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Миссия журнала «R-Economy» – обеспечить публикацию исследований в области региональной экономики. Мы считаем сотрудничество с экономистами из стран БРИКС нашим главным приоритетом. «R» в названии журнала ссылается на три его базовых направления – Region (региональное развитие), Regulation (сравнительное изучение региональной политики) и Reconfiguration (пространственные социально-экономические и политические преобразования).

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Журнал включен в перечень рецензируемых научных изданий, в которых должны быть опубликованы основные научные результаты диссертаций на соискание ученой степени кандидата наук, на соискание ученой степени доктора наук (научные специальности 08.00.05 Экономика и управление народным хозяйством и 08.00.14 Мировая экономика).

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СОДЕРЖАНИЕ

Original Paper

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University-business-government relations in the development of the institutional environment of Russian regions

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ABSTRACT
Relevance. University-business-government relations drive regional innovation. Therefore, in order to stimulate innovation, a favourable institutional environment is necessary.
Research objective. The article proposes an original methodology to examine regional institutional environment based on the analysis of the interactions between the government, business and universities.
Methods and data. The study relies on the statistical data on 12 Russian regions for a 6-year period. The data are used to create three sets of indicators characterizing the institutional sectors 'Government', 'Business' and 'Universities'. Regions are divided into clusters and ranked according to the state of their institutional environments by calculating subindices and the integral index. Other research methods include cluster analysis and correlation regression analysis.
Results. The regions were grouped according to their innovation performance: in lagging regions, the interactions between the government, business and universities are inefficient, which means that their regional institutional environment is not conducive to innovation. The opposite situation is observed in the group of leaders. We also found that interactions between the government, business and universities have a direct influence on GRP.
Conclusion. For each group of regions, areas for improvement and the corresponding measures were identified. Interventions may vary in terms of intensity and government participation.

KEYWORDS
regional institutional environment, university-business-government relations, innovation

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Отношения университетов, органов власти и бизнеса как индикатор развития институциональной среды российских регионов

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АННОТАЦИЯ
Актуальность. Взаимодействие институциональных секторов государства, бизнеса, науки и образования становится источником инновационного развития региона, поэтому важно развивать способствующую этому процессу институциональную среду.
Цель исследования. В статье на основе авторского методического подхода проводится анализ региональной институциональной среды, основанный на оценке интеракций органов власти, субъектов бизнеса, науки и образования.
Методы и данные. Исследование основано на анализе региональных статистических данных двенадцати субъектов Российской Федерации за шесть лет. Показатели сгруппированы в три группы, характеризующие функционирование институциональных секторов «Государство», «Бизнес», «Наука». Регионы делятся на кластеры и ранжируются в соответствии с состоянием их институциональной среды путем расчета субиндексов и интегрального индекса. Другие методы исследования включают кластерный анализ и корреляционный регрессионный анализ.

КЛЮЧЕВЫЕ СЛОВА
региональная институциональная среда, взаимодействие государства, бизнеса, науки и образования, индикаторы взаимодействия

Результаты. Регионы были сгруппированы в соответствии с их инновационной эффективностью: в отстающих регионах взаимодействие между государством, бизнесом и университетами неэффективно, что означает, что их региональная институциональная среда не способствует инновациям. Противоположная ситуация наблюдается в группе лидеров. Мы также обнаружили, что взаимодействие между государством, бизнесом и университетами напрямую влияет на ВРП.
Вывод. Для каждой группы регионов были определены области, требующие улучшения, и соответствующие меры. Вмешательства могут различаться по интенсивности и участию правительства.

ДЛЯ ЦИТИРОВАНИЯ
Vlasova, N.Y., & Lyashenko, E.A. (2021) University-business-government relations in the development of the institutional environment of Russian regions. *R-economy*, *7*(4), 214–224. doi: 10.15826/recon.2021.7.4.019

Introduction

Persistent regional disparities, the lack of adequate infrastructure and centres of economic growth, the prevalence of low-technology industries in regional economies are among the most significant challenges that Russia faces. In order to address these problems, it is necessary to increase the efficiency of collaborative relations between the government, business and universities. Stable and productive relationships between these actors will produce a strong synergistic effect exceeding the individual effect that each of them is capable of producing. Only permanent and well-coordinated interactions between the government, business and universities within the triple helix model can generate innovation synergy. It is, therefore, important to improve the institutional environment on the meso-level – the level where local territories can act as sources of innovation and socio-economic development in general.

This study is aimed at evaluating the regional institutional environment by analyzing the interactions between the government, business, and universities. Our research findings can be used by policy makers to stimulate innovation in specific regions.

This aim has determined the following research tasks:

– to study the approaches to the analysis of institutional environment;

– to develop a methodology for the analysis of institutional environment;

– to test this methodology by using the data on Russian regions;

– to identify the key areas of development of the regional institutional environment in Russian regions.

The structure of the institutional environment is complex and multidimensional. Since there is a lack of regulations or reference points that could be used to measure its development, the most productive approach to describe the institutional environment and reveal its potential is to conduct a cross-regional comparison.

Theoretical framework

In Russia, regionally focused research on institutional environment started to evolve in the 1990s. A significant contribution to this area was made by G.B. Kleiner and R.M. Nureev (2006, 2009), S.V. Doroshenko and E.V. Popov (2002), who analyzed the problems of regional and local development by using the methods of institutional economics. The key goal of such interdisciplinary studies is to investigate the connection between the meso-economic system and institutional space (Markov et al., 2009).

In our view, the regional institutional environment encompasses a variety of political, legal, economic, and social conditions produced by formal and informal institutions and their interactions. These conditions, in their turn, shape the activities of various economic agents in a specific territory.

The theoretical foundations for the research on institutional environment were laid by Douglass North (1997), one of the fathers of new institutional economics. North was interested in the impact of institutional quality on economic performance.

Within the vast body of theoretical and empirical research, both Russian and international, institutional environment may be analyzed by looking at different periods, markets and industries, on the national or regional levels. There are also studies that review and systematize the existing methodologies.

There is sufficient evidence pointing to the fact that institutions have a significant effect on regional development. There is, however, a problem of how institutions should be measured regarding their space and time variability; there are also difficulties in establishing the right mix of formal and informal institutions (Rodríguez-Pose, 2013).

E.D. Weisman and M.V. Podshivalova (2017) systematized the existing methodologies of institutional environment analysis and concluded that for an accurate evaluation of such a complex phenomenon, a combination of methods is required and that one methodology, even if it is well tried and tested, is not enough.

S.G. Kirdina et al. (2011) conducted a quantitative evaluation of the institutional changes and their speed, in particular the changes in the density of the institutional environment, the degree of its homogeneity and hierarchy.

Numerous studies investigate the significance of the relationships between different actors within the institutional environment. S. Dawley et al. (2019) focus on the regional institutions' efforts to attract and embed lead firm investments within global production networks. They evaluate the functions and role of the coalitions of actors that form a system of relationships within the framework of the institutional approach. S. Dawley et al. (2019) emphasize that regional institutions need to develop adaptive coupling creation strategies that co-evolve with the reconfiguration of production networks and changes in national institutional and political environments.

A separate group of studies are based on the triple helix model. For instance, a recent study by N. Yoda and K. Kuwashima (2020) concentrates on the case of Japan to model university–industry–government relations and to demonstrate that the qualitative parameters and the scale of collaborations change in response to reforms in regulations. Zhuang et al. (2020) designed a regional collaborative innovation evaluation model based on the triple helix theory. They analyzed the invention patent data of 31 provincial regions in China for the last 5 years and found that the relationship between the interactions of regional actors and the region's innovation potential is not quite linear since certain provinces with weak regional innovation capabilities have a relatively close cooperation level and vice versa.

The closest to our understanding of the problem is the study by D.L. Napolskhikh (2014), who defines institutional environment as a network structure encompassing multiple interactions and mutual effects, falling within what he describes as the 'neural synapse model'. Napolskikh proposes to measure the efficiency of an institution by calculating the ratio of savings from cutting the transaction and operation costs to the losses caused by institutional restrictions. Density, cohesiveness, complementarity and conductivity of an institutional environment are the criteria that can be used to measure its efficiency and potential to foster innovation.

Analysis of the institutional environment can rely on macro-economic indicators and statistical data, expert surveys, surveys of the key stakeholders and so on. Some studies include calculations of the parameters of certain institutions (for example, the number of legal norms). These methodological approaches underpin the evaluations of institutional environment conducted by Russian and international organizations.

A separate group of studies is devoted to the institutional factors in the development of regional innovation systems. For example, Ott and Ronde consider the processes of knowledge transformation in the sphere of innovation inside the 'black box' of the regional innovation system (2018).

What all these methodologies have in common is their interdisciplinary nature, in other words, they use not only economic but also non-economic indicators, characterizing the legal, political and social processes in individual communities, countries, regions, industrial sectors, and in the world.

It should be noted, however, that only few studies provide a comprehensive analysis of the institutional environment on the national and regional levels. Moreover, there is no commonly accepted methodology to evaluate all the parameters of such an environment. What is worse, many such studies lack robust conceptual foundations and there is still a perceived lack of working concepts that such analysis can be based on.

In this study we rely on the eco-systemic approach to innovation and economic development: the innovation system is seen as a dynamic complex of economic agents and their multi-dimensional internal connections, it also includes a special environment formed through ideas, technologies, rules of the game, social interactions and culture (Mercan, Göktaş 2011; Bramwell, 2012). In their collaborative relationships, the government, business and universities begin to perform untypical functions and thus generate an institutional environment conducive to innovation. Some studies focus on particular groups of actors, showing their role in the formation of the institutional environment and innovation. M.C.J. Caniels and H. van den Bosch mainly focus on the role of higher education institutions as drivers of innovation. L. Fonseca and L. Nieth (2021) emphasize that in order to enhance the role of universities in regional innovation, strategic coordination is necessary, both within the universities and with regional bodies (2011).

Robust coordination of efforts between the government, universities, and businesses is crucial for the creation of triple-helix synergy in innovation systems (Leydesdorff, 2008; Smorodinskaya, 2011) and high technology milieux for spatial transfer of knowledge (Capello, 1999). Quite illustrative in this respect are the cases of Sweden and Finland where regional innovation eco-systems were created through the networks of actors in a bottom-up manner (Smorodinskaya, 2015; Harmaakorpi, Rinkinen, 2020; Hasche et al, 2020).

Method and Data

Some methodologies (Weisman & Podshivalova, 2017; Prokin, 2016) use official indicators characterizing the specific conditions and resources and their impact on innovation. In contrast to other available methodologies, we propose to concentrate exclusively on the indicators characterizing the interactions between different institutional sectors. We believe that the state of institutional environment is mostly shaped by the development of interactions between the institutions.

The proposed approach gives due regard to the impact of interactions between government agencies, businesses, and universities on regional institutional environment and GRP. It is these interactions that determine the type of regional institutional environment. Thus, through this approach, we can gain a better understanding of whether the institutional environment actually fulfills its functions and enables innovation or not. The results of this analysis can be used to identify the areas for improvement and the corresponding measures.

The proposed approach, including the algorithm of analysis, is illustrated by the scheme in Figure 1.

For analysis we selected the following Russian regions: Sverdlovsk region, which is of prime importance for our research; Chelyabinsk region; Tyumen and Kurgan regions; the Khanty-Mansi and Yamalo-Nenets autonomous districts; the Republic of Tatarstan; Tomsk and Novosibirsk regions (these regions are among the innovation leaders in Russia); the Republic of Ingushetia; Jewish Autonomous District; and the Chechen Republic (the latter three are lagging in terms of innovation).

The indicators to evaluate the relationships between the government, business and universities were selected by using the parameters specified in official strategic planning documents[1]. Our study also relied on the official open sources of data, including the statistical database of the Federal State Statistics Service, Higher School of Economics, Ministry of Education and Science (until 2018) and other organizations and agencies. Another condition that we had to take into account was the availability of data for the regions we chose for a period of over 5 years. Since absolute indicators to a great extent depend on the size of the regional economy and do not always reflect its growth trends, we converted them into relative indicators. As a result, the following set of indicators was built:

1. Government performance indicators

1.1. Volume of shipped innovative goods, works, services per 1 rouble of government funding for universities, rbs

1.2. Volume of shipped innovative goods, works, services per 1 rouble of government funding for the development of innovation infrastructure, rbs

1.3. Volume of shipped innovative goods, works, services per 1 rouble of government funding for R&D and innovation, rbs

1.4. Scholarships paid to university students, rbs per person

2. Indicators of universities' research productivity

2.1. Number of technopark units established at universities per 1 rouble of state funding to universities, units

2.2. Number of technopark units established at universities per 1 student, units

2.3. Volume of shipped innovative goods, works, services per 1 rouble of organizations' own expenditures on R&D, rbs

2.4. Volume of shipped innovative goods, works, services per 1 researcher, rbs

[1] Derbeneva A.A. Formation of the Institutional Environment for the Innovation-Oriented Development of Russian Regions: extended abstract of the dissertation for the degree of Cand. Sc. (Economics): 08.00.05. Kazan, 2012. 24 p. (In Russ.); Napolskih D.L. (2014). Institutionalization of Innovative Clusters in the Conditions of the Modern Russian Economy: abstract of the dissertation for the degree of Cand. Sc. (Economics): 08.00.01. Kazan, 26. (In Russ.)

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3. Indicators of business sector performance

3.1. Public spending on higher education per student, rbs

3.2. Public spending on academic R&D per student, rbs

3.3. Volume of innovative goods, works, services per 1 rouble of public spending on higher education, rbs

3.4. Volume of innovative goods, works, services per 1 rouble of public spending on academic R&D, rbs

We used the integral index to group the regions into clusters with similar characteristics. Such clusters can be further used to develop management interventions to improve the institutional environment.

Cluster analysis of the given regions was conducted by applying the Agglomerative Hierarchical Clustering (AHC) method, which works best for a small number of observations, with the help of software package IBM SPSS Statistics 23.

The next stage of the proposed approach is correlation regression analysis, which shows the correlation between the selected indicators and GRP of Russian regions. The results at this stage can be used to identify the areas for management intervention.

The aim of regression analysis is to establish a functional relationship of the type $y = f(x)$ between GRP per capita and the indicators selected through correlation analysis. Thus, we will be able to show the quantitative relationship be-

Preparatory stage

1. Choice of indicators to reveal the untypical functions performed by the government, business and universities
2. Description of the functions performed by the regional institutional environment with the help of these indicators
3. Selection of a sample of Russian regions
4. Building a database of regional statistical data for the selected indicators
5. Assignment of designation X_i

Main stage

6. Normalization and glossing of indicator values X_i	$X_{i\,norm} = \frac{\sqrt{X_i} - \sqrt{X_{min}}}{\sqrt{X_{max}} - \sqrt{X_{min}}}$, where X_i is the value of the indicator in the subindex group; X_{min}, X_{max} are the minimum and maximum values of the indicator in the group
7. Calculation and evaluation of the subindices 'Government' (I_{St}), 'Universities' (I_{Sc}), and 'Business' (I_B)	$I_{StScB} = \frac{\sum_{i=1}^{n} X_{i\,норм}}{n}$
8. Calculation and evaluation of integral index I_{StScB}	$I_{StScB} = 0{,}34 \cdot I_{St} + 0{,}33 \cdot I_{Sc} + 0{,}33 \cdot I_B$
9. Cluster analysis of regions by integral index	9.1. Determining the number of clusters 9.2. Interpretation and profiling of clusters depending on the qualitative characteristics of the institutional environment
10. Correlation and regression analysis of GRP and selected indicators	10.1. Estimation of the pair correlation coefficient of GRP and selected indicators 10.2. Formation and identification of regression models

Final stage

11. Identifying the key areas and priorities of development of institutional environment for each cluster of regions

Figure 1. *Methodology for the evaluation of the regional institutional environment*

Source: developed by the authors

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tween the resultant indicator and the factors that influence it. The models were based on the indicators with positive correlation coefficients with values above 0.70.

Results

The integral index was calculated for selected regions by using the set of indicators (Table 1). As Table 1 shows, the performance of Tyumen and Chelyabinsk region, the Jewish Autonomous Region, the Khanty-Mansi and Yamalo-Nenets autonomous districts and the Republic of Ingushetia improved over time. In other regions, the rates of growth in the integral index are below 100%.

Table 2 shows clusters of regions based on the data for 2013–2018. Different clusters correspond to different qualitative characteristics of the institutional environment[2]. The clusters were ordered from the highest to the lowest values of the centroid (mean value). This way we could rank regional institutional environments and identify their specific types. Table 2 illustrates the dynamics of integral index I_{StScB} of Russian regions.

We conducted a cluster analysis of Russian regions based on the integral index I_{StScB} for 2013–2018. The long-standing leader is the Republic of Tatarstan, which was classified into the first cluster. In comparison with other regions, Tatarstan boasts a higher quality institutional environment, which is more dynamic, innovation-oriented, stable, and also better developed. In the given period, such regions as Ingushetia and Chechnya belonged to the cluster of laggards. The Jewish Autonomous Region, which also lags behind on innovation, belonged to this cluster between 2013 and 2015. Other regions were either in the second or third clusters, which are quite close in terms of the integral index's values.

The statistical evaluation of the coefficients of the pair correlation between GRP per capita and 12 indicators characterizing the relationships between the government, business and universities has led us to the following conclusion. In general, it would be fair to say that potentially, each indicator has a strong or very strong positive correlation with GRP per capita (the correlation coefficient is over 0.7 and over 0.9).

The group of struggling regions (Ingushetia and Chechnya) has the smallest number of indicators closely linked to GRP per capita. For instance, Ingushetia has only one positive correlation coefficient above 0.50 (Indicator 2.4). This means that the institutional environment in these regions is inadequate, that is, there is uncertainty in the behaviour of the stakeholders involved in interactions, their behaviour is uncoordinated, the structure of their interactions is not quite stable, and they lack incentives to collaborate with other stakeholders.

For Tatarstan, Tyumen and Sverdlovsk regions we found a strong and very strong positive correlation between over a half of the indicators and GRP per capita. These regions boast a higher

[2] Lyashenko E.A. Development of the Regional Institutional Environment for Technoparks: dissertation for the degree of Cand.Sc. (Economics): 08.00.05/ Elena Lyashenko; [Defended at the Ural State Economic University]. Ekaterinburg, 2020. 333 p. (In Russ.)

Table 1

Integral index I_{StScB} of Russian regions for 2013–2018

Regions	2013	2014	2015	2016	2017	2018	Growth rate 2018 / 2013, %
Kurgan region	0.5324	0.5222	0.4594	0.4215	0.4620	0.4024	75.58
Sverdlovsk region	0.4831	0.4996	0.4698	0.5365	0.5249	0.4367	90.39
Tyumen region	0.3395	0.3990	0.4142	0.6501	0.6648	0.6530	192.31
Chelyabinsk region	0.4435	0.4787	0.4685	0.5133	0.6018	0.5187	116.95
Khanty-Mansi Autonomous District	0.3085	0.3558	0.3860	0.4153	0.4023	0.4253	137.84
Yamalo-Nenets Autonomous District	0.2295	0.2848	0.4210	0.3556	0.2469	0.2314	100.79
Tatarstan	0.7361	0.7328	0.6893	0.6627	0.6428	0.6075	82.52
Tomsk region	0.4507	0.4137	0.4114	0.4193	0.4203	0.4054	89.95
Novosibirsk region	0.3735	0.3967	0.3762	0.4144	0.4308	0.3702	99.12
Ingushetia	0.1743	0.1819	0.2222	0.2100	0.2176	0.2032	116.61
Jewish Autonomous Region	0.1746	0.2585	0.2635	0.3426	0.4840	0.3814	218.42
Chechnya	0.1716	0.1685	0.2440	0.1939	0.2620	0.1498	87.27

Source: compiled by the authors

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Table 2

Clusters of regions by integral index I_{StScB} in 2013–2018

		1st cluster	2nd cluster	3rd cluster	4th cluster
2013	average value (0.3681)	0.7361	0.4774	0.3405	0.1875
	region	Tatarstan	Kurgan region Sverdlovsk region Chelyabinsk region Tomsk region	Tyumen region Khanty-Mansi Autonomous District Novosibirsk region	Ingushetia Chechnya Yamalo-Nenets Autonomous District Jewish Autonomous Region
2014	average value (0.3910)	0.7328	0.5001	0.3913	0.2234
	region	Tatarstan	Kurgan region Sverdlovsk region Chelyabinsk region	Tyumen region Khanty-Mansi Autonomous District Novosibirsk region Tomsk region	Ingushetia Chechnya Yamalo-Nenets Autonomous District Jewish Autonomous Region
2015	average value (0.4021)	0.6893	0.4659	0.4018	0.2432
	region	Tatarstan	Kurgan region Sverdlovsk region Chelyabinsk region	Tyumen region Khanty-Mansi Autonomous District Yamalo-Nenets Autonomous District Tomsk region Novosibirsk region	Ingushetia Chechnya Jewish Autonomous Region
2016	average value (0.4279)	0.6564	0.5249	0.3948	0.2020
	region	Tatarstan Tyumen region	Sverdlovsk region Chelyabinsk region	Kurgan region Khanty-Mansi Autonomous District Yamalo-Nenets Autonomous District Tomsk region Novosibirsk region Jewish Autonomous Region	Ingushetia Chechnya
2017	average value (0.4467)	0.6364	0.4903	0.4178	0.2422
	region	Tatarstan Tyumen region Chelyabinsk region	Kurgan region Sverdlovsk region Jewish Autonomous Region	Khanty-Mansi Autonomous District Tomsk region Novosibirsk region	Yamalo-Nenets Autonomous District Ingushetia Chechnya
2018	average value (0.3988)	0.6303	0.5187	0.4036	0.1948
	region	Tatarstan Tyumen region	Chelyabinsk region	Kurgan region Sverdlovsk region Khanty-Mansi Autonomous District Tomsk region Novosibirsk region Jewish Autonomous Region	Ingushetia Chechnya Yamalo-Nenets Autonomous District
Characteristics of the regions depending on the value of the centroid in comparison with the overall average value		Leaders	Upper-middle performers	Middle performers	Laggards
Characteristics of the regional institutional environment		Dynamic Innovation-oriented Developed Stable High-quality	Mature Innovation-oriented Developing Adaptive Quite adequate	Mature Innovation-oriented Developing Adaptive Quite inadequate	Inadequate Traditional Conservative Rent-oriented Asynchronous Inert

Source: compiled by the authors

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level of institutional development: the degree of uncertainty is lower and the interests of the key actors are better coordinated, partnerships are encouraged, the system of training and knowledge transfer is well developed, the structure of interactions is quite stable.

Sverdlovsk region ranks high in the correlation coefficients among other regions. We found a strong and very strong positive correlation between the growth of GRP per capita and indicators 1.1, 1.4, 2.2, 2.3, 2.4, 3.1, 3.2. In other words, an increase in the following indicators affects the growth of GRP per capita:

– volume of shipped innovative goods, works, services per 1 rouble of government funding for universities, rub (1.1);

– scholarships paid to university students, rbs per person (1.4);

– number of technopark units established at universities per 1 student (2.2);

– volume of shipped innovative goods, works, services per 1 rouble of organizations' own expenditures on R&D (2.3);

– volume of shipped innovative goods, works, services per 1 researcher (2.4)

– public spending on higher education per student (3.1);

– public spending on academic R&D per student (3.2).

As our correlation analysis shows, in Sverdlovsk region the following indicators need improvement:

– volume of shipped innovative goods, works and services per 1 rouble of spending on the development of innovation infrastructure (1.2)

– volume of shipped innovative goods, works and services per 1 rouble of spending on R&D and innovation (1.3);

– number of technopark units established at universities per 1 rouble of state funding to universities (2.1);

– volume of innovative goods, works and services per 1 rouble of funding for education (3.3).

– volume of innovative goods, works and services per 1 rouble of funding for research (3.4).

Thus, the correlation analysis has revealed the strength and direction of the relationship between GRP per capita and the indicators. The correlation coefficients are significant, which means that there is a significant relationship between the data. It, therefore, makes sense to conduct regression analysis and build a model to explain the relationship between the data and to make predictions. We need to establish the functional relationship of the type y=f (x) between GRP per capita and the indicators selected through correlation analysis. Thus, we will be able to show the quantitative relationship between the resultant indicator and the factors that influence it. The models were based on the indicators with positive correlation coefficients above 0.70.

Identification of the regression models has shown that there is a linear as well as non-linear relationship between the indicators. This relationship is observed in the majority of cases and is characterized by polynomial models of the type $y = a + b_1 \cdot x + b_2 \cdot x^2 + b_3 \cdot x^3$. The relationship varies across regions and indicators (for more on this, see: E.A. Lyashenko[3]).

As our regression analysis has shown, in almost every cluster, except for the clusters based on indicators 2.1 and 2.3, there are models characterizing the influence of the indicators on GRP per capita. Most models demonstrate a positive relationship, which means that the more effective are the interactions between the government, business and universities, the larger is GRP and GRP per capita.

There are no models for the struggling regions (Ingushetia and Chechnya), which means that the relationships between the government, business and universities are ineffective, in other words, their regional institutional environment is inadequate. In other regions, the indicators that had the most significant positive impact on GRP per capita were the amount of funding for education and research; scholarships paid to university students; and the number of technopark units established at universities. In some regions (Tatarstan, Tomsk and Novosibirsk), the number of technopark units established at universities has a considerable impact on GRP. An increase in the volume of shipped innovative goods, works, services per 1 rouble of spending on R&D also leads to an increase in GRP, but to a lesser extent (Kurgan, Tomsk and Novosibirsk regions). In the majority of regions, an increase in the amount of state scholarships paid to students leads to a fall in GRP.

Evaluation of the regression models for Sverdlovsk region in comparison with other regions has led us to identify the following areas for growth and improvement:

[3] Lyashenko E.A. Development of the Regional Institutional Environment for Technoparks: dissertation for the degree of Cand.Sc. (Economics): 08.00.05/ Elena Lyashenko; [Defended at the Ural State Economic University]. Ekaterinburg, 2020. 333 p. (In Russ.)

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– volume of shipped innovative goods, works, and services in relation to spending on the development of innovation infrastructure (an example to aspire to in this regard may be the well-developed innovation infrastructure in Novosibirsk region);

– volume of shipped innovative goods, works, services per 1 researcher, rbs (a reference region in this regard may be Tomsk region);

– commercial funding for higher education per student (a reference region may be Novosibirsk region);

– commercial funding for academic research per student (a reference region may be the Yamalo-Nenets Autonomous District);

– the volume of innovative goods, works and services per 1 rouble of business funding for education (a reference region may be Tyumen region);

– the number of technopark units established at universities per 1 student (reference regions may be Tatarstan and Novosibirsk regions).

Discussion and implications

Our analysis has shown the possible areas of improvement for the selected Russian regions. For each group of regions, a specific set of policies and measures should be devised: for instance, regions of the first cluster need smaller adjustments to enhance their institutional environments; regions of the second cluster, moderate adjustments; regions of the third cluster, more substantial adjustments (active interventions); and regions of the fourth cluster, considerable adjustments (radical interventions). The significance of the government's role increases from group 1 to group 4. Mechanisms recommended for the first and second groups of regions are aimed primarily at mitigating and/or neutralizing negative factors; for the third and fourth groups, the mechanisms should be aimed at eliminating the impediments to the development of an adequate institutional environment.

For regions of the first cluster (Tatarstan, Tyumen region) and of the second cluster (Chelyabinsk region), the following measures are proposed:

a) it is necessary to create a centre to coordinate interactions between the government, business and universities;

b) individuals and legal entities should be subject to administrative/ criminal liability for the misappropriation or misuse of public funds, abuse of tax breaks, and so on;

c) concerted efforts are needed to attract investment to the territory with the help of tax incentives;

d) for individuals and legal entities engaged in innovation activities, lower income and property tax rates may be provided;

e) preferential tax treatment should be offered to businesses engaged in cooperation projects with universities and research institutions;

f) preferential tax treatment should be offered to the universities engaged in cooperation projects with businesses.

These measures may be described as adjustment interventions or moderate interventions. Although they appear almost identical, in the latter case the measures are likely to produce stronger effects (e.g. lower tax rates are applied).

For regions of the third cluster (Sverdlovsk and Kurgan regions, the Khanty-Mansi Autonomous District, Tomsk and Novosibirsk regions, the Jewish Autonomous Region) and of the fourth cluster, the following measures are proposed:

a) it is necessary to create a centre to coordinate interactions between the government, business and universities;

b) more funding should be allocated to the sphere of science and education in these regions;

c) venture capital financing should be used;

d) individuals and legal entities should be subject to administrative/ criminal liability for the misappropriation or misuse of public funds, abuse of tax breaks, and so on;

r) concerted efforts are needed to attract investment to the territory with the help of tax incentives;

f) for individuals and legal entities engaged in innovation activities, lower income and property tax rates may be provided;

g) preferential tax treatment should be offered to businesses engaged in cooperation projects with universities and research institutions;

h) preferential tax treatment should be offered to the universities engaged in cooperation projects with businesses;

i) preferences and benefits (tax preferences, amortization benefits, preferential pricing, etc.) should be provided;

j) clusters and technoparks should be established and developed;

k) marketing tools should be used to promote innovation.

The above-described measures can be described as active or radical intervention. Active intervention implies a broader range of exemptions and preferences, a more active played by the government in spurring innovation and in creat-

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ing an innovation infrastructure. Radical intervention implies a significant transformation in the regional institutional environment to foster innovation, including the creation of technoparks.

What distinguishes the priorities set for regions of the third and fourth clusters from those of the first and second clusters is that the actors involved in innovation activities, including participants of technoparks, should be freed from bearing the accompanying costs. At the same time, individuals and legal entities should be subject to administrative and criminal liability for the misappropriation or misuse of public funds, abuse of tax breaks, and so on. For regions of the first and second clusters we would recommend milder interventions over more stringent approaches. Undoubtedly, with a few adjustments, the instruments proposed for the regions of the third and fourth clusters can be also applied to other clusters.

As for Sverdlovsk region as the key region of our analysis, it is necessary, first, to stimulate the development of the innovation infrastructure and R&D by increasing the volume of shipped innovative goods, works and services per 1 rouble of public spending. Second, it is necessary to increase the number of technopark units established at universities and stimulate commercial investment in university research and education.

Overall, Sverdlosvk region ranks high among the other regions in our sample. Regional authorities go to great lengths to create a more favourable environment that would facilitate university-business interactions. Nevertheless, the region still has a long way to go in this respect compared to other, more advanced Russian territories. Companies and universities should be encouraged to forge long-term collaborations. Moreover, it is necessary to increase the amount of government spending on R&D and innovation and stimulate universities to operate more entrepreneurially, commercializing the results of their R&D, and creating knowledge-based enterprises. Taken together, these measures will ensure the development of the regional institutional environment.

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Excess mortality in Russian regions during the COVID-19 pandemic

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ABSTRACT
Relevance. In Russia, there are significant regional variations in the socio-economic impact of the COVID-19 pandemic (e.g. the growth in the number of deaths ranged from 7% in Novgorod Region to 43% in the Chechen Republic). In this paper, we focus on excess mortality and the key factors that contributed to it in order to get a better understanding of reasons behind such dramatic regional variations.
The research objective is to assess excess mortality due to the COVID-19 pandemic and identify the key factors influencing the growth in mortality and regional variations in this indicator.
Data and methods. The paper uses the analytical, statistical and correlation methods and the statistical data on Russian regions provided by the Federal State Statistics Service (Rosstat).
Results. The analysis of excess mortality in Russian regions during the COVID-19 pandemic, in particular the correlation between excess mortality and intensity of human flows, has been used to build a typology of regions. In total, the regions were divided into four groups, and for each group the main factors that contributed to the growth in mortality were identified. The research findings can be used by policy-makers to devise more efficient regional policies in response to the COVID-19 crisis.

KEYWORDS
excess mortality, intensity of people's flows, COVID-19, regional differentiation, pandemic

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Избыточная смертность в российских регионах в условиях пандемии COVID-19

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АННОТАЦИЯ
Актуальность. В России существуют значительные региональные различия в социально-экономических последствиях пандемии COVID-19 (например, рост числа смертей колебался от 7% в Новгородской области до 43% в Чеченской Республике). В этой статье мы сосредотачиваемся на избыточной смертности и ключевых факторах, которые способствовали ей, чтобы лучше понять причины таких резких региональных различий.
Цель исследования – оценить избыточную смертность из-за пандемии COVID-19 и определить ключевые факторы, влияющие на рост смертности и региональные вариации этого показателя.
Данные и методы. В статье использованы аналитические, статистические и корреляционные методы, а также статистические данные по регионам России, предоставленные Федеральной службой государственной статистики (Росстат).
Результаты. На основе анализа избыточной смертности в регионах России во время пандемии COVID-19, в частности корреляции между избыточной смертностью и интенсивностью людских потоков, построена типология регионов. Всего регионы были разделены на четыре группы, и для каждой группы были определены основные факторы, способствовавшие росту смертности. Результаты исследования могут быть использованы политиками для разработки более эффективных региональных политик в ответ на кризис COVID-19.

КЛЮЧЕВЫЕ СЛОВА
избыточная смертность, интенсивность людских потоков, COVID-19, региональная дифференциация, пандемия

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Introduction

The novel coronavirus infection (COVID-19) first appeared in December 2019 in China (Wuhan) and was registered as a pneumonia outbreak of an unknown origin. As the disease was rapidly spreading around the world, on March 11, 2020, The World Health Organization declared the pandemic, and national health systems struggled to cope with the growing number of cases. As a result, the lack of effective treatment protocols and quarantine-related restrictions on receiving other kinds of medical care led to soaring mortality rates.

The dynamics of COVID-19 morbidity and mortality varies greatly from one country to another. The accumulated international statistics, however, already give some clues as to the main factors contributing to the growing mortality Our study focuses on excess mortality, which is understood as a fast growth in mortality resulting from the outbreak of the novel coronavirus and results from a set of factors such as the unavailability of medical care, low living standards and social stress.

Despite the growing body of research on the pandemic, we have not found any studies discussing the intra-country differentiation of the factors determining the excess mortality. However, such difference is very important for Russia because it has a great number of regions with varying climate, economic development, demographic dynamics, and governance practices. Therefore, the regional differences in the consequences of the pandemic remain largely an underexplored question, which this study seeks to address. What makes this question particularly important is the fact that such regional variations should be taken into account by policy-makers in devising measures to prevent further waves of the pandemic and to address the negative effects of the pandemic on people in the regions and regional economies.

We are going to focus on the disparities in excess mortality in Russian regions during the COVID-19 pandemic. This research goal determines the following research tasks: to calculate the excess mortality rate; to identify the factors contributing to excess mortality; and to create a typology of Russian regions depending on the factors contributing to excess mortality. Our research findings could be useful for national and regional policy-makers to address the challenges of the pandemic.

Theoretical framework

In addition to medical reasons, social and economic factors contribute greatly to the epidemiological process. For example, the climate changes of 'brown' economy lead to the appearance of new pathogens or different variations of already known diseases[1]. Analyzing the economic factors of morbidity, Bloom & Canning have shown the relationship between the epidemics and the living standards and concluded that the vulnerability of a society to the epidemics should decrease together with the improving quality of life in the long-term; however, the growth of well-being generates a significant number of socio-economic risks related to the spreading of viral diseases (Bloom & Canning, 2013). Globalization, open borders and urbanization increase the closeness and intensity of the social contacts contributing to the rapid spread of the viral infections (Bloom et al., 2018). The economic consequences of an epidemic are poverty, social disorders, income inequality, malnutrition, unemployment and high mortality rates at an early age (Uçucu, 2020). During the epidemic, the most damaged industries are usually healthcare, transport, agriculture and tourism (Delivorias & Scholz, 2020).

Although the COVID-19 pandemic shares some of the features, including socio-economic consequences, with other epidemics, this pandemic advanced more rapidly, thus forcing national governments to introduce more rigorous restrictions such as lockdowns. Over the two years of the pandemic, extensive statistics have been accumulated for comprehensive research on its social and economic causes and consequences, peculiarities of its effects in certain territories, and so on. Mathematical models were developed to predict further dynamics of the pandemic: for example, Kim & Loayza have proven that the COVID-19 morbidity and mortality rose due to the unavailability of some medical services (Kim & Loayza, 2021). Other factors discussed in relation to the pandemic are gender (Akter, 2020), age (Kim & Loayza, 2021), employment and unemployment (Shakil et al., 2020), and population mobility (Mu et al., 2020).

The determinants of the rapid rise in COVID-19 mortality are the level of economic

[1] Coronavirus, Climate Change, and the Environment. A Conversation on COVID-19 with Dr. Aaron Bernstein, Director of Harvard Chan C-CHANGE. URL: https://www.hsph.harvard.edu/c-change/subtopics/coronavirus-and-climate-change/ (Accessed: 17.08.2021)

development associated with democracy and personal freedom (Ang et al., 2021; Jain & Singh, 2020), social inequality (Martines et al., 2021), restrictions introduced by the national governments (Andrades-Grassi et al., 2021; Jain & Singh, 2020). Some studies focused on geographical factors, such as climate (Ozkan et al., 2021), population density (Kaplan et al., 2021) and urbanization (Boterman et al., 2021). Other factors include those related to the state of the environment, e.g. air pollution (Bretschger et al., 2020; Coker et al., 2020). A separate group of studies consider the influence of all these factors on the intercountry and intra-country differentiation of COVID-19 morbidity and excess mortality (Kapitsinis, 2020; Kuzmenko et al., 2020).

As for Russian studies, they mainly focus on the reasons behind certain differences in the dynamics of the pandemic and excess mortality. Some studies explore international statistics and use mathematical modeling of the pandemic (Gundarov & Gundarov, 2020; Gadzaov et al., 2020; Ryazantsev & Ange, 2020; Vasiev et al., 2020). Some discuss the medical causes of the epidemic (Sabgayda, T.P. et al., 2020; Tikhonov & Vladimirtsev, 2020) and the socio-economic consequences of the pandemic in the world (Sheremet, 2020; Krotova, 2020), Russia (Kulkova, 2020; Kashepov, 2021) or in Russian regions (Zemtsov & Baburin, 2020).

Thus, the key factors of the COVID-19 pandemic are, firstly, the factors that determine the closeness of social contacts (such as population density, urbanization, mobility), and secondly, social, demographic and economic factors (such as the age structure of the population, standards of living, access to healthcare, etc.). At the same time, each factor contributes to the spread of the infection differently in different territories, which requires an additional study. However, we have not found any studies of the factors that determine the different speed and intensity of the pandemic in Russian regions, which is the research gap we will address in this paper.

Data and Methods

The study comprised several stages. Firstly, we estimated the values of excess mortality in Russian regions for 2020 by calculating the difference between the number of deaths in 2020 and the average annual number of deaths for the previous three years (2017–2019). Additionally, we used the mapping method to visualize the results.

Secondly, using correlation analysis, we revealed the indicators of social and economic development of Russian regions in 2020 that have a statistically significant correlation with excess mortality. The resulting set of indicators was divided into 6 factors: spatial distribution, economic development, standards of living, demographic structure, accessibility of healthcare, human flows intensity.

We found that the regions with intensive human flows (e.g., a high passenger turnover and migration growth) have significant excess mortality. Thus, thirdly, we proposed a typology of Russian regions using the variables 'excess mortality (*Em*) – human flow intensity (*Hf*)', dividing the regions into groups for both variables: with values above the average and with values below the average. As a result, the entire pool of regions is divided into four groups, according to the resulting matrix (Fig. 1).

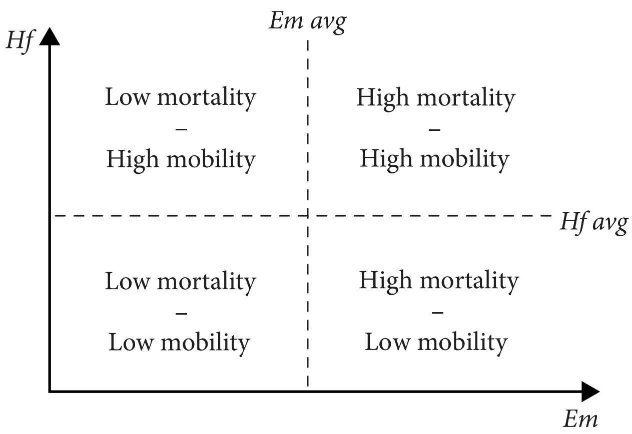

Figure 1. *Matrix for grouping the regions*
Source: Compiled by the authors

Using the correlation analysis, we determined the leading factors of excess mortality for each group of regions. These findings can be used to develop tools for reducing the excess mortality and preventing negative social and economic consequences of the pandemic.

The study relied on the statistical data provided by the Federal State Statistics Service (Rosstat).

Results and Discussion

According to Rosstat, the number of deaths in Russia over the past three years has stabilized at the level of 1.81 million people annually. However, during the COVID-19 pandemic, the mortality rate in Russia rose dramatically to 2.1 million people, or by 17% (Fig. 2). Thus, in Russia excess mortality was about 307 thousand people

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in 2020 compared to the average level of the previous three years. At the same time, according to Yandex.Coronavirus:Statistics[2], 57.5 thousand people died from the diagnosed COVID-19, and it reaches 19% of overall excess mortality.

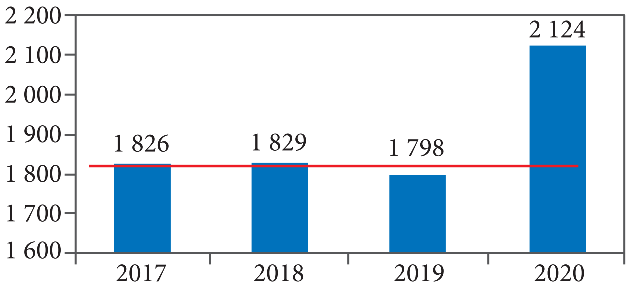

Figure 2. *The number of deaths per year in Russia, thousand people*

Source: the authors' calculations based on statistical data (Rosstat): Socio-economic situation of federal districts, 2020. URL: https://rosstat.gov.ru/bgd/regl/b20_20/Main.htm; Regions of Russia. Socio-economic situation, 2020. URL: https://gks.ru/bgd/regl/b20_14p/Main.htm (Accessed: 21.04.2021)

At the same time, there is a significant variation in mortality rates across Russian regions. The growth in the number of deaths ranged from 7% in Novgorod Region to 43% in the Chechen Republic. At the same time, the share of COVID-19 deaths ranged from 0% in the Nenets Autonomous District to 65% in the Republic of Tyva. In addition, Russian regions differ significantly in terms of the relative indicators of excess mortality, calculated per 100 thousand people of the population (Fig. 3).

Figure 3. *Distribution of excess mortality in Russian regions in 2020, per 100,000 people*

Source: the authors' calculations based on statistical data (Rosstat), indices: Socio-economic situation of federal districts, 2020. URL: https://rosstat.gov.ru/bgd/regl/b20_20/Main.htm; Regions of Russia. Socio-economic situation, 2020. URL: https://gks.ru/bgd/regl/b20_14p/Main.htm (Accessed: 21.04.2021)

The correlation analysis identified a statistically significant relationship between excess mortality and indicators of a social and economic development of Russian regions in 2020 (see Table 1).

The demographic structure has a significant impact on excess mortality. We found the following correlations: first, the higher is the share of the population above the working age, the higher is excess mortality ($R = 0.5$), regardless of the intensity of human flows. Second, the higher is the share

[2] Yandex.Coronavirus:Statistics. URL: https://yandex.ru/covid19/stat?utm_source=main_graph&utm_source=main_notif&geoId=225 (Accessed: 30.04.2021)

Table 1

Factors of excess mortality in Russian regions in 2020

Factors	Indicators	Correlation coefficient ($\alpha = 0.05$)
Spatial distribution	Share of the urban population, %	0.2
	Population density, people per km²	0.1
Economic development	Unemployment rate, %	–0.4
	Volume of industrial production, billion rubles	0.2
Standard of living	Average monthly salary, rubles	–0.3
	Share of the population with incomes below the subsistence minimum, %	–0.3
Demographic structure	Percentage of the population above the working age,%	0.5
	Percentage of the population under the working age,%	–0.5
	Percentage of the working age population,%	–0.3
Accessibility of healthcare	Capacity of outpatient clinics, 1000 visits per shift	0.4
	Provision of beds, per 10,000 people.	–0.2
	Population per one employee of secondary medical staff	0.1
	Share of budget expenditures on healthcare and sports,%	0.1
Intensity of human flows	Passenger turnover of all types of transport, million people	0.3
	Number of arrivals, thousand people	0.4

Source: the authors' calculations are based on statistical data (Rosstat)

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of the population below the working age (R = –0.5 inverse relationship, high) and of the working age (R = –0.3), the lower is excess mortality.

Of course, a key factor of mortality growth is the accessibility of healthcare and its quality, especially the capacity of outpatient healthcare (R = 0.4). Before the pandemic, outpatient healthcare prevented various diseases, including the exacerbations of chronic ones, which significantly reduced mortality. However, the pandemic resulted in extra barriers to accessing medical care, for instance, some of the existing facilities were turned into hospitals for COVID-19 patients and some became temporarily off-limits to patients to reduce the number of social contacts. As a result, people did not receive sufficient medical care, which led to excessive mortality.

The correlation between the living standards and excess mortality is reversed and moderate (R = –0.3) because lower income limits access to paid medical services or to healthy lifestyle opportunities.

The level of economic development also contributes to the growth of excess mortality in two ways: the lower the unemployment rate is, the higher is excess mortality (R = –0.4), and the higher is the volume of industrial production, the higher is excess mortality (R = 0.2). Having low unemployment and high volumes of industrial production, economically developed regions have active labor relations and developed business, transport, and logistics infrastructure, which increases the closeness of social contacts and contributes to the spread of the pandemic. In addition, due to the peculiarities of major industries, such regions have the extra risk of occupational diseases, while postponement of scheduled health care and other restrictions lead to an additional increase of preventable mortality.

The indicators of spatial distribution have a weak correlation with excess mortality across the entire population of Russian regions. However, such an impact seems to be meaningful, especially in the regions with a high share of urban population and high population density. Hence, higher concentration of the population is supposed to increase the rate of the viral diseases spread, including the novel coronavirus infection.

The factors listed above became the main non-medical causes of excess mortality in Russian regions during the pandemic. At the same time, Russian regions differ significantly regarding the significance of these factors. Figure 4 displays a scattering diagram of Russian regions depending on human flows intensity and excess mortality. It should be noted that, in general, excess mortality *Em* decreases together with a decrease in the intensity of human flows *Hf* (R = 0.3 for passenger turnover *Pt* and R = 0.4 for the number of arrivals *Ar*). Thus, having a low intensity of flows and low population density, such regions suffer a lower risk of COVID-19 infection due to less intensive social contacts.

As the scattering diagram in Fig. 4 shows, the pool of the Russian regions is divided into four groups, and Table 2 illustrates the characteristics of each group.

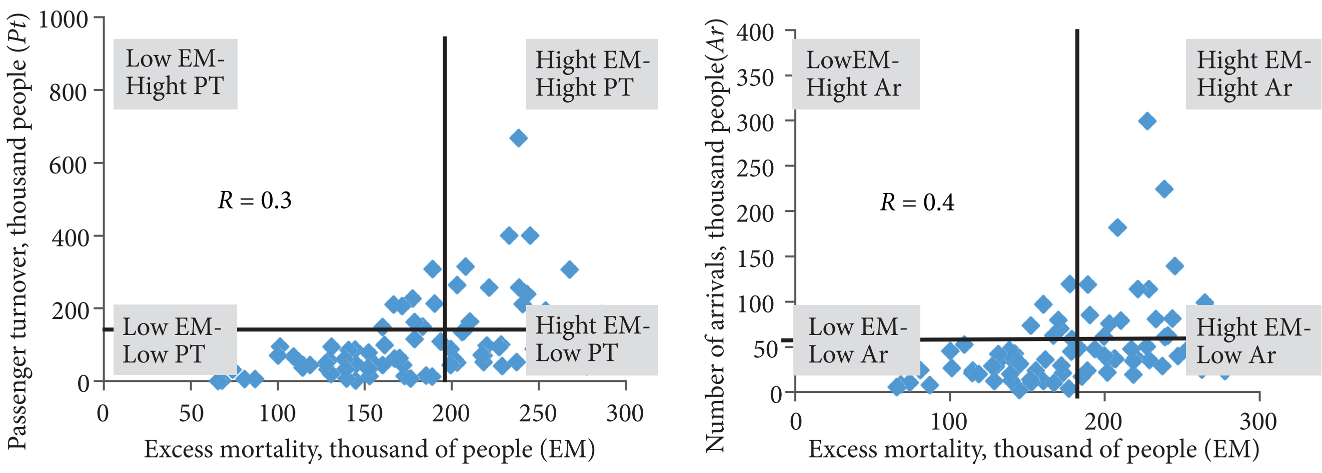

Figure 4. *Scattering diagram of Russian regions by human flows intensity and excess mortality*

Source: the authors' calculations are based on statistical data (Rosstat): Socio-economic situation of federal districts, 2020. URL: https://rosstat.gov.ru/bgd/regl/b20_20/Main.htm; Regions of Russia. Socio-economic situation, 2020. URL: https://gks.ru/bgd/regl/b20_14p/Main.htm (Accessed: 21.04.2021)

High Hf – High Em. There are 17 regions with high excess mortality and high intensity of human flows intensity. These regions demonstrated a dramatic increase in the number of deaths. These regions are logistics hubs with developed transport infrastructure and high migration activity, hence the rapid spread of the pandemic. Despite the common features, the regions of this group (*High Hf – High Em*) are quite different (Fig. 5). Firstly, the group includes financial and economic centers (Moscow and St. Petersburg) with high population density and urbanization of up to 100%; they also have a high intensity of human flows associated with the transport, logistics and transit specialization of these territories. Moreover, the shortage of hospital beds and aging population also contribute to high mortality.

Secondly, these are the regions with a high share of industry in GDP (Orenburg, Samara, Sverdlovsk, Volgograd and Nizhny Novgorod regions, Perm Krai, the Republics of Tatarstan and Bashkortostan). The heavy industry and environmental pollution determine a low level of public health. The poor quality of health care and low accessibility of healthcare (shortage of hospital beds and insufficient government healthcare expenditures) exacerbate the problem. In addition, the predominance of the population above the working age and the high level of urbanization also contribute to the increased mortality in these regions.

Thirdly, these are middle-income agricultural and industrial regions (Saratov, Rostov, Moscow, Novosibirsk, Voronezh regions, Krasnodar and Altai Territories) with such factors contributing to excess mortality as high share of the population above the working age, shortage of hospital beds, high population density and high intensity of human flows.

Table 2

Typology of Russian regions (excess mortality & human flows intensity)

	High human flows intensity	**Low human flows intensity**
High excess mortality	17 regions **Factors:** 1. Spatial distribution: – share of urban population (*R* = 0.2); 2. Economic development: – unemployment rate (*R* = –0.2), – volume of industrial production (*R* = 0.5); 3. Demographic structure: – share of population above the working age (*R* = –0.3), – share of population under the working age (*R* = 0.2); 4. Accessibility of healthcare: – provision of beds (*R* = –0.2)	21 regions **Factors:** 1. Standard of living: – average monthly salary (*R* = –0,2), – share of population with incomes below the subsistence minimum (*R* =–0.2); 2. Economic development: – unemployment rate (*R* = –0.4); 3. Demographic structure: – share of population above the working age (*R* = 0.4), – share of population under the working age (*R* = –0.4); 4. Accessibility of healthcare: – capacity of outpatient clinics (*R* = 0.2), – population per one employee of the secondary medical staff (*R* = –0.4), – share of budget expenditures on healthcare and sports (*R* = 0.4).
Low excess mortality	5 regions **Spatial distribution:** 1. Пространственный: – population density (*R* = 0.8); 2. Economic development: – unemployment rate (*R* = 0.5), – volume of industrial production (*R* = 0.8); 3. Demographic structure: – share of population above the working age (*R* = –0.2), – share of population under the working age (*R* = 0.3); 4. Accessibility of healthcare: – provision of beds (*R* = 0.5), – capacity of outpatient clinics (*R* = 0.5), – population per one employee of the secondary medical staff (*R* = –0.7); 5. Standard of living: – average monthly salary (*R* = 0.7), – share of the population with incomes below the subsistence minimum (*R* = 0.8).	35 regions **Factors:** 1. Economic development: – unemployment rate (*R* = –0.2), – volume of industrial production (*R* = 0.8); 2. Demographic structure: – share of population above the working age (*R* = 0.5), – share of population under the working age (*R* = 0.4); 3. Accessibility of healthcare: – capacity of outpatient clinics (*R* = 0.2); 4. Standard of living: – average monthly salary (*R* = –0.3).

Source: the authors' calculations

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Low Hf – High Em. There are 21 regions with high excess mortality and low intensity of human flows (Fig. 6). Apart from high urbanization and high population density, the main causes of the dramatic mortality increase could be the low standards of living, poor accessibility of healthcare, and high overall morbidity. Moreover, the spatial distribution of the population also contributes greatly because high population density and/or high urbanization intensify social contacts and increase the risk of COVID-19 spread.

Low Hf – Low Em. 35 regions have low excess mortality and low human flows intensity. The little increase in mortality can be explained by poor connectedness of the territories and low population density. Thus, the spatial distribution of population has become crucial for this group of regions.

The regions of this group were divided into two subgroups. The first subgroup consists of 19 regions with a high share of urban population concentrated in 1–2 cities. The main increase of excess mortality occurred in large cities, while remote and rural areas suffered from the pandemic much less. Thus, overall excess mortality was low in such regions. This subgroup includes all regions

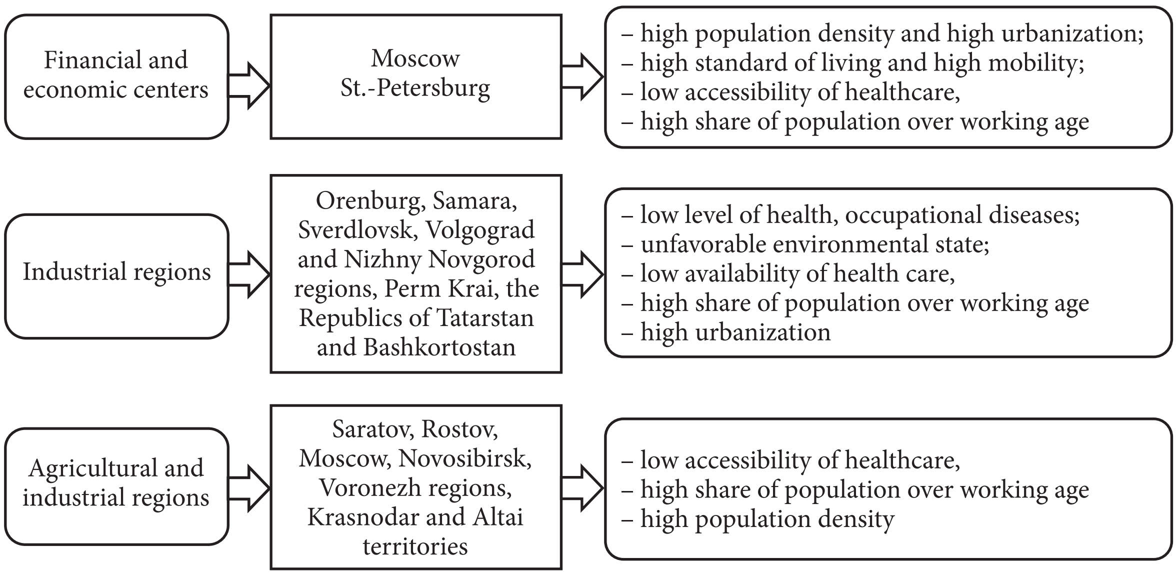

Figure 5. *Regions of High Hf – High Em group*

Source: Compiled by the authors

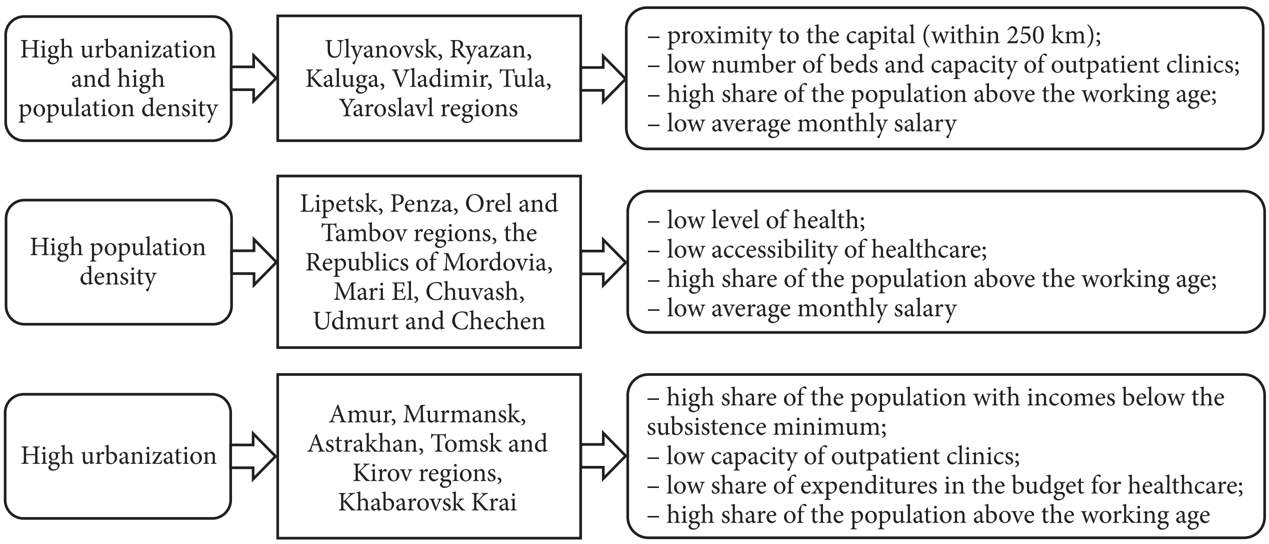

Figure 6. *Regions of Low Hf – High Em group*

Source: Compiled by the authors

of the Northwestern Federal District (except for St. Petersburg), 5 regions of the Central Federal District (Bryansk, Ivanovo, Kostroma, Smolensk and Tver regions), 4 regions of the Far Eastern Federal District (Magadan and Sakhalin Regions, Kamchatka Krai, the Chukotka Autonomous District) and one region of the Southern (Sevastopol) and one of the Ural Federal districts (the Yamalo-Nenets Autonomous District).

The second subgroup comprises 16 regions with predominance of rural areas, so they have a low population density and low urbanization accompanied by poor economic development. This subgroup includes 7 republics of the North Caucasus (the Republics of Adygea, Kalmykia, Dagestan, Ingushetia, Kabardino-Balkaria, Karachay-Cherkessia, North Ossetia-Alania), 7 regions of the Far East (the Republics of Altai, Tyva, Khakassia, Buryatia, Sakha (Yakutia), the Trans – Baikal Territory and the Jewish Autonomous Region), and 2 underdeveloped regions (Kursk and Kurgan regions). In addition, the growth of mortality was less significant due to the low mobility of the population associated with the low living standards and unattractiveness of local labor markets.

High Hf – Low Em. 5 regions have a low level of excess mortality and high intensity of human flows (Stavropol and Krasnoyarsk Territories, Tyumen Region without the Khanty-Mansi Autonomous Area and the Yamal-Nenets Autonomous Area, Irkutsk and Kemerovo regions). In these regions, industrial production prevails and there are considerable variations in standards of living. The accessibility of healthcare is low. The relatively low increase in mortality rates in these regions is primarily due to the predominance of the population under the working age and working age population.

Summing up, the factors that contribute the most to excess mortality differ across regions. Some regions have aging population and low accessibility of healthcare; in others, the death rates increase because of these regions' industrial specialization and the standards of living or population concentration. Policy-makers should take into account these regional differences to develop more efficient measures of fighting COVID-19.

Conclusions

The analysis showed that the demographic consequences of the pandemic cannot be reduced to the COVID-19 mortality statistics alone, which accounted for only about 19% of the total number of excess deaths. Moreover, in some regions, mortality from the COVID-19 makes up only 1.5–1.8% of total excess mortality (e.g., Bashkortostan and Tatarstan), while the increase in overall mortality in these regions had the highest values during the given period.

As for the territorial distribution of excess mortality, it should be noted that the southern, northern and eastern parts of Russia had less deaths in comparison with the central parts and border areas, which had higher mortality rates and more uneven distribution of excess mortality.

Due to the intensity of the human flows between regions and population distribution patterns within the regions, closeness of social contacts turned out to be the key factor that determined the spread of the infection. It was confirmed that the territories with a high level of population concentration (urbanization, density) and/or centers of active migration have had the highest increase in the mortality rates since the pandemic began.

At the same time, although the central and border areas of Russia were an epicenter of the novel coronavirus infection, all Russian regions suffered from the negative demographic consequences. Due to the low accessibility of healthcare and and scarcity of medical resources, Russian regions struggled to address the emergency. In addition, the pandemic has put a strain on the resources that the healthcare system previously used to deal with patients with chronic diseases or acute pain. This led to an increase in the number of non-communicable diseases and subsequently to a rise in the number of preventable deaths. At the same time, some regions suffered from negative economic effects of the pandemic and a decline in the living standards, which led to a higher level of stress and became an additional factor contributing to an increase in overall mortality.

Our findings indicate that it is necessary to develop a differentiated policy in the regions in order to contain the novel coronavirus infection, to monitor a whole range of social and economic indicators and to take into account the demographic structure of the population, which is also a factor that influences excess mortality.

This methodological approach is based on clustering regions by the level of excess mortality in relation to the intensity of human flows.

Our findings can be used for developing regulatory instruments to reduce excess mortality during the pandemic.

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SWOT analysis of smart city projects in capital cities of Russia and Kazakhstan

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ABSTRACT
Relevance. Large-scale digitalization projects contribute to national economic development and to the improvement of the living standards in countries and regions. Cities with high population density and vibrant economic growth can benefit the most from such projects.
Research objective. This study aims to conduct a strategic analysis of smart city projects in capital cities of Russia and Kazakhstan (Moscow, Nur-Sultan, and Almaty).
Data and methods. The study provides an overview of academic and professional media publications on the topic, national and local official documents, materials reflecting expert discussions about the problems of smart city development in Russia and Kazakhstan. Methodologically, the study relies on SWOT-analysis methods used to systematize diverse empirical data and to provide evidence for managerial decision-making.
Results. In this study, we systematized the key approaches to the definition of a smart city and proposed our own interpretation of this term with a special emphasis on SWOT factors. The main digital services in Moscow, Nur-Sultan and Almaty were described. The results of SWOT analysis have shown some significant differences in the way the three capital cities implement their smart city projects as well as similar problems they are facing, such as the institutional barriers, the lack of standards, financial constraints, the shortage of domestically produced equipment and software, of highly qualified human resources, and private investors.
Conclusions. The range of factors that affect the implementation of smart city projects in the three cities include the COVID-19 pandemic, which is likely to stimulate the digital transformation both in the short and long term.

KEYWORDS
smart city, capital, SWOT analysis, comparative analysis, Russia, Kazakhstan

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SWOT-анализ проектов smart-city в столичных городах России и Казахстана

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АННОТАЦИЯ
Актуальность. Крупномасштабные проекты цифровизации способствуют развитию национальной экономики и повышению уровня жизни в странах и регионах. Города с высокой плотностью населения и динамичным экономическим ростом могут извлечь наибольшую выгоду из таких проектов.
Цель исследования – проведение стратегического анализа проектов «Умных городов», реализуемых в крупнейших столичных городах России и Казахстана (Москвы, Нур-Султана, Алматы)
Данные и методы. В исследовании представлен обзор публикаций академических и профессиональных СМИ по данной теме, национальных и местных официальных документов, материалов, отражающих экспертные дискуссии о проблемах развития умных городов в России и Казахстане. Методологически исследование опирается на методы SWOT-анализа, используемые для систематизации различных эмпирических данных и предоставления доказательств для принятия управленческих решений.
Результаты. В данном исследовании мы систематизировали ключевые подходы к определению умного города и предложили собственную ин-

КЛЮЧЕВЫЕ СЛОВА
умный город, столица, SWOT-анализ, сравнительный анализ, Россия, Казахстан

БЛАГОДАРНОСТИ
Исследование финансируется Комитетом науки Министерства образования и науки Республики Казахстан (программа целевого финансирования BR10965247 «Изучение факторов, особенностей и динамики демографических процессов, миграции, урбанизации в Казахстане, разработка цифровых карт и прогнозов»)

терпретацию этого термина с особым акцентом на SWOT-факторы. Были описаны основные цифровые сервисы в Москве, Нур-Султане и Алматы. Результаты SWOT-анализа показали существенные различия в том, как три столицы реализуют свои проекты умных городов, а также схожие проблемы, с которыми они сталкиваются, такие как институциональные барьеры, отсутствие стандартов, финансовые ограничения, нехватка произведенного внутри страны оборудования и программного обеспечения, высококвалифицированных кадров и частных инвесторов.

Выводы. Среди факторов, влияющих на реализацию проектов умных городов в трех городах, можно отметить пандемию COVID-19, которая, вероятно, будет стимулировать цифровую трансформацию как в краткосрочной, так и в долгосрочной перспективе.

ДЛЯ ЦИТИРОВАНИЯ
Urdabayev, M.T., & Utkelbay, R.E. (2021) SWOT analysis of smart city projects in capital cities of Russia and Kazakhstan. *R-economy*, *7*(4), 235–243. doi: 10.15826/ recon.2021.7.4.021

Introduction

The increasing informatization in all spheres of life in Russia and Kazakhstan is part of the global trend which encompasses the digital transformation of cities. In Russia, as part of the 'Digital Economy' program developed by the Ministry of Communications, it is planned to create over 50 smart cities (Akimova, 2019). In Kazakhstan, smart city projects are supported and initiated by the Ministry of Digital Development, Innovations and Aerospace Industry. To develop a more standardized approach for smart city building, in 2019, the Reference Standard of Smart Cities of the Republic of Kazakhstan was adopted.

Smart city projects generally comprise the creation of two types of infrastructure: hard infrastructure (built environment and utilities such as roads, bridges, etc.), which is self-sustaining and resilient to negative impacts, and soft infrastructure (services, human capital and institutions that cultivate it), which holds more potential for fostering innovation. A city develops and modernizes the infrastructure of both types in order to meet the needs of urban communities (Demidov, 2019).

In cities of different types, smart city projects may acquire different characteristics. In this study, we are going to focus on capital cities: the research into the smart city projects and approaches underlying them in national capitals can provide us with some interesting insights as these urban agglomerations concentrate a large part of the population and economic resources and act as centres of political and economic decision-making. Due to the complexity and diversity of the socio-economic processes concentrated in capital cities, their authorities are generally more inclined to spur innovation and implement digital systems for urban development management. Smart city projects in Russia and Kazakhstan are of special interest as they have a lot in common in terms of population distribution patterns, spatial configurations and the role they play in the socio-economic development of their countries.

This study aims to conduct a strategic analysis of smart city projects in capital cities of Russia and Kazakhstan – Moscow (Russia), Almaty and Nur-Sultan (Kazakhstan). Almaty was included in the sample because it has lost its status of national capital only recently, and therefore still retains most of its characteristics, which provides ground for comparison between the old and new Kazakh capitals.

The above-described research objective determined the choice of the following research tasks: first, we are going to systematize the approaches to defining the term 'smart city'; second, we will characterize the key digital services that are currently in use in Moscow, Nur-Sultan and Almaty; and, finally, we will conduct a SWOT analysis of smart city projects in Moscow, Almaty and Nur-Sultan, compare and summarize the results.

Theoretical framework and methodology

The notion of smart city emerged and entered public discourse in the late 1990s. There is, however, no uniform understanding of what constitutes a smart city (Kupriyanovsky, 2016). Robert Hall points out that a smart city should be a safe, secure, environmentally green and efficient place for living. All structures of such a city (power, water, transportation, sewage) should be designed, constructed, and maintained by making use of an advanced infrastructure based on networks, electronic and sensors (Robert E. Hall, 2000).

The British Standards Institute (BSI) defines the term 'smart city' as a built environment characterized by 'the effective integration of physical, digital and human systems ... to deliver sustainable, prosperous and inclusive future for its citizens" (BSI, 2020).

The UN's Economic Commission for Europe defines a smart city the following way: 'A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, cultural and environmental aspects' (Economic and Social Council, 2015).

A similar viewpoint is expressed by Hall et al.: in their view, a smart city is 'a city that monitors and integrates conditions of all of its critical infrastructures, ...can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens' (Hall et al., 2000, p. 2).

Data collection in smart cities through sensors, cameras and other devices helps maintain stable operation of utility services, urban landscaping, healthcare and transport infrastructure (Kuznetsova, 2019).

Urban scholar Murunov defines a smart city as 'a comfortable urban environment which has a positive impact on people's mental health' (Murunov, 2018). In other words, a modern, technologically advanced city is a city that meets all the modern requirements and conditions.

Odendaal believes that information technologies widely used in smart cities contribute to these cities' uninterrupted progress and improvement of the standards of life of their citizens (Odendaal, 2016). Nam & Pardo point out the human dimension of the smart city concept: 'A smart city is a humane city that has multiple opportunities to exploit its human potential and lead a creative life' (Nam & Pardo,2011, p.285). Giffinger et al. emphasize citizen participation as a crucial factor of a smart city's steady development (Giffinger et al., 2010).

The definition of a smart city proposed by P. Nijkamp & K. Kourtit is worthy of special attention (Kourtit & Nijkamp, 2012): they believe that smart cities depend on creative and knowledge resources to maximize their innovation potential through strategies aimed at reaching the desired levels in the environmental, transport, economic, social and other 'smartness' performance indicators.

Nunes et al. offer a more practical approach to the smart city concept, which, in their view, is based on the interactions between several clusters within the city itself (Nunes et al., 2021). They propose a model for decision-making based on cognitive mapping to identify the determinants of smart city success from different areas. The proposed methodological framework provides a comprehensive understanding of a smart city (Nunes et al., 2021).

Rozario et al. (2021) consider the modern focus of smart cities from three angles: infrastructure engineering, information technology and people-centric management. These scholars seek to draw attention to the 'need for developing smart cities with a holistic approach involving multiple perspectives rather than a siloed emphasis on technology alone' (Rozario et al., 2021). They also highlight the fact that the concept of smart city should be more people-centric and that one of the most important purposes of smart cities is 'the satisfaction of those who dwell in them—the citizens' (Rozario et al., 2021).

We believe that innovation lies at the core of the smart city concept. In other words, a smart city is a city where comprehensive technical solutions are implemented and strategies to enhance resource use efficiency and ensure the delivery of high-quality services are realized. Another important aspect of smart cities is that they are aimed at creating a more liveable, resilient, and sustainable urban environment for residents at present and in the future.

Methodologically, this study relies on the method of SWOT analysis, which is a popular strategic analysis tool. It assesses internal and external factors dividing them into four categories: strengths, weaknesses, opportunities and threats. These method of strategic analysis was chosen because it was best suited for the purpose of this study: to systematize and summarize diverse quantitative and qualitative empirical data. The results of such analysis provide valuable evidence for managerial decision-making (Baskakova et al., 2020).

The study is based on the evidence provided by academic publications and professional media publications on the topic, national and local official documents, and materials reflecting expert discussions about the problems of smart city development in Russia and Kazakhstan.

Results and Discussion

Implementation of the Smart City Project in Moscow

In Moscow, the Smart City Project started in 2011. So far, the following smart services have been introduced. The online voting platform 'Active Citizen' was launched in 2014. This platform can be used for conducting local referendums. According to the statistical data, in 2019 the platform had over 2 million registered users; by that time, 2,710 elections had been held and over 86 million votes had been registered (Ptitsyn, 2019). The platform 'Active Citizen' is also suitable for conducting surveys among the citizens of Moscow to assess their satisfaction with parks and green spaces, public transport routes, and so on (Ivanova & Karagulyan, 2021).

Another platform, 'Our City', is also very popular among the citizens of Moscow – it facilitates citizens reporting local problems and sending non-emergency requests to municipal services. This platform has over 1 million registered users.

Platform Crowd4 was created to enhance citizen participation. This platform has over 130 thousand registered users. Over 84 thousand initiatives have been registered, some of which have been accepted by governmental agencies.

The development of smart city technologies is supported by the Department of Information Technologies, which integrates all the ITs into a single system. Most public services in Moscow can now be accessed online. All of the above creates a solid foundation for further development of the smart city system in Moscow (Chudiniva & Afonina, 2018).

Most of the initiatives related to the smart city project are associated with the capital's transport infrastructure. Moscow currently has over 2,000 sets of traffic signals, 3,500 traffic detectors and 2,000 traffic cameras. If the cameras or other devices for traffic control have detected any rule violations, the data are transmitted to the Situation Centre of the Traffic Organization Centre to detect and fine road traffic violations (Golubev, 2018).

Moreover, video surveillance systems help the authorities get a better understanding of how certain measures may influence the whole traffic situation: for example, how the traffic flow will change if a street is closed to cars or whether the number of cars will fall if a one-way system is introduced. Babakin (2019) believes that intelligent transportation systems can be very efficient in reducing the number of road accidents. In Moscow, such innovations have led to a 13% increase in the speed of traffic flow.

In Moscow, there is ongoing construction of smart buildings and smart water supply systems. Smart meters are being installed. Buildings are equipped with smart energy meters for more efficient energy consumption (Pimenov et al., 2020).

The project aimed at providing free WiFi coverage in streets and recreational public spaces has been under way since 2012. Among other things, its outcomes included the installation of free WiFi hotspots at educational institutions and transport stops. As a result of the government's efforts, Moscow now ranks second in the world for free WiFi and connectivity. Free WiFi hotspots are also available in locations which are popular both with locals and tourists such as VDNKh, Moscow Zoo, libraries, and cultural centres (Salkuti, 2021).

Moscow government makes a great contribution to the progress of the smart city project by attracting investors. An important part of the project is the public-private partnerships (PPPs), where all project participants are actively cooperating with various tech companies. Public participation in decision-making is also encouraged.

Table 1 below summarizes the strong and weak points, threats and opportunities of the smart city project in Moscow.

Implementation of the Smart City Project in Nur-Sultan

Nur-Sultan can be described as a competitive, steadily growing city with moderately developed infrastructure, a well-developed health care system, high-quality education, comfortable and sustainable urban environment adapted to the adverse impacts of the local climate (Yuloskov et al., 2021). The city has a number of well-performing clusters and a developed innovation eco-system. The level of entrepreneurial activity of local inhabitants is also quite high. Nur-Sultan was among the first Kazakh cities to implement digital technologies for urban management.

It should be noted that most of such projects in Kazakhstan are realized through PPPs. Quite illustrative in this respect is the creation of a situation centre which collects and processes data from surveillance cameras and helps the local authorities communicate more efficiently with the citizens. The inhabitants of Nur-Sultan enjoy access to a mobile application and a digital platform for online public services.

Nevertheless, despite the latest developments in the city driven by technological progress, it faces a number of problems such as the lack of formalized digital architecture and means of ensuring data security. Over 25% of databases have limited access and they are updated once a month at most (Lebedev, 2019). Another problem is that akimat officials often lack the necessary digital skills and competencies, which has a negative impact on the implementation of smart technologies for the management of the urban infrastructure.

Other problems that need to be addressed include the lack of funding, the lack of domestically produced digital products, the lack of investors and PPPs. The transportation sector also faces some challenges. Local educational institutions offer few digital technologies programmes and courses, which results in the shortage of qualified specialists in this field. The results of SWOT-analysis of Nur-Sultan are shown in Table 2 below.

Implementation of the Smart City Project in Almaty

Almaty is the largest city in Kazakhstan characterized by high levels of socio-economic development, environmental sustainability, demographic potential and secure communication channels[1]. The city is increasingly reliant on digital tools to build a set of services such as an integral fire services command and control system, a system to improve security at schools, and so on. There are also projects for water quality monitoring and for environmental data capture (Turgel, Bozhko, & Pandzhiyeva, 2020).

Speed cameras and traffic sensors have been quite effective at reducing the number of road accidents. In 2020, the number of road deaths fell by 48% in comparison with 2019. Digital solutions have also helped cut down on emergency response time by 20% (Yuloskov et al., 2021). The city's key digital projects include the creation of an automated traffic monitoring

[1] Golubev, M. (2018). 'Big University' City: Expert-Sibir, 30/34, 16–18. (In Russ.)

Table 1

SWOT-analysis of the smart city project in Moscow

Strengths	Weaknesses
1. Capital of Russia and the largest city in the country	1. High project costs due to the need to purchase software from foreign companies
2. High degree of innovation	3. Lack of public awareness of the project's advantages
3. Sustainable infrastructure and environment	3. Long payback period
4. High population growth rates	4. The city hasn't accumulated sufficient technical expertise of its own
5. Secure communication channels	5. Vulnerability to cyber security threats and insecure data storage
6. Free WiFi coverage in streets and public places	7. Lack of project funding
7. Advanced modern technologies: sensors, devices and measuring instruments	7. Lack of resources, especially highly qualified human resources
8. Video surveillance cameras for monitoring road traffic	
Opportunities	**Threats**
1. Accumulation of technical expertise	1. Lack of investors
2. Lower car accident rates and traffic violation rates	2. Lack of domestically produced software solutions
3. Reduced energy, heating and water supply costs	3. Cyber security threats and vulnerabilities of the city's integral information system
4. Faster emergency response	4. Outdated planning solutions
5. Improved performance of urban facilities	5. Aggravation of transportation problems
6. Emergency response management	6. Increased environmental pressures
7. Improved security of systems	7. Urban identity crisis

Source: compiled by the authors by using the data from TADVISER overview. Smart City – Development of Russia. (2020). Retrieved from: https://www.tadviser.ru/index.php/Статья:Умный_город:_развитие_в_России (Accessed: 07.02.2020). (In Russ.)

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system, monitoring system for landslide hazard assessment, emergency alert systems, lifesaving mobile application '102', and some others (Ptitsyn, 2019). The akimat and other government bodies are working together to collect the data on crime rates and traffic violation rates to devise preventive measures against public security breaches.

Despite the array of advantages the city holds, there are also some challenges that need to be addressed. The main problems Almaty faces is the lack of coordinated goal-setting and strategy-making regarding the city's smart development, the lack of funding, and obsolete technological systems. Thus, the city needs to decommission obsolete automated models and stimulate PPPs with companies capable of improving Almaty's digital system (Salkuti,2021).

Almaty holds a great potential for smart development but how soon these technologies will be put into use largely depends on the decision-making process of the akimat, efficient strategic planning and effective PPPs. The results of SWOT-analysis of the situation in Almaty are shown in Table 3 below.

Conclusion

Our SWOT analysis took into account the following characteristics of a smart city: innovation; maintenance of improved living environment at present and in the future; comprehensive technological solutions; efficient resource management; and delivery of high-quality services. The comparative analysis for three capital cities (Moscow, Nur Sultan, and Almaty) has brought to light some significant differences in the way they implement

Table 2

SWOT analysis of the smart city project in Nur-Sultan

Strengths	Weaknesses
1. Capital of Kazakhstan – a competitive, steadily growing city	1. High financial costs due to the lack of domestically produced software
2. Moderately developed urban infrastructure	3. Moderately developed digital infrastructure
3. Integrated city with a developed healthcare system, high-quality education, comfortable and sustainable urban environment adapted to the adverse impacts of the local climate	3. Lack of data access and transparency
4. Efficient transport system	4. Akimat officials lacking the necessary digital skills and competencies
5. Range of globally competitive clusters	5. Long payback period
6. Developed innovation eco-system	6. Lack of funding
7. High entrepreneurial activity	7.Insufficient development of the urban environment; barriers to the city's spatial development (regulatory barriers, poor planning and the opportunistic approach to the implementation of urban planning policies)
	8. Lack of formalization of the digital infrastructure and the lack of detailed cybersecurity strategies
Opportunities	**Threats**
1. The city's advantageous position in comparison to deliver on its smart development goals	1. Lack of investors and PPPs
2. Greater access to resources due to the city's status	2. Lack of domestically produced software and high costs of imported software and equipment
3. Digital technologies contributing to economic performance	3. Unbalanced economic growth and falling living standards
4. High levels of development of different sectors of economy	5. Increasing competition for resources between the regions of Kazakhstan
5. High level of the system's security	5. Aggravation of transportation problems
6. Efficient management of the urban infrastructure	6. Budget risks associated with shrinking government subsidies

Source: compiled by the authors from the data provided by the official web-site of Nur-Sultan akimat (Smart City. Retrieved from: https://astana.gov.kz/ru/page/smart (Accessed: 25.10.2021). (In Russ.))

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their smart city projects (Danilina, Slepnev, 2018). Nevertheless, these cities are facing similar problems, such as the lack of funding, domestically produced equipment and software, highly qualified human resources, and private investors.

For a more sustainable positive result, smart city projects should include optimization of services, expansion of the range of digital services, stimulation of PPPs, and cooperation with tech organizations. Other factors contributing to the success of smart city projects are an efficient management system, transparency, innovative methods of capital raising, a feedback loop in Public Relations, and developed digital competencies and skills of

Table 3

SWOT analysis of the smart city project in Almaty

Strengths	**Weaknesses**
1. The largest city in Kazakhstan with population over 1.98 million.	1. High financial costs
2. Good socio-economic conditions	2. High pollution levels
3. Environmental sustainbility	3. Poor infrastructure
4. High demographic potential	4. Depreciation of the residential housing stock and utility services communications
5. Integral system for improving school security	5. Surging crime rates and car accident rates
6. Emergency alert system	6. Long payback period
7. Secure communication channels	7. Lack of the city's own technical expertise
8. Integral fire services command and control system	8. Shortage of personnel in the Department of Digitalization
9. Emergency call centres integrated into one service – '112'	9. Lack of funds and qualified workforce for project realization
10. Advanced modern technologies: sensors, devices and measuring instruments	10. Complicated procedure for the approval of technological investment projects, which slows down the process of hardware and software procurement and implementation
11. Free WiFi coverage in streets and public places	
12. System of automated monitoring of landslide hazard assessment with sensors being installed in landslide-prone areas in mountanous regions	11. Digital skills shortage among city government officials
Opportunities	**Threats**
1. Emergency alert system	1. Complicated procedure for the approval of technological investment projects, which slows down the process of hardware and software procurement and implementation
2. Integral system of water use monitoring and reporting	2. Lack of investors and PPPs
3. Less road accidents	3. Lack of domestically produced software solutions
4. Faster response to emergency situations	4. Aggravation of traffic congestions and increasing crime rates
5. Lower energy, heating and water supply costs	5. Outdated systems for document management
6. Transition to smart city governance	
7. Human capital development	
8. Creation of an innovation eco-system	
9. Digitalization of different sectors of economy to increase labour productivity and stimulate growth	
10. Increase in the number of public servants capable of working remotely	
11. Emergency response management	
12. Modernization of obsolete systems	
13. Interdepartmental cooperation	
14. Creation of an integral data storage centre	

Source: compiled by the authors from the web-site of 'Smart Almaty' Concept (Concept – Smart Almaty – Effective Innovations. Retrieved from: https://smartalmaty.kz/smart.html (Accessed: 25.10.2021). (In Russ.))

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municipal government officials. Cities also need to ensure effective coordination of projects and invest in the replacement of obsolete systems.

The main institutional barrier impeding the success of smart city projects in Russia is the lack of standards and legislation to regulate the testing of new innovative products and technologies by actors of the digital economy (Kolobova, 2020). Russian cities have yet to accumulate sufficient technical expertise in such spheres as management of transport infrastructure, energy management control systems, control systems for heating and water supply, smart medical systems, remote patient monitoring systems, etc (Vodk, Ulyov, Kubina, 2021).

It should be noted that since the onset of the pandemic, there has been a tremendous surge in digital activity, in particular in the use of digital technologies for urban governance. As humanity continues struggling with the pandemic, its effect on urban life will be long-lasting and will include the rapid spread of digital technologies (e.g. digital tools for delivering online services, for monitoring and control).

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Comparative structural analysis of economic growth in countries of the Eurasian Economic Union

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ABSTRACT

Relevance. The development of the Eurasian Union means economic integration between its member countries (Armenia, Belarus, Kazakhstan, Kyrgyzstan, and Russia). For more efficient coordination of this process, it is necessary to analyze national models of economic growth and adjust the Union's economic policy accordingly.

Research objective. The study aims to identify the national models of economic growth by applying the structural analysis method and building regression models of GDP growth.

Data and methods. The study relies on the structural analysis of GDP growth and regression analysis of the impact of macroeconomic policy instruments.

Results. The study provides an overview of the research literature on the factors affecting economic growth (e.g. the financial structure, government expenditures. Based on the results of the structural analysis, a classification of the models of economic growth in terms of expenditures and sectors is proposed. This classification can be used to devise measures stimulating cooperation and integration within the Eurasian Union.

Conclusions. The study has revealed the differences between the national models of economic growth by looking at each country's reaction to the crises of 2009 and 2015. These differences correspond to the peculiarities of each country's economic policy and need to be taken into account in the Union's policy-making.

KEYWORDS
Eurasian Economic Union, economic growth, GDP structure, structural analysis, GDP growth rate, sectoral economic structure, regression analysis, economic policy

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Сравнительный структурный анализ экономического роста стран Евразийского экономического союза

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АННОТАЦИЯ

Актуальность. Развитие Евразийского союза означает экономическую интеграцию между его странами-членами (Арменией, Беларусью, Казахстаном, Кыргызстаном и Россией). Для более эффективной координации этого процесса необходимо проанализировать национальные модели экономического роста и соответствующим образом скорректировать экономическую политику Союза.

Цель исследования. Исследование направлено на выявление национальных моделей экономического роста путем применения метода структурного анализа и построения регрессионных моделей роста ВВП.

Данные и методы. В основе исследования лежат структурный анализ роста ВВП и регрессионный анализ влияния инструментов макроэкономической политики.

Результаты. В исследовании представлен обзор исследовательской литературы по факторам, влияющим на экономический рост (например, финансовая структура, государственные расходы. На основе результатов

КЛЮЧЕВЫЕ СЛОВА
Евразийский экономический союз, экономический рост, структура ВВП, структурный анализ, темпы роста ВВП, отраслевая структура экономики, регрессионный анализ, экономическая политика

структурного анализа предлагается классификация моделей экономического роста с точки зрения расходов и секторов. Эта классификация может быть использована для разработки мер, стимулирующих сотрудничество и интеграцию в рамках Евразийского союза.
Выводы. Исследование выявило различия между национальными моделями экономического роста, проанализировав реакцию каждой страны на кризисы 2009 и 2015 годов. Эти различия соответствуют особенностям экономической политики каждой страны и должны быть приняты во внимание в политике Союза.

ДЛЯ ЦИТИРОВАНИЯ
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Introduction

Prospects for the development of Eurasian integration and economic cooperation within the Eurasian Economic Union (EurAsEC) should be considered in the light of the current stagnation and recession, which increases the significance of the task of stimulating economic growth in member countries. Each of the countries of the EurAsEC (Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russia), both before and after the formation of the Union, had their own economic dynamics determined by resource opportunities (including the size of the country), institutional changes, the external environment (location), economic policies and many other reasons and factors. The creation of the Union and the special customs regime as well as the reduction of resource exchange costs (capital and labor) have given a new impetus to the development of the member countries (Mostafa & Mahmood, 2018). There is, however, a question as to what are the characteristics of the current growth models of the Union's member states and whether they contribute to the development of the Union or, on the contrary, impede it. On the one hand, within the Union, the economic development of each country should influence other countries, thereby supporting the general growth trend, but when a recession occurs, the crisis processes spread across the Union. On the other hand, the growth model of member states may limit this negative impact. It is, therefore, important to gain a better understanding of the nature and mechanisms of the mutual influence between the countries. Identification of the particular features of economic development in each country will help reveal their mutual influence and the differences between national growth patterns for further analysis.

There is significant body of research on structural changes in national economies. However, within the framework of growth theories, these changes remain an underexplored question (Alonso-Carrera & Raurich, 2015, 2018; Romano & Trau, 2017; Vu, 2017). Much of the work in this area uses aggregate models, while the structural approach takes a back seat. Scientific and technological progress, not structural dynamics, is usually considered as the most important factor (Gabardo & Pereima, 2017).

Modern studies of economic growth and its structure discussed above do not give a full picture of the contribution of various components of GDP to GDP growth rate. Changes in the structure of national economies and their impact on economic growth have been underexplored in economic growth theories.

The aim of the study is to develop a method of structural analysis and to describe the current structural dynamics of member countries of the Eurasian Union (by GDP component and by sector).We also intent to propose a methodology for comparative analysis of the macroeconomic dynamics of the countries under consideration, taking into account their patterns of economic development and the impact of macroeconomic policy instruments.

The structural approach, as noted above, does not fit into modern theories of economic growth (Romano, Trau, 2017, Vu, 2017). The theoretical framework is represented by modern views on economic growth, but it has to be modernized by including the factor of structural dynamics. It is precisely the differences in the structure of the economy and its dynamics that impede the efforts to stimulate integration and expand cooperation within the Union.

In the following section, we will review the main theoretical works devoted to economic growth and changes in the economic structure, identifying their main content and tasks to be solved in order to show other possibilities of structural analysis. In the third section, we will proceed to the research methodology, describing the main method, data and algorithm of analysis. The proposed methodology will be tested by using the data of the Eurasian Union's member countries. The results of the analysis will show the structural dynamics in these countries' economies in comparison with other members of the Union and can thus be used to improve the efficiency of the cooperation within the Union.

Theoretical framework

This study relies on the concept of structural dynamics, which is understood as changes in the elements of the system and their roles in the overall economic growth. The analysis of structural dynamics helps governments build an evidence-based macro-economic policy and strategies of economic development. An example of such a study is the analysis of structural dynamics in China over the past decades (Brondino, 2019).

Modern structural changes are large-scale, which leads scholars to reconsider their views of depression as a situation when the economy functions for a long time at a level below its potential (Tase, 2019). Such situations create the need to invest in transformations of the economic structure and to take measures ensure productivity growth (Samaniego and Sun, 2016; Oreiro and Silva, 2020). Table 1 presents a brief overview of research literature dealing with the factors of economic growth.

As Table 1 shows, Chu (2020) focuses on the impact of the financial structure and uses panel data for 99 countries for 1971–2015 to investigate whether it affects economic growth, the emergence of a banking crisis, and economic volatility. The main result is that the positive effect of the development of the securities market is significantly weakened if the financial structure is not balanced.

Based on the extended neoclassical growth model, the endogenous mechanism between financial structure and economic growth is investigated (Liu and Zhang, 2020). The theoretical analysis shows that there is an optimal financial structure necessary to meet the various needs of the real sector. Their empirical results show that the financial structure has a significant impact on economic growth. However, the impact of the financial structure on regional economic growth is different and has an inverse U-shape. These results confirm the evolving influence of the financial structure on economic growth at different stages of economic development.

The impact of banking sector on the structure of economy and economic growth is considered J. Tongurai & Ch. Vithessonthi (2018), who showed the different impact of the banking sector on the development of the industrial and agricultural sectors. The development of the banking sector has a negative impact on the development of the agricultural sector, but it does

Table 1

Review of the international research on the impact of certain factors on economic growth

Studies	Factors of economic growth	Description
Chu, 2020; Liu, Zhang, 2020; Benczúr et al., 2019	Financial structure	Non-linear influence of the financial structure on economic growth: the influence is different and has an inverse U-shape. The positive effect of the development of the securities market is significantly weakened if the financial structure is not balanced.
Tongurai, Vithessonthi, 2018	Banking sector	Negative impact on the development of the agricultural sector (in countries with developed banking sector), but no impact on the development of the industrial sector.
Facchini, Seghezza, 2018; Olaoye et al., 2020	Government expenditure	The cumulative effect of expansionary government spending shocks on economic growth is positive. The cumulative effect of government spending cuts has a negative impact on economic growth. The existence of an inverted U-shaped relationship between government spending and economic growth is proved. Spending to protect property rights and health care costs contribute to the growth of production.
Zhao, Tang, 2018	Manufacturing, transaction sector	The acceleration of economic growth in China in 2003-2008 compared to 1996-2002 was due to an increase in the contribution of the manufacturing sector and, to a lesser extent, the service sector, while in Russia the growth driver was the service sector, then the primary sector.
Čadil, et al., 2014.	Human capital	Human capital is not a guarantee of economic stability and a quick exit from the crisis. Regional economies reacted differently to the 2014 economic crisis: asymmetric responses are based on structural differences and human capital availability.

Source: compiled by authors.

not have any impact on the development of the industrial sector. At the same time, the negative impact of the banking sector on the development of agriculture is observed only in countries with a developed banking sector. The results also show that the development of the agricultural sector has a negative impact on the development of the banking sector, while the development of the industrial sector has a positive impact on the development of the banking sector.

Benczúr et al. (2019) focus on the groups of high-income countries (OECD, EU, and the EU Economic and Monetary Union to show the non-linear nature of the impact that funding has on economic growth is robust in relation to the structure of financial sources (bank credit, debt securities, stock market) and recipients of finance (households, non-financial and financial corporations). First, the non-linear effect of total bank credit is more pronounced than that of either household credit alone or the amount of bank credit, debt securities, and stock market financing. Second, loans to non-financial corporations tend to have a positive impact on economic growth and loans to households, a negative impact. Third, debt securities and equity financing have different effects on economic growth.

There is extensive literature on the impact of various functional components of government spending on economic growth. Facchini & Seghezza (2018) focus on the impact of the structure of public spending on economic growth in France in 1870–2010. It is shown that the only functional component of expenses that contributes to the growth of French production is expenses aimed at protecting property rights. On the other hand, government intervention to support the economy has no effect on economic growth. As far as social spending is concerned, only health spending contributes to production growth. Thus, in the case of France, empirical evidence seems to support not only the critical importance of property rights protection emphasized by neoinstitutional theory, but also Smith's minimal state hypothesis: limiting the size of the state and delineating its main functions usually contributes to the growth of production.

Comparing the sources of economic growth and the nature of changes in the industrial structure of China and Russia, Zhao & Tang (2018) show that in the period from 1995 to 2008, the Chinese economy was more concentrated in the manufacturing sector and relatively less in the service sector than the Russian one. In addition, the article concludes that in Chine the rates of GDP growth and labor productivity were higher in the period from 1996 to 2008 than in Russia. The acceleration of economic growth in China in 2003–2008 compared to 1996–002 was mainly due to an increase in the contribution of the manufacturing sector and, to a lesser extent, the service sector, while in Russia it was the service sector, followed by the primary sector managed by the mining and oil and gas industries. These results indicate that the Chinese and Russian economies complement each other, which bodes well for further economic cooperation and trade between the two countries.

The phenomenon of asymmetry between public spending and growth in the West African economic community (Olaoye et al., 2020) shows that in this group of countries, the response of economic growth to public spending shocks varies depending on the nature of the shocks, i.e., the cumulative effect of expansionary public spending shocks on economic growth is positive and statistically significant. The cumulative effect of government spending cuts has a negative and statistically significant impact on economic growth. In addition, the existence of an inverted U-shaped relationship between government spending and economic growth is proved.

Human capital as a factor of economic growth is considered by Čadil, et al. (2014). Human capital alone is not a guarantee of economic stability and a quick exit from the crisis. Human capital should reflect the economic structure that promotes economic growth. Otherwise, it can only lead to an increase in the unemployment rate due to the effect of displacement and imbalances in the labor market. Regional economies reacted differently to the 2014 economic crisis: asymmetric responses are based on structural differences and human capital availability.

To sum up, it can be noted that the methodology for comparative analysis of structural dynamics by GDP components, including the impact of certain parameters of macroeconomic policy and the stability of growth, is not sufficiently developed. The above-described research identifies a factor or group of factors that influence growth but does not provide an overall picture of the changes in the structure of GDP. These are the research gaps that this study seeks to address.

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Method and data

Structural analysis is a suitable for studying the complex relationships that arise between the elements of the economy. This method helps not only establish the emerging patterns, but also reveal the influence of elements on the changes in the economic system. With regard to the problem of economic growth, it is possible to determine the contribution of different components of GDP to the overall GDP growth rate and the connection between these components (the method of paired correlations or principal components). In addition, it is possible to determine how much a particular sector dominates, including its contribution to the growth rate, and also estimate the stability of growth rates both for an individual element and for the entire economic system. From a broader perspective, structural analysis allows us to study resource allocation between economic sectors: its toolbox includes the 'input-output' method, the method of direct empirical assessment of the movement of capital and labor between sectors, which is less labor-intensive in application, as well as the method of institutional compositions, etc. (Afonso & Neces, 2020; Bayramov & Breban, 2019; Teixera & Queiros, 2016; Brancaccio & Garbellini, 2018).

Therefore, regarding the quality of economic growth, it is necessary to assess the structure of growth (Ciarli & Valente, 2016; Demir & Hall, 2017; Harada 2015; Hardt & Barett, 2021). The distribution of resources affects structural changes and should be considered as a central issue of structural change and growth structure (Freire, 2019; Kirham, 2016). This or that component of GDP by expenditure (e.g. gross consumption, investment or net exports) can be crucial for the GDP growth rates.This contribution may change over time, and another component of GDP may become dominant, or the impact of some components will be commensurate with the contribution to the rate, so it will not be possible to determine the dominance of one of them over the given period. The selected structural composition is a model of economic dynamics which indicates the component that generates most growth. The same analysis applies to economic sectors or activities. Analysis of the countries of the EurAsEC will allow us to get a better understanding of the economic growth in these countries, which will inevitably affect their economic integration.

The structural formula for estimating the contribution of elements to the growth rate of national GDP is presented below.

To measure GDP by expenditure we are going to use the formula: $Y = C + I + G + NX$, that is, the sum of consumer and investment spending, government spending, and net exports. The growth rate of each component of GDP is denoted as gC, gI, gG, gNX while the share of each component in GDP is denoted as C, i, g, nx. Thus, the structural formula will look the following way:

$$g_Y = g_C \cdot c + g_I \cdot i + g_G \cdot g + g_{NX} \cdot nx. \qquad (1)$$

The contribution to the growth rate of each component is determined by the product of its growth rate and its share in the GDP (according to Formula (1)). Thus, we have four contributions to the GDP growth rate by expenditure (Sukharev, 2020).

Similarly, the contribution of sectors that add up to GDP is determined. The growth rate of each sector multiplied by the sector's share of GDP is the sector's contribution to the economic growth rate, and the sum of the contributions gives the overall growth rate.

The research algorithm comprises the following stages. First, we will devise a formula to measure the structure of economic growth in the countries of the Eurasian Union. Then we will calculate the growth structure by GDP expenditure and by the sectors that make up GDP (raw materials, processing and transaction sectors). We will rank the countries depending on the stability of their economic growth and conduct a regression analysis of the impact on the growth rate of certain parameters of macroeconomic policy: the key rate, level of monetization, oil prices, inflation.

These parameters, in our opinion, give a general idea of the current macroeconomic policy and its features, mainly monetary, since budget expenditures with the exception of Kazakhstan did not make the greatest contribution to economic growth. However, this exception outweighs the impact of other countries on this component of GDP. In the panel data, as will be shown below, the weighting factor of budget expenditures is the largest. A special parameter of economic policy is the world oil prices, whose changes provoke crises, in particular in the Russian economy.

The study interval covers the period from 2001 to 2019. The data source is the official statistics of the World Bank. The data are given in 2010 prices.

We will further analyze the economic growth models in the structure of GDP by expenditure and sectors for the EurAsEC countries in order to determine the current type of economic dynamics. This will shed light on the possibilities of integration, for example, the harmonization of development models. We can also identify the features of these models that may affect the format of further cooperation and strengthen or weaken the relationships within the Union.

Our research findings will be useful for developing further measures of economic cooperation between the Eurasian countries.

Results

Assessment of the economic growth structure of the Eurasian Economic Community

We apply the structural formula to make a quantitative assessment of the economic growth structure in the countries of the EurAsEC, considering the dynamics of GDP by expenditure and sectors. The calculation results are shown in Figures 1–6. The contribution of the sectors until 2018 was estimated by using the available statistics.

Figure 1 shows that Armenia and Belarus have mixed models of economic growth, which means that there is no single dominant component of GDP. However, in Belarus, investment spending makes a more significant contribution to growth than in Armenia, along with gross consumption. Net exports have a significant impact on the economy, unlike in Belarus, where gross consumption is also significant in terms of its impact on the rate, but net exports have a more modest impact. So, two components – gross consumption and investment spending – ensure the growth of these economies, and for Armenia, a third component is added – net exports. Thus, the growth model is mixed, because the contribution of these components is comparable over a significant period of time (Fig. 1). A significant impact of net exports on economic dynamics has been formed since 2009, and until that time, net exports were likely to slow down growth in both Armenia and Belarus. Since 2011, in Armenia, and since 2014, in Belarus, the growth in investment spending has been slowing down. Thus, these two components of GDP – net exports and investment spending – have gradually begun to change places after 2009, which determined the peculiarities of the structural models of economic growth in these countries. Government spending does not make a significant contribution to the growth rate for these countries.

Kazakhstan and Kyrgyzstan (Fig. 2) also have a rather mixed growth model, although in Kyrgyzstan the largest contribution to the growth rate is still made by gross consumption, so we can consider the current model as dominated by consumption. In 2009 and 2015, like in Russia (Fig. 3), in Kyrgyzstan, net exports were essentially resisting the crisis, that is, they accounted for a large part of the growth rate. The same is true for Armenia and Belarus, but not for Kazakhstan (Fig. 2, left). For Kazakhstan, government spending makes a more significant contribution to the growth rate than in other countries. This is a specific feature of the current model of growth and state regulation of the economy in Kazakhstan. Moreover, this model determines the overall result for the group of countries in terms of the impact of government spending on the growth rate, as will be shown below.

The Russian economy also has a consumer-driven growth model: its gross consumption has a major impact on the rate of economic growth (Fig. 3). Investment spending is the second most important contribution to the growth rate. In Kazakhstan, investment spending and net exports account for a large part of the rate of gross consumption and determine economic growth in some years (Fig. 2, left).

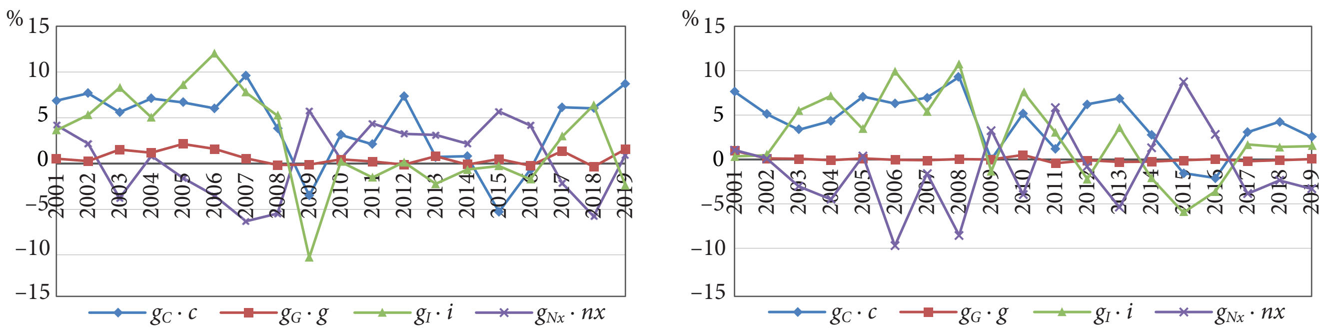

Figure 1. *Structural dynamics of GDP by expenditure in Armenia (left) and Belarus (right), 2001–2019*

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

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In 2009, the growth rate of the countries decreased, but only in Armenia and Russia this decline was very significant (the rate was extremely negative). Figures 4–5 show the accuracy of our calculations, which is quite acceptable, given that the UN statistics also states that the error can reach 5–10% in accounting, which can increase the discrepancy when calculating at certain points. However, the accuracy verified by the growth rate by comparing the actual and calculated values is acceptable (Figs. 4–5).

A very high accuracy of the calculations was achieved for the Russian economy (Fig. 5, right). Thus, the application of the structural formula allows us to identify the features of structural dynamics and the resulting model of economic growth. If we consider the three main growth models in the light of the dominance of the GDP component by contribution to the growth rate, we can distinguish between the mixed, investment-based and consumption-based models. Table 2 summarizes growth models of the countries of the EurAsEC.

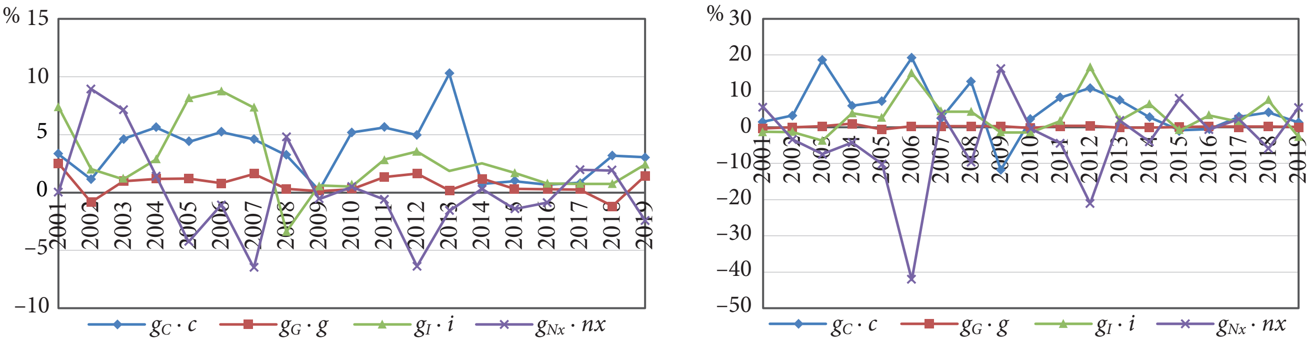

Figure 2. *Structural dynamics of GDP by expenditure in Kazakhstan (left) and Kyrgyzstan (right), 2001–2019*

Source: the authors' calculations were based on the official data from the World Bank.
Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

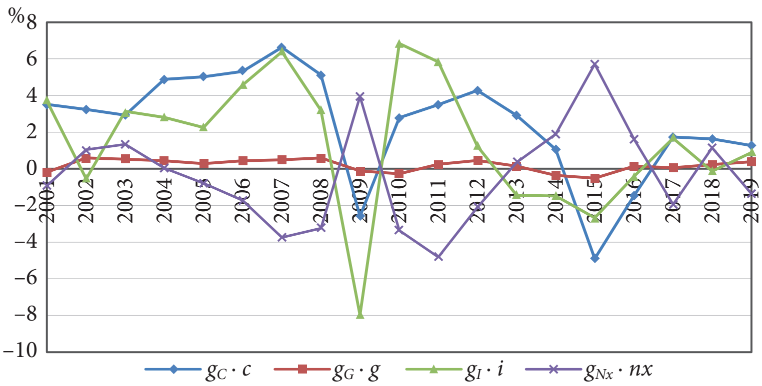

Figure 3. *Structural dynamics of GDP by expenditure in Russia, 2001–2019*

Source: the authors' calculations were based on the official data from the World Bank.
Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

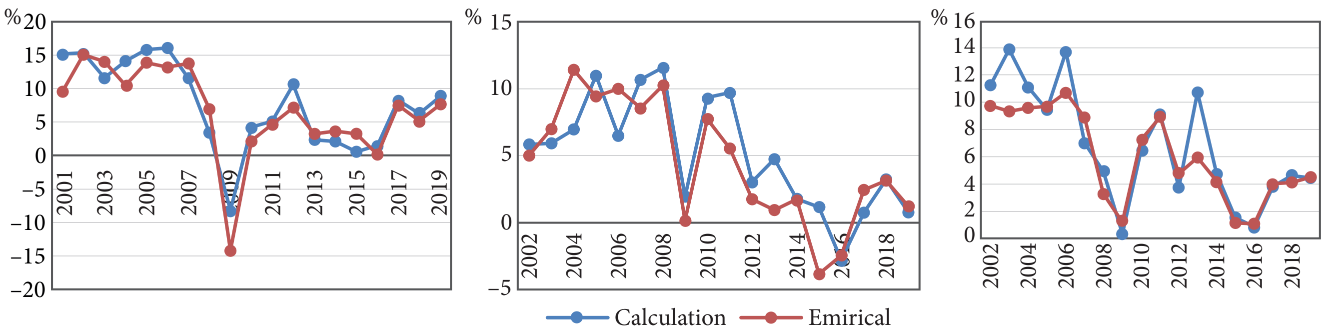

Figure 4. *The accuracy of the calculations for Armenia (left), Belarus (center) and Kazakhstan (right)*

Source: the authors' calculations were based on the official data from the World Bank.
Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

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As can be seen from Table 1 and Figures 1–5, net exports in many countries are the component that constrains growth, since the contribution of this component to the overall rate of this component is often negative. However, during the crisis of 2009 and even in the recession of 2015, it is net exports that resisted the crisis, that is, their contribution to the rate became positive in Russia, Kazakhstan, Armenia, and Belarus. Moreover, growth was generated first by investment spending in Armenia and Belarus, then by net exports, since 2009 for Armenia and since 2014 for Belarus. In fact, these two components change roles. For Kyrgyzstan, net exports mainly inhibit growth, but during the crises of 2009 and 2015 it was the net exports that resisted the recession.

Thus, the countries of the EurAsEC demonstrate not only different growth models but also respond differently to crises: four countries out of five through net exports, and Kazakhstan through investment spending. In addition, only Kazakhstan has the most significant contribution to the growth rate of government spending.

Now we are going to look at the sectoral dynamics of GDP, revealing the dominance of sectors in their contribution to the growth rate (Figs. 6–7).

Figures 8–9 confirm the fairly high accuracy of the calculations of the sectoral contribution to the GDP growth rate of the Eurasian countries.

Table 3 shows the current growth patterns based on the dominance of the sector structure, which makes it possible to rank countries according to the current growth model.

As can be seen from Table 2, Armenia shows a mixed pattern of growth, Belarus has an industrial-service model. Kazakhstan and Russia have a service model as the service sector makes the largest contribution to the growth of transaction sector. Kyrgyzstan has a service model and since 2016, an industrial-service model, as the country's manufacturing sector's contribution became the most significant. Therefore, in the given the period, the growth model can be described as service-industrial, although the negative dynamics of the industrial sector in Kyrgyzstan, as will be shown below, is very high.

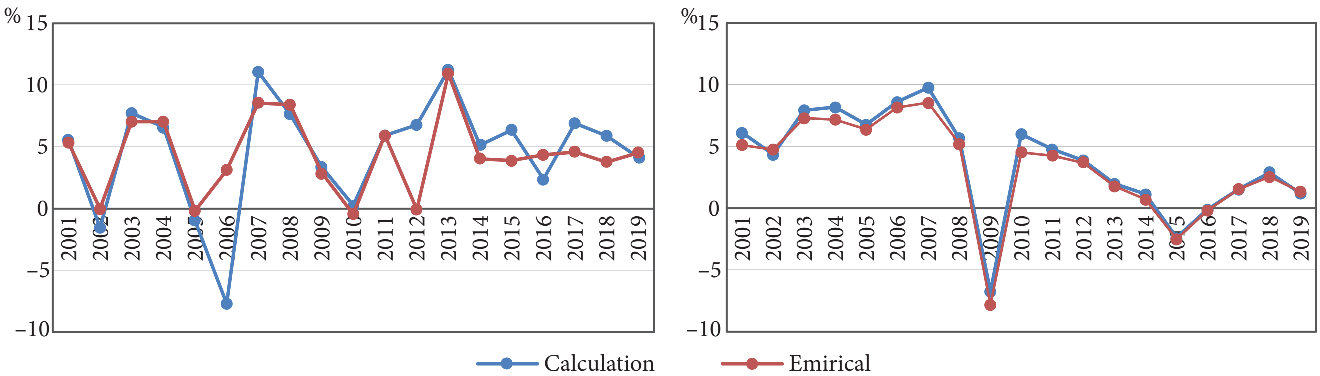

***Figure 5.** The accuracy of the calculations for Kyrgyzstan (left) and Russia (right)*

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

Table 2

Models of economic dynamics of the EurAsEC countries by GDP components, 2000–2019

Country	Main generator of growth	Component restraining the growth	Component that resisted the crisis of 2009	Economic dynamics model: consumption-based; investment-based; mixed
Armenia	Gross consumption, investment spendings, net exports	Net export	Net exports	Mixed
Belarus	Gross consumption, investment spendings, net exports	Investment expenses	Net exports	Mixed
Kazakhstan	Gross consumption, investment spendings, net exports	Net exports	Net exports	Mixed
Kyrgyzstan	Gross consumption	Investment expenses	Investment expenses	Mixed
Russia	Gross consumption	Net exports	Net exports	Consumption-based

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

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Thus, the above-described structural features of economic dynamics should be taken into account in policy-making. They should also be given due regard in the light of the economic integration within the Union. The factors that need to be considered are the current growth model, national economies' responses to recession and the role played by government spending in maintaining the growth rate. Only in Kazakhstan this influence is quite significant. It also matters which sectors dominate the economy. For instance, before 2008–2009, in Armenia and Belarus, the economies had been dominated by the manufacturing sectors (see Fig. 6 above), while the transaction sector was second, and the contribution to the growth rate of the raw materials sectors was not high. Since 2010, the situation has changed dramatically, the contribution of the manufacturing sector to the growth rate has sharply declined and it now plays

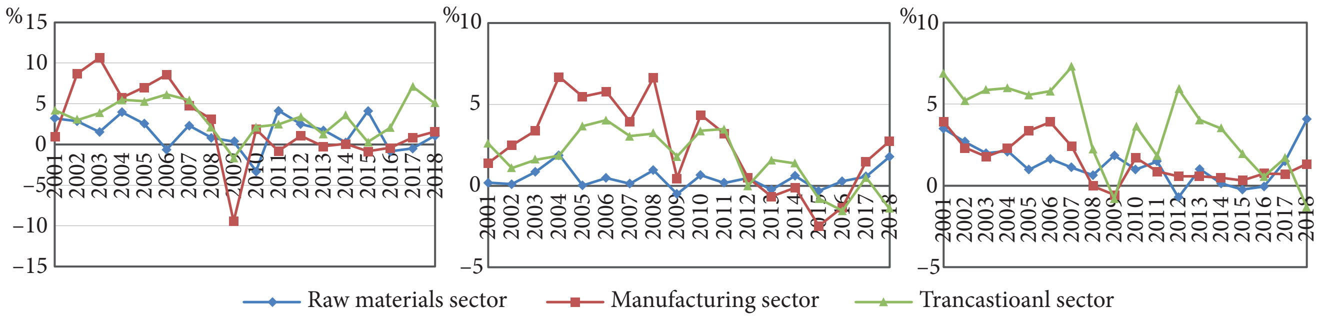

Figure 6. *Structural dynamics of GDP by sectors in Armenia (left), Belarus (center) and Kazakhstan (right), 2001–2018*

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

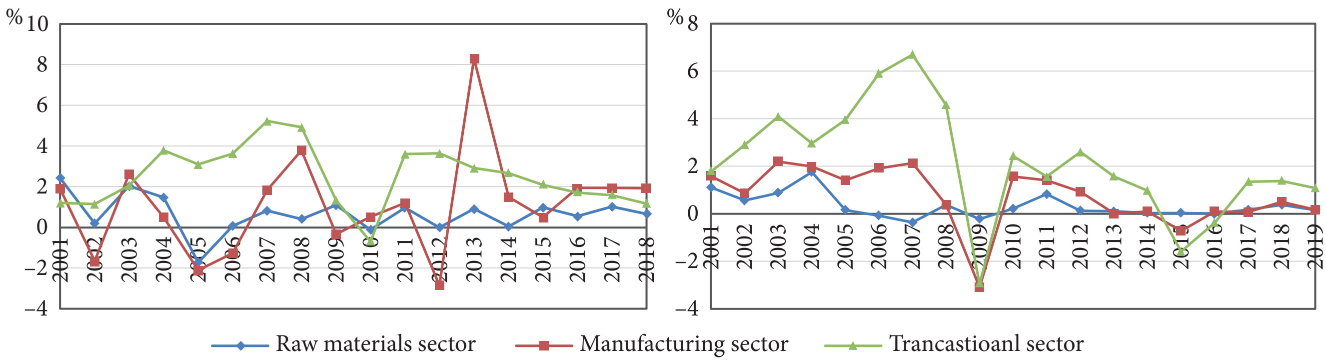

Figure 7. *Structural dynamics of GDP by sectors in Kyrgyzstan (left) and Russia (right), 2001–2018*

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed data: 17.08.2021)

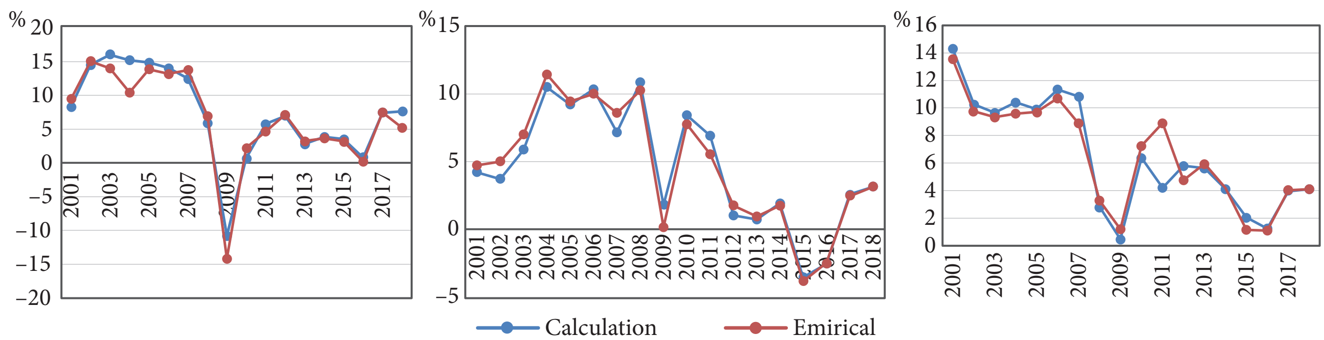

Figure 8. *Calculation accuracy by sectors of Armenia, Belarus and Kazakhstan, 2001–2018*

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

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but a negligible role in economic growth, while the transaction and raw materials sectors have gained significance. Only in 2017, after the stagnation in 2015–2016, manufacturing in Belarus regained its leading position in terms of the contribution to the growth rate. In Kazakhstan, the growth model is based on the transaction sector. It dominated the contribution to the growth rate in the entire period. Manufacturing is the second largest contributor, followed by the raw materials sector. In Kyrgyzstan, up to 2009 (Fig. 7, left), the dynamics had also been determined by the transaction sector, but the contribution of manufacturing was quite significant, commensurate with the contribution to the growth rate of the transaction sector. However, the contribution of the transaction sector began to fall in 2014. At the same time the role of manufacturing was increasing, and by 2016, manufacturing had become the leading sector in Kyrgyzstan. In Russia, the transaction sector dominates. It makes a much larger contribution to the growth rate than other sectors. The second largest sector is manufacturing, which proved to be more resistant to the crisis of 2015 than the transaction sector (Fig. 7, right).

Kazakhstan and Russia have similar growth models in the sectoral context. The transaction sector dominates in terms of contribution, but the models of economic growth in terms of GDP structure and spending for Kazakhstan and Russia differ significantly, including the response to crises and the importance of government spending that contributes to economic growth. Moreover, Kazakhstan has a clear advantage in this regard.

The growth models of Armenia and Belarus are somewhat similar in terms of sector contribution, but Belarus has a more developed manufacturing sector, which determines the dynamics. It should be noted that none of the countries of the EurAsEC has a model of growth based on the raw materials sector, that is, the domination of commodity sectors. Belarus has a model of industrial growth, Armenia has mixed model. Since 2010, the contribution of the raw materials sector to the growth rate has become second after the transaction, while until 2008, it was the manufacturing sector that was at the top. In Kazakhstan and Russia, there was a growth in the contribution of the services sector to GDP. Kyrgyzstan has a service-industrial model, so

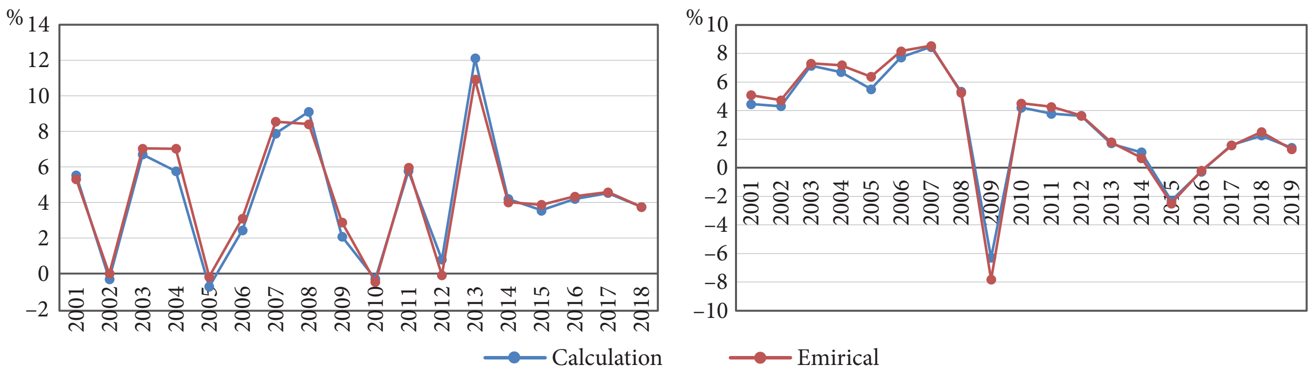

Figure 9. *The accuracy of the calculation by sectors of Kyrgyzstan and Russia, 2001–2018*

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

Table 3

Models of economic growth of the EurAsEC countries by sector, 2000–2018

Country	Sector generating most of the growth	Prevailing model (industrial, service, raw materials, mixed)
Armenia	Until 2009 the manufacturing and transaction sectors dominated. After the 2009 crisis – raw materials and transaction sector	Mixed
Belarus	Manufacturing sector, since 2012 – transaction sector	Industrial and service
Kazakhstan	Transaction sector	Service
Kyrgyzstan	Transaction sector	Service, since 2016 industrial service
Russia	Transaction sector	Service

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

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in 2016 the manufacturing sector played the key role in economic growth. It should be noted that these models are distinguished by the sector's contribution to economic dynamics, rather than by the sector's share in the country's GDP structure.

In the following parts of the article, we are going to apply this approach to assess the stability of the structural dynamics of growth in the countries of the EurAsEC. We will evaluate the stability of the dynamics by calculating the stability coefficient as the average largest deviation when the parameter fluctuates relative to the abscissa axis. The risk is estimated as the standard deviation of the contribution of GDP of each component and the overall growth rate for each country.

We need to estimate the coefficient of the stability of growth rates: the higher is the coefficient, the less stable is economic growth, due to the greater the average deviation from the time axis. The sum of deviations is divided by the number of corresponding largest vertices of deviations (see below). Table 4 shows the coefficient of stability of the GDP contribution by expenditure to growth rate (Table 4) and Table 5, GDP growth rate. Tables 6 shows the coefficient of stability of the sectors' contribution to GDP growth rate and Table 7, GDP growth rate. We rank countries by the stability coefficient, comparing the empirical and calculated values. The lower is the coefficient, the higher is the stability of growth rates.

As we can see from Table 5, the calculated and empirical estimates of stability differ. Armenia showed a very high level of instability. According to our calculations, there were two countries that were close in terms of stability: Belarus and Russia. In fact, Kyrgyzstan showed the most stable dynamics. This does not mean that the dynamics in Kyrgyzstan was better than in Belarus or Russia. We are talking about the average greatest deviation from the abscissa axis, that is, an assessment of the stability of growth rates. Of course, it is also necessary to take into account how much GDP has increased in terms of purchasing power parity in comparable assessment in each of the countries of the EurAsEC.

Table 6 shows the ranking of countries by the coefficient of stability of the contribution of sectors. Armenia shows high volatility regarding the contribution of the raw materials sector to GDP growth. Russia, on the other hand, is characterized by the most stable contribution of the raw materials sector to GDP among these countries. A similar situation is observed in the manufacturing sector, whose contribution to GDP was very unstable. Russia is the most stable in this sector, i.e. the sector's deviations from the abscissa axis are the smallest. In the transaction sector, there is a different trend: the largest deviations from the abscissa axis are in Kazakhstan, followed by Armenia, then Russia, Kyrgyzstan and Belarus.

Table 4

Ranking of countries by the stability coefficient of the contribution of GDP components by expenditure, 2001–2019

Country	$g_C \cdot c$	Country	$g_G \cdot g$	Country	$g_I \cdot i$	Country	$g_{Nx} \cdot nx$
Kyrgyzstan	9.61	Kazakhstan	1.02	Belarus	5.37	Kyrgyzstan	10.03
Armenia	5.20	Armenia	0.76	Kyrgyzstan	4.86	Belarus	5.07
Belarus	4.56	Russia	0.44	Armenia	4.21	Russia	3.59
Russia	3.84	Kyrgyzstan	0.37	Russia	3.80	Armenia	3.90
Kazakhstan	3.57	Belarus	0.17	Kazakhstan	2.75	Kazakhstan	3.26

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

Table 5

Ranking of countries by the stability coefficient of GDP growth rate (by expenditure): empirical and calculated values

Country	Calculation	Country	Empirical
Armenia	9.30	Armenia	9.58
Kazakhstan	7.77	Belarus	6.12
Kyrgyzstan	6.43	Kazakhstan	5.81
Russia	5.88	Russia	5.54
Belarus	5.44	Kyrgyzstan	4.20

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

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Table 6

Ranking of the countries according to the stability of their raw materials, transaction and manufacturing sectors' contribution to economic growth

Country	Raw materials sector	Country	Manufacturing sector	Country	Transaction sector
Armenia	2.22	Armenia	3.72	Kazakhstan	3.93
Kazakhstan	1.48	Belarus	3.58	Armenia	3.72
Kyrgyzstan	0.79	Kyrgyzstan	2.52	Russia	2.92
Belarus	0.60	Kazakhstan	1.35	Kyrgyzstan	2.93
Russia	0.50	Russia	1.26	Belarus	2.21

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

Table 7

Ranking of the countries according to the stability of GDP growth rate (by sector)

Country	Calculated	Country	Empirical data
Armenia	9.30	Armenia	9.58
Kazakhstan	7.77	Belarus	6.12
Belarus	6.43	Kazakhstan	5.81
Russia	5.88	Russia	5.54
Kyrgyzstan	5.44	Kyrgyzstan	4.20

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

We use standard deviation as a measure of risk of growth volatility in sectors' contributions to GDP growth rates in the EurAsEC in 2001–2018 (see Fig. 10). The risk is calculated as the standard deviation of the sector's contribution and growth rate of GDP, in percentage. Among the member countries, Armenia has the highest risk level in the raw materials and manufacturing sectors as well as in terms of GDP growth. Russia is characterized by the highest risk in the transaction sector. A similar level is characteristic of Kazakhstan – 2.3%.

Thus, Armenia demonstrates very unstable dynamics in manufacturing and in general economic development (shown by the stability coefficient and development risk).

The average risks of the contribution of the GDP component to GDP growth and the GDP growth rate in the EurAsEC countries in 2001–2019 are shown in Fig. 11. It is clear that Kyrgyzstan has the greatest risk in consumer spending, investment spending and net exports. However, in terms of the stability coefficient, Kyrgyzstan showed a very decent result when evaluated by sectors. Thus, there is a discrepancy not only in the empirical data and calculated estimates, but also in the assessment of structural dynamics by sectors

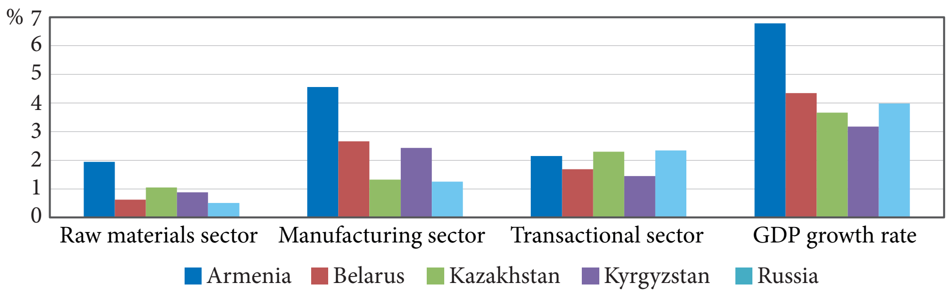

Figure 10. *Standard deviation (risk) of the sectors' contributions to GDP growth in member countries of the EurAsEC, 2001–2018*

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

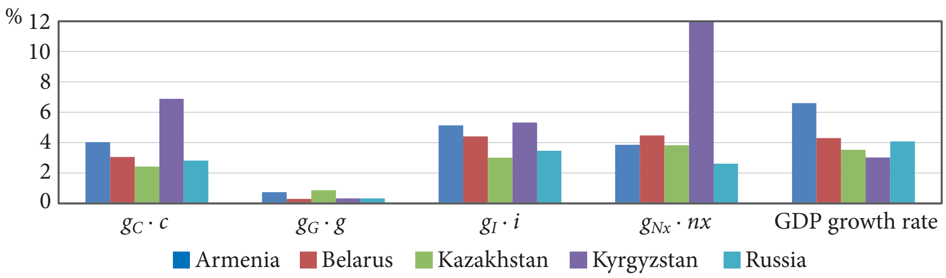

Figure 11. *Risks of the contribution of the GDP component by expenditure and GDP growth rate, 2001–2019*

Source: the authors' calculations were based on the official data from the World Bank. Retrieved from: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD (Accessed: 17.08.2021)

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and expenditure. Moreover, risk assessment may differ from the assessment made with the help of the stability coefficient. The risk may be high if the dynamics is relatively stable.

Let us now analyze the impact of some macroeconomic policy instruments on the growth rate (y) of the EurAsEC. The parameters of interest include the following: the price of Brent (brent), the key interest rate (i), the level of monetization ($M3/Y$, Y is GDP, $M3$ is money supply), and inflation (inflation). We use the Gretl 2020b software module to build a multiple regression of the growth rate for each of the countries, having 20 observation points (2000–2019), using the least squares method to obtain the regression, selecting a model with the best statistics (see Tables 7–11).

The selected models were tested and selected according to the Gretl 2020b software package, taking into account the tests shown in Appendices 1–2, to determine autocorrelation and heteroscedasticity and to evaluate the normal distribution.

Using a set of hypotheses (Greene, 2002), we test the regression models for their quality. The adequacy of the regression model to empirical data is checked based on the analysis of residuals. The analysis of the residuals shows how well the model is selected and how well the method of estimating the coefficients is chosen. According to the general assumptions of regression analysis, the residuals should behave as independent (in fact, almost independent), equally distributed random variables. The quality of regression models is estimated by the fulfillment of the OLS assumptions.

To test the regression for heteroskedasticity, the Breusch Pagan test was used. It is used if there is reason to believe that the error variance may depend on some set of observed variables. To check the first-order autocorrelation, the Breusch-Godfrey test is used, which is used to check the arbitrary-order autocorrelation in random errors of regression models. The test is asymptotic, meaning that a large sample size is required for the validity of the conclusions. To test these hypotheses, we constructed auxiliary regressions of the OLS residuals of the original model.

Table 1 in Appendix 1 presents the results of testing models (1)–(6) for heteroskedasticity using the Breusch Pagan test and first-order autocorrelation according to the Breusch-Godfrey test. The results confirm the hypothesis that all the models presented above are homoscedastic, since the critical chi-square value exceeds the test statistics in all cases. First-order autocorrelation tests confirm that there are no random errors in the autocorrelation models.

Figures 1–6 in Appendix 2 show the residue graphs for models (1)–(6). The selected regression models describe the dependence well, using independent, normally distributed random variables with zero mean, and there is no trend in their values.

To test the assumption of a normal distribution of errors, we construct normal distribution graphs based on point graphs (Fig. 7–12), on the vertical axis of which the values of the residuals are plotted, and on the horizontal axis – the corresponding quantiles of the standardized normal distribution. For the construction of these graphs, the values of the residuals are ordered in ascending order.

The data shown in Figure 7–12 does not differ too much from the normal distribution, since all points lie on or near the same straight line. The stability of the regression analysis and the small sample size suggest that the condition for the normal distribution of errors is slightly violated.

Figures 13–18 confirm that the resulting sample has a normal distribution.

The models selected according to the given criteria are arranged in alphabetical order: Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russia, the models numbered from 2 to 6.

$$y_{Armenia} = 10.3 + 0.02 \cdot brent - 0.3 \cdot \% + \\ + 0.1 \cdot M3 / Y - 0.4 \cdot inflation; \tag{2}$$

$$y_{Belarus} = 15.3 + 0.1 \cdot brent + \\ + 1.1 \cdot M3 / Y - 0.1 \cdot inflation; \tag{3}$$

$$y_{Kazakhstan} = 107 + 0.3 \cdot brent - 1.8 \cdot \% + \\ + 2.3 \cdot M3 / Y - 2.5 \cdot inflation; \tag{4}$$

$$y_{Kyrgyzstan} = 0.01 - 0.0004 \cdot brent + 0.1 \cdot \% + \\ + 0.2 \cdot M3 / Y - 0.02 \cdot inflation; \tag{5}$$

$$y_{Russia} = 844 + 1.8 \cdot brent - 12.9 \cdot \% + \\ 14.8 \cdot M3 / Y - 0.4 \cdot inflation. \tag{6}$$

Tables 1–5 (Appendix 3) by country confirm the significance of the models. The collinearity of the factors in the models were not found. The remaining criteria are shown in the tables and reflect the satisfactory selection of models from the point of view of statistical estimates.

Thus, the selected models adequately describe the real processes: the residuals are uncorrelated and normally distributed, the condition of homoscedasticity is met, i.e., all the residuals fit into a symmetric band relative to the zero line, then we can assume that the variance of the observation errors is constant.

The results are summarized in Table 8, which reflects the qualitative impact of the increasing parameters on the growth rate. If the impact is positive, it means that an increase in this parameter led to an increase in the growth rate. If the impact is negative, then, on the contrary, an increase in this parameter led to a fall in the growth rate. If the parameter had almost no impact, then the table adds a rating of weak positive or negative impact.

As can be seen from Table 9, a common sign of growth in the countries was the positive impact of the level of monetization on the growth rate. The increase in the price of oil contributed to the growth of the Russian economy. For other countries, this influence was negligible. For all of the countries, except for Belarus, the interest rate had a negative impact on the growth rate. Inflation had a weak negative impact on the economic growth in Russia but in Armenia and Kazakhstan an increase in inflation had a considerable negative impact on the growth rates. This difference is fundamental, since it means that these countries cannot pursue an identical policy in terms of curbing inflation, provided that a reduction in the interest rate stimulates growth and monetization in all of these countries. The reduced raw material component of growth for all the countries, with the exception of Russia, makes their growth independent of the oil prices.

Using panel data for five countries of the EurAsEC to estimate the contribution of the GDP component to the growth rate, we obtained the following model:

$$y = 0.77 \cdot g_C \cdot c + 1.26 \cdot g_G \cdot g + 0.91 \cdot g_I \cdot i + 0.69 \cdot g_{Nx} \cdot nx, \quad (7)$$

where y is the GDP growth rate; *C*, *i*, *g*, *nx* are the share of consumption, investment, government spending and net exports in GDP; *gC*, *gI*, *gG*, *gNx* are the growth rate of each of the GDP components by expenditure.

The best model showed a significant dependence of dynamics on fiscal policy and a very low dependence on net exports. Therefore, the trade relations of the Union countries are expected to develop further and their impact on the economic growth rate of the countries will also grow.

Table 8

Influence of the increasing parameters on the economic growth rates of the Union's member states, 2000–2019

Country	Oil prices	Interest rate	Level of monetization	Inflation
Armenia	Weakly positive	Negative	Positive	Negative
Belarus	Weakly positive	Absent	Positive	Weakly negative
Kazakhstan	Weakly positive	Negative	Positive	Negative
Kyrgyzstan	Weakly positive	Negative	Positively	Weakly negative
Russia	Positive	Negative	Positive	Weakly negative

Source: the authors' calculations were based on the official data from the World Bank.

Table 9

Statistics of the growth rate model of the Union member countries*

	Coefficient	Standart error	*t*-statistics	*p*-value	
Consumption	0.772508	0.0514548	15.01	< 0.0001	***
Government	1.25839	0.345555	3.642	0.0004	***
Investment	0.910725	0.0624419	14.59	< 0.0001	***
Nx	0.691936	0.0444464	15.57	< 0.0001	***

Average of the dependent variable	5.053740	Standard deviation of the dependent variable	4.670178
Sum of squared errors	346.7950	Standard error	1.952162
R^2	0.922530	R^2_{adj}	0.830848
$F(4, 90)$	270.9129	P-value (F)	1.23e-49
Loglikelihood function	−196.3049	Akaike criterion	400.6097
Schwartz criterion	410.8253	Hannan–Quinn Criterion	404.7376
Rho parametr	−0.064097	Durbin-Watson Statistics	2.046204

* The model was selected using the least squares method, 95 observations were used; 5 spatial objects were included, and the time series length was 19.

Source: the authors' calculations were based on the Gretl.

The results also suggest that due to the differences in certain parameters and economic dynamics, it is yet impossible to apply the same tools as part of the macroeconomic policy for all the members of the Union.

Discussion

Armenia, Belarus, Kazakhstan, Kyrgyzstan and Russia have formed the Eurasian Economic Union in order to promote closer economic cooperation between the states. The Union, however, is going through a difficult period due to the marked deterioration in economic conditions as well as the ongoing conflict between Russia and Ukraine and the lack of the necessary level of trust between the member states (Mostafa and Mahmood, 2018).

After the financial crisis of 2015–2016, the fall in the oil prices and new sanctions imposed on Russia, the economies of the member countries experienced an economic downturn. The research on the Eurasian Union mainly focuses on the individual aspects of the integration – trade and customs, the effects of state ownership and business models on financial and capital stability of banks of the Union, the effect of sanctions on the economic leader of the Union – Russia, foreign economic activity or investment (Pak, 2019; Hartwell, 2013; Nurgaliyeva, 2016; Mostafa, 2013; Shibasaki et al., 2021; Saivetz, 2021; Galiakberov and Abdullin, 2014; Hale, 2010; Gurova et al., 2018; Zahorka and Sargsyan, 2014). At the same time, we have not found any works discussing the structural model of economic growth or its changes, especially involving comparative structural analysis of growth in the countries of the Eurasian Union. The lack of such research creates difficulties for the coordination of measures of macroeconomic policy, which has its own specific impact on the economies of member countries.

This study looked at the crises, especially currency crises in the member states, which affected these countries' competitiveness and trade relations, in the context of various measures for coordination of the member states' monetary policies within the Union. Moreover, unlike previous studies (see, e.g. Vinokurov et al., 2017), we included into our analysis the structure of economic growth and the impact of macroeconomic policy instruments on economic growth. The impact of the country's membership in the Eurasian Union was also estimated based on regression models, revealing low financial benefits and an increase in the trade deficit with Russia (Libman, 2006; Khitakhunov et al., 2017; Bayramov et al., 2019).

Structural analysis showed the difference in the current patterns of economic growth and regulatory methods applied in member countries. In contrast to other works (Bezrukov, 2018; Salnikov et al., 2016; Patalakh, 2018), which did not take into account the structure of growth, the impact of economic policies and stability of growth, our study investigates the structure of growth, the stability of growth rates and the influence of economic policies in the Union's member countries.

Conclusion

Our research findings can be summarized as follows.

First, the countries of the EurAsEC have different economic growth patterns, which can be seen from the analysis of their GDP dynamics, both in terms of expenditure and sectors.

Second, the stability of growth, as measured by each component of GDP or sector dynamics, also differs considerably. The Russian economy in 2001-2019 showed less stable growth than the economies of Kazakhstan and Kyrgyzstan, but more stable than the economies of Armenia and Belarus. This can be seen from the stability coefficient, which shows the magnitude of deviations when the relevant parameter fluctuates. The contribution of investment spending and gross consumption showed better stability in Kazakhstan than in other countries. The contribution of the raw materials sector was most stable in Belarus and Russia. However, the value of this contribution differs significantly. The spread of values characterizing the contribution of the manufacturing sector was smaller for Kazakhstan and Russia (the standard deviation is 1.3 for both countries). The transaction sector for Russia is the most unstable in terms of its contribution to the rate (the standard deviation is 2.4, while for other Eurasian countries it is lower).

There were also differences between the countries in terms of macroeconomic policy instruments. While the level of monetization had an equally strong impact on the countries' economies, inflation had a completely different impact: in Armenia and Kazakhstan it significantly slowed down growth, while in other countries it did not have an equal impact on the economic development. An increase in the interest rate,

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however, have always had a negative effect on the growth rate. The only country that was strongly affected by the oil prices was Russia.

Our analysis based on the proposed methodology has revealed the models of economic growth that affect the relationships between the member states of the Union. Since net exports do not determine the economic dynamics, there is a need for extra efforts on the part of member countries to stimulate trade within the Union, which was one of the Union's key goals.

These research findings can be useful for the development of the Union's strategy as they show the factors of structural dynamics and the impact of the countries' economic models on their cooperation. It is shown that coordinated macro-economic measures within the EurAsEC are required in order to ensure the Union's more balanced economic development. The question as to how the membership in the Union will affect the general dynamics of the member countries is open for debate and requires further research.

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Appendix 1

Table 1

Test for heteroskedasticity and first-order autocorrelation in the EurAsEC countries

Country	Breusch-Pagan test		Breusch-Godfrey test	
	test statistics: LM	p-value	test statistics: LMF	*p*-value
Armenia	4.265364	0.371282	1.108738	0.31
Belarus	3.772477	0.437673	0.219447	0.647
Kazakhstan	3.286443	0.511083	9.771558	0.00744
Kyrgyzstan	3.824050	0.430341	0.811321	0.383
Russia	3.572844	0.466889	0.021520	0,886
EurAsEC countries	45.633547 (White test)	0.000032	20.7249	3.20236e-005

Source: the authors' calculations were based on the Gretl.

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Appendix 2

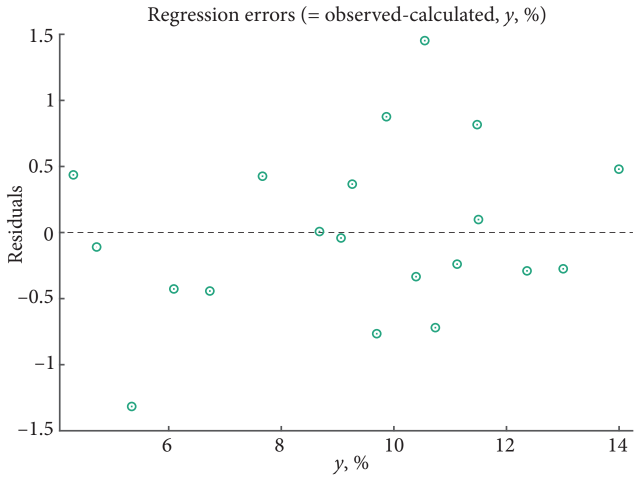

Figure 1. *Residuals in the model (Armenia)*
Source: the authors' calculations were based on the Gretl

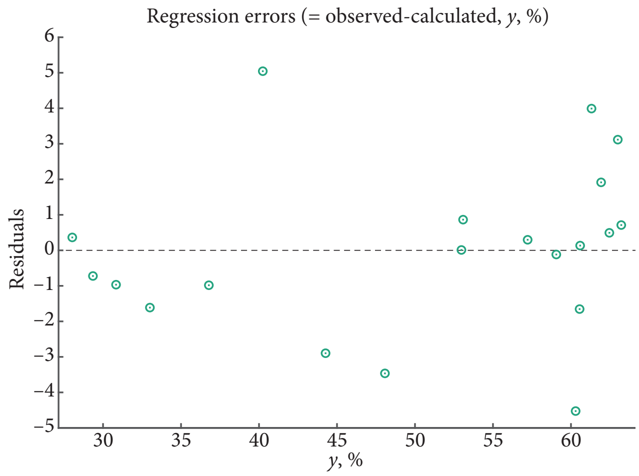

Figure 2. *Residuals in the model (Belarus)*
Source: the authors' calculations were based on the Gretl

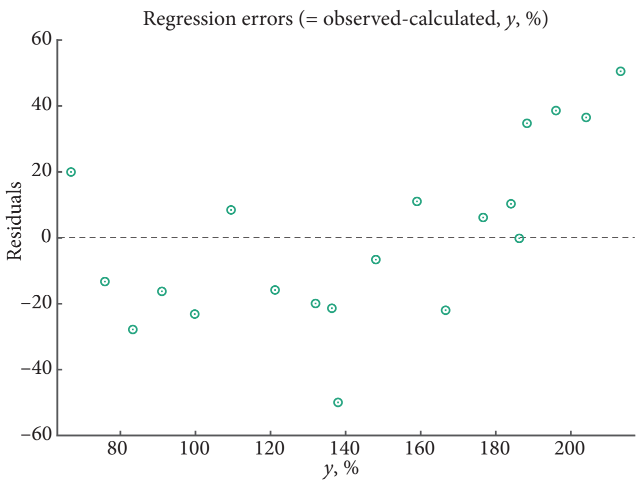

Figure 3. *Residuals in the model (Kazakhstan)*
Source: the authors' calculations were based on the Gretl

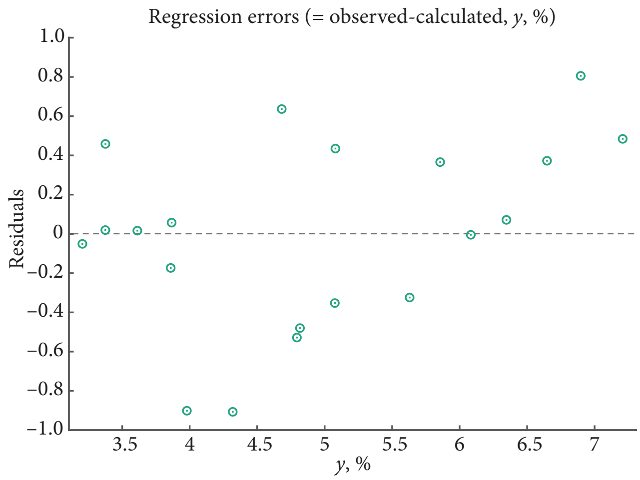

Figure 4. *Residuals in the model (Kyrgyzstan)*
Source: the authors' calculations were based on the Gretl

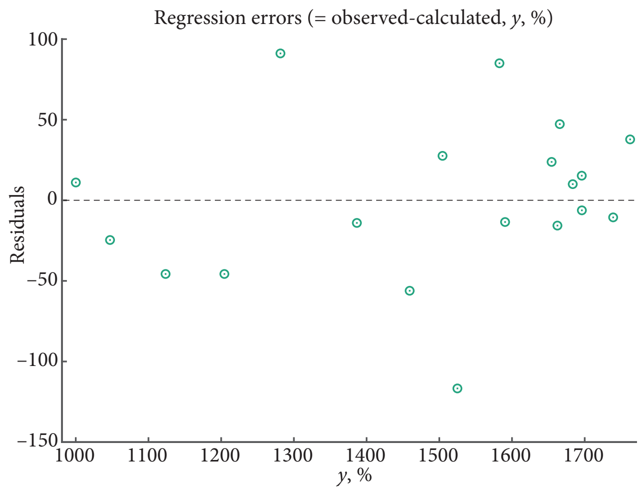

Figure 5. *Residuals in the model (Russia)*
Source: the authors' calculations were based on the Gretl

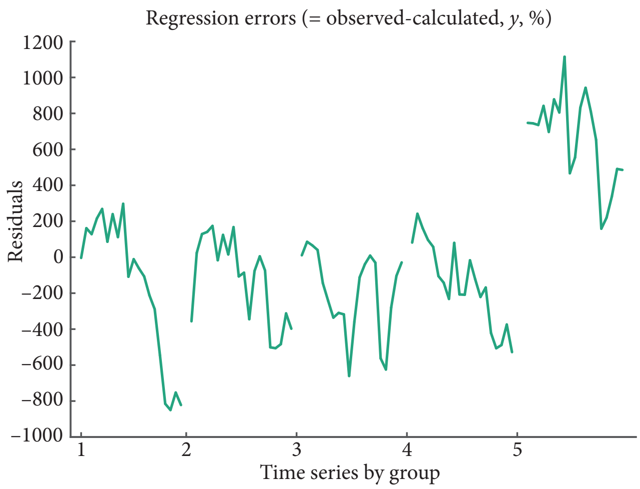

Figure 6. *Residuals in the model (EurAsEC countries)*
Source: the authors' calculations were based on the Gretl

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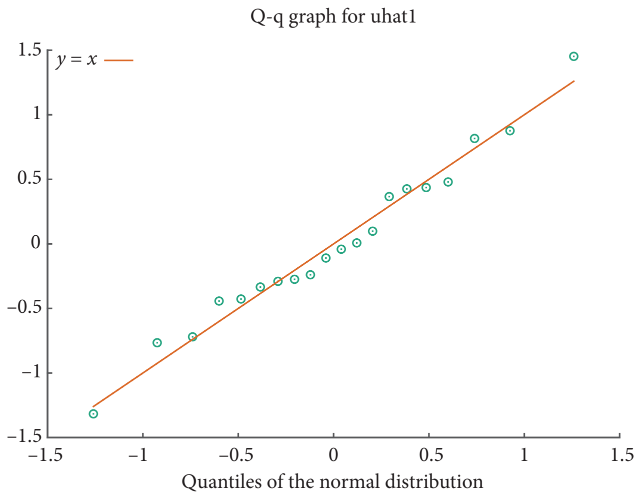

Figure 7. *Q-q plot for the model (Armenia)*
Source: the authors' calculations were based on the Gretl

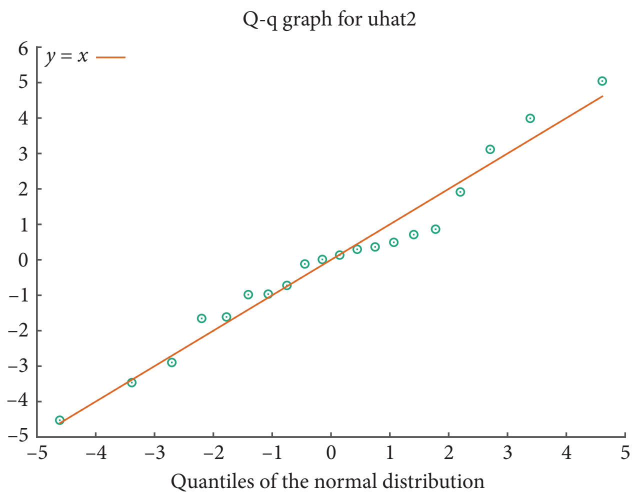

Figure 8. *Q-q plot for the model (Belarus)*
Source: the authors' calculations were based on the Gretl

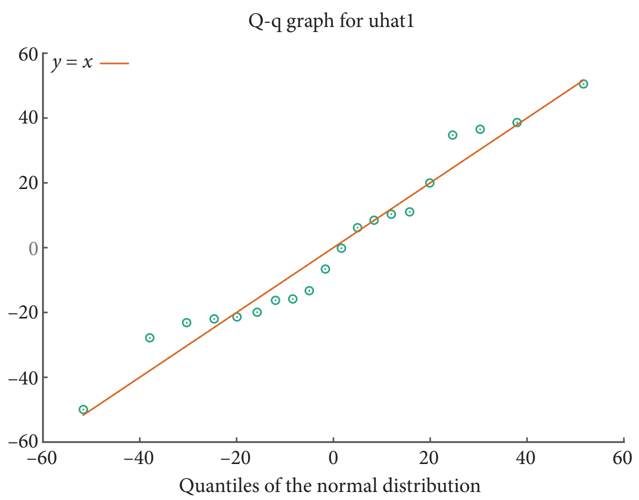

Figure 9. *Q-q plot for the model (Kazakhstan)*
Source: the authors' calculations were based on the Gretl

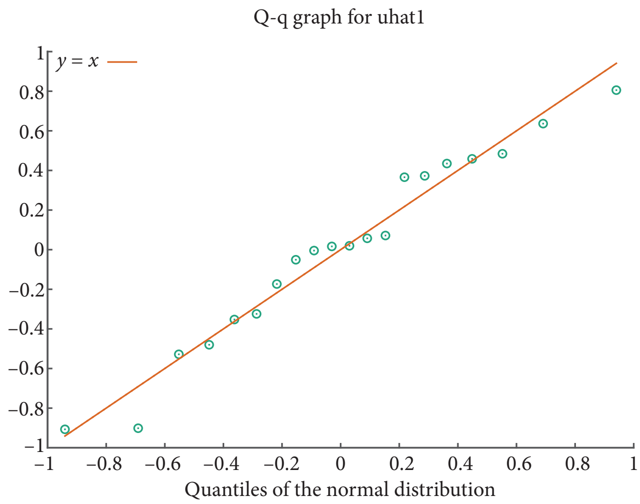

Figure 10. *Q-q plot for the model (Kyrgyzstan)*
Source: the authors' calculations were based on the Gretl

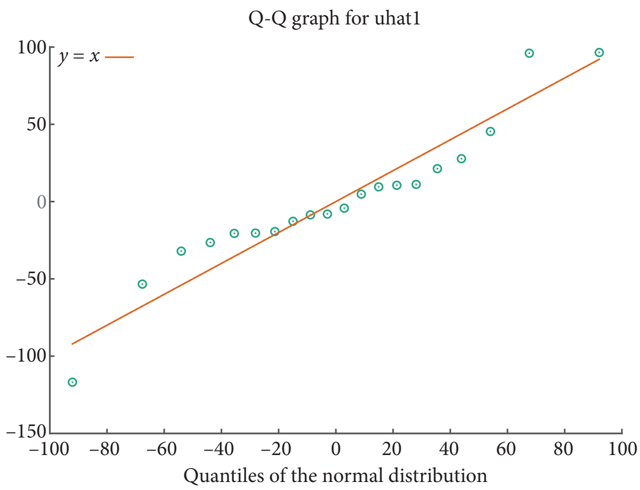

Figure 11. *Q-q plot for the model (Russia)*
Source: the authors' calculations were based on the Gretl

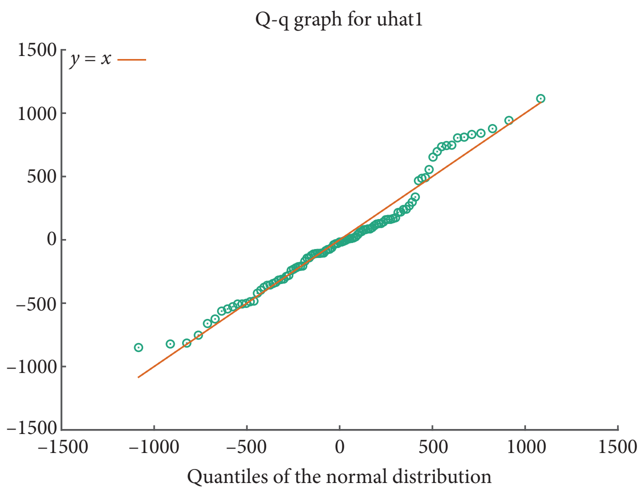

Figure 12. *Q-q plot for the model (EurAsEC countries)*
Source: the authors' calculations were based on the Gretl

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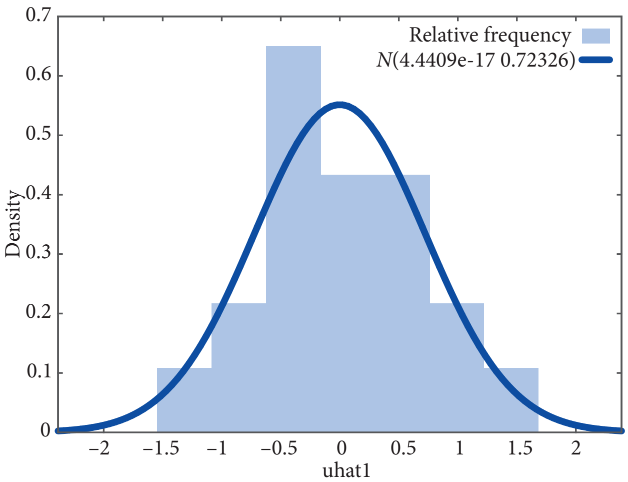

Figure 13. *Test for the normal distribution in the model (Armenia)*

Source: the authors' calculations were based on the Gretl

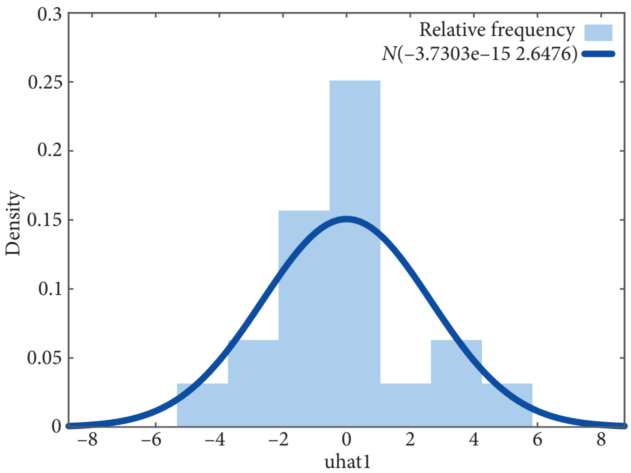

Figure 14. *Test for the normal distribution in the model (Belarus)*

Source: the authors' calculations were based on the Gretl

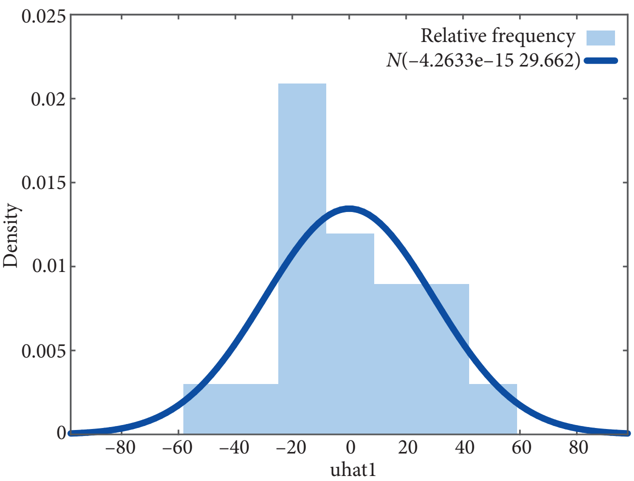

Figure 15. *Test for the normal distribution in the model (Kazakhstan)*

Source: the authors' calculations were based on the Gretl

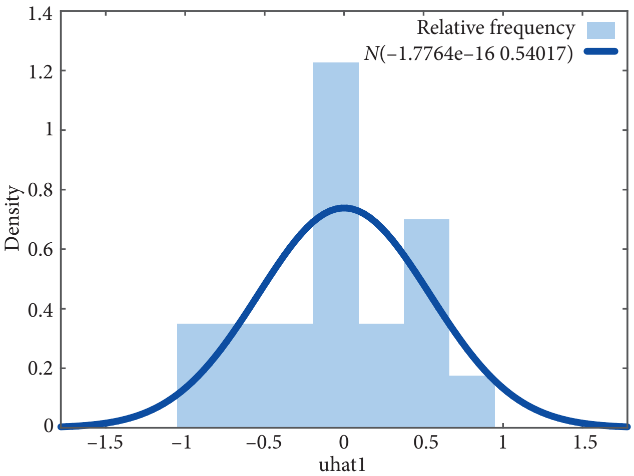

Figure 16. *Test for the normal distribution in the model (Kyrgyzstan)*

Source: the authors' calculations were based on the Gretl

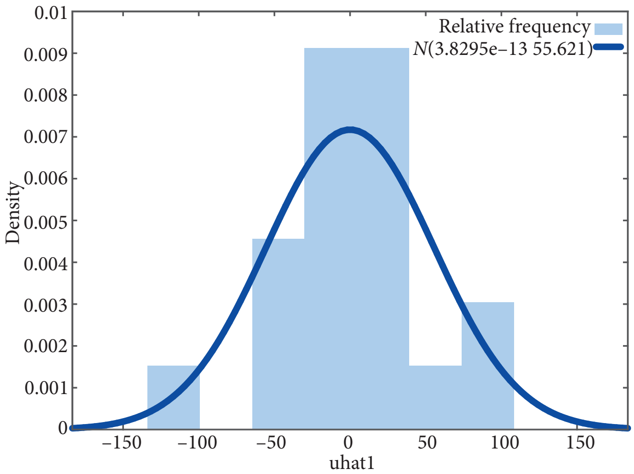

Figure 17. *Test for the normal distribution in the model (Russia)*

Source: the authors' calculations were based on the Gretl

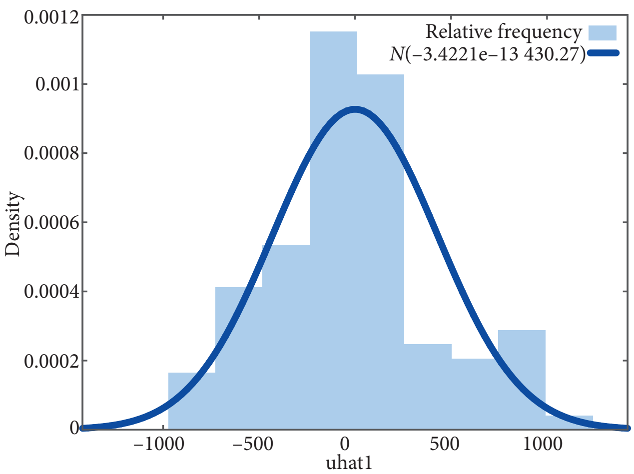

Figure 18. *Test for the normal distribution in the model (EurAsEC countries)*

Source: the authors' calculations were based on the Gretl

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Appendix 3

Table 1

Statistics of the Armenian growth rate model

	Coefficient	Standart error	*t*-statistics	*p*-value	
const	10.3191	2.13992	4.822	0.0002	***
Brent	0.0151948	0.00686416	2.214	0.0428	**
%	−0.274482	0.0676599	−4.057	0.0010	***
Broad money of GDP	0.120732	0.0290688	4.153	0.0008	***
Inflation	−0.373690	0.177579	−2.104	0.0526	*

*** – level of statistical significance 0.001; ** – level of statistical significance 0.05; * – level of statistical significance 0.01.

Average of the dependent variable	9.328621	Standard deviation of the dependent variable	2.762209
Sum of squared errors	7.846544	Standard error	0.723259
R^2	0.945873	R^2_{adj}	0.931440
$F(4, 15)$	65.53188	P-value (F)	2.56e-09
Log likelihood function	−19.02218	Akaike criterion	48.04436
Schwartz criterion	53.02302	Hannan–Quinn Criterion	49.01625
Rho parametr	0.270254	Durbin-Watson Statistics	1.421764

Source: the authors' calculations were based on the Gretl.

Table 2

Statistics of the Belarusian growth rate model

	Coefficient	Standart error	*t*-statistics	*p*-value	
const	15.3308	2.42285	6.328	< 0.0001	***
Brent	0.138603	0.0220748	6.279	< 0.0001	***
Broad money of GDP	1.06027	0.0934121	11.35	< 0.0001	***
Inflation	−0.0567762	0.0150982	−3.760	0.0017	***

Average of the dependent variable	50.31556	Standard deviation of the dependent variable	12.81771
Sum of squared errors	106.2658	Standard error	2.577133
R^2	0.965958	R^2_{adj}	0.959575
$F(3, 16)$	151.3344	P-value (F)	5.93e-12
Log likelihood function	−45.08089	Akaike criterion	98.16177
Schwartz criterion	102.1447	Hannan–Quinn Criterion	98.93928
Rho parametr	−0.079468	Durbin-Watson Statistics	2.153116

Source: the authors' calculations were based on the Gretl.

Table 3

Statistics of the Kazakhstan's growth rate model

	Coefficient	Standart error	*t*-statistics	*p*-value	
const	106.563	54.4100	1.959	0.0690	*
Brent	0.321985	0.263432	1.222	0.2405	
%	−1.83095	1.65542	−1.106	0.2861	
Broad money of GDP	2.31874	1.07418	2.159	0.0475	**
Inflation	−2.47042	1.10129	−2.243	0.0404	**

Average of the dependent variable	143.8082	Standard deviation of the dependent variable	45.45958
Sum of squared errors	13197.48	Standard error	29.66196
R^2	0.663886	R^2_{adj}	0.574256
$F(4, 15)$	7.406930	P-value (F)	0.001680
Log likelihood function	−93.29926	Akaike criterion	196.5985
Schwartz criterion	201.5772	Hannan–Quinn Criterion	197.5704
Rho parametr	0.652263	Durbin-Watson Statistics	0.724158

Source: the authors' calculations were based on the Gretl.

Table 4

Statistics of the Kyrgyz growth rate model

	Coefficient	Standart error	*t*-statistics	*p*-value	
const	0.0123861	0.941768	0.01315	0.9897	
Brent	−0.000358849	0.00625004	−0.05742	0.9550	
%	0.0607081	0.0350755	1.731	0.1040	
Broad money of GDP	0.155768	0.0233123	6.682	<0.0001	***
Inflation	−0.0197644	0.0230170	−0.8587	0.4040	

Average of the dependent variable	4.935439	Standard deviation of the dependent variable	1.255097
Sum of squared errors	4.376733	Standard error	0.540169
R^2	0.853768	R^2_{adj}	0.814773
$F(4, 15)$	21.89423	P-value (F)	4.05e-06
Log likelihood function	−13.18447	Akaike criterion	36.36895
Schwartz criterion	41.34761	Hannan–Quinn Criterion	37.34083
Rho parametr	0.156768	Durbin-Watson Statistics	1.649102

Source: the authors' calculations were based on the Gretl.

Table 5

Statistics of the Russian growth rate model

	Coefficient	Standart error	*t*-statistics	*p*-value	
const	877.087	163.215	5.374	<0.0001	***
Brent	1.79719	0.535905	3.354	0.0047	***
%	−12.8581	5.51088	−2.333	0.0351	**
Broad money of GDP	14.8467	1.85116	8.020	<0.0001	***
Inflation	−0.409906	3.06542	−0.1337	0.8955	

Average of the dependent variable	1487.630	Standard deviation of the dependent variable	244.2015
Sum of squared errors	43312.15	Standard error	55.62126
R^2	0.959650	R^2_{adj}	0.948122
$F(4, 14)$	83.24162	P-value (F)	1.34e-09
Log likelihood function	−100.4115	Akaike criterion	210.8229
Schwartz criterion	215.5451	Hannan–Quinn Criterion	211.6221
Rho parametr	0.030295	Durbin-Watson Statistics	1.905639

Source: the authors' calculations were based on the Gretl.

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From 'candidates' to 'grandmasters': internationalization strategies of universities

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ABSTRACT
Relevance. Higher education is one of the main areas for the development of national and world economy. To remain competitive on the national and international markets of higher education, universities need to invest considerable financial, human and other resources into internationalization. There is, however, no 'one-size-fits-all' solution and universities may choose from an array of strategies to become more visible on the international arena and to move up the global rankings.
Research objective. The purpose of this article is to clarify the concept of internationalization in the field of higher education, to identify the key factors that influence universities' success in internationalization and to explore the strategies and activities used by universities from different countries to internationalize.
Materials and Methods. Methodologically, this study relies on the methods of directed content analysis, cluster analysis with SPSS statistics, case studies and interviews. The sample included 32 universities from Western Europe, China and Japan, Russia and the USA – participants of international programs of competitiveness enhancement.
Results. 7 key factors that determine the success of a university's internationalization efforts were identified, the most important of which are financial resources and international interaction. The study also proposes a methodology based on calculation of the internationalization index, which can be applied to determine this or that university's type and choose the optimal activities to enhance its internationalization.
Conclusions. Relocation of the university to a type (cluster) of a higher level through the implementation of the proposed activities can be considered as a modern way of their internationalization.

KEY WORDS
internationalization of higher education, world class university, comparative analysis, integration into the world economic system, university internationalization, types of universities

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От «кандидатов» к «гроссмейстерам»: стратегии интернационализации университетов

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АННОТАЦИЯ
Актуальность. Высшее образование – одно из основных направлений развития национальной и мировой экономики. Чтобы оставаться конкурентоспособными на национальном и международном рынках высшего образования, университетам необходимо инвестировать значительные финансовые, человеческие и другие ресурсы в интернационализацию. Однако универсального решения не существует, и университеты могут выбирать из множества стратегий, чтобы стать более заметными на международной арене и подняться в глобальных рейтингах.
Цель статьи – прояснить концепцию интернационализации в сфере высшего образования, выявить ключевые факторы, влияющие на успех университетов в интернационализации, а также изучить стратегии и действия, используемые университетами из разных стран для интернационализации.
Данные и методы. Методологически данное исследование опирается на методы направленного контент-анализа, кластерный анализ в SPSS, тематические исследования и интервью. В выборку вошли 32 университета из

КЛЮЧЕВЫЕ СЛОВА
интернационализация высшего образования, университеты мирового класса, сравнительный анализ, интеграция страны в мирохозяйственную систему, факторы интернационализации университетов, типы университетов

Западной Европы, Китая и Японии, России и США – участников международных программ повышения конкурентоспособности.
Результаты. Были определены 7 ключевых факторов, определяющих успех усилий университета по интернационализации, наиболее важными из которых являются финансовые ресурсы и международное взаимодействие. В исследовании также предлагается методология, основанная на расчете индекса интернационализации, с помощью которой можно определить тип того или иного университета и выбрать оптимальные направления деятельности для усиления его интернационализации.
Выводы. Перемещение университета в тип (кластер) более высокого уровня за счет реализации предложенных мероприятий можно рассматривать как современный способ их интернационализации.

ДЛЯ ЦИТИРОВАНИЯ
Beliaeva, V.S., & Frolova, E.D. (2021) From 'candidates' to 'grandmasters': internationalization strategies of universities. *R-economy*, *7*(4), 266–275. doi: 10.15826/ recon.2021.7.4.023

Introduction

Higher education is one of the areas of national economy which has recently attracted a lot of scholarly attention, since it is one of the main elements of the knowledge economy along with R&D, IT, and knowledge dissemination[1]. This article builds on and develops the understanding of internationalization of higher education as the inclusion of the international dimension in the educational process (Hans de Wit, 2019).

Internationalization of higher education has been a major trend in Russia as well. In fact, it is one of the key goals of the national project 'Export of Education'[2]. Its successful implementation is based on new forms and directions of the internationalization of universities as the main providers of educational services, since the traditional methods no longer cover the entire range of tasks (Danilchenko, 2015).

The purpose of this article is to clarify the concept of internationalization in the field of higher education, to identify the key factors that influence universities' success in internationalization and to explore the strategies and activities used by universities from different countries to internationalize.

Theoretical framework

Even though systematic studies of internationalization in higher education began only in the 1980s, as of today, in this area sufficient knowledge has been accumulated, which needs to be systematized.

[1] Asmyatullin, R.R. (2021) Export strategies of universities in the world market of educational services. Abstract of the dissertation for the degree of Cand.Sc. (Economics). Moscow: RUDN.32 p.

[2] Start of the priority project 'Development of the export potential of the Russian education system' until 2025 (as a continuation of the 'Concept for the export of educational institutions of the Russian Federation for the period 2011–2020').

Modern approaches to internationalization in higher education

Table 1 provides a general overview of the key concepts related to internationalization of higher education (*hereinafter – HE internationalization*).

The concepts described above reflect different aspects of internationalization; therefore, it is necessary to use them all comprehensively in order to understand the nature of modern HE internationalization.

Internationalization of universities: from local to global players

The international activity of a modern university includes several areas: export of higher education systems, dissemination of research results, academic mobility of students and scientists (Hans de Wit, 2019). The types of international activities depend on whether the university is publicly funded or uses specialized funds (Ayse Nil, 2018). Other forms of internationalization include creating exchange programs for students, lecturers, and researchers (exchange programs, internships); developing and implementing educational programs that meet international standards; attracting faculty members from the world labour market, increasing the number of faculty members participating in international conferences and competitions; stimulating the faculty to obtain foreign postgraduate and doctoral degrees; increasing the number of publications in international journals; expanding opportunities for obtaining grants in foreign organizations.

However, not all universities are able to compete successfully in the global market. Researchers have repeatedly emphasized that the greatest effect is achieved in large universities, which are sometimes described as 'global in size' (Sergeev & Ryzhkova, 2010). R. Asmyatullin draws an analogy with TNCs, emphasizing that 'to increase competitiveness, the trends towards consolidation and integration in the education system have intensified; … large global players appear, which offer various courses and have many campuses in different countries – equivalent of transnational companies in the global market of educational services, for example, companies Navitas, Academies Australasia, Apollo Education Group and many others'. Hans de Wit (2019) points out that an organization like a university is global in its nature.

Development trends in the world include formation of elite universities, which create competitive educational products. There may be not one but a range of university models (the current model is designated as University 4.0) – 'evolutionary and informative models of a world-class university' (Pavlov and Zashchina, 2020, p. 687). However, only the combination of these models can help universities achieve success on the international market. Moreover, the leaders of the world economy, as was mentioned above, operate within the framework of large companies, most often TNCs. In the light of the above, universities appear to be naturally evolving into world-class educational institutions.

World-class universities are diverse, although not so numerous. They form the 'agenda' and directions for the development of higher education in the world, they are fighting for a top positions in world rankings, they are chosen by students as places for education and teachers as places for employment. Therefore, we consider the transformation of national universities into world-class universities as a new way of internationalization.

In connection with the above, there are two problems that should be considered: firstly, it is necessary to identify the types of universities that assume the role of global players; secondly, to develop strategies to promote regional and national universities on the international market.

Data and Methods

The research includes several stages.

Stage 1. Identification of the factors of university internationalization.

At this stage, we searched the key phrase "internationalization factors" through the databases Scopus, Web of Science, and EBSCO; then, an extra search word "universities" was added. We also analysed the data from the QS, THE, ARWU and MosIUR rankings, then the group of experts assessed the significance of factors, after that the data were uploaded to the SPSS program (Beliaeva, 2018).

Stage 2. Selection and identification of the university types based on a combination of the factors of internationalization. With the help of the SPSS statistical analysis program, we divided

Table 1

Main concepts of internationalization of higher education and their content

№	Concepts	Description
1	International activity	1. The education process is organized in accordance with the international standards (Knight, 1999). 2. Incorporation of an international dimension in the educational process (Hans de Wit, 2019). 3. Initially, internationalization was seen as equivalent to international education (Beregovaya and Kudashov, 2019) and it was associated with the implementation of a certain type of activities at the level of individual organizations (Bednyi, 2020)
2	Resource integration	The prevailing global knowledge economy «has made the field of science and higher education more important than ever» (Hans de Wit, 2019). Currently, it is important not only to educate students by calculating the volume of educational services, but also to produce knowledge by attracting (and providing) foreign resources in order to meet the changing technological and economic demand for highly qualified specialists in the country and the world (world labour market, global market for educational services)
3	Internationalized education process	Similar to how the final product in the industry is created within the framework of the global value chain, the modern educational product is also formed through the implementation of many stages. Internationalization affects almost all components and activities of the university, including research, postgraduate programs, international co-authorship, teaching and learning methods, brand (Hans de Wit, 2019).
4	Networking	In the field of higher education, networking is a modern way to gain knowledge and information about the market, which allows universities to expand international partnerships and interact freely and flexibly within a network structure. The most famous network educational organizations are NAFSA (National Association of Foreign Student Advisers) in North America, EAIE (European Association for International Education) in Europe, APAIE (Asia-Pacific Association for International Education) in Asia, which set the standards for the development of university internationalization

Sources: compiled by the authors based on (Knight, 1999), (Hans de Wit, 2019), (Beregovaya & Kudashov, 2019), (Bednyi, 2020); World Investment Report (2013). Global Value Chains: Investment and Trade for Development, 2013, United Nations Publication, New York and Geneva, 2013, p. 125.

Table 2

Factors and indicators of internationalization: results of content analysis

Name, year	Factors					
	Number of foreign teaching staff and student	Number of online courses	…	Income from R&D	Financial resources	Campus infrastructure
Hans de Wit (2019)	+	–	…	+	+	–
Papanastasiu, Pier, Zanfei (2021)	–	–		+	+	+
Lee, Kai (2018)	+	+		-	+	-
MsAlir, Nakamura (2019)	+	+		-	+	+
Glas, Lee (2018)	+	-		-	+	+
…	…	…	…	…	…	…
Asmyatullin R., Balykhin M.	+	+	…	+	–	+

Sources: compiled by the authors based on Hans de Wit (2019), Papanastasiu, Pier, Zanfei (2021), Lee, Kai (2018), MsAlir, Nakamura (2019), Glas, Lee (2018), Asmyatullin, R. (2015), Balykhin, M.G. (2009). Trends in the development of the international market for educational services: EU countries and the Russian Federation. Abstract of the dissertation for the degree of Cand.Sc. (Economics).

the group of selected world-class universities according to the specified factors into type-clusters (Beliaeva, Frolova, 2021).

Stage 3. Calculation and comparative analysis of the internationalization index for each type-cluster. For each type-cluster we calculated the index of internationalization (I_{ic}). The index is determined as the arithmetic mean of the factors identified at Stage 1.

Stage 4. Development of strategies and activities to enhance internationalization. On the basis of the comparative analysis of the information from the sites and interviews with the leading specialists from these universities, we have selected and systematized the activities from these universities' export strategies. The international experience is represented by a wide range of activities. There is no 'one-size-fits-all' solution and universities' export strategies may be developed depending on their own specifics and history as well as on the regional and national context.

Results

At the first stage, the factors of university internationalization were identified through directed content analysis. The search word 'internationalization' in the databases Scopus and WoS has brought us 433 publications between 2000 and 2020, and in the EBSCO database, 215 publications between 2005 and 2020. The search phrase 'internationalization of universities' has brought 33 search results in Scopus and Web of Science and 43 in EBSCO. We found that there are two groups of factors – external (political, macro-economic, etc.) and internal, which are directly influenced by the main stakeholders. Next, we identified the factors of university internationalization by analysing 76 selected publications.

Table 2 illustates the results of content analysis based on the publications indexed in the Web of Science.

Academic and international student mobility had the greatest number of mentions (Taradina, 2021)[3]. Other factors of university internationalization include university websites in foreign languages and universities' online visibility (Arzhanova & Vorov, 2016). As for the economic factor, it is associated with making a profit not only from the export of educational services, but also from the residence of foreign citizens (Novikova, 2021; Stukalova, 2017; Stukalova, 2019).

Since the factors are also taken into account by world university rankings, we supplemented our analysis with data from the rankings QS, THE, ARWU and MosIUR (Table 3). The number of Russian universities that participate in rankings, for example, in QS, is growing and has increased 5 times since 2005 (Stukalova, 2019).

Table 3

Factors affecting the university's position in world rankings

Factors	ARWU	QS	THE	MosIUR
Academic reputation	+	+	+	–
Employer reputation	–	+	+	–
Number of prestigious international awards	+	–	–	+
Visibility in the Internet space	–	–	–	+

Sources: QS, retrieved from https://www.topuniversities.com, THE, retrieved from https://www.timeshighereducation.com/world-university-rankings, ARWU, retrieved from http://www.shanghairanking.com/index.html and MosIUR, retrieved from https://mosiur.org

[3] Gorshkova L.Yu. (2012). Export of educational services of higher education: world experience and Russia. Abstract of the dissertation for the degree of Cand. Sc. (Economics).

As a result of directed content-analysis, we identified 19 factors. These factors were further grouped with the help of the SPSS statistical data processing program.

We also interviewed expert groups of 250 representatives from 15 countries. The experts occupied high positions in their HEIs and performed both administrative and research functions related to internationalization of higher education. Based on these interviews, we determined the significance of the factors (assessed on a 7-point scale).

We applied factor analysis, the main tool in SPSS, to split the array of variables into a small number of groups called factors. As a result, seven groups of factors were identified, which are further reflected in Formula 1 below. For example, the first group 'Financial Resources' includes such variables as government funding, income from research activities, income from students, including overseas students, contributions to the endowment fund. The second group 'International Interaction' included the variables corresponding to the number of programs taught in English, the number of overseas students, and the number of foreign faculty. Other groups of factors include university reputation, student competitiveness, transparency, publication activity, and campus infrastructure. There are different approaches to the classification of these factors: for example, in their discussion of universities' attractiveness to overseas students, L.D. Taradina et al. (2021) distinguish between the positive (associated with benefits) and negative (associated with the risks of studying abroad) factors. R. Asmyatullin (2015) considers only the demographic factor as the dominant one and argues that this factor should determine strategies for export of educational services.

At Stage 2 we considered a set of data of 32 international universities from different territories, namely, 8 US universities from the Ivy League; 9 universities that are the top performers in the competitiveness enhancement programs of Western Europe, China and Japan; and 15 Russian universities selected to participate in the 5-100 Competitiveness Enhancement Program, which ended in 2020 (Table 4).

According to the statistical data of these universities, between the 2016 and 2019 academic years, cluster analysis was conducted for the two factors – international interaction and financial resources. Using SPSS Statistics, we have classified these 32 universities into cluster types (each cluster corresponds to the cluster of points in the space of variables) (Fig. 1).

Table 4

International universities participating in the competitiveness enhancement programs

Country	Project	Start year	Participants	Finance (USD, billion)	Participating Universities / Winners
China	Project 211	1995	99	2.2	2 universities in top-100 THE (Peking University, Tsinghua University)
		2001	107	2.3	
		2006	118	1.6	
	Project 985	1998	9	1,6	
		2004	39	2.3	
Germany	Excellence initiative	2006	9	1.9	5 universities in top-100 THE (University of Göttingen, University of Heidelberg, Humboldt University Berlin)
		2012	11	2.7	
France	Excellence initiative	2010	8	7.7	2 universities in top-100 THE (ENS de Paris, Ecole Polytechnique (Paris))
		2014	3	2.2	
Japan	10/100	2014	14	0.1	2 universities in top-100 THE (Kyoto University, Tokyo University)
Russia	Competitivenes Enhancement Program 5/100	2011	9	1.5	Far Eastern Federal University, Kazan Federal University, MIPT, MISiS, Tomsk State University, Tomsk Polytechnic University, Higher School of Economics, MEPhI, Nizhny Novgorod State University, Novosibirsk State University, Samara National Research University named after academician S.P. Korolev, Peter the Great St. Petersburg Polytechnic University, St. Petersburg State Electrotechnical University, ITMO University, Ural Federal University
		2012	15	0.014	
		2015	21	0.0135	

Sources: THE, retrieved from https://www.timeshighereducation.com/world-university-rankings, excellence initiatives retrieved from https://www.5top100.ru, https://www.dfg.de/en/research_funding/programmes/excellence_initiative/, https://op.europa.eu/en/publication-detail/-/publication/3cbc48f1-3f4e-11e6-af30-01aa75ed71a1/language-en

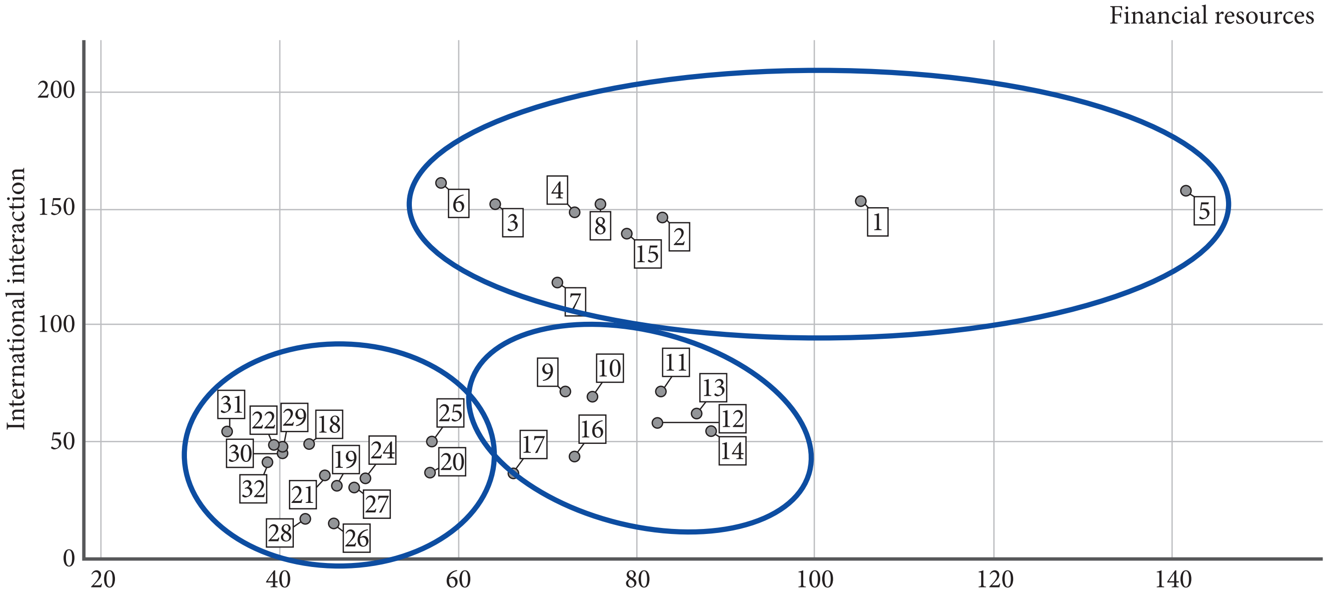

Figure 1. *Diagram of the distribution of universities by cluster types (for two factors: international interaction and financial resources)*

Source: Beliaeva & Mariev, 2020

As a result, we can see that nine universities with the best indicators are in the first cluster, eight in the second, and fifteen in the third. According to the level of achievement, we named the cluster types 'grandmasters', 'masters' and 'candidates'. For example, the first cluster type includes American universities of the Ivy League and one French university – Harvard University, Columbia University, Yale University, Princeton University, Pennsylvania University, Cornell University, Dartmouth College, Brown University, and Ecole Polytechnique (Paris). French, Chinese, Japanese and German universities established in the 17th – 19th centuries were included into the second type, for example, Peking University and Tokyo University. Russian universities, including the Kazan Federal University and Moscow Physics and Technology University, belong to the third type and represent different regions of Russia. In terms of territorial distribution, we can see that universities are unevenly represented by type. Thus, the first type is dominated by American universities, the second is dominated by European and Asian universities, and the third is occupied by Russian universities.

At Stage 3, an internationalization index was calculated for each type-cluster. We have constructed this index (Formula 1) by using the arithmetic mean of the 7 factors of university internationalization.

$$I_{ic} = \frac{I_i + I_f + I_r + I_c + I_t + I_p + I_{inf}}{7}, \qquad (1)$$

where I_i is the value of the factor 'international interaction'; I_f, the value of the factor 'financial resources'; I_r, the value of the factor 'reputation of the university'; I_c, the value of the factor 'students' competitiveness'; I_t, the value of the factor 'transparency'; I_p, the value of the factor 'publication activity'; I_{inf}, the value of the factor 'campus infrastructure'

The factor 'Financial Resources' is influenced by government funding, income from research activities, income from students' tuition fees and contributions to the endowment fund.

The factor 'International Interaction' increases together with the increase in the number of foreign students, lecturers and programs in foreign languages.

The factor 'Publication Activity' depends on the proportion of articles cited in WoS and Scopus. This factor reflects the involvement of the university in the life of global academia, affects the university's position in world university rankings and the trajectory of its development.

The factor 'University Reputation' reflects both the academic assessment of the university by experts and the assessment of the work of university graduates by employers, it is one of the decisive components of the university's position

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in the rankings. An increase in the 'transparency' of an educational institution will have a positive effect on its academic reputation.

The advantage of the proposed methodology is that it can be simplified by focusing on the two key factors – 'International Interaction' and 'Financial Resources'. By calculating the index of internationalization, the cluster this or that university belongs to can be identified.

The index was calculated for each university and then we could compare the results of individual universities with each other, for example, the Harvard University's score for the factor 'Financial Resource' is 105.074, and for 'International Interaction', 153.5, therefore, the index is 129.2871188. The scores of the Higher School of Paris are lower – 78.814 and 139.5, respectively.

For the 'grandmasters', the index range was from 94.7 to 149.8.

The calculation for other types was carried out in a similar way: for the 'masters', the index was from 58.2 to 77.2; and for the 'candidates', from 29.9 to 53.5. The universities in the fourth cluster have the index below 29.8.

Stage 4. Development of strategies for enhancement of internationalization in HEIs. In order to increase the level of internationalization, each university develops its own strategies and policies, for example, sets the target to increase the volume of exports of educational services or the mobility of students and lecturers. There are certain patterns, however, in the ways universities pursue internationalization depending on the national and regional contexts (see Table 5 below).

Using Immanuel Wallerstein' world-systems theory, L.D. Taradina (2021) offers an unusual approach to explaining the export strategies of universities: student mobility flows are directed from the countries of the semi-periphery towards the core, and from the periphery to the semi-periphery. As was said above, R. Asmyatullin states that the directions of student mobility flows are largely determined by the demographic factor. Chinese scientists have proposed a concept of the export strategy for world-class universities as part of the large-scale 'One Belt, One Road' Initiative (Xu Hong, Zhan Jiahui, 2021).

The cluster approach reveals a set of techniques that world class universities use in their internationalization strategies. In Table 6 below, we summarized and compared the activities from the export strategies of the universities from the clusters. The data were obtained from the universities' websites and interviews with their leading specialists. Hans de Wit (2019, p. 15) highlighted that the leading universities share a number of distinctive feature, for example, high concentration of talented scientists, an abundance of resources, and reputation. Thus, movement from lower to higher-level clusters can be associated with universities achieving higher degrees of internationalization.

Thus, in order to join the group of global leaders ('Grandmasters'), a university needs to implement the measures listed in Table 4: to ensure the dominance of self-financing from endowment funds among their sources of funding; maintaining the franchise, to facilitate

Table 5

Comparative analysis of the prevalent internationalization strategies of universities

General for all regions	Special regions			
	Asia	Middle East	Europe	Russia
– stimulating the export of educational services; – promotion of the country's brand; – increasing state funding for higher education; – strategies to attract foreign students; – development of the educational infrastructure; – active interaction with educational agencies and scholarship foundations; – positioning of the country as a world educational centre	– Internet accessibility through mobile applications; – good infrastructure; – reduction of the cost of living; – creation of English-language educational programs; – incentives for lecturers to study abroad in order to adopt the Western teaching style; – facilitating student mobility	– creation of offshore institutions – autonomous educational institutions; – positioning the country as an educational centre; – free economic zones in the field of higher education	– blended financing of education; – reducing tuition fees; – ensuring the availability of the Internet through mobile applications	– strengthening the regional component in the exports of educational services; – adaptation of foreign students; – reducing the costs of education

Source: compiled by the authors by using the data from the websites of leading universities and the evidence provided in Ammar Al Hauazh, Asmyatullin, 2016; Asmyatullin, 2015; Rogova, 2013; Ayse Nil, 2018; Scott, Nazli, 2018.

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Table 6

Activities to enhance internationalization of universities

№	Type of activity	Internationalization activities	
		Transition from 'Candidates' to 'Masters'	Transition from 'Masters' to 'Grandmasters'
1	Pooling of resources	Creation of international consortia with partners of the 'Master' level	Creation of international consortia with 'Grandmaster' level partners
2	International mobility of the faculty	Attraction of foreign professors from universities from the 'Masters' group on the basis of the intercultural competence enhancement	Attraction of international faculty from universities from the 'GrandMasters' group to enhance cross-cultural competence
3	Sources of financing	Increasing the share of funding from endowment funds	Dominance of self-financing from endowment funds
4	Organizational and institutional development	Opening of franchise educational units	Opening branches in recipient countries of educational services
4	Recipient countries	Recruiting of students and lecturers from developing countries	Recruiting of students and lecturers from developed countries
5	Development of infrastructure	Development of individual elements of residential infrastructure for foreign students	Development of the infrastructure complex as a whole, incl. campus, in accordance with the best world practices

Source: Compiled by the authors based on the information from the official websites of Harvard University retrieved from https://www.harvard.edu, Princeton University retrieved from https://www.princeton.edu, Kyoto University retrieved from http://www.kyoto-u.ac.jp/ja, Ecole polytechnique (Paris) retrieved from https://www.polytechnique.edu and interviews with experts

the opening of branches in the countries which are the recipients of educational services; to target developed countries but continue recruiting students from developing countries through marketing campaigns and activities.

Conclusions

We identified 7 factors, the most important of which are 'financial resources' and 'international interaction'. We also found that universities might be grouped depending on their internationalization levels into three types (clusters): the first cluster comprises American universities, the second type, universities from China and Europe, the third, universities of different regions of Russia. According to the calculated index of internationalization, we have also identified one more type of universities – those whose internationalization level is below that of the universities from the 'Candidates' group.

We have also identified the activities included in the export strategies of universities from different clusters. Any university can calculate the internationalization index according to the proposed formula, determine its type and choose activities to move to a higher level. By implementing the selected export strategy and using the proposed activities, a university can internationalize more effectively and improve its prospects of becoming a world-class university.

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Strategic priorities of regional investment policy for advanced technological development (the case of Sverdlovsk region in Russia)

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ABSTRACT
Relevance. The study investigates the structural and technological imbalances impeding Russian regions' transition to sustainable development.
Research objective. The study aims to describe and test an original methodological approach by using the case of a large industrial region in Russia – Sverdlovsk region. The proposed approach can provide a framework for the analysis of federal and regional strategies of long-term innovation and investment development, especially their industrial and spatial priorities.
Methods and data. The study relies on official statistical data covering a five-year period. A special focus was made on the strategies' key indicators, which were then compared with the long-term goals and targets of industrial and spatial development. The comparison of the key strategic indicators is supplemented by spatial analysis of regional investment activity by territory and type of investment.
Results. The study shows the need to align regional investment strategies with the strategies and policies of industrial, innovation and spatial development. For Sverdlovsk region, the study has revealed a pattern of spatial distribution of investment, which tends to concentrate in old industrial areas, that is, large cities and their agglomerations where the main production facilities are located.
Conclusion. The study identifies the drawbacks of regional strategies and shows why the strategies fail to fulfill their function in the general system of strategic planning.

KEYWORDS
regional investments, strategic landmarks, investment climate, scientific and technological development, technological breakthrough

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Стратегические приоритеты региональной инвестиционной политики для передового технологического развития (пример Свердловской области России)

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АННОТАЦИЯ
Актуальность. В исследовании исследуются структурные и технологические дисбалансы, препятствующие переходу регионов России к устойчивому развитию.
Целью исследования является описание и апробация оригинального методологического подхода на примере крупного промышленного региона России – Свердловской области. Предлагаемый подход может обеспечить основу для анализа федеральных и региональных стратегий долгосрочного инновационного и инвестиционного развития, особенно их промышленных и пространственных приоритетов.
Методы и данные. Исследование опирается на официальные статистические данные за пятилетний период. Особое внимание было уделено ключевым показателям стратегий, которые затем сравнивались с долгосрочными целями и задачами промышленного и пространственного развития.

КЛЮЧЕВЫЕ СЛОВА
региональные инвестиции, стратегические приоритеты, инвестиционный климат, научно-техническое развитие, технологический прорыв

Сопоставление ключевых стратегических показателей дополняется пространственным анализом инвестиционной активности регионов по территории и типу инвестиций.
Результаты. Исследование показывает необходимость согласования региональных инвестиционных стратегий со стратегиями промышленного, инновационного и пространственного развития. Для Свердловской области исследование выявило закономерность пространственного распределения инвестиций, которые имеют тенденцию концентрироваться в старопромышленных районах, то есть в крупных городах и их агломерациях, где расположены основные производственные мощности.
Вывод. В исследовании выявляются недостатки региональных стратегий и показано, почему стратегии не выполняют свою функцию в общей системе стратегического планирования.

ДЛЯ ЦИТИРОВАНИЯ
Vlasov, S.V. (2021) Strategic priorities of regional investment policy for advanced technological development (the case of Sverdlovsk region in Russia). *R-economy*, *7*(4), 276–288. doi: 10.15826/ recon.2021.7.4.024

Introduction

The persisting structural-technological imbalance in Russia is a major impediment to the country's transition to a sustainable economy and technological leadership. The federal and regional governments are striving to bridge this imbalance through a set of measures meant to ensure advanced technological development and to stimulate fixed capital investment. Confronting this problem, however, requires the government to tackle two interrelated issues – the contradictions between the national innovation policy and its regional counterparts and the lack of salient dynamics in the indicators of innovation development in recent years. All of the above means that, first and foremost, it is necessary to align the goals of regional investment policies and strategies with the priorities of industrial and innovation development.

The article aims to evaluate regional investment activity by gauging the goals of advanced technological development set by national and regional strategies. Advanced technological development in this context implies acceleration of the pace of R&D progress through incubation and adoption of new technologies. It is particularly important to modernize the traditional sector by upgrading fixed assets and implementing the corresponding industrial and investment policies on the regional level.

The above-described research problem has determined the following tasks:

– to develop and test a methodology for analyzing goals, targets and priorities (their alignment and attainability) in state strategic planning in Russia;

– to compare planned indicators with the actual outcomes of the long-term strategies of investment, innovation and industrial development on the national and regional levels;

– to describe spatial patterns of investment in the region.

The main focus of the analysis is the investment processes in Sverdlovsk region, one of the core Russian regions for industrial production. It is also one of the top ten Russian regions in terms of gross investment, the volume of industrial output and gross regional product.

Theoretical Framework

In today's world, staying on top of technological advances is the key to economic leadership and sustainable development. In this light, what comes to the fore is the state policy that would give due regard to regional disparities in technological development (Komkov, 2003). In Russia, stimulation of the country's technological and socio-economic development was included into the national high-priority goals and aligned with other, more specific tasks, such as setting the country on a track to become one of the five largest economies in the world (Medvedev, 2018). Simachev et al. (2014), however, argue that there is a lack of efficient vertical and horizontal industrial policy-making, mainly due to the absence of feedback channels and the inadequacy of state institutions. This problem should be addressed by improving policy-making and policy implementation and by ensuring the high-quality of public administration.

In international studies, scholarly interest also centres on new regional industrial path development. Within the paradigm of evolutionary economic geography (EEG), Hassink et al. (2019) propose a new research agenda and outline four new avenues of research exploring the reasons why some regions succeed in nurturing the rise and further development of new paths while others fail. Bosák et al. (2018), in their discussion of the case of an old industrial city (Ostrava), show that in order to become more competitive, old industrial areas need to combine the following two approaches: 'assessment of intrinsic features of the structures' and consideration of the general global trends.

Studies on the development of science and technology often seek to identify the emerging technologies that would shape the future of economy and help countries stay ahead in global leadership (see, for instance, Borisov et al. (2018); Sidorov, 2020). An important contribution is made by foresight studies that provide a qualitative evaluation of the tech shifts and identify the priority areas of industrial development (Dezhina & Ponomarev, 2016; Wagner & Popper, 2003; Martin, 2010; Lane & Kalil, 2005). Coates et al. (2002) highlight the need for clear, timely and inexpensive forecasts of technological development for different enterprises, including small-scale ones.

At the same time, as regional practice shows, despite the vast body of research describing the most promising technologies and markets to be included into regional strategies, there is still no sufficient understanding of how advanced technological development should be achieved. Moreover, in the last decade, Russian regions has experienced acute shortage of investment, which hampered the modernization of the fixed assets of capital-intensive industries.

Abalkin (2002) believes that the general flow of investment in fixed capital is determined by the government's ability to provide a clearly defined industrial and investment policy. Ivanter (2017) argues that technological development should go hand in hand with the modernization of the leading companies and other major manufacturing facilities. Thus, many Russian researchers see the task of stimulating fixed capital investment as crucial for the country's technological development (Barinova & Zemtsov, 2015; Vlasov, 2015, 2018, 2019).

Vasiliev (2009) argues that the institutions imported from other countries and principles of the national innovation system do not fit the current needs of innovation development in Russia. On the other hand, Kotlyarova et al. (2010) contend that problems may stem from the lack of innovation culture. Golichenko (2011) states that, regardless of the national context, a well-designed system of measures for creating the conditions for fostering innovation can be quite effective, especially if combined with the restructuration of state institutions and connections between them. Golova & Sukhovey (2011) observe that for a more efficient technological development, innovation goals should be aligned with the goals of socio-economic policy and that due attention should be given to the spatial aspect.

In the research literature, Sverdlovsk region is widely considered to have everything it takes to become a centre of advanced technological development in the twenty-first century (Tatarkin et al., 2015; Bochko, 2011, 2015, 2019; Maslennikov, 2015). This region can drive the modernization of the Russian economy (Silin & Animitsa, 2016, 2021). Silin and his associates (Silin et al., 2019) and Ivanova (2017) foreground the industrial localization pattern of Sverdlovsk region, where the main production facilities tend to concentrate around large cities, forming industrial agglomerations.

Analysis of regional investment activity should focus not only on the sectoral but also on spatial aspect. There is significant research evidence on the influence of strategic planning and agglomeration processes in large cities on investment flows (Gordon, 1993; Porter, 1996; Adams et al., 1999). Kemp (1992) showed how strategic planning in the public sector can help local governments plan the future of their municipalities proactively and better meet the public expectations concerning effective governance.

Comparative analysis of the priorities of innovation development in different economic sectors shows that these priorities are often not properly aligned with each other (Frolov, 2015). According to A.G.Aganbegyan (2021), a major 'technological turn' is required in Russia, since at the moment, the country is virtually a technology laggard: two-thirds of Russian enterprises are in need of thorough modernization. Aganbegyan (2021) argues that the only solution to the problem is a carefully designed strategic plan in combination with rigorous and high quality public administration.

The theory and practice of regional innovation systems are again high on the research agenda. There is a perceived need for a comprehensive analysis underpinning practical guidelines for more effective regional investment policies and strategies to boost technological development.

Methods and Data

This study takes as a point of departure the following assumption: in order to ensure the country's advanced technological development, policy-makers should align the long-term goals and priorities in the sphere of investment, innovation, industrial and spatial development

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of regions. The same should be done for the methods of implementation of the corresponding strategies and policies. Importantly, goal-setting should take into account the resources and other characteristics of the regions in question. The goals should be relevant, realistic and time-bound.

This study proposes a research methodology based on a comprehensive analysis of the national and regional statistical data on innovation and investment in the last 10 years in its spatial and sectoral aspects. The study examined the 'vertical' dimension of innovation and investment in Russia: from the macro- (national) to meso-level (regional – the case of Sverdlovsk region). The actual outcomes of the strategies were compared with the expected results in the sphere of R&D, innovation and investment. The analysis also encompassed the 'horizontal' dimension of investment – the indicators and statistical data on municipalities and administrative-territorial districts of Sverdlovsk region, more specifically, the relative amount of private and state investment and the total amount of investment. The indicators for analysis were selected by using the parameters specified in the national and regional strategic planning documents[1]. The analysis took into account the agglomeration tendencies in the urban districts and the spatial distribution patterns of industrial production.

The study relies on the statistical data published by the Federal State Statistics Service (Rosstat) and its branch for Sverdlovsk Region and Kurgan Region as well as the Higher School of Economics, Ministry of Economy and Territorial Development of Sverdlovsk Region and other government agencies. The criterion for data selection was the availability of statistical data for the period when the strategies in question were implemented – from 2010 to 2020 – but not less than the last 5 years of the whole period in order to compare the expected results and the actual outcomes. The analysis of the spatial aspect of investment covered the period from 2010 to 2020 and focused on the concentration of investment and the spatial distribution of production facilities during the period of the innovation strategy's implementation. To examine the structure of investment, I looked at the statistics for 2000-2020, that is, the period preceding the adoption of the strategies and the period when these strategies were implemented. Thus, the analysis reflects the impact of these strategies on the key indicators in the long term.

The proposed methodology can be applied to gauge the long-term goals of innovation and investment development and to devise practical recommendations for regional governments concerning the choice of long-term investment priorities.

Results

Strategic goals and the highest-level indicators specified in the federal strategy create a vision of the future that guides regional governments and businesses in their own policy-making and goal-setting in the decades to come. Attainment of these goals and targets is not only a sign that the economic development is going in the right direction but also a measure of the quality and efficiency of national and regional strategic management.

Sluggish growth in the innovation indicators in recent years is confirmed by the analysis of the main outcomes of the Strategy of Innovation Development until 2020[2]. Sadly, the planned indicator values were not achieved and there was no positive dynamics in terms of innovation development (Table 1).

Like national-level indicators, the key socio-economic indicators of Sverdlovsk region have demonstrated stagnant growth in recent years. The industrial production index has fallen from 106.2% in 2011 to 102.3 in 2020. A similar trend is observed in fixed capital investment, which dropped from 115.9% in 2011 to 90.1% in 2020.

The aim of the region's own strategy of innovation development until 2020 was to stimulate the transition of the economy to the innovation-oriented model. Among the targets set by the regional strategy, it was planned to achieve an increase in the share of exports of innovative goods in the total volume of exports from 23.3% in 2011 to 40% in 2020. In 2020, however, this figure was only 7.5%. The share of innovative goods, works and services of new-to-market organizations in the total volume of goods, works and services of industrial enterprises was 0.8%. The actual indicator and its growth rates (see the diagram below) show that the strategy had obviously set the bar too high – the level of 40% by 2020 was clearly unrealistic.

[1] See: Strategy of Innovation Development of the Russian Federation until 2020; Strategy of Innovation Development of Sverdlovsk Region until 2020; Investment Strategy of Sverdlovsk Region until 2035; Strategy of Industrial and Innovation Development of Sverdlovsk Region until 2035.

[2] Decree of the Government of the Russian Federation of 08.12.2011 No. 2227-p 'On the Approval of the Strategy of Innovation Development in the Russian Federation until 2020'. In: Collection of Legislation of the Russian Federation, 02.01.2012, No. 1, Article 216.

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Table 1

Dynamics of the key indicators of the Strategy of Innovation Development of the Russian Federation until 2020

№	Indicator	Unit of meas.	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019, trend to plan 2020	2020 actual (planned)
1	Invention activity coefficient (the number of patent applications submitted in Russia per 10 thousand people)	units	2.01	1.85	2.00	2.00	1.65	2.00	1.83	1.55	1.70	↓1.59	1.6 (2.8)
2	Share of organizations engaged in technological innovation in the total number of organizations, including	%	7.9	8.9	9.1	8.9	8.8	8.3	7.3	7.5 20,8*	19,8*	↓21,6*	– (25)
	extractive and manufacturing industries, production and distribution of power, gas and water		9.3	9.6	9.9	9.7	9.7	9.5	9.2	9.6 19,6*	18,5*	↓20,0*	– (40)
	communications and other ICT-related activities		10.8	9.9	10.3	10.3	9.5	9.4	7.7	5.6 9,4*	13,1*	↓17,9*	– (35)
3	Share of innovative goods, works and services in the total volume of exported goods, works and services	%	4.5	8.8	12.1	13.7	11.5	8.9	8.4	7.1	6.6	↓5.2	– (15)
4	Intensity of investment in R&D of industrial enterprises (share of R&D expenditures in the total costs of production of goods shipped and execution of works and services of industrial enterprises)	%	-	1.5	1.8	2.2	2.1	1.8	1.8	1.7	1.5	↓1.5	– (2.5)
5	Share of innovative goods, works and services in the total volume of goods, works and services	%	4.9	6.1	7.8	8.9	8.2	7.9	8.4	6.7	6.0	↓6.1	– (25)
6	Share of innovative goods, works and services of new-to-market organizations in the total volume of goods, works and services of industrial enterprises	%	0.8	0.6	1.1	1.1	1.1	0.9	1.0	1.3	0.9	↓0.6	– (8)
7	Share of innovative goods, works and services that are new to the global market in the total volume of goods, works and services of industrial enterprises	%	0.0	0.1	0.1	0.0	0.0	0.3	0.1	0.2	0.2	↑0.3	– (0.28)
8	Aggregate level of innovation activity of industrial enterprises (share of industrial enterprises engaged in technological, organizational and/or marketing innovation activities in the total number of industrial organizations)	%	10.8	11.1	11.1	10.9	10.9	10.6	10.5	10.6 17,8**	15,6**	↓15,1**	– (60)
9	Exports and imports of technologies,	mln US dollars	–798.1	–1277.9	–1354.7	–1693.0	–1176.6	–550.7	–1221.7	–2124.0	–1659.3	↓–1316.7	(over 300.0)
10	Gross domestic spending on R&D, % of GDP	%	1.13	1.02	1.05	1.03	1.07	1.10	1.10	1.11	1.0	↓1.03	– (3)
11	Gross domestic spending on R&D, by source of funding	%											
	government's funds		68.8	65.6	66.0	65.8	67.1	67.5	65.9	63.8	64.3	↓64.4	– (43)
	extra-budgetary funds		31.2	34.4	34.0	34.2	32.9	32.5	34.1	36.2	35.7	↓35.6	– (57)

Source: compiled by the author

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The regional strategy also set the target of expanding the share of innovative goods in the total volume of industrial goods from 5.7% (in 2011) to 25% in 2020.

Figure 2 below illustrates the dynamics in this indicator. The highest level in a 5-year period was 10.2% in 2017 and the indicator did not rise above this level. It is obvious that the figure of 25% set by the strategy was impossible to reach by 2020 (the actual indicator value was 7.4%).

One more goal was to increase the domestic expenditures on R&D as percentage of GRP from 1.2% (in 2010) to 2.5% in 2020. Current domestic expenditures on R&D have accounted for 1.15–1.46% of GRP and so far there has been no indication of further growth. After 2017, the expenditures started to show a decreasing tendency.

In the structure of expenditures, wages and insurance costs account for the largest share. Interestingly, however, there was a colossal increase in the expenditure item 'Other Material Costs' between 2010 and 2017: by 279%. This fact seems especially remarkable in contrast with the insignificant increase in other types of expenditures. After 2017, the share of this kind of expenditures is gradually declining but it is still a prominent category in the expenditures' structure. At the same time the expenditure level of 2.5% of GRP until 2020 set by the Strategy remained unachievable.

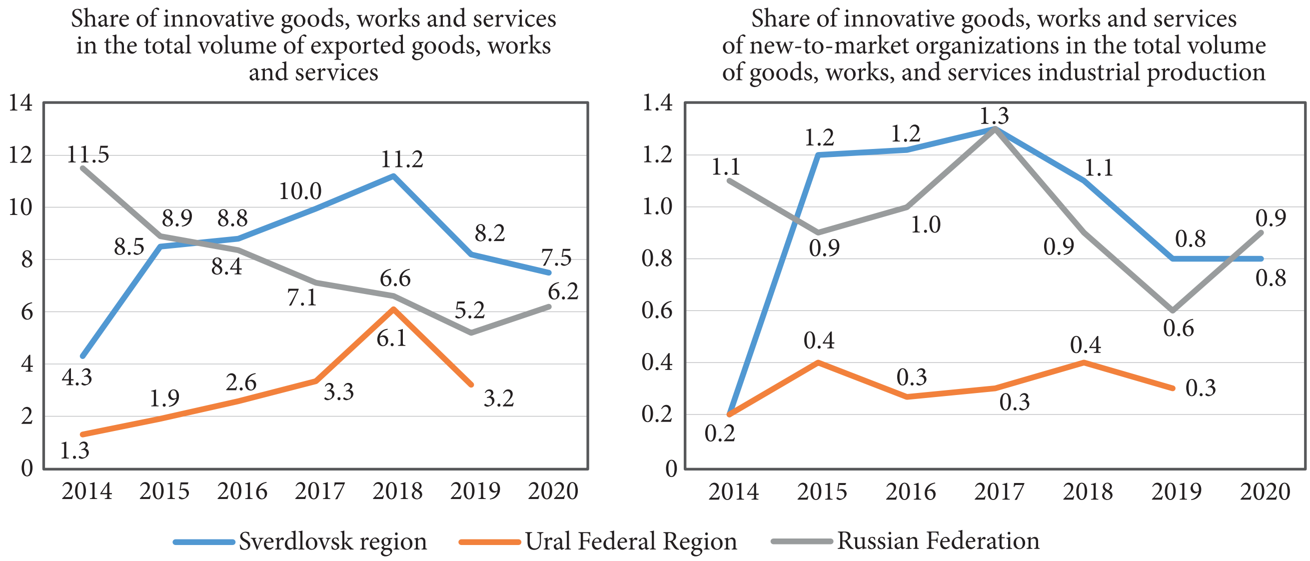

Figure 1. *Shares of innovative goods, works, services of industrial enterprises in Sverdlovsk region*
Source: compiled by the author

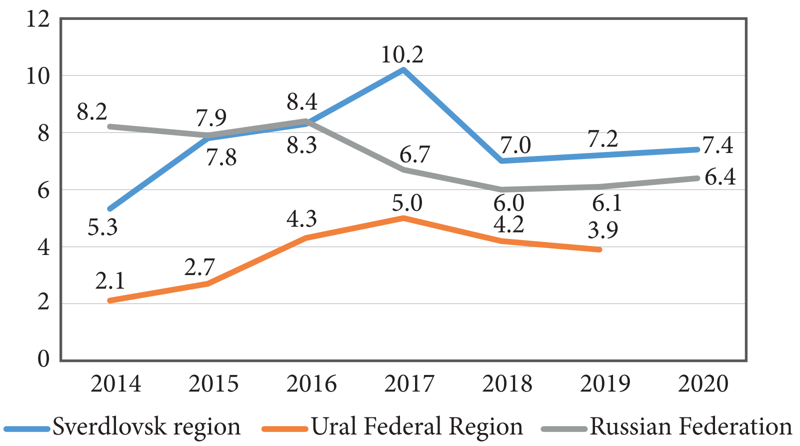

Figure 2. *Share of innovative goods, works, services in the total volume of goods, works and services of industrial enterprises*
Source: compiled by the author

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Since 2000, the R&D staff numbers shrank by 6.7 thousand people. The most significant decline was observed in the number of researchers – 3.2 thousand people (25.7%) – while the number of auxiliary staff remained virtually unchanged: 7.8 thousand people in 2000 and 7.5 thousand people in 2020 (this phenomenon is described by Bochko (2019) as the 'shrinkage' of R&D personnel).

The Investment Strategy of Sverdlovsk Region until 2035[3] was adopted in 2019. A special emphasis was laid on the growth in the amount of investment. Since 2012, however, the growth of investment has come to a halt and the index of physical volume of investment in fixed capital has started to decline: from 98% in 2021 to 85.1% in 2015 and 91.4% in 2017. The trend was reversed in 2018, when a number of large investment projects were launched in the region. In 2020, however, investment flows plunged again due to the COVID-19 pandemic. In 2020, the volume of investment in fixed capital was 381.1 billion roubles or 97.2% of the level of 2019 in comparable prices.

Investments of large and medium-sized enterprises make up the largest part of the investment volume (295.4 billion roubles or 77.5%). These enterprises operate in such sectors as manufacturing (71.1 billion); transportation and storage (56.5 billion); real estate (45.3 billion); electricity, gas, steam and air conditioning supply (21.6 billion); and ICTs (18.6 billion).

[3] Decree of the Government of Sverdlovsk Region of 15.08.2019 No. 535-ПП 'On the Approval of the Investment Strategy of Sverdlovsk Region until 2035'.

Metallurgy accounts for approximately a half in the structure of investment by type of activity in the manufacturing sector – 49.3%; production of vehicles and equipment, 14.2%; other kinds of manufacturing, 9.3%; production of ready-made metal products, except machinery and equipment, 8.8%.

Enterprises' own funds remain the main source of fixed capital investment. The share of these funds in the total structure of investment has remained relatively stable in the last 20 years, demonstrating a steady, although modest increase and reaching the current level of over 61%. The share of government investment declined in 2015–2020. After 2020, the trend went upward, reaching 17.5% of federal investment and regional budgets (Table 4).

The main trend in the change of the investment structure by form of ownership was a twofold decline in the share of state property from 33.7% in 2000 to 15.8% in 2020. In the same period, the share of private investment almost doubled: from 24.7% in 2000 to 50.7% in 2020 (Table 5). The effect from investment in any economic sector and enterprise is determined by the structure of investment according to types of fixed assets.

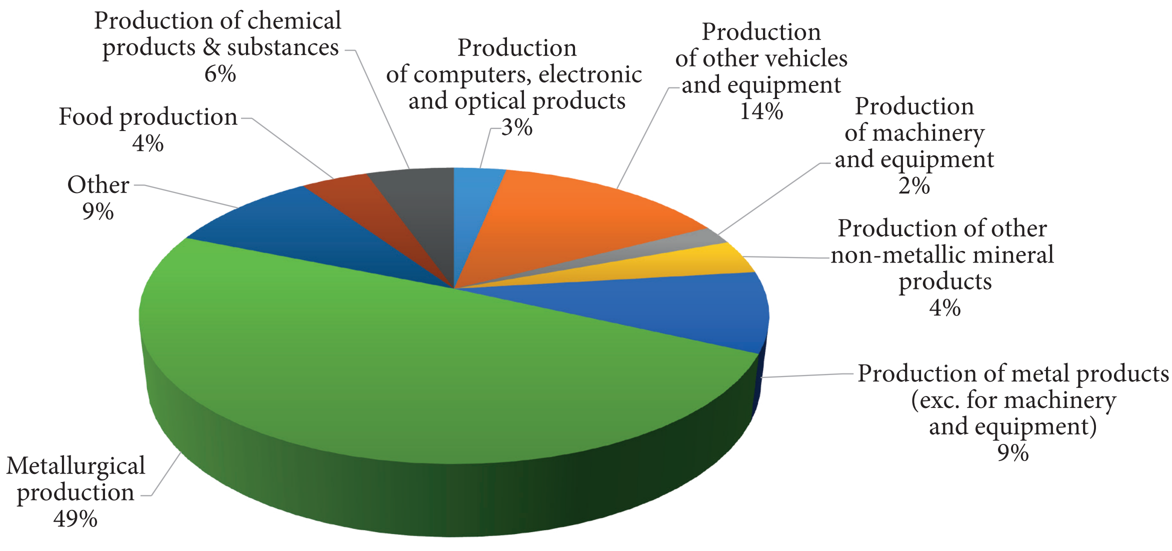

Figure 3. *Structure of investment in fixed capital by type of activity of industrial enterprises in January-December 2020 (large and medium-sized enterprises) in % of the volume of investment in the manufacturing sector*

Source: compiled by the author

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Investment into the active part of fixed capital, primarily machinery and equipment, R&D, and advanced technologies, is the key to rapid technological change. In Sverdlovsk region, however, only a half of the investment is spent on these goals while investment into production facilities and buildings makes up over 30%, thus reflecting the region's industrial heritage. Investment in machinery and equipment accounts for 55.2%, showing a 6.7% increase in the last 5 years, which is clearly not enough in view of the enormous obsolescence of fixed assets.

Depreciation of fixed assets in Sverdlovsk region is above 52%, which is higher than the national average by 14.9%. A fairly high rate of depreciation of fixed assets is characteristic of the region's manufacturing enterprises, although their depreciation level remains almost the same as the national average – 48%. The growing depreciation trend in manufacturing seriously impedes the prospects of a rapid technological transformation.

The main goals, targets, industrial and regional growth points are specified in the new Strategy of Industrial and Innovation Development of

Table 4

Structure of fixed capital investment in Sverdlovsk region, by source of funding (% of total)

	Years						
	2000	**2014**	**2015**	**2016**	**2017**	**2018**	**2020**
Fixed capital investment – total	100	100	100	100	100	100	100
Including: by source of funding organizations' own funds	62.7	48.1	46.7	54.3	58.7	58.4	61.3
external funds	37.3	51.9	53.3	45.7	41.3	41.6	38.7
Including: bank loans	…	13.7	14.6	13.5	10.3	5.4	6.6
loans from other lenders	…	1.8	3.6	1.5	1.6	4.6	2.9
foreign investment		0.0	0.7	0.2	0.1	0.2	0.1
government funds	23.9	18.2	13.6	11.9	14.5	14.1	17.5
Including: funds from the federal government	5.7	10.4	5.2	4.9	7.1	5.6	5.9
funds from regional governments	14.1	5.1	5.7	4.7	4.9	5.5	6.6
extra-budgetary funds	…	0.1	0.1	0.1	0.1	0.2	0.2
funds of organizations and individuals for co-funded construction	…	4.3	5.5	4.9	4.6	6.4	4.6
other	…	13.8	15.2	13.6	10.1	10.7	6.8

Source: compiled by the author.

Table 5

Structure of fixed capital investment in Sverdlovsk region, by form of ownership (% of total)

	Years						
	2000	**2014**	**2015**	**2016**	**2017**	**2018**	**2020**
Fixed capital investment – total	100	100	100	100	100	100	100
Including: by form of ownership Russian	79.6	84.5	84.8	82.6	85.3	86.8	86.4
Including: state	33.7	12.9	12.1	12.4	15.0	13.2	15.8
municipal	10.2	5.5	5.5	5.3	5.2	5.9	8.1
private	24.7	49.5	55.9	51.7	52.0	54.7	50.7
consumer cooperatives	0.0	0.0	0.0	0.0	0.0	0.0	0.0
public and religious organizations (associations)	0.2	0.0	0.0	0.0	0.0	0.0	0.0
mixed Russian	10.8	7.7	5.7	8.9	10.8	10.7	11.1
state corporations' ownership	…	8.9	5.6	4.3	2.3	2.3	0.7
foreign	0.5	4.2	5.4	5.4	6.9	3.8	9.0
joint Russian and foreign	19.9	11.3	9.8	12.0	7.8	9.4	4.6

Source: compiled by the author

Sverdlovsk Region until 2035. In the Middle Urals, over 80% of the output is provided by three industries: metallurgy, mechanical engineering (primarily heavy engineering) and chemical industry. Analysis of the spatial distribution of industrial production assets in Sverdlovsk region shows that the municipalities with a long prior history of industrial development have now become centres of industrial agglomerations – the city of Ekaterinburg, Gornozavodskoy administrative-territorial district, and the northern urban agglomeration. A separate, fourth production zone is located in the town of Kamensk-Uralsky.

The Strategy's priorities are determined for specific industries and territories. The Strategy also specifies the growth points which could be used to enhance the competitive advantages of the mechanical engineering industry on the global high tech market. In this industry, most production facilities are concentrated in the regional centre – Ekaterinburg (it has over 40% of enterprises, accounting for about 33% of the industry's output and employing about 35% of the staff). In total, in Sverdlovsk region there are over 200 mechanical engineering enterprises. In 2020, mechanical engineering accounted for 19.8% of the output of the region's manufacturing sector while the total output of the industry exceeded 412.8 billion roubles.

The period of investment implementation is crucial for its effective use. The choice of growth points as priorities for investment is of prime importance.

In order to get a clearer picture of the spatial distribution of investment in the region, its administrative-territorial districts and municipalities were ranked by the amount of investment in 2010 and 2020. The total amount of investment from all sources was 2,674,359,675 thousand roubles, including 1,276,655,897 thousand roubles in Ekaterinburg and 1,397,703,778 thousand roubles in other municipalities (see Figure 4 above). The industrial areas and large industrial cities, with Ekaterinburg at the top, occupied the highest positions in terms of fixed capital investment in the given period. Most investment is concentrated in the region's industrial agglomerations with a long prior history of industrial development.

The ranking of territories by the amount of federal and regional fixed capital investment in 2010–2020 has showed the following picture. Most of the investment in fixed capital was also concentrated in industrial agglomerations and large cities. The data on municipalities, however, have shown significant overlaps in the municipalities at the bottom of both rankings (total fixed capital investment and government investment) (see Table 6 below). For example, most of the investment, both total investment and government investment, in the given period was received by Ekaterinburg while Pelym was the municipality that got the least. The top five municipalities are also the same in both rankings. Similarly, three out of five municipalities at the bottom of the list are the same in both rankings – Pelym, Makhnevo, and Malyshevsky. There are multiple similar overlaps throughout both rankings.

The analysis of the spatial aspect of investment in Sverdlovsk region brings us to the following conclusions: first, spatially, investment follows a pattern where most funds are concentrated in large cities and agglomerations, in other words, the sites where the main production assets are located; and, second, large private investments in a particular area tend to draw or attract large government investment to this area (this feature may be referred to as the area's attractiveness to investment).

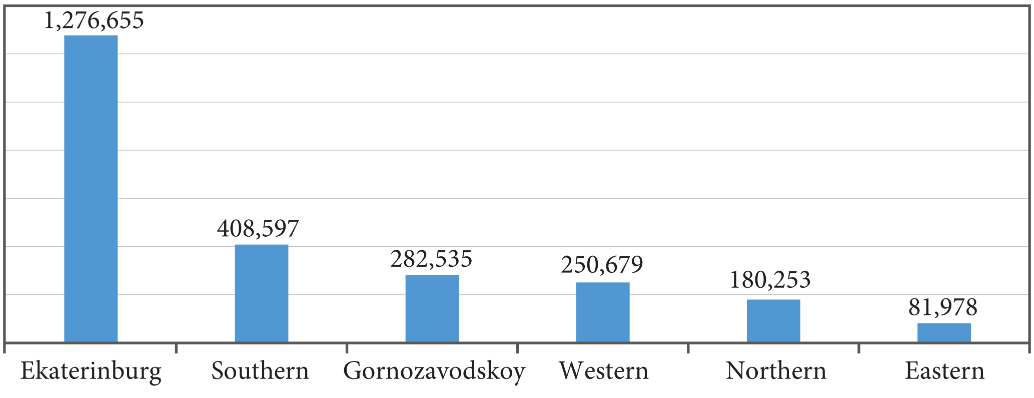

***Figure 4**. Ranking of administrative-territorial districts by the amount of investment in 2010–2020, mln rbs*
Source: compiled by the author

Table 6

Comparative analysis of municipalities by fixed capital investment in 2010–2020 (aggregate investment and government investment)

Ranking of municipalities by fixed capital investment in 2010-2020 (large and medium-sized enterprises), ths rbs			Ranking of municipalities by the amount of government investment in total fixed capital investment in 2010–2020, ths rbs		
Position	**Municipalities**	**Total**	**Position**	**Municipalities**	**Total government investment**
1	Ekaterinburg (city)	1,276,655,897	1	Ekaterinburg (city)	151,468,362
2	Nizhny Tagil (city)	174,345,682	2	Zarechny (urban district)	63,639,157
3	Zarechny (urban district)	148,111,618	3	Nizhny Tagil (city)	18,738,635
4	Kamensk-Uralsky (town)	106,544,657	4	Verkhnyaya Pyshma (urban district)	9,790,450
5	Verkhnyaya Pyshma (urban district)	85,450,759	5	Kamensk-Uralsky (town)	4,961,296
Ranking of municipalities by fixed capital investment in 2010-2020 (large and medium-sized enterprises), ths rbs			Ranking of municipalities by the amount of government investment in total fixed capital investment in 2010–2020, ths rbs		
65	Verkhneye Dubrovo (urban district) (54th in the ranking by budget size)	898,199	65	Makhnevo (municipality)	98,326
66	Malyshevsky urban district	527,601	66	Verkhny Tagil (urban district)	82,218
67	Staroutkinsk (urban district) (62nd in the ranking by budget size)	399,752	67	Malyshevsky (urban district)	80,924
68	Makhnevo (municipality)	178,590	68	Bisert (urban district) (58th in the ranking of total investment)	71,552
69	Pelym (urban district)	123,311	69	Pelym (urban district)	70,308

Source: compiled by the author

Conclusion

The study has proven the viability of the proposed methodology based on a combination of statistical methods, methods of quantitative and qualitative analysis of national and regional strategies with a particular focus on the sectoral and spatial aspects.

It was found that on the national level, the general dynamics of innovation was fairly steady between 2010 and 2020. In some areas (technology imports, innovation, patent activity), the trends were mostly negative. As far as the national strategy is concerned, the priorities of innovation development and the upper bound for the key indicators were set correctly – these targets fully reflected the challenges of the technological change that the country had to go through.

The analysis has also revealed the lack of effective mechanisms necessary for the implementation of the national strategy and control over this process. Moreover, the document said nothing about feedback from the regions while feedback is crucial to ensure the federal government's adequate and prompt responses to the problems that may occur in the process.

On the regional level, the analysis focused on the case of Sverdlovsk region and its Strategy of Innovation Development until 2020. It was found that the target values of the indicators were set correctly from the strategic perspective but they were unrealistic from the tactical point of view.

The regional strategy failed to set reference points to guide decision-making in the innovation sphere and thus it did not play the intended role of a comprehensive document for the intensification of innovation processes in the region.

In the way similar to the federal strategy, its regional counterpart failed at the execution stage due to the lack of implementation mechanisms and the insufficient amount of investment.

A more recent document, the Investment Strategy of Sverdlovsk Region until 2035 is mostly declarative as it does not align the measures for the region's industrial and innovative development with the corresponding national programs and does not consider exports. Moreover, the investment strategy lacks a clearly defined aim and does not specify even a minimum set of priorities for the region's industrial development. The investment strategy also fails to provide any guidelines regarding the sources of funding and

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priority areas for investment in the core industries and technologies. Neither does the strategy mention any 'anchor investors' that the region should rely on in the long term and that should thus be entitled to the maximum state support.

The features of Sverdlovsk region's strategies of investment and industrial development until 2035 that appear worthy of special attention are as follows: first, priority-setting underlying these strategies relies on a multitude of approaches and encompasses particular economic sectors, innovation priorities, production technologies, the goals set in the National Technological Initiative, the Governor's 5-year development program, national projects, and so on. Second, the priorities of industrial and innovation development are not aligned with those of the investment strategy. Finally, these strategies do not take into account the export orientation of the industrial policy.

The proposed methodology was used to conduct a comprehensive analysis of the regional policies for investment, innovation and industrial development. The analysis shed light on the 'pain points' of the investment and innovation spheres and the lack of alignment between the strategies both in terms of the vertical (federal and regional levels) and horizontal coordination (coordination between the actors operating within the territory of one region). It was found that the strategy delineating the priorities and indicators of the higher, federal level is not decomposed into mutually aligned goals, targets, priorities and steps on the regional level. Moreover, these documents fail to specify the sources of investment and do not take into account the region's industrial and territorial characteristics. Similarly, regional investment, industrial and innovation strategies are not aligned with each other and thus fail to ensure successful channeling of the resources to priority sectors and to stimulate technological development in the long run.

Analysis of investment in Sverdlovsk region has shown that most investment is concentrated in the region's old industrial areas. Moreover, it was found that there is a direct correlation between the amount of government investment and private investment in these areas.

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