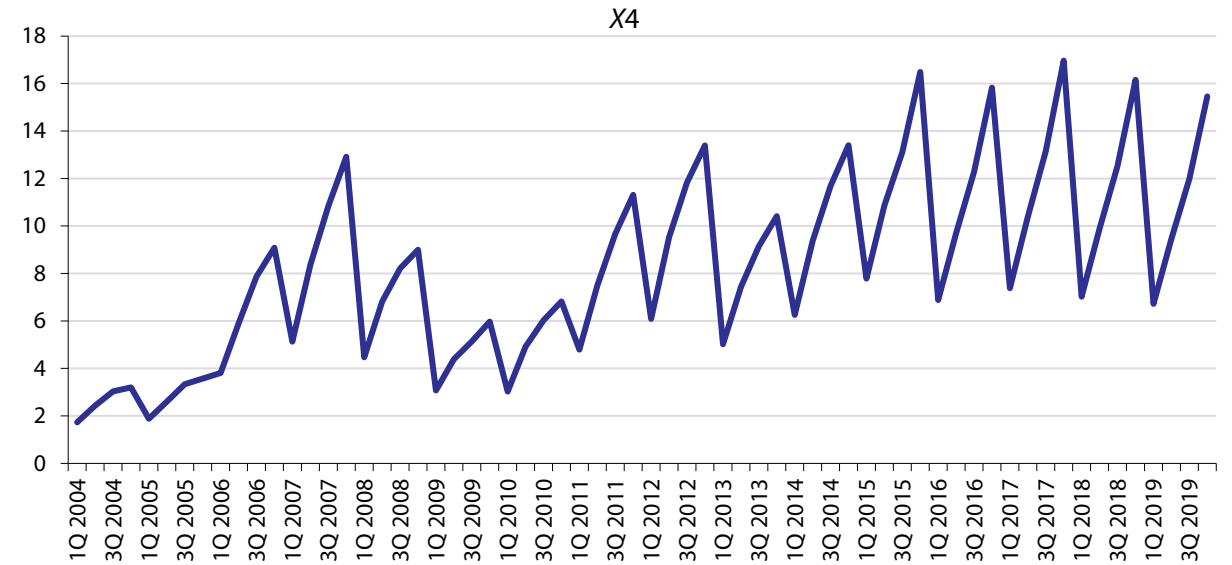

Fig. 4. *GRP created by the construction sector in the Arkhangelsk region, bln. roubles (quarterly data) (source: Obtained using Gretl software based on the official statistics. Retrieved from: https://29.rosstat.gov.ru)*

The share of wholesale and retail trade (Figure 5) decreased from 11.4 % in 2005 to 7.5 % in 2019. The full title of the article in statistics is "Wholesale and retail trade, repair of motor vehicles, motorcycles, and items of personal use". The sector plays an important role in the regional economy, its share in GRP is close to construction.

The region does not have a highly developed sector of tourism and entertainment. The same applies to the financial sector. The share of GRP created by these areas of activity is small, the total contribution of the both to GRP can be estimated at 2–2.5 %.

The labour market and employment in the region. The labour market is considered in the research as a component of socio-economic development. The indicator of the labour market taken into account is the average regional wage rate (Y_1). The situation on the labour market in the Arkhangelsk region in 2016 is stable. According to the statements of the regional officials, no massive reductions in enterprises and organisations in the region are expected.

The number of unemployed in the Arkhangelsk region is 10,147 people. The number of vacancies is 8,800. The officially registered unemployment rate is 1.7 %.

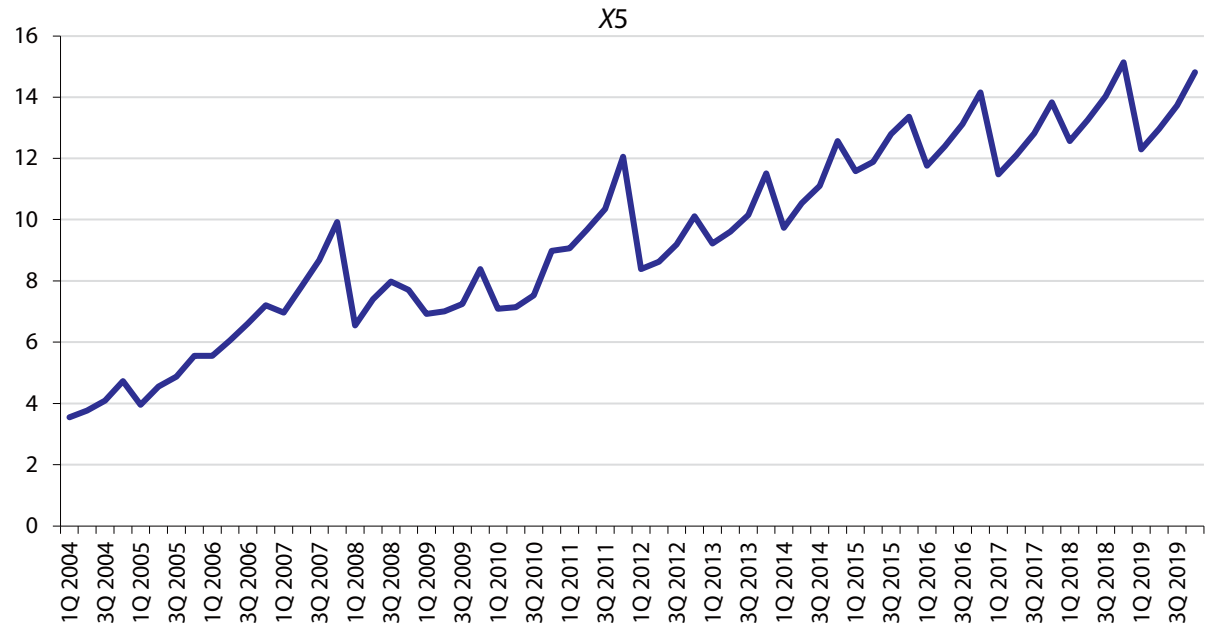

Fig. 5. *GRP generated by wholesale and retail trade in the Arkhangelsk region, bln. roubles (quarterly data) (source: Obtained using Gretl software based on the official statistics. Retrieved from: https://29.rosstat.gov.ru)*

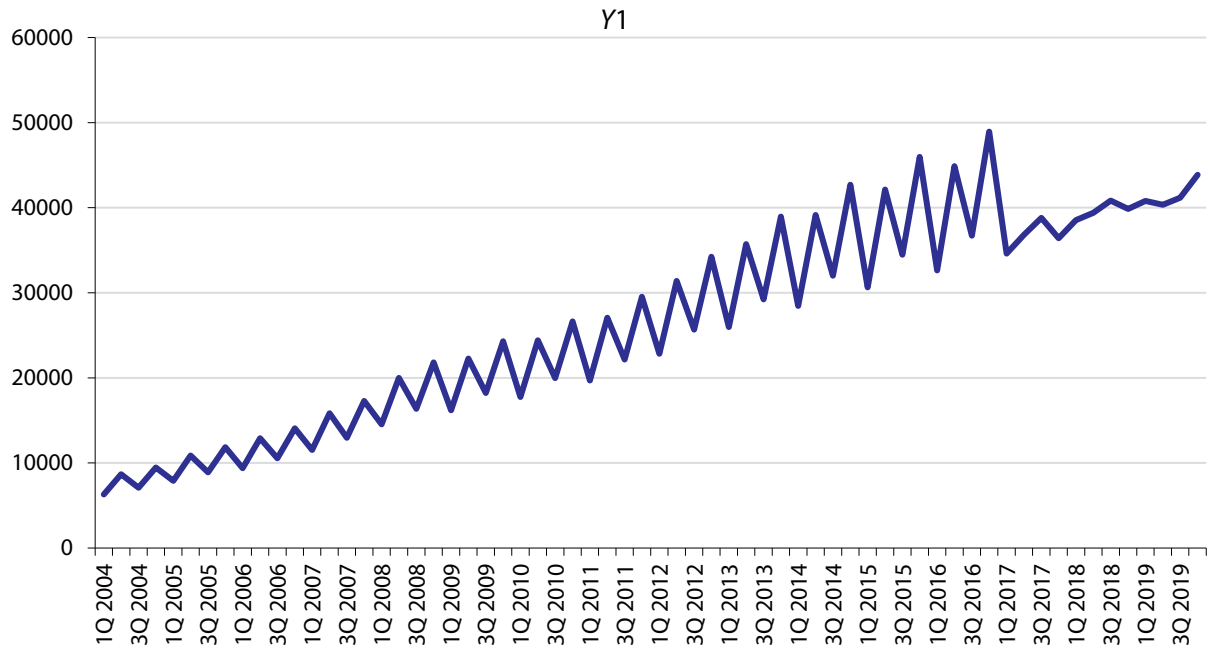

Fig. 6. *The average monthly wage in the Arkhangelsk region, rub. (quarterly data) (source: Obtained using Gretl software based on the official statistics. Retrieved from: https://29.rosstat.gov.ru)*

According to monitoring data, the biggest reductions are planned at the Solombalsky Pulp and Paper Mill (about 100 people) and Oktyabrsky House-Building Factory due to the closure of production (up to 170 people). However, at least partially the dismissed workers can be employed at the newly organised production of particle boards.

The regional labour market has an increased demand for construction professions (bricklayer, concrete worker, carpenter, finisher) and some drivers, sellers, skilled workers in shipbuilding are required as well.

Over half of 3.2 thousand vacancies for specialists and employees are in the sphere of healthcare: more than a thousand doctors and paramedics are required, and about 600 vacancies are open for nurses. Besides, the region needs about a thousand unskilled specialists — workers, cleaners, janitors.

The salary chart for the period from 2004 to 2019 is presented below (Figure 6).

Demographic situation. The demographic situation is also important as it is included in the research as one of the variables — Y_3 (the birth

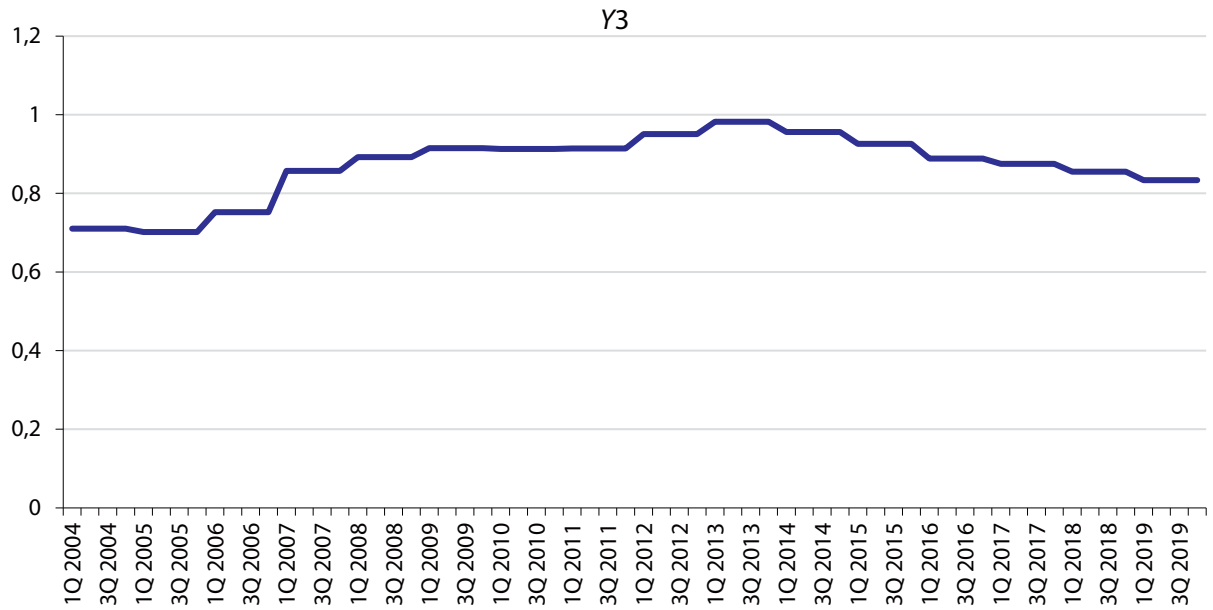

Fig. 7. *The birth rate in the Arkhangelsk region (quarterly data) (source: Obtained using Gretl software based on the official statistics. Retrieved from: https://29.rosstat.gov.ru)*

rate). The regional birth rate is still lower than the mortality rate. So, in 2019, the natural population decrease in the region amounted to a little more than 900 people. The main causes of deaths are diseases of the cardiovascular system, cancer, trauma, poisoning, and road accidents.

The birth rate graph is presented below (Figure 7).

Thus, we have performed some preliminary analyses for the region and now move on to the method used in the research.

Methods

The main idea of the study is to analyse the dynamics of the socio-economic development of the region. The analysis has to reveal the role of the regional sectoral structure in the dynamics of the selected indicators of socio-economic development. Using a regression model, the indicators appear to be dependent on the activity of various sectors of the regional economy. If significant relationships are found, it can be argued that through the stimulation of certain sectors of the regional economy, it is possible to influence the dynamics of the indicators of regional development. The research used quarterly data on the main indicators of the socio-economic development of the region for the period 2004–2016. The study has endogenous and exogenous variables of the regression model.

The following indicators of socio-economic development are endogenous (resulting) variables:

Y_1 — average monthly wage per employee, roubles.

Y_2 — gross regional product at basic prices.

Y_3 — birth rate.

For exogenous variables that determine socio-economic development, were taken the following:

X_1 — the share of agriculture, hunting, and fishing in GRP, roubles.

X_2 — the share of the mining sector in GRP, roubles.

X_3 — the share of manufacturing in GRP, roubles.

X_4 — the share of construction in GRP, roubles.

X_5 — the share of wholesale and retail trade in GRP, roubles.

X_6 — the share of hotel and restaurant business in GRP, roubles.

X_7 — the share of the financial sector in GRP, roubles.

The model, which estimates the regression dependence between variables, includes not only the factors themselves but also the same exogenous variables taken with a lag, as well as an element of autoregression. This model is often used in economic studies and is called the autoregressive distributed lag model or ADL-model. A similar approach is employed in the work Shvetsov et al. (2019).

Creating an ADL-model involves several steps, the first of which is checking the stationarity of time series since the time series that make up the model must be stationary. This test was conducted in the study according to three well-known criteria: the extended Dickey-Fuller criterion (ADF test), the ADF-GLS criterion, and the KPSS criterion.

First, it is necessary to check the data for stationarity using the tests. If the time series appears to be stationary at least in two tests out of three, we are assuming the time series to be stationary. The ADF and ADF-GLS tests involve constructing an autoregression with some coefficient for the time series. If the coefficient in autoregression exceeds the absolute threshold value of 0.2, the hypothesis of stationarity of the series is accepted, so the time series is assumed to be a TS time series. Otherwise, the time series is non-stationary, so it is a DS time series. According to the KPSS test, the hypothesis of stationarity of the series is accepted with the p-value greater than 0.05. The considered time series for all the variables in our case appeared to be non-stationary, i. e. DS. The test results are shown in Table 1 below.

To modify the initial non-stationary time series, the standard differentiation procedure should be conducted. The next step will be a new check for stationarity of the differentiated series according to the tests ADF, ADF-GLS, KPSS. The logic of the tests remains the same. The results are presented in Table 2 below.

As seen in Table 2, all the differentiated time series turned out to be stationary, the procedure for construction of the model will be proceeded with the obtained differentiated variables, denoted as d_X instead of the original time series X.

Table 1

The results of the tests for stationarity of the initial data time series

Variable	Stationarity test			Result
	ADF	ADF-GLS	KPSS	
X_1	0.055	0.078	< 0.01	DS
X_2	0.014	0.047	< 0.01	DS
X_3	0.023	0.004	< 0.01	DS
X_4	–0.129	–0.097	< 0.01	DS
X_5	–0.031	0.03	< 0.01	DS
X_6	0.023	0.012	< 0.01	DS
X_7	–0.044	–0.019	< 0.01	DS
Y_1	0.003	–0.005	< 0.01	DS
Y_2	0.014	0.017	< 0.01	DS
Y_3	–0.15	–0.031	< 0.01	DS

Source: authors' calculation in Gretl software.

Table 2

The results of the tests for stationarity of the modified (differentiated) time series

Variable	Stationarity test			Result
	ADF	ADF-GLS	KPSS	
d_X1	–2.048	–2.048	> 0.1	TS
d_X2	–0.988	–1.12	> 0.1	TS
d_X3	–1.556	–0.43	> 0.1	TS
d_X4	–1.772	–0.675	> 0.1	TS
d_X5	–1.655	–1.636	> 0.1	TS
d_X6	–0.905	–0.701	0.086	TS
d_X7	–0.894	–0.878	> 0.1	TS
d_Y1	–1.787	–0.016	0.093	TS
d_Y2	–1.889	–0.642	0.090	TS
d_Y3	–0.453	–0.438	0.047	TS

Source: authors' calculation in Gretl software.

Results and Discussion

Following the steps of creating the model, we are trying to find the variables and the lags of the variables that influence the resulting values significantly. Other variables with insufficient influencing power will be excluded from the equations. As a result of this sequence of steps, we obtain the final relationship between the independent and dependent variables that we have selected for the model.

Firstly, we construct autoregressions for every dependent variable. The autoregression includes the lagged variable up to the 10th period. The most significant lags of a 1 %-5 % significance level are selected. Secondly, the search for the lags of exogenous variables is carried out similarly. Multiple one-factor models are constructed. Insignificant coefficients for variables are removed from the regressions. As a result, a search for possible regressors of the equation with the most significant lags is performed for each endogenous variable. A general equation is formed with all potentially significant variables and lags for each endogenous variable.

After determining the significant lags for dependent variables (Y_1–Y_3), as well as significant lags for independent variables (X_1–X_7) and after removing all the non-significant variables from the equations, we obtain the three-equations model.

Table 3 below shows the coefficients of the first equation for the indicator of the average monthly wage in the region, the equations for d_Y1.

The significance level of the coefficients of the equation can be determined in Table 3 by the rightmost column. Three stars correspond to a 1 % significance level; two stars correspond to a 5 % significance level; one star tells us of a 10 % significance level of the coefficient. In the notation of variables, d denotes the differentiated time series of the initial variable, the first digit is the number of the variable, the second is the lag. So, if we have d_X4_4, then we understand it as the fourth exogenous variable X_4 on the fourth lag.

Similarly, the other two equations of the model were obtained for the regional GRP and the birth rate. Table 4 below shows the second equation for d_Y2.

Table 5 shows the third equation for d_Y3.

Table 3

The first equation of the model for d_Y1

	Coefficient	St. error	*t*-statistics	*P*-value	
const	500.029	127.306	3.928	0.0002	***
d_X4_4	336.112	59.5601	5.643	< 0.0001	***

RSS	1.99e+08	St. error of the model	1886.961
R-squared	0.928240	Adj. *R*-squared	0.926959
F(1, 56)	31.84628	*P*-value (*F*)	5.74e–07
rho	–0.063847	Durbin–Watson	2.125077
Avg. of dep. variable	568.9012	St. dev. of dep. variable	6981.988

Source: authors' calculation in Gretl software.

Table 4

The second equation of the model for d_Y2

	Coefficient	St. error	*t*-statistics	*P*-value	
const	1.41173	0.164685	8.572	< 0.0001	***
d_X1_2	0.911152	0.323121	2.820	0.0069	***
d_X1_3	–0.783245	0.0953074	–8.218	< 0.0001	***
d_X1_4	1.96700	0.365357	5.384	< 0.0001	***
d_X2	0.673888	0.0642510	10.49	< 0.0001	***
d_X3	1.21380	0.121571	9.984	< 0.0001	***
d_X4	0.944874	0.139648	6.766	< 0.0001	***
d_X4_4	0.473981	0.135112	3.508	0.0010	***

RSS	138.0307	St. error of the model	1.661510
R-squared	0.984821	Adj. *R*-squared	0.982696
F(7, 50)	620.4580	*P*-value (*F*)	2.75e–46
rho	0.011889	Durbin-Watson	1.952815
Avg. of dep. variable	3.583226	St. dev. of dep. variable	12.63047

Source: authors' calculation in Gretl software.

Table 5

The third equation of the model for d_Y3

	Coefficient	St. error	*t*-statistics	*P*-value	
const	0.00306524	0.00236276	1.297	0.2000	
d_X4	–0.00455979	0.00151775	–3.004	0.0040	***
d_X4_4	0.00645847	0.00177153	3.646	0.0006	***
d_X6_4	–0.0487955	0.0209398	–2.330	0.0236	**

RSS	0.016942	St. error of the model	0.017713
R-squared	0.209043	Adj. *R*-squared	0.165101
F(3, 54)	4.755869	*P*-value (*F*)	0.005151
rho	–0.000196	Durbin-Watson	1.990895
Avg. of dep. variable	0.002270	St. dev. of dep. variable	0.019385

Source: authors' calculation in Gretl software.

The model with the differentiated time series will have the form presented in Table 6.

The analysis of heteroscedasticity in the obtained models can be carried out by the values of the residuals. The residuals for the models as a whole show a constant scatter, with the exception of individual single observations.

It is important to note that ADL-models are built on the basis of data transformed into a stationary form, which generally helps to reduce multicollinearity. In addition, models, even burdened with multicollinearity, can be well applied if they

Table 6

The ADL-model with the differentiated time series

Variable	Equations of the model
d_Y_1	$d\_Y_1 = 336.11 d\_X_4^4 + 500.03$
d_Y_2	$d\_Y_2 = 0.91 d\_X_1^2 - 0.78 d\_X_1^3 + 1.96 d\_X_1^4 + 0.67 d\_X_2^0 + 1.21 d\_X_3^0 + 0.94 d\_X_4^0 + 0.47 d\_X_4^4 + 1.41$
d_Y_3	$d\_Y_3 = -0.0046 d\_X_4^0 + 0.0065 d\_X_4^4 - 0.0049 d\_X_6^4 + 0.0031$

Source: authors' calculation in Gretl software.

Table 7

The final equations of the ADL-model

Variable	Equations of the model
Y_1	$Y_1 = Y_1^1 + 336.11X_4^4 - 336.11X_4^5 + 500.03$
Y_2	$Y_2 = Y_2^1 + 0.91X_1^2 - 1.69X_1^3 + 2.74X_1^4 + -1.96X_1^5 + 0.67X_2^0 - 0.67X_2^1 + 1.21X_3^0 -1.21X_3^1 + 0.94X_4^0 - 0.94X_4^1 + 0.47X_4^4 - -0.47X_4^5 + 1.41$
Y_3	$Y_3 = Y_3^1 - 0.0046X_4^0 + 0.0046X_4^1 + 0.0065X_4^4 -0.0065X_4^5 - 0.0049X_6^4 + 0.0049X_6^5 + 0.0031$

Source: calculation of the authors.

are highly significant. In our example with the Arkhangelsk region, we see that all models are significant at the 1 % level. The first equation, which reflects the dynamics of the average monthly wage in the region, is highly significant: the *F*-statistics indicator equals 32, the coefficient of determination is 0.93. It can be seen from the equation that the construction sector plays a significant role in the dynamics of wages in the region. The second equation on the dynamics of GRP has the greatest significance of all three equations: the *F*-statistics indicator is 620, the coefficient of determination is 0.98. It can be seen from the equation that the dynamics of GRP is determined by the agro-industrial and mining sectors, as well as by the industrial and construction sectors. The third equation for the birth rate is also generally significant. The *F*-statistic is 4.8 units, while the probability of the equation being insignificant is about 0.5 %. Noteworthy is the rather low coefficient of determination — 0.21. This can be explained by the fact that only in some part the economic development of the region affects the social sphere. Some other possible factors are not encompassed in the study.

The autocorrelation of errors in the obtained equations can be judged by the Durbin-Watson criterion, which in all equations is very close to 2, which almost certainly allows us to exclude the presence of both positive and negative autocorrelations.

Having transformed the model from differentiated time series to the initial values, we get the final model:

As can be seen in all the equations of the model, all coefficients of the variables are significant, and the value of the coefficient of determination varies from 0.91 to 0.98, which indicates the high accuracy of the model. All equations of the model are significant by the *F*-criterion. Moreover, the first and the second equations have very high values of the *F*-criterion.

The coefficients for the model variables are also significant, mainly at the 1 % level. Some coefficients are still left in the equations, although their significance is somewhat lower. This was done to improve the accuracy of the model.

According to the constructed model, we can conclude that the average regional wage in the current period is most closely related to the wage for the previous quarter and with the sector of construction. It is the sphere of construction that has the most significant positive effect on the average wage in the region. If we take the activity in the sector as a constant value, then the current increase in the contribution of the sector to GRP by 1 bln. roubles will increase the average regional wage by 336 roubles.

The second equation for GRP shows the dependence of the indicator on the agricultural sector, mining and manufacturing sectors and the sector of construction. The influence of the agriculture is mixed but positive in general. The most influence on GRP is exerted by the sectors of mining, manufacturing and construction. If we take these factors as conditionally constant for the previous periods, then the current increase in the mining sector by 1 bln. roubles will mean an increase in GRP by 0.67 bln. roubles; an increase in the manufacturing sector by 1 bln. roubles will bring an increase in GRP of about 1.21 bln. rubles; finally, an increase in the construction sector by 1 bln. rubles will increase GRP by 0.94 bln. roubles.

The birth rate is largely determined by the birth rate for the previous period (a quarter ago). GRP created in construction has a somewhat positive impact, but the immediate influence is negative. The sector of restaurants and hotels for the previous 4th quarter has a negative impact on the regional birth rate.

Conclusion

The study presented a model consisting of three equations describing the dynamics of the socio-economic development of the Arkhangelsk region in various aspects. The first equation speaks of the average wage in the region, the second indicates the dynamics of GRP, and the third equation presents the dynamics of the birth rate in the region. The factors influencing the socio-economic development of the region are the shares of GRP created by various sectors of the regional economy in monetary terms.

The first equation shows that one sector has a statistically significant influence on the size of the average regional monthly wage. Here we can talk only about a positive impact of the sector of building and construction (X_4), that stimulates an increase in average regional wages. Other sectors do not have a significant impact on the average re-

gional wages, probably due to the fact that wages in these sectors are fairly close to the average, whereas the building and construction sector offers significantly higher salaries, especially in the projects financed by the federal government. So, every start of such a project stimulates a rise of this resulting variable.

The second equation models the influence of the selected sectors of the regional economy on the dynamics of GRP. The equation shows a significant positive contribution of mining, manufacturing and construction sectors to the economic development of the region. The agriculture plays also a somewhat positive role in GRP. Due to the relative weakness of tourism and the financial sectors in the region, the influence of these sectors on GRP has not been identified.

The third equation analyses the dynamics of the birth rate in the region. The indicator is largely determined by the birth rate during the previous period. The equation also shows a somewhat positive role of the construction sector and a weak negative impact of the regional tourism sector.

The above-presented approach can be applied for the analysis of any region. With the help of regression analysis, the method will show the importance of various sectors of economy for the socio-economic development of the area. This is especially important for the regions where the most significant sectors cannot be easily identified.

It is possible to delineate some guidelines for further research in the field, such as the analysis of development not only of some separate regions but on the country level. Moreover, comparative studies using cluster analysis and grouping of regions and countries according to their development properties can be useful. The latter could probably give some guidelines for interregional cooperation and trade.

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About the authors

Kirill G. Sorokozherdyev — Cand. Sci. (Econ.), Assistant Professor, Institute of Industrial Management, Economics and Trade, Peter the Great St. Petersburg Polytechnic University; Researcher ID: G-9776-2018; https://orcid.org/0000-0002-5489-3989 (29, Politekhnicheskaya St., Saint Petersburg, 195251, Russian Federation; e-mail: sorokozh_kg@spbstu.ru).

Evgeniy A. Efimov — Student, Institute of Industrial Management, Economics and Trade, Peter the Great St. Petersburg Polytechnic University; https://orcid.org/0000-0001-8177-1082 (29, Politekhnicheskaya St., Saint Petersburg, 195251, Russian Federation).

Информация об авторах

Сорокожердьев Кирилл Григорьевич — кандидат экономических наук, доцент, Институт промышленного менеджмента, экономики и торговли, Санкт-Петербургский политехнический университет Петра Великого; Researcher ID: G-9776-2018; https://orcid.org/0000-0002-5489-3989 (Российская Федерация, 195251, г. Санкт-Петербург, ул. Политехническая, 29; e-mail: sorokozh_kg@spbstu.ru).

Ефимов Евгений Александрович — студент, Институт промышленного менеджмента, экономики и торговли, Санкт-Петербургский политехнический университет Петра Великого; https://orcid.org/0000-0001-8177-1082 (Российская Федерация, 195251, г. Санкт-Петербург, ул. Политехническая, 29).

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