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СОДЕРЖАНИЕ

Original Paper

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Analysis of the residential mortgage market in the Ural Federal District

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ABSTRACT
The relevance of this study stems from the fact that it analyzes the current situation on the mortgage market in Russia: the influence of macro-economic factors causes a fall in collateral value, dramatic increase in mortgage default and poor performance of the Agency for Housing Mortgage Lending (AHML). **The study is aimed** at investigating the current state of residential mortgage lending on the regional level in Russia by focusing on the case of the Ural Federal District. The study considers the interests of all the participants of this market: individual borrowers, state authorities, financial and credit institutions engaged in mortgage lending. **The study analyzes statistical data** on the primary residential mortgage market in the Ural Federal District provided by the Central Bank of the Russian Federation, Federal State Statistics Service and the AHML. **Results.** Modern approaches to mortgage system evaluation are compared in order to identify and systematize the key criteria and statistical indicators characterizing the current state of this form of lending relationships. The analysis also brings to light the negative trends in mortgage lending in the Ural Federal District. As a part of our further research, we are going to develop a procedure for evaluating the performance of a mortgage system.

KEYWORDS
residential mortgage, primary mortgage market, lenders, balanced autonomy model, single-tier and two-tiered models, mortgage institutions, lending market

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Анализ состояния рынка ипотечного жилищного кредитования в Уральском федеральном округе

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АННОТАЦИЯ
Актуальность статьи обусловлена тем, что макроэкономическая ситуация последних лет оказала самое серьезное влияние на быстроразвивающуюся систему ипотечного кредитования в Российской Федерации, обнажив целый комплекс проблем – падение стоимости залога, резкий рост просроченной задолженности по выданным ипотечным кредитам, низкая эффективность работы Агентства по ипотечному и жилищному кредитованию. **Цель исследования** – проанализировать состояние ипотечного жилищного кредитования в региональном разрезе на примере Уральского федерального округа, учитывая интерес всех участников: населения, государства и финансово-кредитных институтов, имеющих в распоряжении временно свободные денежные средства и предоставляющие их во временное пользование. **Исследование базируется** на аналитическом обзоре статистической информации, характеризующей первичный рынок ипотечного жилищного кредитования в Уральском федеральном округе. Информационно-эмпирическую базу исследования составили статистические материалы Центрального банка Российской Федерации, Федеральной службы государственной статистики, официальные отчетные данные Агентства по ипотечному и жилищному кредитованию. **Результаты.** По итогам сравнительного анализа многообразия подходов к оценке эффективности функционирования системы ипотечного кредитования определены и систематизированы основополагающие критерии и статистические показатели, характеризующие качество данной формы кредитных отношений; выявлены негативные тенденции, характерные для системы ипотечного кредитования Уральского федерального округа. В рамках дальнейшего исследования будет предложен алгоритм функционирования системы ипотечного кредитования.

КЛЮЧЕВЫЕ СЛОВА
ипотечное жилищное кредитование, первичный рынок ипотечного жилищного кредитования, кредитные организации, модель сбалансированной автономии, одноуровневая и двухуровневая модель, ипотечные институты, кредитный рынок

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Introduction

The recent macro-economic situation has had a considerable effect on the rapidly growing mortgage lending system in Russia, causing a fall in collateral value, a dramatic increase in mortgage default and poor performance results of the Agency for Housing Mortgage Lending (AHML). Nevertheless, despite these negative conditions, the experience of developed countries shows that in a market economy, this form of credit relationships is one of the key instruments to handle socio-economic problems and ensure the affordability of housing.

Mortgage market contributes to the development of a competitive economy, its stabilization and modernization, it also helps decrease inflation and social tension by proving people with housing and stimulating construction and other industries, by stabilizing the financial market and enhancing investment.

Mortgage lending can differ from country to country due to differences in their socio-economic development, financial and credit systems, legislation regulating mortgage relationships and the corresponding models of such relationships.

In Denmark, most mortgages have been provided by one of the major mortgage banks for 150 years. In Germany, loans are offered not only by mortgage banks but also by building societies (*Bausoarkassen*)[1]. In the USA, although mortgages are issued by commercial banks, savings-and-loan associations, and credit unions, it is the government sponsored enterprises (GSEs) established by the US Congress which hold a significant part of the national mortgage portfolio[2].

In the process of building a comprehensive residential mortgage system of its own, Russia can benefit from the experience of mortgage lending services accumulated by foreign banks. Comparative analysis of international models of mortgage lending can provide us with insights about the model that may hold most promise for Russia. In this article, we are also going to explore the current state of mortgage lending in Russian regions by focusing on the case of the Ural Federal District, in particular by looking at the interests of the key participants of the mortgage market: individual borrowers, state authorities, financial and credit institutions engaged in mortgage lending.

This general aim comprises the following specific objectives: we are going to consider the existing models of mortgage lending in different countries (USA, Canada, UK and Germany); investigate the main challenges faced by the mortgage lending system in Russia; and conduct a comprehensive analysis of the primary mortgage market and its efficiency by using the case of the Ural Federal District.

As for the practical implications of this study, the described model of mortgage lending can be used by regional authorities in strategizing and decision-making in the sphere of socio-economic development of their respective regions. Our findings can also be useful for devising ways of stimulating housing construction through policy-making and legislation. Our research can be of interest to housing construction companies seeking to enhance their cooperation with the regional authorities. The results of this study can be used for rationalization of the use of funds in Russian regions and municipalities and their reallocation to address issues in the sphere of housing construction as a part of regional socio-economic policies.

Conceptual and methodological framework

The conceptual and methodological framework of this study is based on classical and contemporary, theoretical and applied research works on mortgage lending written by Russian and international scholars. It also relies on the main legal acts regulating lending relationships in general and mortgage lending in particular.

At the centre of our study is the category 'model of mortgage lending', which corresponds to specific aspects of mortgage lending in different countries determined by their socio-economic development, financial and credit systems, and laws governing mortgage lending. It should be noted that the model of mortgage lending is usually understood as a set of characteristics and relationships within the system of mortgage lending in a specific country [1].

In international practice, there are two basic models of attracting funds to the sphere of mortgage lending: these are single-tier (European countries) and two-tiered (USA, UK and Canada) models [2]. In both models funds are attracted by means of refinancing of mortgage markets

[1] *Getting a mortgage in Germany*. Expatica site. Retrieved from: http://www.expatica.com/de/housing/How-to-get-amortgage-in-Germany_740222.html (19.04.2017).

[2] *Compare Mortgage Options*. U.S. Bank National Association site. Retrieved from: https://www.usbank.com/home-loans/mortgage/compare-mortgage-options.aspx (19.04.2017).

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through assignment of home loans by secondary market operators and securitization[3]. For all the local variations, mortgage lending tends to follow some general patterns, which can be described as three basic models: contractual-savings, secondary market model (or American model) and mortgage bank model [3; 4].

As the experience of developed countries shows, rational state policy in the sphere of mortgage lending may ensure the transformation of this sphere into a self-financing sector, capable of providing stable development of a housing market. Mortgage serves as a catalyst of the real estate market and interconnected spheres since growth in effective demand for housing stimulates construction, manufacturing of building materials and equipment as well as innovation in architecture. It also contributes to growth of retail industry and enhances employment rates [5].

In developed countries, the mortgage mechanism of housing acquisition is prioritized by the state socio-economic policy due to its efficiency: it helps attract considerable investment to the real sector of economy by encouraging housing construction. Moreover, affordable mortgages help the state meet the housing needs of its citizens. A long history of mortgage lending has resulted in the appearance of three classical models [6; 7]: truncated-open, balanced-autonomous and expanded-open. Let us consider them in more detail:

1. The balanced autonomous model (contractual savings system) is a model of mortgage lending based on the loan and savings principle similar to private building societies such as German *Bausparkasse*, French *Livret Epargne Logement*, and American savings and loans. The total portfolio of credit resources is formed not from the funds attracted on the open capital market but from the savings of future borrowers following the same principle as mutual funds [8]. In this model, lenders are not only mortgage banks, but also specialized savings banks such as building societies and savings banks [9]. An essential element of this model is the housing contractual savings, exceedingly wide spread in Germany, France, and Australia. Recently, they have also come in use in the new EU member states such as the Czech Republic, Croatia, Slovakia and Hungary[4]. Apart from Europe, this model is also applied in Angola, Indonesia, Morocco, Thailand, Tunisia, and Chile.

We believe, however, that the balanced autonomous model is not well-suited for Russia for the following reasons: first, it limits the amount of attracted funds to the savings of contributors interested in obtaining credits for buying or building homes and does not include savings and resources of other economic entities; and second, inflation makes it impossible to set acceptable mortgage rates [10].

2). The truncated-open model (traditional, single-tier) is limited to the primary market of mortgage lending where lenders receive mortgage bonds from their clients and use them as security to attract external investment. This model is typical of Western Europe (the UK, France, Denmark, and Spain), Eastern Europe (Bulgaria, Poland and Hungary), Israel, Australia and some Latin American countries. In EU countries, however, mortgage rates vary significantly (the difference can be more than two times) [11; 12]).

In Spain, the terms and conditions of a mortgage credit are the most liberal in Europe: a buyer can borrow up to 100% of the property's value for up to 35 years, with the mortgage origination fee of 1.5% of the property value. However, if a buyer decides to use a construction mortgage, they could save up to a half of the origination fee [13]. In France, a typical mortgage allows a buyer to borrow up to 80% of the property's value for up to 25 years. French banks' lending standards are generally more conservative than in some other European countries and the recent cuts to subsidized interest-free loans for home purchasing have changed the situation as banks started to raise their mortgage lending standards [14]. In the UK, the loan to value ratio is up to 70% while the mortgage rates continue falling and at the moment are at the level of 3.14%. The minimum down payment is about 15% of the property's value [15].

Although the truncated-open (traditional, single-tier) model of mortgage lending is a prototype of the market model of lending relationships, we believe that it would not be a good fit to the Russian national context.

A key characteristic of the truncated-open model is the direct dependence of mortgage rates on the general state and stability of the country's economy, which also affects mortgage banking

[3] *Want A Mortgage?* Forbes site. Retrieved from: https://www.forbes.com/sites/nickclements/2016/09/30/want-a-mortgagethe-credit-score-used-by-mortgage-companies-will-surprise-you (19.04.2017).

[4] Top 5 countries with the lowest mortgage rates. Tranio site. Retrieved from: https://tranio.com/switzerland,japan,finland,germany,luxembourg/analytics/top_5_countries_with_the_lowest_mortgag e_rates_5108/ (19.04.2017).

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activities in specific favourable and unfavourable periods. In practice, within this model, there are no universal standard parameters of mortgages, instead such parameters as the costs and terms of home loans are usually set by each individual mortgage bank depending on specific conditions.

While the scope of mortgage service is limited in Russia, the mortgage rates tend to be higher and the mortgage terms are shorter than in its European counterparts.

3. The expanded open model (model of the secondary mortgage market, two-tiered) is also commonly referred to as the 'American mortgage model' because it is the most popular in the US[5] [16]. The primary mortgage market is where borrowers can obtain home loans directly from primary lenders while the secondary market deals with sales of securities or bonds collateralized by the value of mortgage loans.

The expanded open model means that a person with a certain annual income purchases a move-in ready home paying in cash only an insignificant part of its value (10–20%) while the rest is borrowed from a specialized mortgage bank with the borrower's property (either already owned or being purchased) used as a collateral (at the interest rate of 7–9%). As a rule, it takes about 15–30 years to repay such mortgage loans depending on the borrower's annual income and the mortgage type.

Within this model, the primary lender can refinance the issued mortgages either by selling them directly to investors or specialized institutions of the secondary market (secondary market operators) or by exchanging them for mortgage-backed securities [17; 18].

The expanded open model is more suitable for the Russian context since, unlike the contractual savings system, it does not require much time for the accumulation of natural persons' funds in the initial period [19]. This means that the expanded open model can be implemented much faster and on a massive scale.

Our analysis of different models of mortgage lending has led us to the conclusion that the expanded open model is optimal for Russia (Figure 1) and that it will help make housing more affordable and accessible for Russian citizens.

Since this model is open and oriented towards obtaining resources from the free market, it is quite susceptible to changes in the financial and credit market. The stability of the system, however, is ensured by the government through legal, financial and licencing regulation. The government can also give guarantee and insurance against risks, provide tax preferences and offer targeted subsidies.

It should be noted that the structure of the current legal framework for mortgage lending in Russia is oriented towards building a secondary mortgage market, that is, it relies on the expanded open model. This becomes obvious if we look at Chapters 3 and 8 of the Federal Law 'On Mortgage (Pledges of Immovable Property)', describing the mortgagee's rights to the obligation secured by mortgage, assignment of rights under mortgage agreement, transfer and pledge of encumbrance.

The two-tiered scheme of mortgage lending in Russia was officially adopted in the 'Concept of the Development of the Residential Mortgage System'[6], which launched the implementation of a consistent government policy aimed to ensure the rights of lenders and investors on the mortgage market and at the same time to make housing and mortgages more affordable and accessible for creditworthy citizens.

The two-tiered model of mortgage lending underpinning the Russian residential mortgage system holds considerable potential for state regulation of this market and, consequently, the real estate market, securities market and macro-economic regulation in general [1].

Results and discussion

The main focus of this study is the financial, economic, institutional and legal relationships in the residential mortgage market in Russia. At the key stage of this study we analyzed the available statistical data on the primary mortgage market in Russian regions [20; 21]. The data we used at this and the following stages of analysis were provided by the Central Bank of the Russian Federation, Federal State Statistics Service (Rosstat) and AHML in 2014–2018.

[5] Homebuying Step by Step. Canada Mortgage and Housing Corporation site. Retrieved from: https://www.cmhcschl.gc.ca/en/co/buho/step-by-step/index.cfm (19.04.2017).

[6] The Decree of the Government of the Russian Federation of 11.01.2000 № 28 (amended as of 08.05.2002) 'On the Measures for the Development of the Residential Mortgage System in the Russian Federation' (together with the 'Concept of the Development of the Residential Mortgage System in the Russian Federation' and the 'Plan of Preparation of the Drafts of Regulatory Acts for the Development of the Residential Mortgage System in the Russian Federation'). Retrieved from: http://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=LAW&n=36649&fld=134&dst=100000,0&rnd=0.8203381367685081#049319826734995775 (02.03.2020).

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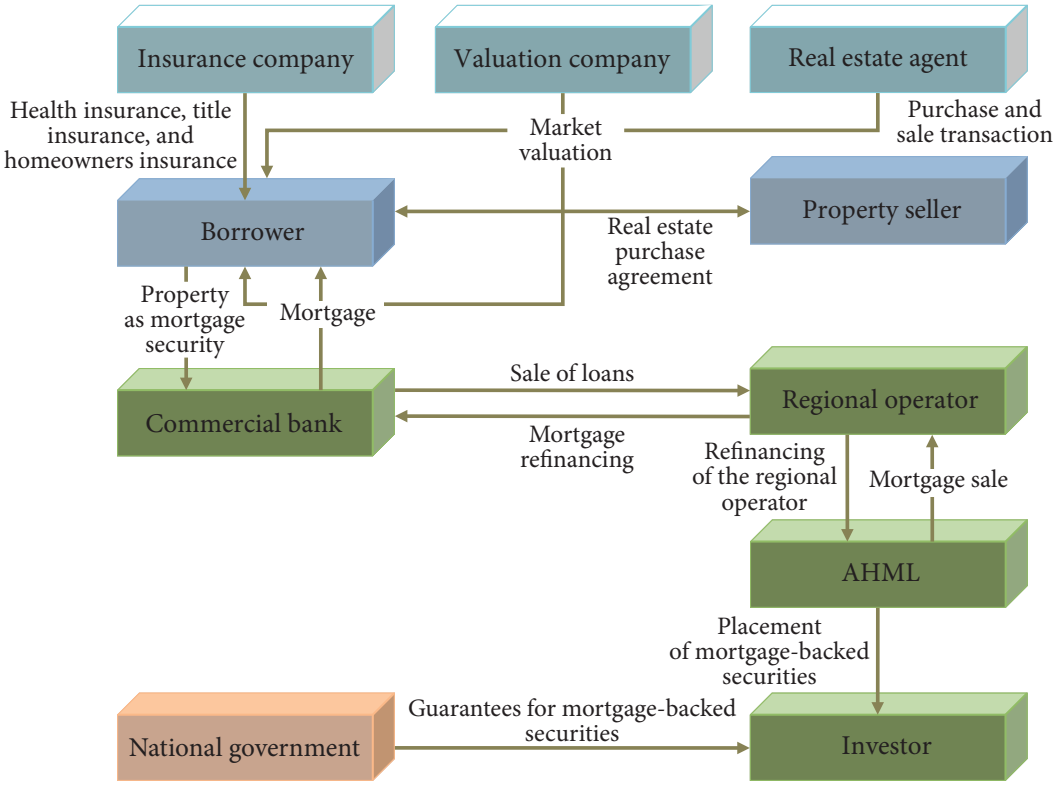

Figure 1. *Expanded open model (secondary, 2-tiered) of mortgage lending in Russia* [3]

If we look at the statistics on the number of lenders on the primary mortgage market in the Ural Federal District, we see the following picture: in the given period, the Central Bank's policy led to a decline in the number of lenders, including mortgage lenders; falling national currency value on the global market; and reduced demand for banking products (see Table 1).

Table 1

Number of lending institutions on the mortgage market of the Ural Federal District in 2014–2018

Year	Number of lenders,				
	total	including:			
		mortgage lenders	mortgage investors	mortgage refinance lenders	lenders attracting secondary market investors
2014	35	34	9	1	6
2015	32	31	8	0	3
2016	29	28	8	1	1
2017	26	26	9	4	3
2018	23	23	10	8	3

Compiled by the authors based on the AHML data. Retrieved from: https://cbr.ru/statistics/pdko/Mortgage/ (Accessed: 02.03.2020)

In 2014–2018, 11 lenders left the primary mortgage market, that is, the number of participants fell by 32.3%, from 35 to 23.

According to Figure 2, Sverdlovsk region had the maximum number of lenders on the mortgage market in 2014 (15 participants). In 2016, this region accounted for the largest share (45%) in the total number of lenders in the Ural Federal District. In 2014–2018, Kurgan region had the smallest number of lenders on the mortgage market.

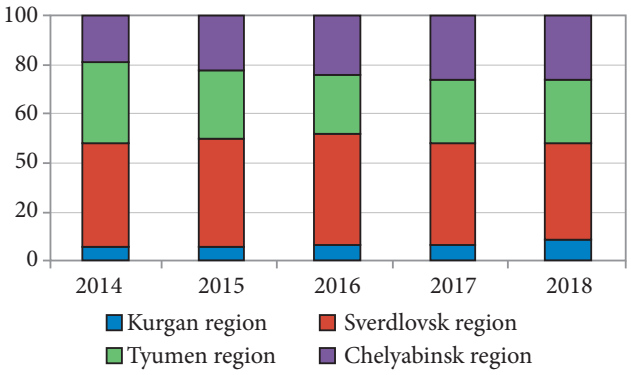

Figure 2. *Structure of the mortgage market in the Ural Federal District in 2014–2018*
Compiled by the authors based on the AHML data. Retrieved from: https://cbr.ru/statistics/pdko/Mortgage/ (Accessed: 02.03.2020)

The regional distribution pattern of issued mortgages in the given period remained practically the same. Borrowers in Tyumen region accounted for the largest volume of issued mortgages and, accordingly, the highest percentage in the overall volume of operations on the mortgage

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market in 2014–2018. The lowest figures were supplied by Kurgan region and the Yamalo-Nenets Autonomous District (Figure 3).

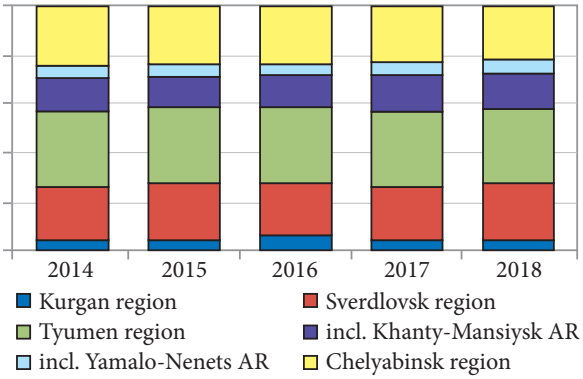

Figure 3. *Volume of mortgage loans given to natural persons in 2014–2018 in the Ural Federal District*
Compiled by the authors based on the AHML data. Retrieved from: https://cbr.ru/statistics/pdko/Mortgage/ (Accessed: 02.03.2020)

The dynamics of the volume of mortgage lending shown in Figure 3 determined the dynamics of mortgage debt, which grew steadily in 2014–2018. As of the end of 2018, the amount of mortgage debt in roubles increased by 18,743 roubles (by 117.5%) in comparison with 2014 and reached 125,792 roubles.

This situation to a significant extent was determined by per capita income in the region (Table 2).

In the Ural Federal District, per capita income increased from 28.7 thousand roubles a month in 2013 to 34.9 thousand roubles a month in 2018. According to Rosstat, the Yamalo-Nenetsk Autonomous Region ranked first among other Ural regions in 2018 in terms of per capita income and its dynamics (79.3 thousand roubles a month) while the poorest region, lagging behind the rest, is Kurgan region with per capita income of 20.3 thousand roubles a month.

Table 2

Per capita income in the Ural Federal District, rbs

Regions	2013	2014	2015	2016	2017	2018
Ural Federal District	28719	29997	32794	32907	33643	34955
Kurgan region	17076	18315	20310	20175	20660	20334
Sverdlovsk region	30459	31538	34113	34718	35210	36735
Tyumen region	36167	37783	41893	42657	44241	46124
Khanty-Mansiysk Autonomous Region – Yugra	39882	40811	46221	46934	48834	50717
Yamalo-Nenets Autonomous Region	58829	62020	67624	72358	76027	79398
Tyumen region without autonomous regions (Khanty-Mansiysk and Yamalo-Nenets)	23169	25142	27448	27044	27672	29162
Chelyabinsk region	21971	23070	24654	23657	23719	24386

Compiled by the authors on the basis of Rosstat data. Retrieved from: https://www.gks.ru/free_doc/new_site/population/urov/urov_11sub.htm (Accessed: 02.03.2020)

Table 3

Weighted average period and rate of mortgages in roubles given to natural persons in 2014–2018 in the Ural Federal District

Region	2014		2015		2016		2017		2018	
	Weighted average mortgage period, months	Weighted average rate, %	Weighted average mortgage period, months	Weighted average rate, %	Weighted average mortgage period, months	Weighted average rate, %	Weighted average mortgage period, months	Weighted average rate, %	Weighted average mortgage period, months	Weighted average rate, %
Ural Federal District	187.3	12.39	189.8	12.41	183.4	13.42	186.4	12.73	187.3	10.65
Kurgan region	215.0	11.61	205.5	12.26	199.9	13.19	195.3	12.60	194.3	10.58
Sverdlovsk region	180.2	12.48	184.4	12.46	182.0	13.53	186.2	12.71	189.0	10.66
Tyumen region	200.9	12.31	203.6	12.33	192.2	13.35	197.3	12.71	194.7	10.62
including Khanty-Mansiysk Autonomous Region – Yugra	220.1	12.31	203.5	12.33	188.5	13.30	190.5	12.83	190.4	10.67
including Yamalo-Nenets Autonomous Region	217.0	11.83	211.3	11.91	193.5	13.52	196.3	12.58	194.7	10.50
Chelyabinsk region	159.6	12.68	163.8	12.55	156.7	13.60	159.9	12.83	165.6	10.75

Compiled by the author based on Rosstat data. Retrieved from: https://cbr.ru/statistics/pdko/Mortgage/ (Accessed: 02.03.2020)

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In the given period, the weighted average rate in roubles for the Ural Federal District fell by 1.74 percentage points and the weighted average mortgage period in 2014–2018 remained virtually unchanged – 187.3 months (15.6 years) (Table 3).

In the given period, the weighted average rate decreased in all the regions – in Kurgan region, by 1.03%; in Sverdlovsk region, by 1.82%; in Tyumen region, by 1.69%; and in Chelyabinsk region, by 1.93%. As for the mortgage period, in some regions it became longer (Sverdlovsk region, by 7.2 months and in Chelyabinsk region, by 6 months) while in Kurgan and Tyumen regions, it, on the contrary, shortened – by 20.7 months and 6.2 months respectively.

Conclusion

The study of theoretical principles and aspects of mortgage lending has led us to the following conclusions.

Our analysis of the problems and prospects of the Russian mortgage system centred around the model of mortgage lending [1]. Analysis of the three key models (balanced autonomous model or contractual savings system; truncated open model or traditional single-tier model; and expanded open model or secondary mortgage model, two-tiered), characteristic of international practices of mortgage lending [22; 23], in their relation to the Russian context has brought to light the following priorities in the development of the national system of lending relationships: first, it is essential to safeguard the interests of both lenders and borrowers; second, to enhance affordability of mortgages for average consumers and assign a priority role to mortgage lenders in the credit sector; and, finally, to enhance state regulation of mortgage lending relationships [24; 25].

The comprehensive analysis of the primary mortgage market in the Ural Federal District has revealed the following problems.

First, in the given period, the number of participants of this market fell dramatically, in particular the number of lenders (by 32.3%). At the end of the period, there were 23 participants. It is expected that this negative trend will have negative long-term repercussions such as a decline in competition in the banking sector and tiering of the banking system, reduced number of market niches where the right lenders could be found for investment projects (borrowers) of different risk levels.

Second, in 2014–2018, there was a steady growth of mortgage debt, which increased by 18,743 roubles (or 117.5%). Another trend was the ageing of mortgage debt due to poor asset management, unstable financial and economic situation of borrowers caused by the changing macro- and microeconomic conditions in the country.

Third, in the given period, there was a drop in the mortgage rates from 12.41% in 2014 to 10.65% in 2018, which significantly affected the real estate prices and made housing more attractive in terms of investment opportunities.

Overall, our analysis of the financial, economic, institutional and legal relations on the primary mortgage market in the Ural Federal District has demonstrated that at its current stage, the research in this sphere lacks consistency, particularly in the evaluation of the mortgage system's efficiency on the regional level.

In our further studies we intend to bridge the existing gaps in research literature by developing a methodology for systematizing the criteria and indicators of the mortgage system's efficiency. The procedure will include the following stages: creating a ranking system based on the mortgage system's efficiency criteria and the corresponding set of statistical indicators; analysis of the influence that specific statistical indicators have on the system; and, finally, developing an integral indicator for evaluation of the system's efficiency on the regional level.

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The role of interregional relationships in research talent development

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ABSTRACT
The relevance of research. Workforce quality is paramount to the development of innovative economy and socio-economic development of territorial systems. Not all regions, however, are able to train sufficient R&D personnel to meet the needs of their innovative economies. The lack of research talent can be compensated by establishing cooperative relationships with other territorial systems. Therefore, it is important to study the existing interregional interconnections in the development of research talent and to identify the key priorities in this sphere. **The aim of the study** is to demonstrate the relationship between the indicators of development of research talent in different regions and their innovative activity. **Data and Methods.** The study uses spatial econometric modeling tools and methods for calculating global and local spatial autocorrelation indices of Moran P. and their dispersion diagrams. The spatial autocorrelation was calculated by using a standardized matrix of distances along the roads between the regional administrative centers. **As a result of the analysis**, a close relationship was found between the indicators of development of research talent in Russian regions and their innovative activity. The constructed regression model based on spatial data lead us to the conclusion that efficient innovative development requires a pool of STEM talent in the regions, which means that it is necessary to provide sufficient opportunities for training and education in this sphere. **Conclusions.** The study of the interconnections between the regions using the improved method of spatial autocorrelation of P. Moran revealed a cluster of closely interconnected regions (Moscow – St. Petersburg – Moscow region – Nizhny Novgorod region – Ryazan region – Ivanovo region – Tver region – Kostroma region – Tula region) and three potential clusters: 'Volga', 'Ural', and 'Siberia'.

KEYWORDS
regional system, research talent, innovative economy, inter-regional relations, spatial autocorrelation, spatial autoregressive analysis

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Исследование межрегиональных связей в процессе развития научных кадров инновационной экономики

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АННОТАЦИЯ
Актуальность исследования. Существующая инфраструктура научно-технического комплекса не в состоянии обеспечить условия для формирования и развития инновационной экономики без наличия необходимого научно-технического кадрового потенциала, даже если рассматривается территориальная система, обеспеченная финансовыми ресурсами. В связи с этим важно изучить существующие межрегиональные взаимосвязи в развитии кадрового потенциала инновационной экономики и определить приоритетные направления их развития. **Целью исследования** является поиск и подтверждение взаимосвязи между показателями развития научных кадров в регионах и показателем их инновационной активности. **Данные и методы.** Исследование межрегиональных связей основано на использовании инструментов пространственного эконометрического моделирования, а также методов расчета глобальных и локаль-

КЛЮЧЕВЫЕ СЛОВА
региональная система, научно-кадровый потенциал, инновационная экономика, межрегиональные связи, пространственная автокорреляция, пространственный авторегрессионный анализ

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ных пространственных индексов автокорреляции Морана П. и диаграмм дисперсии. Пространственная автокорреляция рассчитывалась с использованием стандартизированной матрицы расстояний вдоль дорог между областными административными центрами. **В результате анализа** была обнаружена тесная связь между показателями развития научных кадров в регионах и инновационной активности. Построенная регрессионная модель на основе пространственных данных позволила сделать вывод о том, что формирование инновационной экономики требует развития кадрового научного потенциала, воспроизводства персонала, занимающегося исследованиями и разработками. В ходе исследования мы пришли к выводу, что для инновационного развития регионов необходимо воспроизводить научные кадры в области фундаментальных и прикладных исследований, а также инженерно-технические кадры. **Выводы.** Изучение взаимосвязей между регионами с использованием усовершенствованного метода пространственной автокорреляции П. Морана позволило установить кластер тесно взаимосвязанных регионов (Москва – Санкт-Петербург – Московская область – Нижегородская область – Рязанская область – Ивановская область – Тверь область – Костромская область – Тульская область) и три потенциальных кластера: «Волга», «Урал», «Сибирь».

ДЛЯ ЦИТИРОВАНИЯ
Naumov, I.V., & Barybina, A.Z. (2020). The role of interregional relationships in research talent development. *R-economy*, 6(1), 14–27. doi: 10.15826/recon.2020.6.1.002

Introduction

Workforce quality is paramount to the development of innovative economy and socio-economic development of territorial systems along with other factors such as financial resources; institutional environment; production, transport, engineering and research infrastructure. Highly qualified researchers and engineers are necessary to generate innovative ideas and create the necessary conditions for their successful implementation, which, in its turn, also relies on constant engineering support and technical supervision.

The key role of research talent in the formation and development of an innovative economy in Russia has been confirmed by our previous studies [1; 2]. In these works, we have identified the active reduction in the number of research personnel in the field of natural and technical sciences as well as the decrease in the number of engineering personnel. These negative trends in the reproduction of human resources in R&D resulted from the structural shift in the state priorities of funding applied research. Since 2004, basic science in Russia has been funded on a residual basis.

Since 2009, the number of patents for inventions granted to innovative enterprises and research organizations has been reduced. The patent structure has come to be dominated by utility model patents rather than inventions as it used to be. This has led to the situation where Russian innovative enterprises and research organizations are focused not on the creation of fundamentally new technologies, technical innovations, but on the modernization and improvement of the existing ones. A study of the dynamics of scientific and technological potential in Russia, intellectual resources, research of the processes of their reproduction has led us to the conclusion that the accumulated scientific potential is not used to create advanced technologies and the current trends can lead to its further deterioration in the future.

Formation and development of an innovative economy can be impeded by the lack of qualified scientific, technical and engineering personnel. Figure 1 shows that in Russia there are few innovation-oriented regions with sufficient human resources in R&D. This figure shows that the leading regions in this respect are the city of St. Petersburg, the city of Moscow, Moscow region, Nizhny Novgorod region, Sverdlovsk region, Chelyabinsk region, Tyumen region, Samara region, Rostov region, Perm region, Krasnodar region, the Republic of Tatarstan and the Republic of Bashkortostan. Some regions have sufficient scientific personnel, but do not differ in high rates of innovation activity (Novosibirsk Region, Voronezh Region, Tomsk Region, Kaluga Region, Leningrad Region, Yaroslavl Region and Krasnoyarsk Krai). Despite the high rates of innovation activity, some regions do not have enough specialists to generate new ideas and technologies (Belgorod Region, Arkhangelsk Region, Tula Region, Lipetsk Region, Khabarovsk Territory, the Republic of Mordovia and Udmurtia).

Obviously, not all regions have the scientific and technical potential, innovative infrastructure, R&D personnel necessary to develop an innovative economy, which complicates the process of in-

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novative development of these territories but does not impede its implementation. In modern conditions of economic development and the strengthening of cooperative relationships between territorial systems, the generation and implementation of technological innovations does not require the construction of new research institutions and the creation of a powerful innovation infrastructure in each region. It is enough to form and develop close relationships with scientific and technological complexes, objects of innovative infrastructure that operate in other territorial systems and have powerful human resources for the generation of new technologies. Interregional cooperation of the territories in the sphere of research talent development will allow them to compensate for the lack of innovation infrastructure in the territory and create conditions for the development of an innovative economy. Interregional cooperation between the territories is necessary for the exchange of technological experience and implementation of technologies, training of R&D personnel, involvement of unique specialists for the development of technical and technological innovations and their implementation, for cooperation in servicing innovative production technologies and so on.

The study of the interregional connections in the development of research talent and the identification of priorities for its development is particularly relevant in the light of the processes described above. The main objectives of this study are to analyze the availability of research talent necessary for the formation of an innovative economy and to evaluate the relationships between regions in terms of developing human resources for an innovative economy.

Literature review

The most significant theory for understanding the economic essence of human resources in R&D, in our opinion, is the human capital theory of T. Schulz and G. Becker [3], who saw human capital as a component of innovative production: 'knowledge, skills, practical experience, inspired by intellectual activity, are a form of realization of a person's intellectual, moral and culturally oriented abilities to create new, previously unknown knowledge, providing intellectual rent and various advantages over competitors' [4, p. 332].

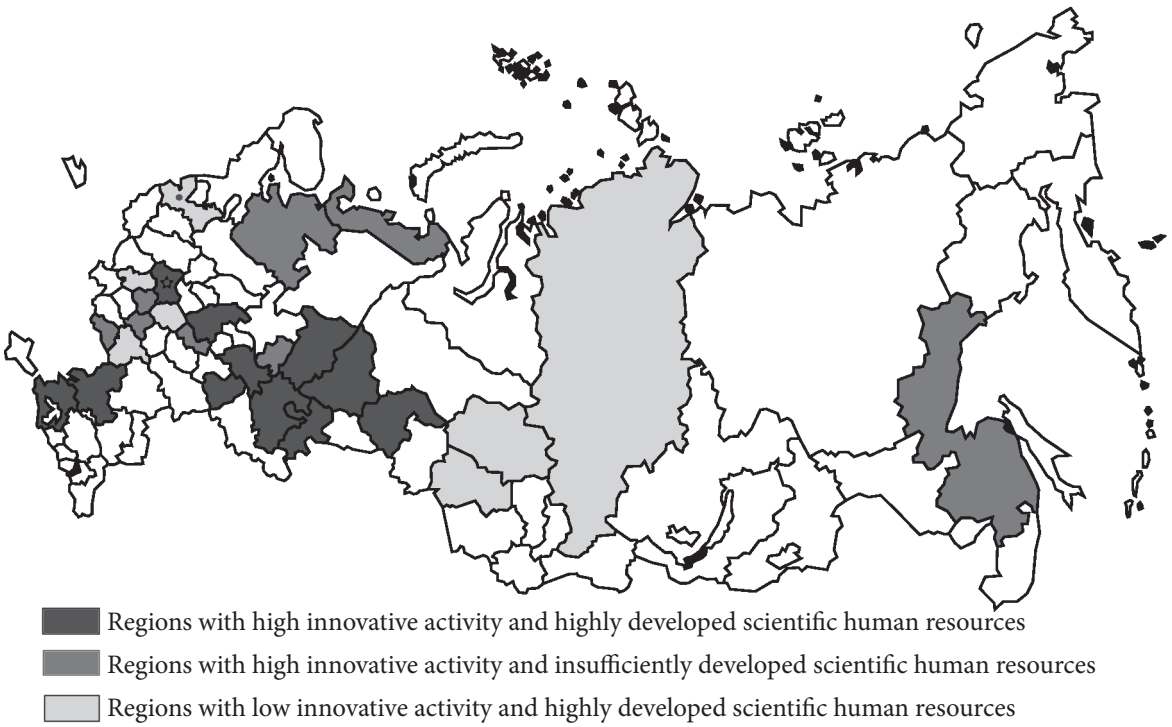

Figure 1. *Spatial differentiation of regions according to the level of innovative activity and research talent*[1]

Source: the authors' calculations are based on the data from 'Regions of Russia. Socio-economic indicators'. 2018, statistical data. Moscow: Rosstat; 2018, pp. 1162, 902–907, 954–955

[1] In this study, we consider a value that exceeds the average level in terms of the volume of produced and shipped innovative goods, works, services in million rubles as a high level of innovative activity in the region; a value that exceeds the average level in terms of the number of R&D personnel, as a high level of development of research talent.

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Therefore, intellectual activity is the component that distinguishes creative work abilities from performing work abilities, human capital from simple labor, and determines the conditions and nature of the process of 'capitalization' of intellectual labor abilities.

There is no universally accepted definition of 'research talent'. In the National Human Development Report of the Russian Federation: 'Demographic Challenges of Russia', there are outlined three methodological approaches:

– philosophical approach [5, p. 1472], which interprets research talent as 'an abstract category, deprived of the ability to change over time, but having initial creative power' (Thomas Aquinas, A.A. Ukhtomsky, P.A. Florensky);

– psychological and pedagogical approach [6, p. 25], which defines research talent as 'the ability to learn, intellectual abilities (competence, initiative, creativity, self-regulation, uniqueness of mindset)' (D.B. Epiphany, L.S. Vygotsky, A.I. Kochetov, A.I. Subetto);

– socio-economic approach [4; 7, p. 228; 8; 9], which links the complex characteristics of the development of intellectual, creative capabilities of an individual and the country's resources with the functioning of the fields of education and science and the acceleration of scientific and technological progress (V.K. Levashov, B.G. Kleiner, Y.P. Lezhnina, R.E. Leshchiner, A.I. Tatarkin, A.F. Martynov).

The essence of the research talent may be considered in relation to the two key concepts – 'intelligence' and 'potential', the latter being understood as 'funds, stocks available and those that can be mobilized, used to achieve a specific goal, implement a plan, solve a problem' [10, p. 281]. Intelligence is an individual property that determines the possibility of mental activity [11, p. 71]. In modern studies, intelligence is often associated with the philosophical concept of noosphere [12, p. 25]. For R&D personnel to fulfill their functions, such elements of intelligence as knowledge and mental abilities are needed. In other words, their function is to solve practical or theoretical problems with the required efficiency. Researchers and engineers possess specific competencies – 'a strategic resource that predetermines the social and economic life of the country for decades' [13, pp. 76–96]. Certain efforts on the part of social institutions such as the family and the state contribute not only to the formation of highly qualified workforce, but also to the realization of their intellectual potential in production, creation of cultural values, social management, upbringing, etc. Within this approach, intelligence is considered as a socio-economic category [14].

The role of research talent in the formation and development of an innovative economy can be evaluated differently. Some studies consider the research talent as a combination of material, labour, financial, natural and information resources of social production and, therefore, as a reflection of the national economy's ability to use knowledge technologically and commercially for socio-economic development [15, p. 18; 16, p. 20]. Another approach was proposed by L.S. Blyakhman, F.L. Merson, and E.M. Peat [17, p. 56], who put the main emphasis on the results of innovation, in particular financial gains from the sale of intellectual goods in foreign markets. Some studies use a resource-effective approach ([18, p. 45]), in which case the analysis and assessment of intellectual potential is based on an integral indicator combining the results of intellectual activity and resources. Within this approach, the main focus is made on the national economy's ability to benefit from the intellectual capabilities of the research staff [19, p. 20]. The problem of the role that research talent plays in building an innovative economy is discussed in a number of other studies [20–32]).

Methodology

Our spatial non-linear regression analysis uses the least-squares method and confirms the close relationship between the research talent in the regions and their level of innovation[2]:

$$V = e^{10.4} P^{0.009}, \quad (1)$$

where V is the volume of produced innovative goods and services in 2017, mln rubles; P is the number of R&D personnel in 2017, people.

As a result of the analysis of 84 Russian regions in 2017, we constructed a statistically significant non-linear regression model. The correlation coefficient (R = 0.8) and determination ($R2$ = 0.63) indicated a close correlation between the variables; the significance of the determination coefficient ($F < 0.05$) confirmed the statistical significance of this indicator and the sufficiency of statistical data for building the model. P-values of all regression coefficients confirmed the de-

[2] To assess the level of development of research talent, we used an indicator of the number of R&D personnel; to assess innovation in the region, we analyzed the volume of innovative products produced.

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pendence of the volume of produced innovative goods, works, services on the number of R&D personnel (see Table 1). All Gauss-Markov conditions for the constructed regression model are satisfied. The mathematical expectation of residuals in the model is close to zero, multicollinearity between factor variables and autocorrelation between residuals is absent. The accuracy of the constructed regression model was confirmed graphically. The simulated values of the volume of output of innovative goods and services in the regions copy real values.

The study of the relationship between territorial systems today is carried out by using three theoretical and methodological approaches:

– spatial econometrics (spatial autocorrelation and autoregression);

– spatial agent-based modeling;

– simulation of socio-economic processes in space using interindustry balance.

Despite the significant substantive difference between these methodological approaches, they have one thing in common, that is, the correlation and regression functional relationships between the given objects in space. Therefore, the formation of a spatial simulation model is impossible without an idea of the existing functional relationships between regional systems, without regression dependencies of the processes under study on the action of external and internal factors. These relationships are revealed in the course of spatial autocorrelation and autoregressive analysis. The functional regression dependences revealed through spatial econometrics create the foundation for agent-based modeling of the interaction of specific objects in space. Spatial autocorrelation and autoregressive analysis allow us to identify clusters of interconnected territories, which, when implementing an agent-based approach, can help us solve the most important problem of research and modeling the processes of moving agents between territorial systems. Our study showed that the methodological approach involving the use of tools such as spatial autocorrelation and autoregression is the basic approach in studying the interconnections between territorial systems of various levels in socio-economic processes. The basics of spatial autocorrelation analysis were formed by P. Moran [33], W. Alonso [34], L. Anselin [35], R. Geary [36], A. Getis and J.K. Ord [37]. In this article, the study of interregional relationships in the development of research talent will be based on the use of spatial econometrics tools according to the algorithm tested in our earlier work (Figure 2).

The main goal at the initial stage of our study was to study the structure and the key elements constituting research talent. To this end, we propose the use of correlation and multiple linear / non-linear regression analysis using the least squares method with an assessment of the statistical reliability of the constructed model. Regression analysis will allow us to establish the core elements that contribute to the development of an innovative economy in regional systems, which means that these elements should be prioritized and their reproduction will require active interregional cooperation. The study of interregional interconnections is to be carried out by using a modified methodology for calculating global and

Table 1

Results of non-linear spatial regression analysis of the dependence of the volume of produced innovative goods, works, services on the number of R&D personnel

Regression statistics	
Correlation coefficient (R)	0.80
Coefficient of determination	0.63
Standard error	18.1

Analysis of variance

	df	*SS*	*MS*	*F*	*F* value
Regression	1	44737	44737	136	7.08E-19
Residual	79	25932	328		
Total	80	70669			

Regression coefficients		Standard error	*t*- statistics	*P*-value	Lower 95%	Upper 95%
constant	10.4	2.1	4.9	4.6E-06	6.2	14.6
P	0.0009	7.3E-05	11.7	7.1E-19	0.0007	0.001

Source: the authors' calculations based on the data from 'Regions of Russia. Socio-economic indicators'. 2018, statistical data. Moscow: Rosstat; 2018, pp. 1162, 902–907, 954–955.

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local spatial autocorrelation indices P. Moran, diagrams of their dispersion. This analysis will allow us to do the following:

– establish the relationship between regional systems in terms of the development of elements of research talent;

– determine the direction of this connection (direct or reverse);

– establish the main centers of localization of research talent and their influence zones;

– identify the territories that lack human resources and are in need of close interactions with other regions for the development of an innovative economy.

The P. Moran dispersion diagram will help us identify spatial priorities for the development of research talent and closely related regions which receive a strong impetus in the development of human resources. The algorithm for the implementation of spatial autocorrelation of regions in terms of the development of elements of research talent is presented in Figure 2 above. The spatial autocorrelation to be carried out by using a standardized matrix of distances along the roads between the administrative centers of Russian regions. Our studies have shown that the use of other types of standardized distance matrices in the calculation of Moran indices does not lead to radically different results from the technique we use. According to the traditional technique of Patrick Moran, interterritorial relationships are estimated by using spatial adjacencies (using a matrix of standardized distances along adjacent borders). The determination of the neighborhood of territories in this methodology is based on the presence of common borders. The weights between features form a matrix of spatial weights. It reflects the intensity of geographical relations between neighboring objects. The type of distance matrices does not seriously affect the search for interconnections between territorial systems. In all cases, the results we obtain from the P. Moran dispersion diagram have a similar form. When using various distance measurement systems, the values of the global and local Moran indices differ, which are used to assess the tightness of the relationship. The calculation of these indicators is proposed to be carried out according to the traditional method of spatial autocorrelation of Moran:

$$I_G = \frac{N}{\sum_i \sum_j W_{ij}} \cdot \frac{\sum_i \sum_j W_{ij}(x_i - \mu)(x_j - \mu)}{\sum_i (x_i - \mu)^2}; \quad (2)$$

$$I_{Li} = N \cdot \frac{(x_i - \mu)\sum_i w_{ij}(x_j - \mu)}{\sum_i (x_i - \mu)^2}, \quad (3)$$

where I_G is the global autocorrelation index of the given regions; I_{Li} is the local autocorrelation index of the given regions; N is the number of regions; W_{ij} is the element of the matrix of spatial weights for regions i and j; μ is the average value of the in-

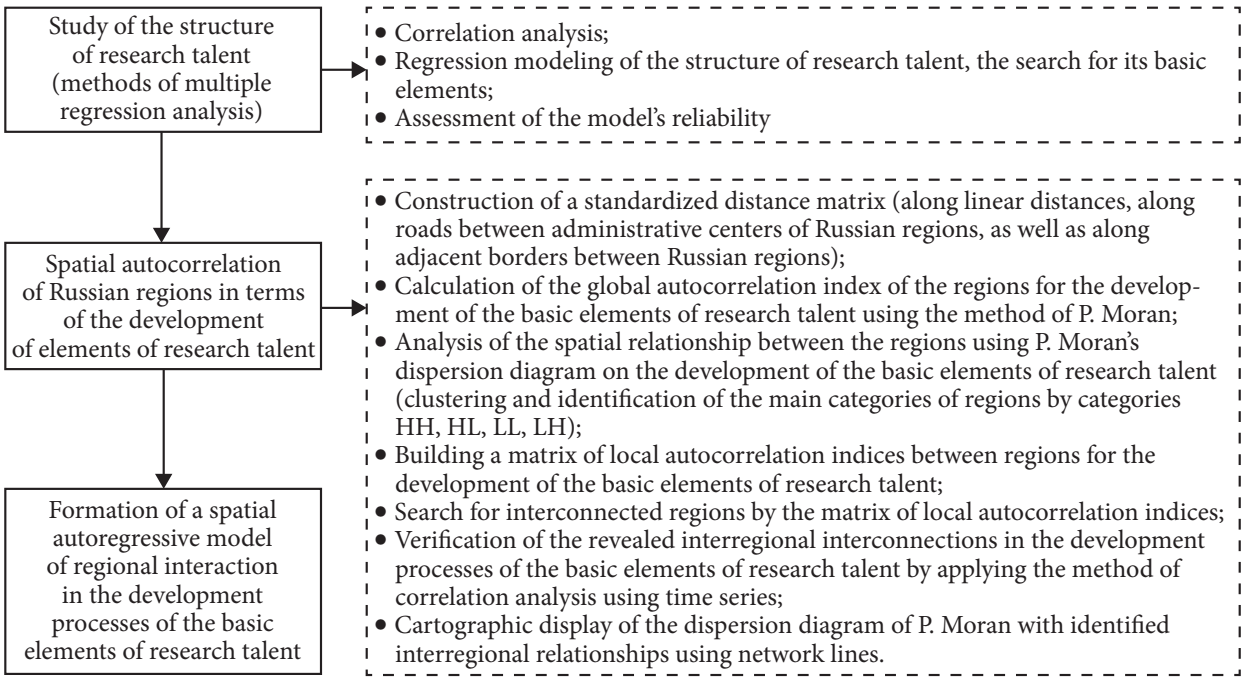

Figure 2. *Algorithm for the study of interregional relationships in the development of research talent*

Source: compiled by the authors by using the data from [38]

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dicator; x_i is the analyzed indicator of one region; x_j is the analyzed indicator of another region.

We propose to conduct the analysis the spatial relationship between regions for the development of the basic elements of research talent by forming a dispersal diagram of P. Moran (Figure 3). This diagram will allow us to group the regions into four categories (HH, HL, LL, LH) depending on the level of development of human resources and the features of their spatial distribution. In contrast to the traditional approach, in this study in each category of regions we propose to distinguish territories with high values of the local autocorrelation index (above the average value). This will allow us to select territories with the highest degree of interconnection and cluster them out of the totality of regional systems belonging to a particular category (HH, HL, LL, LH). This refinement of the traditional methodological approach is explained by the need to eliminate the ambiguity of the results.

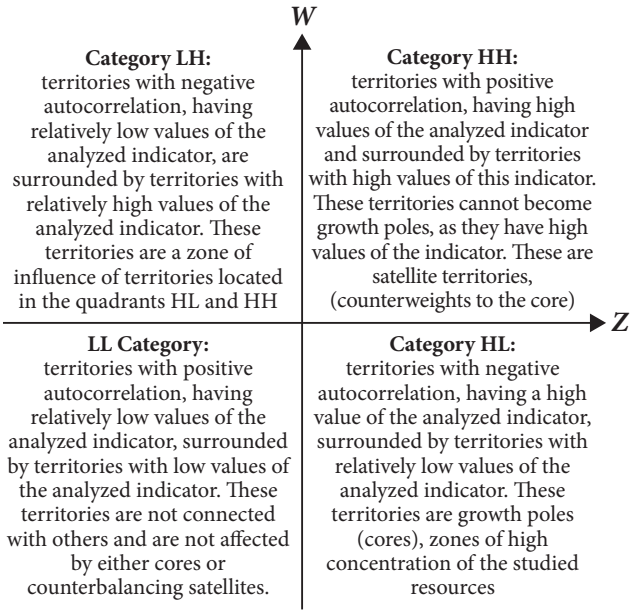

Figure 3. *Patrick Moran P. Dispersion Diagram*

Source: compiled by the authors by using the data from [38]

According to the Moran P. dispersion diagram, the HL category includes regions with a high value of the analyzed indicator and surrounded by territories with relatively low values of this indicator. These territories are the 'growth poles' for other territorial systems. However, calculations of the local Moran autocorrelation indices show that regions with weak interregional relationships, which are not growth poles, can also be included in this category. Regional systems located in the HH and LH categories are a kind of zone of mutual influence of the 'growth poles' and have a close relationship with them. At the same time, not all regions of these categories have high values of local autocorrelation indices. As a result, a contradictory situation arises, according to which the relationship between the regions revealed in the P. Moran Dispersion Diagram is not confirmed by calculations of autocorrelation indices. Therefore, to the truly interconnected regional systems in the HH and LH categories, we propose to assign only territories with high autocorrelation indices (if they exceed the average value calculated for all Russian regions). The remaining regions in the HH and LH categories are not associated with HL, but receive impetus from their development. The development of the traditional methodological approach to spatial autocorrelation was carried out in the direction of confirming the identified relationships between territorial systems. The revealed interregional relationships in terms of the development of research talent as a result of the formation of a matrix of values of local autocorrelation indices, we propose to check using correlation analysis using time series. Correlation analysis will allow us to assess the tightness of the revealed relationship between the regions not only by spatial but also by temporary statistics.

The established interconnections between the regions in the processes of developing research talent are presented for illustrative purposes in cartograms. Its basis will be formed by the results of the clustering of territories according to the dispersion diagram of P. Moran, as well as interregional relationships established by the matrix of local autocorrelation indices. We propose to depict the relationships between the regions in the cartogram in the form of network lines. The final stage in the study of interregional ties in the development of research talent is the formation of a spatial autoregressive model of the interconnection of regions. This stage not only confirms the relationships between the regions identified at the previous stage, but also forms a model that predicts a change in these relationships in the future.

Results and discussion

In this study, we propose to consider research talent from the perspective of resources (as intellectual resources of a particular territory) and from the perspective of ability of a certain territorial system to form and develop an innovative economy. Human resources are drivers of innovative economy. In our opinion, territorial systems

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can engage in active innovative development even if their research talent is insufficient through interregional ties and cooperation with other territories with stronger scientific potential. The study of such interregional relations will allow us to draw conclusions about the readiness of regional systems for innovative development.

In accordance with the resource-related approach, the research talent in regions comprises researchers (specialists in STEM fields); engineering and technical staff; and support staff.

We used the statistical data for 82 Russian regions for 2017 to conduct multiple least squares regression analysis and identified the two main elements of the research talent structure necessary for the formation and development of an innovative economy:

$$RT = 1.64R + 1.73ES, \quad (4)$$

where RT is research talent (the number of employees engaged in R&D), people; R is the number of researchers, people; ES is the number of engineering staff, people.

The regression analysis did not include statistics on the Jewish Autonomous Region and the Chukotka Autonomous Region due to the lack of data; Tyumen Region was considered without the Yamalo-Nenets and Khanty-Mansiysk Autonomous Districts to avoid double counting. The constructed regression model satisfies all the necessary requirements: the initial data have a normal Gaussian distribution, there are enough observations to conduct the study, the main regression parameters are statistically significant. There is no multicollinearity between factor signs and autocorrelation between residues in the model. The reliability of the regression model was confirmed by graphical analysis. The curves of the real and simulated values of the number of staff engaged in R&D coincided completely. There were no significant deviations from the constructed model (see Table 2).

The results of the regression model based on the spatial data are shown in Table 1 above. They allowed us to conclude that the formation of an innovative economy requires the reproduction of R&D personnel. The second spatial regression model revealed those elements of research talent that should be prioritized in talent development. In the course of the study, we came to the conclusion that for innovative development of regional systems, it is essential to put the main emphasis on the development of the research talent in the STEM fields. Unfortunately, the number of such specialists has fallen sharply in the recent years (Figure 4): from 2000 to 2017, the number of research staff decreased by 20% (179,842 people).

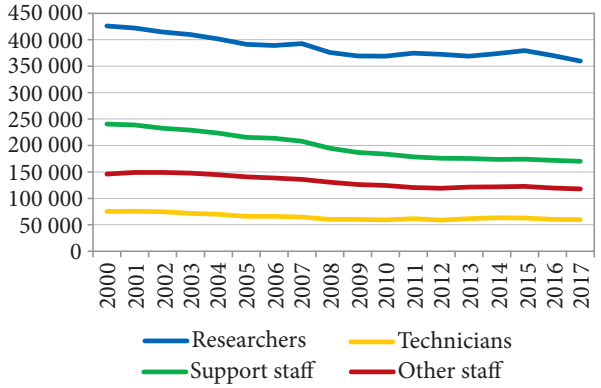

Figure 4. *Dynamics of research talent in Russia in 2010–2017, people*

Source: the authors' calculations are based on the data from 'Regions of Russia. Socio-economic indicators'. 2018, statistical data. Moscow: Rosstat; 2018, pp. 1162, 902–907

Table 2

Results of spatial regression analysis of research talent in Russian regions in 2017

Regression statistics	
Correlation coefficient (R)	1.00
Coefficient of determination	1.00
Standard error	1545

Analysis of variance

	df	SS	MS	F	F value
Regression	2	6.79E+10	3.39E+10	14212.0	9.7E-102
Residual	80	1.91E+08	2387957		
Total	82	6.81E+10			

Regression coefficients		Standard error	t-statistics	P-value	Lower 95%	Upper 95%
R	1.64	0.08	20.21	3.6E-33	1.48	1.80
EP	1.73	0.52	3.31	0.001	0.69	2.78

Source: the authors' calculations are based on the data from 'Regions of Russia. Socio-economic indicators'. 2018, statistical data. Moscow: Rosstat; 2018, pp. 1162, 902–907, 954–955.

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The number of researchers and engineers decreased by 15% and 20% respectively in the same period. Calculation of the global and local Moran indices by the number of R&D personnel in Russian regions in 2017 allowed us to create a dispersion diagram of Moran P. and group the given regions into four categories (HH, HL, LL, LH). These categories were formed on the basis of the development indicator of research talent and the patterns of its spatial distribution (see Table 3).

The HL category included regions with negative autocorrelation and relatively high values of the number of R&D personnel, namely, Tomsk and Novosibirsk regions. These regions are growth poles as they are surrounded by territories with a smaller number of researchers and engineers. On the other hand, these territories are spatially remote and, therefore, lack close interconnections with other regional systems (Figure 5).

The cartographic image of the Moran dispersion diagram shows that the eastern part of Russia (highlighted in white colour) was not interconnected with other regions in using research talent, even with those regions that are considered as 'growth poles'. The research talent of the innovation economies in Tomsk and Novosibirsk regions is sought only by the Khanty-Mansi Autonomous District, Yamalo-Nenets Autonomous District, Tyumen, Omsk, Kemerovo Regions, and Altai Krai. These regions are zones of influence of the specific growth pole, as they have less human resources in R&D, a smaller number of researchers and engineers.

The category of regions with a high level of development of research talent (category HH) and close interconnections with other territorial systems includes Moscow and Nizhny Novgorod regions, the city of Moscow and the city of St. Petersburg. In these regions, according to the calculation results presented in Table 3, a positive autocorrelation is observed, the local Moran index exceeds the country's average level (0.001). The increase in the number of R&D personnel in these regions will contribute to its growth in other related territorial systems in the LH category.

Other territorial systems, such as Sverdlovsk, Chelyabinsk, Voronezh, Kaluga, Samara, Rostov regions, Tatarstan and Perm Krais are also included in the category of regions with a high level of development of research talent and innovative

Table 3

Moran dispersion diagram of research talent development in Russian regions with the values of the local autocorrelation index

LH		HH	
Ryazan Region	–0.00272	Moscow Region	0.03055
Tver Region	–0.00151	Moscow City	0.02057
Ivanovo Region	–0.00148	St. Petersburg City	0.00442
Tula Region	–0.00148	Nizhny Novgorod Region	0.00415
Kostroma Region	–0.00122	Kaluga Region	0.00026
Novgorod Region	–0.00110	Voronezh Region	0.00013
Vladimir Region	–0.00102	Republic of Tatarstan	0.00010
• Smolensk, Oryol, Lipetsk, Bryansk, Vologda, Tambov, Pskov, Leningrad, Kursk, Yaroslavl, Belgorod, Arkhangelsk, Kaliningrad, Kirov, Penza, Murmansk, Orenburg, Ulyanovsk, Kurgan, Saratov, Omsk, Volgograd regions; • Republics: Mordovia, Karelia, Chuvashia, Mari El, Udmurtia, Komi and Bashkortostan; • Altai Krai; • Yamal-Nenets and Khanty-Mansi Autonomous Districts.		Sverdlovsk Region	0.00009
		Chelyabinsk Region	0.00007
		Samara Region	0.00005
		Perm Krai	0.00003
		Rostov Region	0.00000
LL		**HL**	
• Amur, Magadan, Irkutsk, Sakhalin, Astrakhan regions; • Republics: Ingushetia, North Ossetia-Alania, Dagestan, Crimea, Kalmykia, Tuva, Adygea, Khakassia, Sakha (Yakutia), Buryatia, Altai, Chechen, Kabardino-Balkaria, Karachaevo-Cherkessk; • Stavropol, Khabarovsk, Transbaikal, Krasnodar, Primorsky, Krasnoyarsk, Kamchatka Krais; • Chukotka Autonomous Region; • Jewish Autonomous Region; • Sevastopol City.		Novosibirsk Region	–0.00028
		Tomsk Region	–0.00004

Source: the authors' calculations are based on the data from 'Regions of Russia. Socio-economic indicators'. 2018, statistical data. Moscow: Rosstat; 2018, pp. 1162, 902–907.

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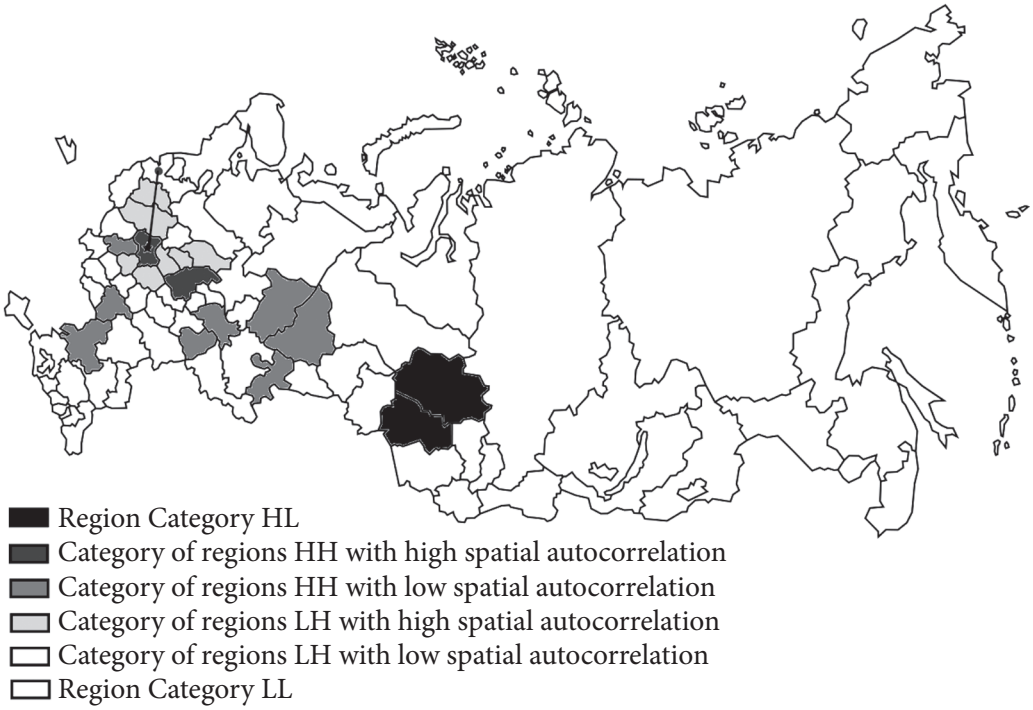

Figure 5. *Cartographic image of the Moran dispersion diagram by the number of R&D personnel in Russian regions in 2017*

Source: the authors' calculations are based on the data from 'Regions of Russia. Socio-economic indicators'. 2018, statistical data. Moscow: Rosstat; 2018, pp. 1162, 902–907

economy (HH category). These regions have powerful human resources in R&D, however, unlike other territorial systems in this category, they do not have close interregional ties with other territories for its use. Their influence on the development of the human potential of the surrounding territories is not as strong as that of Moscow and Nizhny Novgorod regions, the city of Moscow and the city of St. Petersburg (see Figure 5, the surrounding areas are highlighted in grey colour). Regions with developed research talent and close interregional ties, in contrast, have a stronger influence on the adjacent territorial systems included in the LH quadrant. In Figure 5, the zone of strong influence is highlighted in darker gray and includes Ryazan, Tver, Ivanovo, Tula and Kostroma regions. These regions are closely connected with the city of Moscow and Moscow region and together form a cluster for the development of research talent. The formation of a matrix of local Moran autocorrelation indices confirmed the presence of close interregional relationships between these regions (see Table 4). The local Moran autocorrelation index for interregional relationships presented in Table 4 exceeds the average value calculated for all Russian regions (0.0011).

Table 4

The value of local autocorrelation and correlation indices by time series for the period 2000–2017 between closely interconnected regions for research talent

Region included in the HH category with strong research talent	Regions included in the LH category, with less developed research talent, but included in the zone of influence of the HH category	Local Moran Autocorrelation Index for 2017	Correlation coefficient between regions calculated over time series
St. Petersburg City	Nizhny Novgorod Region	0.0029	–0.31
Moscow City	Saint Petersburg City	0.0054	0.61
	Moscow Region	0.0373	–0.39
	Nizhny Novgorod Region	0.0033	–0.26
	Ryazan Oblast	–0.0017	0.08
	Ivanovo Region	–0.0015	0.51
	Tver Region	–0.0014	0.74
	Kostroma Region	–0.0014	0.25
	Tula Region	–0.0013	0.13
Moscow Region	St.Petersburg City	0.0017	–0.50
	Ryazan Region	–0.0015	0.17
	Nizhny Novgorod Region	0.0014	–0.05

Source: the authors' calculations are based on the data from 'Regions of Russia. Socio-economic indicators'. 2018, statistical data. Moscow: Rosstat; 2018, pp. 1162, 902–907.

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For other regions that are not represented in this table, the value of this indicator is significantly lower than the average. This once again confirms the presence of a not significant influence of regions with powerful scientific personnel potential (Sverdlovsk, Chelyabinsk, Voronezh, Kaluga, Samara, Rostov regions, Tatarstan and Perm Krai) on the territorial systems included in the LH category. The formation of a matrix of local autocorrelation indices made it possible to identify the direction of interregional interconnections (Table 4). Thus, we revealed a positive relationship between the city of St. Petersburg and Nizhny Novgorod Region, between the city of Moscow and the city of St. Petersburg, Moscow and Nizhny Novgorod regions as well as Moscow and Nizhny Novgorod regions, the city of St. Petersburg.

A positive autocorrelation relationship indicates a possible joint increase or decrease in the number of R&D personnel in related regions. Accordingly, the development of the research talent in Moscow will contribute to its growth in St. Petersburg, Moscow and Nizhny Novgorod regions. The negative value of the local Moran index, on the contrary, characterizes multidirectional interconnections between regional systems (growth of the indicator in one region and its decrease in another). As a result, an increase in the number of R&D personnel in the city of Moscow will affect its reduction in Ryazan, Ivanovo, Tver, Kostroma and Tula regions. Based on the identified relationships, we can conclude that the development of the research talent of the city of Moscow will occur primarily due to these regions.

Correlation analysis of interregional relationships in terms of the research talent development based on time series for the period 2000–2017 allowed us to identify the most stable relationships observed over a long period. An example of such a stable interregional relationship is the relationship between the city of Moscow and the city of St. Petersburg (the correlation coefficient was 0.61). In other cases, the calculated correlation coefficient was either significantly lower than the threshold value or the sign of the established relationship did not match the va-lue of the local Moran index. Thus, the study of interregional relationships using the improved spatial autocorrelation technique of P. Moran allowed us to establish a cluster of closely related regions (Moscow – St. Petersburg – Moscow Region – Nizhny Novgorod Region – Ryazan Region – Ivanovo Region – Tver Region – Kostroma Region – Tula Region). We have identified three centers of potential clusters: Volga (Samara Region – Tatarstan), Ural (Sverdlovsk Region – Chelyabinsk Region – Perm Krai), and Siberia (Tomsk Region – Novosibirsk Region).

Centers of potential clusters have significant human potential for development of an innovative economy but have not yet developed relationships with other regional systems. A zone of influence is formed in their environment, there are regions that need researchers in the field of basic, applied R&D. These regions are also experiencing a shortage of engineering and technical personnel involved in setting up, adjusting, and checking the operational status of instruments and equipment involved in experiments, testing, software development and preparation of technical documentation.

For the formation and development of an innovative economy in Russia, we consider it necessary not only to strengthen the already existing cooperative ties in central regions, but also to establish them in the Ural, Volga and Siberian macroregions.

Conclusion

Our study showed that not all territorial systems possess the scientific and technical potential necessary for the formation of an innovative economy, innovative infrastructure and training highly qualified research staff. This situation seriously complicates the process of innovative development of these territories, but does not impede its implementation. In the modern conditions of economic development and increasing cooperation between territorial systems, generation and implementation of technological innovation does not require each region to build new research institutions and a powerful innovation infrastructure. Instead, it is necessary to establish and maintain close relationships with the research facilities operating in other territorial systems, objects of innovative infrastructure that have strong research talent. Territorial cooperation can involve exchange of experience in the sphere of development and implementation of technologies, training of research and engineering personnel, maintenance of innovative production technologies and so on. Such interregional cooperation will, in our opinion, enable Russian regions mutually enhance their innovative development.

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Cluster policies of large cities in Russia and Kazakhstan

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ABSTRACT
Relevance. Faced with globalization challenges, large modern cities need to develop their competitive advantages. One source of such advantages is clustering of urban economy. Questions dealing with cluster-based policies and classification of clusters operating on the regional and national levels have attracted much scholarly attention while there is still a research gap regarding urban cluster policies and comparison of city-based clusters. **Research objective.** The purpose of this study is to analyze the legal framework of cluster policies in Russia and Kazakhstan and to describe the criteria for classification and comparison of city-based clusters. **Data and methods.** The study used methods of systemic and comparative analysis, formalized methods of analysis of regulatory acts. The selected criteria are universal and can be used for cluster analysis in different countries. We considered strategies for socio-economic development of large cities in Russia and Kazakhstan from the official websites of city administrations as well as the regulatory acts of specific cities. **Results.** In both countries, clusters play a significant role in the development strategies of territories. The Russian and Kazakh governments take similar measures to support cluster initiatives. The regulatory legal acts of both countries emphasize the allocation of subsidies and co-financing of regional programs and R&D in clusters. The process of cluster creation in Russia started later than in Kazakhstan but was also more intensive. A popular specialization for clusters in both countries is information technologies and communications, which corresponds to the goals set by the national governments. **Conclusions.** In both countries, the number of clusters in large cities is increasing annually. Typically, clusters have 11-50 participants. In both countries, there are clusters of different specialization. Strategies for socio-economic development serve as the main documents for devising cluster policies of cities. The practical significance of the study is that it proposes an approach to classification and comparison of clusters that can be used in further analysis and for identification of cluster policy priorities.

KEYWORDS
clusters, large cities, cluster policy, classification of clusters, Russia, Kazakhstan

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Кластерная политика крупнейших городов (опыт России и Казахстана)

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АННОТАЦИЯ
Актуальность. В современном мире, подверженном активным процессам глобализации, возрастает необходимость выявления конкурентных преимуществ городов. Одним из источников таких преимуществ является кластеризация городской экономики. При этом остается открытым вопрос классификации и сравнений кластеров, локализованных в разных городах и разных странах. Исходя из вышесказанного, актуальность исследования обуславливается необходимостью разработки системы критериев для классификации кластеров, позволяющей осуществлять межгородские и кросс-национальные сравнения. **Цель исследования.** Анализ нормативно-правового регулирования кластерной политики в крупнейших городах РФ и Республики Казахстан, предложение и апробация критериев для классификации кластеров, созданных в городах данного типа. **Данные и методы.** В исследовании использованы методы системного и сравнительного анализа, формализованные методы анализа нормативно-правовых

КЛЮЧЕВЫЕ СЛОВА
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актов. Предложен и обоснован выбор перечня критериев для классификации кластеров. Новизна авторского подхода состоит в универсальности отобранных критериев, возможности их использования для анализа кластеров в различных странах. Информационную базу исследования составили стратегии социально-экономического развития крупнейших городов России и Казахстана, представленные на официальных сайтах городских администраций. Эмпирической основой анализа послужили результаты исследований, проведенных в рамках НИР «Совершенствование политики государственного регулирования ускоренной кластеризации индустриальных регионов», выполняемой по грантовому финансированию Министерства образования и науки Республики Казахстан. **Результаты.** В ходе исследования был проведен анализ нормативно-правовых актов, составляющих основу кластерной политики в РФ и Республике Казахстан; изучен спектр услуг, оказываемых региональными центрами кластерного развития; установлены критерии для классификации кластеров в крупнейших городах, проведена классификация кластеров крупнейших городов РФ и Казахстана по заданным критериям. **Выводы.** На примере России и Казахстана были апробированы критерии для классификации кластеров, созданных в крупнейших городах. Практическая значимость исследования заключается в разработке подхода, позволяющего провести анализ и сравнение кластеров, созданных в крупнейших городах разных стран. Полученные в ходе классификации результаты могут быть использованы для выявления приоритетов кластерной политики на территории города.

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Introduction

Clusters are drivers of modern economic development. Regardless of their specialization, clusters affect the key parameters of socio-economic development of a territory such as employment, wages, the number of enterprises, their stability and development. It has now become particularly important to study the role of cluster policies in socio-economic development of large cities. Each of them is unique in its own way, in particular in the resources and technologies they use and their prospects for development. Therefore, it is important to establish a set of criteria applicable for classification and comparison of different city-based clusters, which, in its turn, would enable researchers to identify general trends in clustering and analyze the key priorities of cluster development.

From the perspective of cluster theory, the contribution of this study is that it proposes a set of criteria to classify clusters in large cities of various countries. Practically, this classification can be used to identify cluster policy priorities in a city.

The research goal is to analyze the legal regulation of cluster policies in large cities of Russia and Kazakhstan as well as to propose criteria for classifying clusters that emerge in these cities. This research goal includes the following objectives:

– to analyze legal acts that form the basis of cluster policy in the Russian Federation and the Republic of Kazakhstan;

– to propose criteria for classifying clusters in large cities;

– to classify clusters of large cities in Russia and Kazakhstan according to the specified criteria;

– to analyze the priorities of cluster development in urban development strategies.

Theoretical background

The existing body of literature on the problems of clusters and cluster policies in large cities can be divided into two groups. The first group is devoted to questions concerning the nature of clusters and cluster policy, the impact of clusters on regional economic development. L.S. Markov, V.B. Kurmashev, and A.Yu. Nizkovsky contend that 'cluster policy is used as a generic notion for various ways of supporting and creating network enterprises' [1]. M.S. Kokareva systematized the approaches of Russian and international scholars to defining the term 'cluster' and concluded that cluster is a 'spatial form of organization of productive forces, factors of production and social (economic and social) relations, which are characterized by the following features: geographical localization; specialization of manufacturing companies; diversity and plurality of participants, their interdependence and complementarity; competition and cooperation' [2]. H. Furre emphasizes the importance of clusters' influence on economy and, in connection with this, the need for a thorough study of the concept 'cluster policy' and its components. He defines cluster as

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'a geographically close group of interconnected companies and associated institutions in a certain field, connected by common features and complementarity' [3]. 'Cluster policy' is understood here as any policy from the following three categories: policies aimed at creating, mobilizing, or strengthening a specific cluster; policies that use clusters to increase efficiency; and policies aimed at creating an optimal environment for development and creation of clusters [3].

S. Brakman and R. van Marrewijk identified a number of reasons why cluster policy is not always effective: the lack of an exact definition of the concept 'cluster'; difficulties in limiting a cluster in space; and the partial character of Porter's model [4].

L. Corrado, R. Martin, and M. Weeks propose a methodology to conduct endogenous selection of regional clusters using a multidimensional stationary criterion, where the number and composition of clusters are determined by applying pair wise criteria for regional differences in production output per head of the population in time [5].

Of particular interest is the study of Ye. Kozonogova [6], assessing the role of cluster policies in regional governments' problem-solving: improvement of the quality of life in the territory where the cluster is located; attracting investment; stimulation of small and medium-sized enterprises; development of international scientific and technical cooperation. As a result, she showed that clusters affect the level of wages in the territory. Moreover, as the number of clusters increases, there is also an increase in investment in fixed assets.

C. Ketels proves that cluster development is closely related to changes in regional development indicators. The most significant criteria affecting cluster policies include cluster location, its specialization, size, etc. [7].

E. DiMariaE and G. Costalonga discuss the general theoretical foundations of the cluster concept in economics and concepts of internationalization of business activity. Internationalization of clusters offers great opportunities for reorganization of regional innovative processes based on new forms of labor division and cooperation among cluster participants from around the world. Using the example of Italian industrial regions, the study shows that clusters open their borders through expansion of production and distribution chains both at the national and international levels. There are two main scenarios for the development of cluster internationalization: production and commercial [8].

Ye. Kutsenko and D. Meissner [9] analyze the impact of clustering on territorial development and emphasize that the application of the cluster approach makes innovation policies more comprehensive as they serve to coordinate the support of various participants and their efforts, thus linking the localized priority industries.

A separate group of studies is devoted to the problem of selecting criteria for classifying clusters. L. Bozhko emphasizes the importance of analysis of regulatory legal acts in studying cluster policies [10]. M.N. Nikonova [11] provides an analytical review of a modern package of documents, definitions, basic institutional factors and concepts that determine cluster policies in Russia. E.S. Kutsenko analyzes characteristics of a successful cluster: the quality of the urban environment; critical mass of core companies; dominance of private initiative; internal competition and openness; presence of specialized independent governing bodies and active working groups; formalization of rights, responsibilities and decision-making mechanisms; implementation of joint innovative projects and formation of a belt of innovative startups around large companies or universities. This study also focuses on the compliance of Russian pilot innovation clusters with the above-described characteristics and draws quantitative compraisons between Russian and foreign clusters [12].

Criteria for classification of clusters were identified by I. Rodionova, T. Kreidenko and C. Mandra [13]: territorial location of a cluster, specialization, number of participants, duration, year of creation, level of organization, and status. I.V. Mitrofanova, D.A. Sheikin, N.P. Ivanov and O.Yu. Trilitskaya [14] emphasize the importance of taking into account territorial location. Using correlation and regression analysis, dependence of the number of clusters in the territory on the number of commodity, financial and innovative markets is established. Identical criteria were selected for the comprehensive analysis of S.P. Zemtsov, P.N. Pavlov, A.V. Sorokina [15], who proposed a methodology for measuring cluster performance by the scale index, cluster development index, and its management efficiency index.

E.V. Kutsenko, E. Islankina, V. Abakshin [16] assess the impact of national cluster policy, cluster age, cluster development guidelines in neighboring regions and the cumulative level of regional

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innovation potential on the number and quality of cluster initiatives in Russia.

Other studies of cluster policies include those conducted by M. Delgado, M. Porter, S. Stern [17], K. Beshimbaeva [18], O.V. Kostenko [19], Ch. Karlsson [20], E.E. Kolchinskaya, L.E. Limonova, E.S. Stepanova [21], O.A. Vasilieva [22], E. Islankina [23], A.K. Akhmetova, D.M. Serikova, B.T. Sovetovich [24], J.S. Engel, I. del-Palacio [25].

Best practices of Russia and Kazakhstan in the field of regional cluster policy were explored by I.D. Turgel, L.L. Bozhko, and E.V. Pracheva [26].

Questions dealing with cluster-based policies and classification of clusters operating on the regional and national levels have attracted much scholarly attention while there is still a research gap regarding urban cluster policies and comparison of city-based clusters.

Methods and data

This study analyzes cluster policies and the corresponding legislation frameworks by focusing on clusters located in large, million-plus cities – Almaty, Nur-Sultan and Shimkent in Kazakhstan and fourteen large cities in Russia (Moscow and St. Petersburg were not included in the sample, since their population is much bigger). The main sources of data were the socio-economic development strategies of these cities or, in the absence of an approved strategy, other similar documents; database 'Map of Russian Clusters' developed by specialists of the Russian HSE Cluster Observatory; and the official sites of clusters operating in large cities of Kazakhstan. Russia and Kazakhstan were chosen because these two countries have close political, economic and social ties.

In addition to the analysis of regulatory acts, the study examined information portals of the Russian Federation and the Republic of Kazakhstan devoted to cluster policy implementation. Particular attention was paid to the statistical data from the official portal of the project 'Map of Russian Clusters'.

The study includes four stages. At the first stage, we analyzed the main regulatory legal acts in the field of cluster policy in Russia and Kazakhstan. strategies for socio-economic development of territories, municipal programs, and other official documents. We also looked at the regulatory frameworks and government measures. At the second stage, universal criteria for classification and comparison of clusters in large cities were identified. At the third stage, clusters in large Russian and Kazakh cities were classified and compared in accordance with the selected criteria. At the final stage, the study compares approaches that justify priorities of cluster development in the strategic plans of Russian and Kazakh cities. For clarity, the results are displayed in the form of graphs, charts, and tables.

Results

Regulation of cluster policies in Russia and Kazakhstan

Our analysis of the regulatory frameworks for cluster policies has brought to light the key areas of cluster development in both countries. In Russia, the regulatory framework comprises the Strategy for Innovative Development of the Russian Federation until 2020 and the Strategy for Spatial Socio-Economic Development of the Russian Federation until 2025. One of the 6 key objectives of the Strategy for Innovative Development of the Russian Federation until 2020 is associated with the development of clusters: intensification of activities to implement innovative policies in Russian regions and municipalities, formation of territories for innovative development, and development of innovative clusters.

The need for cluster development is also emphasized in the Strategy for Spatial Socio-Economic Development of the Russian Federation. According to the Strategy, 'innovation-related and social areas of the long-term socio-economic development of the Russian Federation include the following: formation of territorial production clusters (at least 6-8), focused on high-tech industries in priority sectors of the economy, with a concentration of such clusters in urbanized regions; formation of territorial-production clusters in poorly developed territories, focused on the deep processing of raw materials and energy production using modern technologies'[1].

In Kazakhstan, the need to develop a coherent cluster policy was emphasized by President Nazarbayev in his Message to the People of Kazakhstan. In the strategy of 'Kazakhstan-2050', the President set the goal to design roadmaps for the formation of national clusters. The regulatory documents include the State Program for In-

[1] Strategy for Spatial Socio-Economic Development of the Russian Federation. Retrieved from: https://economy.gov.ru/material/directions/regionalnoe_razvitie/strategicheskoe_planirovanie_prostranstvennogo_razvitiya/strategiya_prostranstvennogo_razvitiya_rossiyskoy_federacii_na_period_do_2025_goda/

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dustrial and Innovative Development (SPIID) of the Republic of Kazakhstan for 2015–2019 and the project of the Government of the Republic of Kazakhstan and the World Bank – 'Improvement of Competitiveness of Small- and Medium-Sized Enterprises in Kazakhstan', which identified 6 pilot territorial clusters.

The normative legal act describing the main provisions of the cluster policy is the Concept of National Cluster Formation of the Republic of Kazakhstan until 2020. According to the Concept, the cluster policy has two main focus areas: national clusters in traditional sectors and clusters in the 'economy of the future'. This line is continued in the State Program of Industrial and Innovative Development of the Republic of Kazakhstan for 2020–2025, which describes the mechanism for stimulation of territorial cluster development.

In both countries, clusters play a significant role in the development strategies of territories. The measures the Russian and Kazakh governments take to support cluster initiatives are to a great extent identical. The regulatory legal acts of both countries emphasize the allocation of subsidies and co-financing of regional programs, financing of R&D in clusters. Considerable attention is paid to the need to establish relationships between the main stakeholders involved in the process of creating and maintaining clusters.

Classification and comparative analysis of clusters in Russia and Kazakhstan

The following criteria were selected for comparing clusters in large cities of **Russia** and **Kazakhstan:**

– year of the cluster's creation;
– number of participants;
– cluster specialization;
– the role of cluster policy, indicated in the strategy of socio-economic development of a territory

We classify the clusters of large Russian and Kazakh cities depending on the year of their creation (see Table 1).

Clusters in Russia started to be created later than in Kazakhstan and this process was also more intensive. In Kazakhstan, the first officially registered clusters appeared in 2005, but their creation went much slower (Figure 1).

The second criterion deals with the number of participants in clusters (see Table 2).

Figure 2 illustrates the distribution of million-plus cities in Russia by the number of participants. Most Russian clusters are quite small. Clusters with most participants are located in Kazan (Kama Innovation Territorial-Production Cluster, Machine-Building Cluster), Novosibirsk (scientific and production cluster 'Siberian Naukopolis'), Ufa (Petrochemical Territorial Cluster of the Republic of Bashkortostan). There are 51-100 participants in the Innovative Territorial Cluster of Medical and Pharmaceutical Technologies of Samara Region as well as in the Information Technology Cluster (Kazan).

In Kazakhstan, distribution of clusters by the number of participants is more even (Figure 3). Like in Russian cities, most clusters have 11-50 participants. Clusters with most participants (over 250) are concentrated in Almaty. The largest in terms of the number of participants is the Astana International Financial Center located in Nur-Sultan (387 participants).

Classification of clusters depending on their specialization is presented in the following table (see Table 3).

As the table above shows, in four Russian cities there are clusters specializing on IT technologies (Perm, Rostov-on-Don, Novosibirsk, Kazan) and in production of machinery and equipment (Chelyabinsk, Voronezh, Rostov-on-Don, Yekaterinburg). On the other hand, many clusters' specializations are found in one city only.

For the Russian government, the key priority tasks are to enhance economic performance and to stimulate innovation-based development. The intensive development of telecommunication industry is one of the main areas in this process. The national program 'Digital Economy of the Russian Federation' emphasizes the importance of IT cluster development, which means that such clusters are more likely to receive state support. As for the second type of specialization, production of machinery and equipment, its popularity largely stems from the availability of Soviet-period production facilities. The second reason is that many territories prioritize the development of production infrastructure.

In Kazakhstan, the most popular specializations for clusters are related to informatization and digitalization; IT technologies; smart industry; new materials; 'smart environment', etc. Like in Russia, the choice of clusters' specialization in Kazakhstan is largely determined by the priorities of the state. For instance, as a part of the state program 'Digital Kazakhstan', IT clusters are provided with state support.

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Table 1

Years of creation of the clusters in large cities of the Russian Federation and the Republic of Kazakhstan

City	Cluster	Year of creation
Kazan	Kama innovation territorial-production cluster	2012
	Engineering cluster	2015
	IT Cluster	2015
	Food cluster	2016
	Innovative territorial cluster in the field of nanotechnology	2014
	Territorial and industrial cluster AGROPOLIS 'ALKIAGROBIOPROM'	2014
Yekaterinburg	Innovative territorial cluster 'Titanium Cluster of Sverdlovsk Region'	2012
	Cluster of lifting (crane) equipment	2015
Novosibirsk	Scientific and production cluster 'Siberian Sciencepolis'	2016
Rostov-on-Don	Biotechnology (cluster for deep processing of grain in Millerovsky district of Rostov region)	2015
	Wine-making territorial cluster 'Don Valley'	2015
	Volgodonsk industrial cluster of nuclear engineering	2016
	Innovative-territorial cluster of machine tools	2015
	Innovation and technology cluster 'Southern Constellation'	2015
	Innovative territorial cluster of civil marine instrumentation 'Marine Systems'	2015
	Information and communications technology cluster (ICT cluster) of Rostov region	2015
	Cluster for the production and processing of dairy products 'Don Dairy Products'	2015
	Tourist area cluster	2017
Ufa	Petrochemical territorial cluster of the Republic of Bashkortostan	2012
Omsk	Agro-biotechnological industrial cluster of Omsk region	2016
	Cluster of high-tech components and systems of Omsk region	2013
	Cluster of oil refining and petro chemistry of Omsk region	2013
Voronezh	Voronezh aviation cluster	2014
	Cluster 'Voronezh Electromechanics'	2010
	Cluster of manufacturers of oil and gas and chemical equipment in Voronezh region	2016
	Furniture cluster of Voronezh region	2013
	Radio-electronic cluster of Voronezh region	2010
Nizhniy Novgorod	Nizhny Novgorod industrial innovation cluster in the field of automotive and petrochemicals	2015
Chelyabinsk	Cluster of lifting (crane) equipment	2015
Samara	Innovative territorial aerospace cluster of Samara region	2012
	Innovative territorial cluster of medical and pharmaceutical technologies of Samara region	2014
Krasnoyarsk	Cluster of innovative technologies ZATO in Zheleznogorsk	2011
Perm	Innovative territorial cluster Technopolis 'Novyi Zvyozdnyi'	2012
	Innovative territorial cluster of fiber-optic technologies 'Photonics'	2014
	Perm cluster of information and communication enterprises	2013
Krasnodar	'Farm Valley'	2017
Volgograd	Innovative territorial cluster for the production of modern building materials and high-purity chemical products based on Svetloyarsky and Narimanovsky magnesium chloride deposits in Volgograd region	2013
	Chemical-pharmaceutical cluster in Volgograd region	2012
Nur-Sultan	Innovation cluster of Nazarbayev University	2017
	International financial center 'Astana'	2015
	High-tech industrial cluster	2016
Almaty	Innovation cluster 'Park of Innovative Technologies'	2014
	Tourism development cluster	2016
Shymket	Pharmaceutical cluster	2015
	Construction industry cluster	2005
	Cotton-textile cluster of SEZ 'Ontustik'	2005
	Petrochemical cluster SEZ 'Ontustik'	2017

Source: compiled based on the data of the Institute for Statistical Studies and Economics of Knowledge. Russian Cluster Observatory. Map of Russian Clusters. Retrieved from: http://map.cluster.hse.ru/list and the data of Kazakhstan Center for Industry and Export. Retrieved from: https://qazindustry.gov.kz/ru/analytics_regions (Accessed: 25.02.2020).

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Table 2

The number of participants in the clusters of large cities of Russia and Kazakhstan

City	Cluster	Number of participants
Kazan	Kama innovation territorial-production cluster	213
	Engineering cluster	157
	IT Cluster	70
	Food cluster	20
	Innovative territorial cluster in the field of nanotechnology	12
	Territorial and industrial cluster AGROPOLIS 'ALKIAGROBIOPROM'	33
Yekaterinburg	Innovative territorial cluster 'Titanium cluster of Sverdlovsk region'	20
	Cluster of lifting (crane) equipment	10
Novosibirsk	Scientific and production cluster 'Siberian Sciencepolis'	227
Rostov-on-Don	Biotechnology (cluster for deep processing of grain in Millerovsky district of Rostov Oblast)	10
	Wine-making territorial cluster 'Don Valley'	10
	Volgodonsk industrial cluster of nuclear engineering	17
	Innovative-territorial cluster of machine tools	13
	Innovation and technology cluster 'Southern Constellation'	23
	Innovative territorial cluster of civil marine instrumentation 'Marine Systems'	10
	Information and communications technology cluster (ICT cluster) of Rostov region	25
	Cluster for the production and processing of dairy products 'Don Dairy Products'	20
	Tourist area cluster	10
Ufa	Petrochemical territorial cluster of the Republic of Bashkortostan	211
Omsk	Agro-biotechnological industrial cluster of Omsk region	18
	Cluster of high-tech components and systems of Omsk region	10
	Cluster of oil refining and petro chemistry of Omsk region	14
Voronezh	Voronezh Aviation Cluster	10
	Cluster 'Voronezh Electromechanics'	20
	Cluster of manufacturers of oil and gas and chemical equipment in Voronezh region	16
	Furniture cluster of Voronezh region	13
	Radio-electronic cluster of Voronezh region	16
Nizhniy Novgorod	Nizhny Novgorod industrial innovation cluster in the field of automotive and petrochemicals	33
Chelyabinsk	Cluster of lifting (crane) equipment	10
Samara	Innovative territorial aerospace cluster of Samara region	13
	Innovative territorial cluster of medical and pharmaceutical technologies of Samara region	55
Krasnoyarsk	Cluster of innovative technologies ZATO in Zheleznogorsk	10
Perm	Innovative territorial cluster Technopolis 'Novyi Zvyozdnyi'	44
	Innovative territorial cluster of fiber-optic technologies «Photonics»	34
	Perm cluster of information and communication enterprises	10
Krasnodar	'Farm Valley'	15
Volgograd	Innovative territorial cluster for the production of modern building materials and high-purity chemical products based on Svetloyarsky and Narimanovsky magnesium chloride deposits in Volgograd region	10
	Chemical-pharmaceutical cluster in Volgograd region	10
Nur-Sultan	Innovation Cluster of Nazarbayev University	20
	International financial center «Astana»	387
	High-tech industrial cluster	40
Almaty	Innovation cluster 'Park of Innovative Technologies'	285
	Tourism development cluster	267
Shymket	Pharmaceutical Cluster	7
	Construction Industry Cluster	20
	Cotton-textile cluster of SEZ 'Ontustik'	13
	Petrochemical cluster SEZ 'Ontustik'	9

Source: compiled based on the data of the Institute for Statistical Studies and Economics of Knowledge. Russian Cluster Observatory. Map of Russian Clusters. Retrieved from: http://map.cluster.hse.ru/list and based on the data of Kazakhstan Center for Industry and Export. Retrieved from: https://qazindustry.gov.kz/ru/analytics_regions (Accessed: 25.02.2020).

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Table 3

Clusters' specialization in large Russian and Kazakh cities

City	Number of clusters	Specialization
Kazan	6	Automobile and automotive components manufacturing
		Automobile and automotive components manufacturing
		ICT
		Food and beverage production, tobacco products
		New materials
		Environmental protection and waste recycling
Yekaterinburg	2	Metallurgy, metal working and ready-made metal goods production
		Production of machinery and equipment (including machining facilities, special equipment, lifting and hydro pneumatic equipment, robots)
Novosibirsk	1	ICT
Rostov-on-Don	9	Industrial biotechnology (production of products based on enzymes and microorganisms for further use in chemical industry, healthcare, food and forage production, detergents, paper and pulp, textiles, bio energy)
		Food and beverage production, tobacco products
		Nuclear and radiation technologies
		Production of machinery and equipment (including machining facilities, special equipment, lifting and hydro pneumatic equipment, robots)
		Microelectronics and instrumentation
		Microelectronics and instrumentation
		ICT
		Agriculture and fisheries
		Tourism (entertainment and leisure industry, art, sports)
Ufa	1	Chemical industry
Omsk	3	Industrial biotechnology (production of products based on enzymes and microorganisms for further use in chemical industry, healthcare, food and forage production, detergents, paper and pulp, textiles, bio energy)
		Defense industry
		Chemical industry
Voronezh	5	Aircraft industry
		Microelectronics and instrumentation
		Production of machinery and equipment (including machining facilities, special equipment, lifting and hydro pneumatic equipment, robots)
		Furniture manufacturing
		Defense industry
Nizhniy Novgorod	1	Automobile and automotive components manufacturing
Chelyabinsk	1	Production of machinery and equipment (including machining facilities, special equipment, lifting and hydro pneumatic equipment, robots)
Samara	2	Space industry
		Medical industry
Krasnoyarsk	1	Nuclear and radiation technologies
Perm	3	Space industry
		Optics and photonics
		ICT
Krasnodar	1	Pharmaceuticals
Volgograd	2	Production of building materials and other products from glass, concrete, cement, gypsum, clay, ceramics and porcelain
		Medical industry
Nur-Sultan	3	Information and Communication Technologies, Internet of Things (IOT), Big Data Analysis, information security, artificial intelligence, machine learning, industrial automation, healthcare and medicine, agricultural technologies, technologies in construction sector, energy efficiency
		Brokerage activity, asset management, cash management, banking, Islamic finance, insurance, financial technology, green technology
		Engineering, pharmaceuticals, food and chemical industries, building materials and logistics
Almaty	2	Smart industry and new materials, new energy and clean technologies, smart environment, fin tech, e-commerce and new media
		Tourism (entertainment and leisure industry, art, sports)

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End of Table 3

City	Number of clusters	Specialization
Shymket	4	Pharmaceuticals
		Construction
		Light industry
		Chemistry, petro-chemistry

Source: compiled on the basis of the data of the Institute for Statistical Studies and Economics of Knowledge. Russian Cluster Observatory. Map of Russian Clusters. Retrieved from: http://map.cluster.hse.ru/list and the data of the Kazakhstan Center for Industry and Export. Retrieved from: https://qazindustry.gov.kz/ru/analytics_regions (Accessed: 25.02.2020).

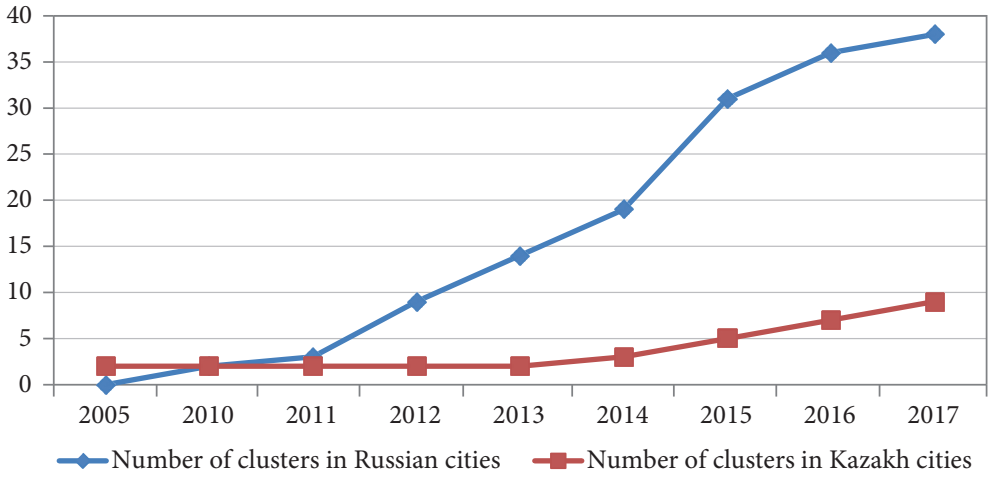

Figure 1. *Dynamics of the number of clusters in large cities of Russia and Kazakhstan*

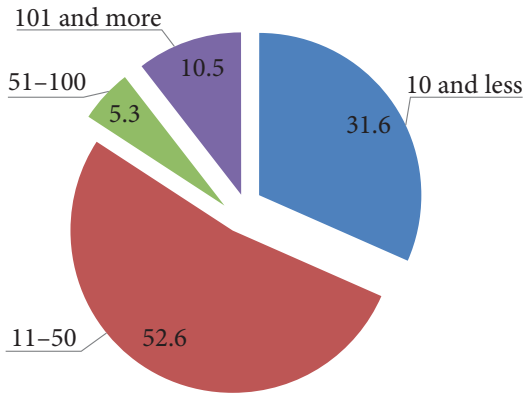

Figure 2. *Number of participants in clusters of million-plus Russian cities, %*

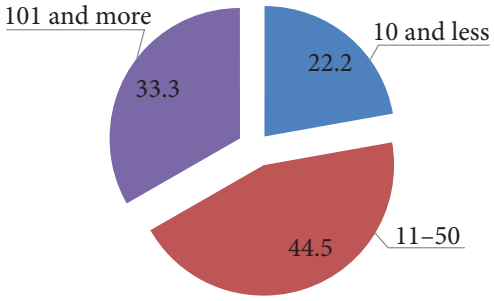

Figure 3. *Number of participants in clusters of Kazakh cities, %*

Comparing clusters in Russia and Kazakhstan, it can be noted that in both countries, in one municipality there may be located clusters of various specializations. This is due, in particular, to an increase in diversity of network leaders: in addition to regional authorities and businesses, this role may be played by universities and R&D organizations. 'Clusters arise naturally in places where there is a 'related diversity' of agents of economic activity, resources and components necessary for it. An important factor is 'cooperation and rivalry': participants of clusters do not only cooperate but also compete fiercely – for people, talents and customers. Finally, the proximity of clusters plays an important role'[2].

Cluster policy priorities of large cities

Most of the cities we discussed above seek to consolidate the cluster policy priorities and strategic urban development plans (see Table 4).

It is worth noting that not all urban strategies mention a cluster policy (for example, strategies of socio-economic development of Ufa, Omsk, Chelyabinsk, and Nizhniy Novgorod).

[2] Cluster approach: why some regions are more successful than others. Retrieved from: https://cluster.hse.ru/news/341473882.html (Accessed: 27.02.2020)

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Table 4

Cluster policy priorities in accordance with the strategy of socio-economic development of large Russian and Kazakh cities

City	Cluster policy priorities
Kazan	Formation of 'smart economy' clusters
	Technical re-equipment of production facilities for the clusters being formed
	Assistance in creative campus clusters creating, co-working for innovative and creative entrepreneurship, attracting international partners
	Promoting the effective interaction of business, science and government in clusters
Yekaterinburg	'IT-cluster' as a project within the framework of strategic programme 'Digital Yekaterinburg'
Novosibirsk	Development of scientific and industrial clusters as one of the opportunities for novosibirsk development
	Development of an information cluster as one of the ways to develop digital economy
Rostov-on-Don	Revitalization and expansion of the cluster policy in key areas of industry
	Launch of cluster projects in the fields of engineering, food industry and digital media communications
	Participation in the development of the existing and creation of new cluster interactions for information and communication infrastructure development
Voronezh	Creating conditions for activation of the city's universities: creation of technology parks, clusters, and other forms of integrative interaction
	Activation of the cluster policy in industry
	Formation of scientific-educational and scientific-production clusters in high-tech sectors of economy
Samara	Planning of further development of product-related, technological and managerial elements of manufacturing industries and clusters as a goal of innovative technological production
	Development of tourism and aerospace clusters
Krasnoyarsk	Ensuring the development of a tourist and recreational cluster
	Creation of conditions for the development of high-tech competitive economic clusters
	Creation of conditions for the formation and development of a medical cluster
Perm	Ensuring coordination of plans and programs for the city's development, including formation of clusters to assist the city's enterprises in obtaining resources for modernization and development as one of the key tasks of the functional and targeted programme of 'economic development'
Krasnodar	Development of a cluster of 'creative industries', financial cluster, transport and logistics cluster, industrial construction cluster, agro-scientific cluster, tourism cluster, educational and scientific cluster, 'olympic' cluster
Volgograd	Formation of a transport and logistics cluster as one of the goals of the transport and logistics complex development
	Creating an enabling environment for tourism industry, formation and development of a full-fledged tourism cluster in volgograd
Nur-Sultan	Development of an educational cluster as a tool of providing highly qualified personnel and a way to attract investment
	Development of a cluster of financial services to improve their quality, stimulating development of financial technologies, creating knowledge and technologies transfer
Almaty	Development of an international-level tourism cluster
	Creation of scientific-educational-production clusters in conjunction with the coordination training centers for training, retraining, advanced training and certification of personnel in organizations of technical and vocational education
Shymket	Development of greenhouse clusters in the peripheral territory as a way of forming an agricultural zone with intensive technologies
	Implementation of the concept 'food clusters' with characteristics of the agricultural park

Source: compiled based on the data of the Institute for Statistical Studies and Economics of Knowledge. Russian Cluster Observatory. Map of Russian Clusters. Retrieved from: http://map.cluster.hse.ru/list and the data of the Kazakhstan Center for Industry and Export. Retrieved from: https://qazindustry.gov.kz/ru/analytics_regions (Accessed: 25.02.2020).

Conclusion

In our research, we presented an algorithm to analyze cluster policies in large cities and demonstrated the results of such analysis by focusing on the cases of Russian and Kazakh cities.

The regulatory legal acts we considered form the basis of cluster policies in Russia and Kazakhstan, describing their priority areas and state support measures. Cluster policies form an important integral part of regional and urban development.

The universal criteria for cluster classification include the year of creation; number of cluster participants; specialization; and the role of the cluster policy indicated in the strategy of socio-economic development of the territory.

According to the proposed algorithm and criteria, clusters located in large Russian and Kazakh

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cities were compared and classified, which led us to the following conclusions:

– the number of clusters in large Russian and Kazakh cities is increasing annually;

– most such clusters have 11-50 participants;

– in both countries there are clusters of different specialization;

– strategies for socio-economic development serve as the main documents for devising cluster policies of cities

The proposed set of criteria can be further expanded to obtain qualitatively new results and draw conclusions about the efficiency of the processes of cluster formation and operation.

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Smart city development projects in the Republic of Korea

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ABSTRACT
Research relevance. The article discusses the experience of South Korea in the sphere of smart city projects. The study's relevance is determined, on the one hand, by the role smart cities play in the creation of the new urban living space, in enhancement of urban economy and, on the other, by the need to analyze and systematize the best practices of smart city development. **Research aim.** The study describes the development of the 'smart city' concept in South Korea. Smart city is understood as a complex eco-system, which, on the one hand, comprises a range of technological and socio-economic processes and, on the other, involves such actors as government, corporations, research organizations and urban communities. **Data and methodology.** The study relies on methods of comparative and evolutionary analysis to analyze the concept of smart city and its structure by focusing on the case of South Korea, the world's renowned ICT leader. The study also provides cross-national comparisons of the experience of other developed Asian countries (Japan and China), which, like South Korea, are actively supporting building of smart cities on the state level. **Results.** The study describes the main stages in the development of the smart city concept in South Korea as well as the main types of smart city projects (pilot projects, research validation projects, and city restoration projects). The study identifies problems of planning, design and implementation of smart city projects and compares the relevant experience of South Korea, Japan and China. It is shown that although smart city projects in these countries were launched in approximately the same period, each of these countries has its own approach to smart cities and ways of their development. **Conclusions**. The key to Korea's success in smart city development lies in large-scale direct state support, public trust in the government and the application of an integrated approach to smart city development. At the current stage, smart city services not only provide enhanced comfort to city dwellers but also create more opportunities for their personal growth.

KEYWORDS
smart cities, South Korea, smart city pilots, infrastructure, urban ecosystem

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Исследование опыта продвижения умных городов в Республике Корея

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АННОТАЦИЯ
Актуальность. В статье рассматривается опыт Южной Кореи по реализации проектов «умных городов». Актуальность исследования определяется с одной стороны, значением умных городов для формирования нового пространства жизнедеятельности людей, повышения эффективности городской экономики; а с другой стороны, наличием значительного числа позитивных примеров внедрения проектов умных городов в Южной Корее. **Цель исследования.** Выявление особенностей внедрения концепции «умный город» в Южной Корее. При этом «умный город» рассматривается как сложная экосистема, которая включает в себя с одной стороны, технологические, и социально-экономические процессы, а с другой стороны такие факторы, как правительство, корпорации, научно-исследовательские организации и общественность. **Данные и методы.** Использованы методы сравнительного и эволюционного анализа подходов к формированию и реализации концепции «умного города» применительно к конкретной стране, Южной Корее. Выбор страны обусловлен лидерством

КЛЮЧЕВЫЕ СЛОВА
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Южной Кореи в практическом воплощении проектов умных городов. В состав анализируемой совокупности при проведении кросс-национальных сравнений включены другие экономически развитые страны Азии (Япония и Китай), которые, как и Южная Корея, реализуют активную политику государственной поддержки умных городов. **Результаты.** Выделены основные этапы развития концепции «умного города» в Южной Корее, а также основные типы проектов «умного города», использующиеся в этой стране (пилотные проекты, проекты валидации НИОКР и проекты по восстановлению городов). Выделены проблемы, связанные с планированием, разработкой и реализацией проектов «умных городов». Выполнено сравнение опыта реализации концепции «умного города» в Южной Корее, в Китае и Японии. Показано, что, хотя проекты «умного города» в этих странах были запущены в один и тот же период, каждая из этих стран имеет свое понимание умного города и способов его развития. **Выводы.** Успех Южной Кореи в развитии концепции умного города обеспечен за счет высокого уровня прямой государственной поддержки и доверия населения к правительству, а также за счет комплексного подхода к внедрению. На современном этапе развития сервисы умного города обеспечивают не только более высокий уровень комфорта, но и возможности для саморазвития каждого жителя умного города.

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Introduction

The development of information society led to the emergence of smart cities. Today the smart cities are the main component of the infrastructure of the future. For example, the McKinsey Company by 2020 predicts the emergence of 600 'smart cities', which will generate about two thirds of the world's GDP[1]. The British standards institute describes the smart city as 'effective integration of physical, digital and human systems in an artificially created environment with the purpose to provide the steady, safe and comprehensive future for citizens'[2].

The 'smart city' technology can be used to improve the management of city flows and ensure fast reaction to difficult tasks [1]. It should be emphasized that the term 'smart city' does not have a standard definition and is often used together with such synonymous terms as 'smart city' and 'digital city'. From the technical point of view, the 'smart city' represents a city information and telemetric network which gives to heads of different levels access to the uniform database and knowledge renewed in real time. Any project of a 'smart city' is a combination of several subsystems, which include different functional parts (both individual and universal). In general, the concept of 'smart city' covers both the current needs of various city services and development prospects, as well as the demographic situation, ecology, and the requirements of organizations and residents.

A large body of contemporary research focuses on the phenomenon of smart cities, including the reports prepared by consulting companies such as McKinsey, PwC and European Data Portal, research groups and individual scholars such as L. Anthopoulos [2], I. Karabegovic [3], D. Keyson [4], S. Lee [5], D. Pal [6], V. Socheeva [7], J. Wagner [8] and others. Monardo describes 'Smart Strategies' in Boston as one of the most innovative cities in the United States and emphasizes the importance of proper 'territorialization' for the implementation of smart strategies and focuses on the fact that understanding the purpose of the territory and traditions of the local population is a key factor for the implementation of urban innovation [9]. Masucci shows that as smart cities form, inequalities between cities increase: the rich spaces of the new economy become smart, but most of the cities are far behind [10]. The purpose of this research consists in the identification of specifics of the implementation of the concept of a smart city in Korea. The study considers such topics as South Korean Government's smart cities policy, stages of smart city development, classification of smart services and the current status of Korea's smart city service; compares approaches to smart city development in South Korea, Japan and China.

[1] Henke, N., Bughin, J., Chui, M., Manyika, J., Saleh, T., Wiseman, B., Sethupathy, G. (2016). The age of analytics: competing in a data-driven world. Retrieved from: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/McKinsey%20Analytics/Our%20Insights/The%20age%20of%20analytics%20Competing%20in%20a%20data%20driven%20world/MGI-The-Age-of-Analytics-Full-report.ashx

[2] UNESCO (2019). Smart cities: shaping the society of 2030. Retrieved from: https://unesdoc.unesco.org/ark:/48223/pf0000367762

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Theoretical framework and methodology

Our research draws from several groups of studies. First, there are studies discussing the role of the state in smart city projects. A. D'Auria, M. Tregua, and M. Vallejo-Martos show how the concept of smart cities influences the socio-economic conditions local communities are living in [11]. Angelidou, M .considers the factors that affect the choice of smart city models and the corresponding strategies of project development [12]. A. Meijer and M.P.R. Bolivar demonstrate the interconnection between state and local policies regarding smart city development [13]. There is also research focusing on the role of smart cities in the achievement of global and national development goals, for example, I. Turgel, L. Bozhko, E. Ulyanova, & A. Khabdullin [14] consider the potential of smart city technologies in the light of global sustainable development goals. S. Praharaj, J.H. Han, and S. Hawken demonstrate the need to support smart city projects to stimulate innovation on the national level [15].

The second group of studies focus on the outcomes of smart city evolution in South Korea. The reason why South Korea attracts so much scholarly interest is this country's outstanding performance in ICT, the unique role played by the government in the process of smart city development (not only did the government initiate the search for new technological solutions but it also provided large scale support for such projects). In the last decades of the twentieth century, technological innovation was placed at the core of Korea's national idea. The vision of smart cities as a part of the national idea of economic leadership is discussed by J. Suh, H.C. Chen Derek, C. Choi, J. Choi, C. Kim and D. Lee, who conducted a comprehensive analysis of the state support of smart cities in South Korea, exploring the strengths and drawbacks of the state policy [16; 17]. In this respect, what seems particularly important is these authors' conclusion that at a certain stage, there has been a decline in the international competitiveness of the smart city projects in question. The studies of specific cases of Korean smart cities and their counterparts in other countries provide us with an understanding of the shortcomings of the state support system and their causes as well as the micro-level problems of smart cities' competitiveness (see, for example, J.H. Lee, M.G. Hancock and M.C. Hu [18]).

W. Yu and C. Xu [19] and H. Tamai [20] highlight the unique nature of South Korean cities in comparison with other Asian countries (China and Japan). South Korean experience is most often compared with that of China and Japan because these countries are high economic achievers and have similar visions of the role of state in national economy. In these countries, there is a substantial state-owned sector and the state acts as an economic agent in its own right to ensure the achievement of national development goals. Studies systematizing the most interesting cases of flagship smart city projects in South Korea describe the instruments used for smart city development. O. Benedikt [21], for example, describes the development of the smart city of Songdo. S.Y. Lee and H.J. Yoon [22] discuss the smart city project in Busan and Y. Kwon [23], in Sejong.

Results and discussion

Five stages of smart city development in Korea

Smart cities are important elements of the state industrial policy in South Korea[3]. On the one hand, a smart city ensures the infrastructural and innovative development of the territory. On the other hand, it is a promising investment project in which investors from other countries are ready to invest. To date, the Government 's position is to ensure the improvement of urban infrastructure and to allow citizens to determine the role of the new technologies in their lives.

The smart city has emerged as a new alternative solution to address urban problems such as urban deterioration, traffic congestion, energy shortages, environmental pollution, and crime. With the help of the smart city technology, it is possible to manage urban resources by collecting and analyzing urban information through ICT [24]. The smart city market is an innovative growth engine centered on energy, transportation and safety by utilizing ICT such as AI, Big Data, and 5G. The smart city is one of the many convergence types based on ICT such as smart distribution, smart welfare, smart environment, and smart energy.

The five stages of smart city development in Korea are as follows:

Stage 1: infrastructure (existing U-city project). This stage combines the innovation and infra-

[3] Ubicom Programme. (2011). Ubiquitous City in Korea. Services and Enabling Technologies. Tekes-Finnode-Finpro.

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structure of a smart city. This provides the basis for the full-scale construction of smart cities [25]. Urban infrastructure plays a critical role in developing smart city development strategies. ICT infrastructure includes the construction of wired / wireless communication networks, e-government, the creation of an information society, the use of innovative technologies, such as open data.

Stage 2: vertical grid. It is a step to enhance the efficiency of urban operation by vertically linking and integrating individual sectors and services. Instead of integrating cities into one, a separate service-specific business approach is adopted. In the case of Korea, there is an increasing number of cases where an integrated city operation center is established and individual services are linked.

Stage 3: horizontal grid. Related functions and tasks share data and a platform to provide more sophisticated analysis and services. This stage is much more complicated than the second because governments must create convergence or inter-sector linking services.

Stage 4: city platform. It is a stage where the city works as one platform and the project is completed. By releasing the data-sharing problem into the technical architecture, data sharing within the city is transformed into a basic state, not a special one. The 'Algorithm and Service' layer of the Smart City Platform is developing dramatically with smooth data supply.

Stage 5: the city of the future. The most important thing in the technology of the urban platform is the function of 'artificial intelligence', which implements many types of data in real-time and increases the value of use and added value. At this stage, a smart city becomes a full-blown intellectual society. Just as the highest level of e-government in the past was 'government transformation', the next step in a smart city is moving to a new city. If a smart city will introduce intelligent technologies into the existing urban system, then at the next level, intelligent technologies can be used to create a new urban structure that does not currently exist.

Steps of smart city development

As the experience of South Korea shows, the process of planning, constructing an optimal customized smart city generally consists of four steps (see Table 1).

Table 1

Steps to build a smart city

Steps	Content	Role	Keypoints
[Step 1] Analysis of urban situation	Diagnose the problems and the situation that the city is facing	Identifying urban problems and analyzing ways of smart city promotion	Diagnosis of urban problems Urban system research ICT infrastructure diagnosis Deriving core service sector
[Step 2] Solutions	Finding the best smart solutions for urban problems	Provide technical alternatives for smart city service implementation	Find solutions by service Building an architecture Basic structure concept
[Step 3] System design	Designing the system of the smart city	Design specific systems based on architecture	Center system design Field system design Communication system design
[Step 4] Business promotion	Promotion of smart city business through validation of business	Extend the scope for systematic project management	Cost / benefit analysis Pilot project promotion Implementation of this project

Let us look at these steps in more detail.

Step 1: Analysis of urban situation

At this stage, urban problems are diagnosed through surveys and in-depth interviews with citizens [26]. For the government, it is necessary to ensure the maximum transparency of this process to stimulate citizen cooperation [27].

The smart city types are divided into an old urban type and new urban type. The old urban type refers to a city that has been providing smart city related services gradually for at least 10 years, and it is a city that has received favorable evaluations from the users [28].The services already existing in 'old' smart cities usually include intelligent traffic and security systems. The new urban type is characterized by services and systems built in a short period of time by investing in urban development profit. The old city takes a long time to regulate the operation and maintenance of the system. In the case of the old city type, it is necessary to construct a system (construction design) based on the existing system. It is also necessary to conduct a thorough investigation of the existing systems to promote a new level of smart city.

As for smart city services, ICT plays a pivotal role as a means of implementing services to solve urban problems. The level of ICT infrastructure in the city is largely divided into supply and demand

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levels, which requires close examination. The supply dimension is divided into infrastructure diagnosis, which evaluates the development status of the ICT industry and network topology, and service diagnosis, which evaluates communication services such as Internet access and communication speed. The demand dimension is divided into acceptance diagnosis, which tests whether information service is available at a low cost, and content diagnosis, which evaluates the content development level using various applications.

Finally, it is necessary to identify the type of the future smart city's service sector and the most pressing urban issues; set priorities; and devise the basic policy directions of the government.

Step 2: Solutions

Based on the connectivity, cost-benefit and feasibility of the existing services and possible solutions, it is necessary to devise a unique solution for each smart city [29]. This process comprises prioritizing the core service areas, search for the possible options and choose the best solutions for each smart service.

The smart city architecture has four types: center system; field system; vehicle system; and personal portable system. The center system is an information platform where various real-time data such as traffic, crime prevention, disaster prevention, and water supply and drainage collected in the city are concentrated. The field system collects various situations occurring in the city by using advanced information gathering technology such as detectors, centers, and IoT, and it is a variety of devices such as CCTV and sensors. The vehicle system is installed inside a moving vehicle in the city to grasp the traffic situation and transmit it to the center in real time. The personal portable system utilizes the functions of smartphone software and hardware to induce citizen participation in urban administration without time and space limitations.

Step 3. System design

The center of all city information in the design of a smart city system is very important. It is a platform for combining information flows of the city [30]. In the case of the new city type, there is no problem because it is a new design, but in the case of the old city type, it is essential to integrate various information centers that have already been constructed physically and systematically.

A smart city field system design is important to find effective ways to build on-site equipment. Various sensors, CCTV, emergency bell, roadside communication equipment, license plate detector, etc. are required to collect various kinds of information according to service characteristics. It is desirable to plan multi-purpose structures in advance and systematically install them in order to efficiently build on-site systems. In order to build an effective smart city, it is essential to establish a self-dedicated optical communication network.

Step 4. Business promotion

In order to prove the feasibility of a smart city, it is important to calculate and compare the costs and benefits. Costs and benefits are important to calculate and compare to assess the feasibility of creating a smart city. It is especially important to evaluate the services provided by the public sector. Most services lack qualitative methodology because they have many qualitative benefits such as convenience enhancement, information provision, and satisfaction improvement. A preliminary feasibility study for a public project should include a calculation of the effect of reducing costs, the effect of reducing pollution, the effect of reducing the cost of accidents, and a methodology for calculating time savings as part of the implementation of smart city technologies.

For the step-by-step construction of a smart city, it is necessary to verify the feasibility of the project by promoting the pilot project as the first priority [31]. Pilot projects are an essential process to test the applicability of relevant technologies and to test local adaptability. It is a very important step to diagnose the effect of providing smart city service in advance.

Project management involving design planning, schedule management and supervision, pre-evaluation and post-evaluation is important. The business effect can be maximized by expanding the scope of smart city construction.

Smart services in Korea: types and classification

Inhabitants of smart cities in South Korea enjoy access to a large number of smart services. Smart services in all their diversity can be divided into 7 key functional areas: mobility healthcare, education, energy/environment, governance, culture and shopping, jobs and infrastructure (see Table 2). What should be emphasized is the comprehensive nature of smart services in the sense that they seek to encompass all aspects of contemporary urban life. In other words, the development of smart services is primarily oriented towards meeting the needs of in-

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dividual consumers. It should be noted that the Korean concept of smart services is associated with meeting such higher-order human needs as culture and education. Smart services, including those in the sphere of social entrepreneurship, are expected to facilitate the satisfaction of human needs. The functions of smart cities' services in Korea go far beyond the range of customary services for the improvement of mobility, energy efficiency and infrastructure.

Overall, there are 80 smart city services in South Korea. In fact, the experience of this country shows that smart city services not only create new opportunities to provide people with services of a better quality but also the opportunities for personal growth. Such understanding of smart cities is, however, just a starting point for further development in this sphere. The ultimate goal of these projects is to help city dwellers achieve their personal development goals.

Table 2

Smart Service in Korea

Classification	3rd party services	City Operates
Mobility	Future vehicle test bed Autonomous driving Drone courier Drones management and tailor Shared vehicle service Manage shared bikes Smart crosswalk	Logistics robot C-ITS Signal control for emergency vehicles Autonomous Infrastructure Management Local base logistics Smart parking management Smart streetlight Smart Bus Shelter Management BRT control service
Health care	Emergency drones Unmanned Patrol On-demand automatic shuttle Robot assistant Power wear wearable Telemedicine Service Real-time monitoring of resident health	Intelligent Crime Prevention System Electronic prescription (Blockchain) Urban smart farm Real-time disease analysis Disease prediction Disease map Exercise compensation service
Education	Educational environment provision by brain development cycle On-line training space Smart Classroom International Baccalaureate	Educational cloud rental Ecology Online Library
Energy / Environment	Energy exchange (vehicles, building) Smart AMI Electric vehicle charging infrastructure Solar Power (Solar) Fuel cell vehicle spread Smart leak detection Smart water quality management BIM / BEMS	Independent Energy Management Power Exchange (Urban DER: Distributed Energy Resources) ESS management Garbage transport robot control Road cleaning robot control Fine dust monitoring Drone control for air quality measurement Smart protection Underground Community Management
Governance	Mobile space rental Location tracking	Digital Twin-AR (Augmented Reality) / VR Integrated resident card (Blockchain) City Tuning Infrastructure Urban Design Analysis (Digital Twin) Public chatbot Smart Security Integrated city operation control GIS-based city control Operate low-income infrastructures
Culture and Shopping	O2O service Famers Market (flea market) Culture / Shopping Street Smart Performance Platform Smart payment system	Local Currency Service (Blockchain) Smart signage Social enterprise – employment for the disabled
Job and infrastructure	Incubation Service Innovation Jim Silver courier Single bike delivery	Data Marketplace (Living Lab) Hacker ton

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Current status of Korea's smart city services

There are three types of smart cities in Korea: pilot projects, R&D validation projects, and urban regeneration projects. Let us look at their characteristics in more detail.

Pilot projects

These cities were selected in 2018 from a total of 39 candidate cities. In the two pilot cities (Sejong and Busan), plots of 2–3 square kilometers were selected for subsequent development based on the calculated time and costs. Sejong City (officially known as Sejong Special Autonomous City) is the central administrative city of Korea, located 150 km south of Seoul, while Busan is located in the southeastern part of the country, 500 km from Seoul.

The Smart City Project in Sejong, located in a northeast residential area, covers 2.7 km^2 and upon completion will have a population of 23,000 residents living in 9,000 households. The Busan Smart City Project, located in its western Gangseo district, will be called Eco-Delta City (EDC). The future Eco Delta City will be based on the area of 2.2 km^2, including a part of the Nakdong River and its tributaries.

Some project components will be distributed in adjacent areas, bringing the total project size to 11.8 km^2. The development will be led by two state-owned corporations, LH Corporation in Sejong and K-Water in Busan. LH Corporation, officially the Korea Land and Housing Corporation, is engaged in public housing and land administration. K-Water has expanded from managing water supply and resources to developing industrial complexes and clean energy projects.

R&D validation projects

This type of smart cities includes the cities of Daegu and Siheung. Siheung is a satellite city of Seoul. These cities were chosen as test sites or 'living laboratories' for the Korean smart city model in 2018. Urban development of this type of cities includes data collection, storage and sharing on an integrated city-wide platform.

The sites will be operational for five years until the end of 2022. Research in Daegu will focus on intellectual mobility, crime prevention and resilience to natural disasters and disasters. The projects inSiheung will focus on the environment, welfare and energy.

Urban regeneration projects

These smart cities are urban restoration projects aimed at reviving old urban areas and dealing with such problems as the lack of parking lots and potential security concerns through the use of data connectivity rather than large-scale redevelopment. These are projects of a small and thematic nature. Since February, 2019, these cities have included Daejeon, Gimhae, and Bucheon. The theme for Daejeon's development is 'The New Science City'. The project aims to demonstrate popular research and development, as there are many corporate and public research centers in the city. Bucheon will focus on using big data analytics to monitor and reduce air pollution across the city, and Gimhae will invest in AR and VR attractions for its historic sites.

The experience of South Korea is interesting to compare with that of its counterparts – China and Japan. In both countries, the process started in 2010. In China, the smart city development is a part of the 12th Five-Year Plan. The first city to publish a municipal smart city development plan was Ningbo city in Zhejiang Province. In 2012, 6 pilot city projects were launched: in Beijing, Shenzhen, Shanghai, Hangzhou, Guangzhou, and Xiong'an. As for Japan, the four pilot projects were located in Keihanna, Kitakyushu, Toyota City and Yokohama. Starting from 2012, the Japanese government also chose several municipalities in Fukushima, Miyagi and Iwate prefectures for smart city projects in order to accelerate the urban and economic reconstruction of these areas.

In China, the development of a smart city is based on a centralized model with an emphasis on streamlining and enhancement of the efficiency of urban systems, especially regarding municipal government and public services. In Japan, the model is also centralized and focuses on fostering energy security and efficiency, local socio-economic development and enhancement of regional and global competition. The priority areas of smart city development in China include smart transport; smart water, smart energy and smart healthcare, while in Japan the focus is mainly on the reform of the electricity sector, introduction of the advanced metering structure (AMI), energy management system (EMS) and intelligent transport systems (ITS). In China, the process of building smart cities is managed by the Ministry of Housing and Urban-Rural Development (MOHURD); in Japan, it is the Ministry of Finance that is in charge of the reform.

While in Japan there are two types of smart city projects – those initiated by the private sector and initiated by LGs, in China, behind this process is

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the coalition of the public and private sector, authorities working together with large companies such as Huawei, Baidu, Alibaba, Tencent and so on.

It should be noted that the Chinese understanding of smart cities is technology-centric based upon cutting-edge information technologies such as IoT, big data, 5G, AI, and cloud computing. Smart city policies and initiatives in China focus mostly on the goals of enhancing the efficiency and effectiveness of economic development and urban management. In Japan, smart cities are highly specialized projects. Citizens do not take an active part in these projects. Although universities and R&D institutions are often mentioned in these projects and planning schemes, with the exception of Keihanna, they are not active players in this field and have but a limited influence on smart city projects.

Thus, smart cities in China, Japan and South Korea are generally focused on the introduction of advanced technologies. Cities in Japan are more focused on energy-saving technologies while China uses an integrated approach to smart cities as the government is building a system of interaction between the state, population and business. In Korea, a national strategic development project was launched – u-City (the ubiquitous computer city), whose goal is to improve the quality of life in cities through the ubiquitous ICT services supported by both the public and private sectors. The goal of u-City was to integrate advanced ICT-based infrastructures and ubiquitous information services into urban space to provide residents with a high quality of life, including safety, wealth, convenience and comfortable urban environment. Song-do City in Korea can be considered one of the most advanced Digital City projects in Asia.

Conclusion

Globalization, development of new technologies and related factors inevitably lead the cities to cardinal transformation. Thus, problems of cities turn into sources of new opportunities and their development involves innovative methods of management and new flexible strategies of development. Hidden sources of potential growth can be identified in multidisciplinary research. It is necessary to use progressive policy tools simultaneously at the conceptual, disciplinary and practical levels. In this case, it is important to train city managers in specially designed programs, partnerships with research universities, the creation of their own departments for urban development research, etc. Scenarios of the future of the cities – gradual decline or total energies of the city with a new quality of life depend on the existence or lack of similar factors.

Smart city is a complex concept, which implies an interaction of all factors of urban environment and innovative technologies. The smart city model improves the quality of life, decreases the crime rate, increases the efficiency of the use of resources, productivity, transparency of public administration and mobility, leads to the emergence of the e-government, provides better access to education and helps decrease the unemployment rate and the level of air pollution.

In general, the situation in South Korea demonstrates the success of the smart city. Comparison with other countries shows that Japanese smart cities are more focused on energy-saving technologies while China uses an integrated approach to smart cities as the government is building a system of interaction between the state, population and business.

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Consumption of addictive goods in Russian regions and its impact on the quality of human capital

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ABSTRACT
Research relevance. Consumption of addictive goods and its impact on the human capital is widely discussed in contemporary research literature, not only on the micro- and macro- but also on the meso-level. At the present stage of the ongoing transformations we are prompted to reassess current approaches to this problem and to re-evaluate its public significance; moreover, practical application of available research outcomes should also be reconsidered. In Russia, consumption of addictive goods is subject to significant regional variations determined by socio-economic and other factors. **Research aim.** The study is aimed at investigating the impact of consumption of addictive goods (alcohol) on the quality of Russian consumers' human capital and at building a system of indicators to estimate this impact. **Data and methods.** The study uses the methods of comparative analysis, expert estimation, ranking, and economic-statistical analysis, it also proposes a spatial approach to problems associated with regional variations in human capital of consumers of addictive goods. The study relies on the Russian and international research evidence; the data of the Federal State Statistics Service and its regional offices; expert estimates and the authors' own calculations. **Results.** The study demonstrates the connection between consumption of addictive goods and consumers' human capital. It also describes a system of statistical indicators that can be used for estimating the impact of alcohol consumption on human capital and the criteria such indicators should meet. Based on the proposed indicator set, the study analyzes and compares the trends in human capital deterioration on the regional and national levels. As a result of cross-regional analysis, regions with the highest and lowest figures of human capital deterioration are identified. **Conclusions.** As their addiction progresses, alcohol consumers face an increasing devaluation of their human capital. This parameter varies significantly across Russian regions due to a range of climatic, regional, and socio-economic factors, which should be taken into account when devising and implementing regional alcohol policies. The existing system of statistical observations uses a limited set of indicators that needs to be expanded to allow for a more comprehensive cross-regional analysis.

KEYWORDS
addictive goods, consumer behaviour, theory of consumer demand, government regulation, human capital, regional variation, regional policy

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Влияние аддиктивных товаров на качество человеческого капитала потребителей: региональный аспект

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АННОТАЦИЯ
Актуальность. Разработка научной проблемы формирования человеческого капитала потребителей аддиктивных товаров приобретает все большую актуальность не только на микро- и макроуровне, но и на мезоуровне. Современный этап трансформационных процессов заставляет переосмысливать представления об указанной проблеме, ее общественной значимости, использовании прикладных результатов исследований. В российских условиях актуальность изучения территориальных аспектов дифференциации потребления аддиктивных товаров связана с высокой поляризацией соци-

КЛЮЧЕВЫЕ СЛОВА
аддиктивные товары, потребительское поведение, теория потребительского спроса, государственное регулирование, человеческий капитал, региональные различия, региональная политика

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ально-экономического положения регионов и многообразием факторов ее определяющих. **Цель исследования.** Выявить результаты влияния аддиктивных товаров на качество человеческого капитала потребителей в регионах России (на примере потребления алкогольной продукции) и сформировать систему показателей, определяющих тенденции указанного процесса. **Данные и методы.** В исследовании были использованы методы сравнительного анализа, экспертных оценок, ранжирования, методы экономико-статистического анализа. Предложен пространственный подход к исследованию проблем региональной дифференциации показателей человеческого капитала потребителей аддиктивных товаров. Информационную базу исследования составили результаты исследований отечественных и зарубежных экономистов потребления аддиктивных товаров; официальные данные Федеральной службы государственной статистики и ее территориальных органов, а также экспертные оценки и авторские расчеты. **Результаты.** Раскрыта связь между потреблением аддиктивных товаров и человеческим капиталом потребителя; обоснованы требования к показателям, которые целесообразно использовать для оценки влияния на человеческий капитал потребления алкоголя; с учетом данных требований предложена совокупность статистических показателей; проведена оценка динамики показателей деградации человеческого капитала на общероссийском уровне и межрегиональные сравнения. В ходе межрегиональных сравнений выделены регионы с наиболее высокими и наиболее низкими показателями деградации человеческого капитала. **Выводы.** Злоупотребление аддиктивными товарами сопровождается деградацией человеческого капитала индивида по мере роста зависимости. Уровень «деградации» человеческого капитала от потребления аддиктивных товаров в российских регионах значительно варьируется в силу многообразия климатических, религиозных, социально-экономических особенностей, которые необходимо учитывать при разработке и реализации дифференцированной антиалкогольной политики. Существующая система статистических наблюдений позволяет провести межрегиональные сравнения по ограниченному числу показателей и нуждается в совершенствовании.

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Introduction

Consumption of harmful addictive goods presents an interesting problem for researchers. G. Becker [1], G. Edwards [2], J. Gruber [3], J.V. Koch, and S. Group [4] devote considerable attention to consequences of addictive consumer behaviour, in particular the development of bad habits. The scale of the negative consequences of consumption of goods posing health risks and the rapid deterioration of consumers' human capital determine the practical relevance of research in this area. Consumption of addictive goods and its negative consequences are determined by a range of economic, social, psychological and other factors, which vary considerably across regions and countries. That being said, significant regional variations are observed in consumption patterns as well. In Russia, the level of consumption of addictive goods is quite high, although there has been a long-term downward trend. For example, in the commodity market, the retail turnover of alcoholic beverages and tobacco products fell from 19 % in 1970 to 9% in 2015 [5; 6]. However, there are multifold regional differences in the consumption of these goods and in its negative effects.

In the light of the above, the purpose of this study is to describe the changes in the human capital of consumers of addictive goods in Russian regions by focusing on alcohol consumption.

The following research objectives would facilitate the achievement of this aim. First, we are going to characterize the existing approaches in Russian and international research to the choice of indicators for analysis of the deterioration of human capital due to consumption of addictive goods. Second, we are going to develop a system of indicators to estimate the impact of alcohol consumption on consumers' human capital and apply these indicators for cross-regional comparative analysis (our findings can be used for devising national and regional alcohol policies). Finally, we will rank Russian regions depending on the levels of deterioration of the human capital caused by alcohol consumption.

Literature review

Economic analysis of addictive consumer behaviour relies on a range of methodological and theoretical frameworks, such as neoclassical economics, institutionalism and neoinstitutiona-

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lism. G. Becker and K. Murphy's model of 'rational addiction' [7] laid the foundation for a large number of theoretical and practical studies, such as A.Maynard and A.Wagstaf's study of government intervention into the illicit drug markets in the UK [8]; F.Chaloupka and K.Warner's study of the myopic behaviour of consumers underestimating the risks of smoking [9]; D. Gieringer's study of cannabis legalization [10]; mathematical analysis justifying controlled partial legalization of currently illicit drugs and the analysis of the data on cocaine and marijuana demand among the youth by F. Chaloupka, M. Grossman and J. Tauras [11]; liquor consumption analysis by B. Baltagi and J. Griffin [12]; K. Wangen's discussion of the problems arising in the course of econometric implementation of rational addiction theory [13]; models of alcohol consumer behaviour in different stages – 'periodic bingers', 'in recovery', and 'detox' [14]; B.Gordon and B.Sun's dynamic model of rational addiction [15]; and D. Evans's study of the socio-economic impacts of marijuana legalization [16]. In Russia, there are comparatively few studies that use economic models of addictive behaviour with the exception of the research published by M. Levin [17], K. Filippov [18], M. Ponomareva [19] and L. Timofeev [20].

Although, according to the classical rational addiction theory, consumers of addictive goods are expected to behave as rational utility maximizers, in reality their behaviour tends to be more complex and inconsistent as they may lose sight of their budget constraints and ignore the future consequences ('conscious' lifetime utility maximization leading to the lethal outcome), which requires further analysis.

International research of the alcohol market, which is a typical addictive market, distinguishes between two types of consumption: the northern type characterized by heavy drinking of strong liquors while the southern type, by the prevalence of wine and beer consumed in relatively small doses[1] [2; 15; 16]. There are also different forms of state regulation of addictive markets such as state monopolies over retailing alcoholic beverages or monopolies on manufacturing and distribution of alcohol; the use of state licensing to control the competition on the alcohol market [21–23]. In both cases, state plays a key role in this market. Despite the diversity of consumption types and market regulation models as well as considerable regional disparities in socio-economic development, Russia continues to implement a unified federal alcohol policy.

Indicators to measure the alcohol-related deterioration of consumers' human capital

Personal consumption is crucial for the formation of human capital. Consumption of vital goods ensures simple reproduction of human capital while consumption of such commodities as education, science, and medicine provides expanded reproduction of human capital. The human capital of an employee who has begun to consume addictive products in abnormal doses will decline. For a woman, it takes on average about 3–5 years to develop an addiction; for men, 8–9 years of regular consumption of alcoholic beverages [24]. According to the Labour Code of Russia, an employment contract can be terminated by the employer if an employee shows up to work in the state of alcohol, drug or toxic intoxication [25].

Top executives of enterprises consider alcohol abuse as the third most important health issue facing their employees (after smoking and cardiovascular diseases). Most top executives (74%) believe that alcohol abuse has a negative impact on their companies' performance [26]. Alcohol addicts are likely to lose a stable source of income and engage in low-paid menial work. The share of unskilled labor in GDP of developed and developing countries, including Russia, is shrinking, and in technologically advanced countries it is already vanishingly small [26], so the human capital of unskilled workers will increase together with the growth rate of the real gross domestic product of the world economy or may remain unchanged.

C. Loveland-Cherry brought to light the inverse relationship between academic performance and alcohol consumption among students [27]. They also showed a positive relationship between increasing alcohol consumption, on the one hand, and low academic performance and school absenteeism, on the other. P. Cook and M. Moore found that heavy drinking in high school (consumption of alcohol twice a week) reduces the average number of years of schooling completed after high school by 2–3 years [28]. V. Kim and S. Roschin demonstrated that alcohol abuse among males has a significant negative effect on employment op-

[1] Economic forecast «The World in 2050» (2015). Joint Stock Company «PricewaterhouseCoopers Audit». (In Russ.) Retrieved from: http://www.pwc.ru/ru/press-releases/2015/economic_forecast_2050.html

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portunities, wage level and the number of hours worked [6].

The WHO[2], G. Edwards [2], E. Andreev and I. Zbarskaya [29] show that consumption of addictive goods has a negative impact on people's physical and mental health and increases their vulnerability to various illnesses. V. Grigoryev and Y. Zeitlin explain the increase in new HIV diagnoses since 1996 in Russia by the spreading substance use and abuse [30]. Alcohol plays an important role in Russian 'supermortality' – deaths from such causes as homicide, suicide, road accidents, injuries, fatalities and so on [31]. In Russia, 61% of deaths from external causes are alcohol-related[3]. According to D. English, in developed countries, 34% of deaths from drowning, falls and road injuries as well as 47% of homicides, 41% of suicides and 44% fire deaths were attributable to alcohol consumption[4].

The influence of addictive goods on life expectancy was discussed by K. Danishevsky [32], A. Korotaev and D. Khalturina [33], A. Nemtsov and A. Podlazov [26; 34–35]. It is shown that an increase in effective consumption of 1 litre per person a year lowers the average life expectancy for men by 0,84 ± 0,04 years and for women, by 0,32 ± 0,03 years [34].

There is a broad range of indicators reflecting different aspects of alcohol-related human capital deterioration, which makes systematization of these indicators a problem in its own right [36; 37]. In the context of our study, however, the main challenge is to select the indicators suitable for estimating the influence of alcohol consumption on human capital and for making cross-regional comparisons. In our view, these indicators should meet the following criteria:

– they should be among the indicators used for regular monitoring by the official statistical and other state agencies or by expert organizations;

– they should include regional and federal-level data;

– they should reflect direct rather than indirect influence of alcohol consumption on the quality of human capital.

It is necessary to have access to long-term statistical observations in order to detect random variations, make forecasts, and use methods of economic-statistical analysis and modelling to formulate evidence-based guidelines and recommendations. Availability of the regional-level data, in its turn, enables us to draw cross-regional comparisons and bring to light the role of different factors in specific regions in shaping alcohol consumption patterns. As for the third requirement, it helps us eliminate ambiguity in the interpretations of the results. Table 1 summarizes the indicators we are going to use in our analysis.

Table 1

Indicators of alcohol-related deterioration of human capital in Russian regions

Indicator	Notation
Number of deaths from alcohol poisoning per 100,000 people, ths people	HC_1
Number of alcohol-related crimes per 100,000 people, units per year	HC_2
Household consumption expenditures on alcoholic beverages, % of aggregate consumer expenditures	HC_3
Number of newly diagnosed cases of alcoholism and alcohol-induced psychosis per 100,000 people	HC_4
Number of cases of recurrent alcoholism and alcohol-induced psychosis per 100,000 people	HC_5
Percentage of adult non-drinkers, %	HC_6

Indicator HC_1 is calculated by the Federal State Statistics Service (Rosstat) as a ratio of the number of alcohol-related deaths to mid-year population.

Indicator HC_2 is calculated as a ratio of the number of alcohol-related crimes (from the number of investigated crimes) to mid-year population. For this indicator we used the data from Form '3-EGS' of the Federal Statistical Monitoring 'Data on Registered, Solved and Unsolved Crimes', based on the reports of the information centres of regional law enforcement agencies.

Indicator HC_3 relies on the data of the household sample surveys conducted by Rosstat.

Indicator HC_4 is computed by Rosstat as an integer of the number of newly diagnosed cases of alcoholism and alcohol-induced psychosis and

[2] WHO. Global Status Report on Alcohol. (2004). Country profile. Retrieved from: http://whqlibdoc.who.int/publications /2004/9241562722_(425KB).pdf

[3] Report of the Public Chamber of the Russian Federation of May 13, 2009 'Alcohol abuse in the Russian Federation: socio-economic consequences and countermeasures'. Public Chamber of the Russian Federation. (In Russ.) Retrieved from: http://www.oprf.ru/files/dokladalko.pdf

[4] The average monthly nominal wages of employees of organizations of the Russian Federation in 1991–2016. Federal State Statistics Service. (In Russ.) Retrieved from: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/wages/

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the end of year population by using the following formula:

$$HC_4 = a/b \cdot 100\,000,$$

where a is the number of newly diagnosed cases of alcohol and alcohol-induced psychosis and b is the end of year population;

Indicator HC_5 is the number of cases of recurrent alcoholism and alcohol-induced psychosis per 100,000 people calculated by Rosstat the same way as indicator HC_4.

Indicator HC_6 is based on the data provided by the Russian Public Opinion Research Center (VTsIOM). Their telephone survey covered 1,600 respondents aged 18 or older. The survey was conducted by using stratified dual-frame random sample based on a complete list of landline and mobile phone numbers operating in Russia. So far VTsIOM has provided no geographic breakouts of their survey data for Russian regions.

Analysis of the impact of alcohol consumption on human capital (national and regional aspects)

The above-described indicators were tested and found suitable for analyzing the impact of alcohol consumption on human capital in Russia on the regional and national levels. Table 2 illustrates the level of deterioration of human capital associated with alcohol consumption in Russia.

Overall, we can observe downward trends in the indicators characterizing the alcohol-relatead deterioration of human capital in Russia. The most remarkable trend is an almost 30% decrease in the number of deaths from alcohol poisoning. Interestingly, the share of alcohol in consumer expenditures of households has remained virtually unchanged. There is a gradual decrease in the number of alcohol-related crimes as well as in the number of people suffering from alcoholism and related psychiatric disorders. Nevertheless, these figures are still quite high in Russia.

At the next stage of our analysis, we compared these figures in different Russian regions by using the ranking method. First, each region was ranked for each of the indicators H_1–H_5. Then, the total score for each region was calculated by summing its positions in each of the indicators. The regions were ranked (R) from the most successful (top of the ranking) to those lagging behind (bottom of the ranking). The less the region scored, the more successful it was and the higher was its position in the ranking. Since the information for some regions was incomplete, we used the data for 2015, which proved to be sufficient for our calculations and we could systematize the data for all the chosen indicators. Indicators HC_3 and HC_6 were excluded due to the lack of the necessary regional data [37]. Table 3 summarizes the results of our analysis.

The top of the ranking is occupied by such regions as Ingushetia, Chechnya, Dagestan, St. Petersburg and Moscow cities, North Ossetia, Krasnodar region, Karachay-Cherkessia, Belgorod and Stavropol regions. Religion is an important factor shaping consumer behavior in Muslim-majority regions: Ingushetia has the lowest rates of deaths caused by alcohol poisoning, alcoholism and alcohol-induced psychic disorders; Chechnya has the lowest level of alcohol-related crimes; Tatarstan ranks 12th, after Kabardino-Balkaria. Surprisingly, however, religion appears to be less significant in Bashkortostan, which has the 30th position in our ranking.

Table 2

Deterioration of human capital in Russia caused by alcohol consumption

Indicator	2014	2015	2016	2017	2018
Number of deaths from alcohol poisoning per 100,000 people, ths people	10.71	10.41	9.56	8.36	7.5
Number of alcohol-related crimes per 100,000 people, units per year	241.86	273.92	300.09	257.43	239.46
Household consumption expenditures on alcoholic beverages, % of aggregate consumer expenditures	1.7	1.8	1.7	1.6	1.6
Number of newly diagnosed cases of alcoholism and alcohol-induced psychosis per 100,000 people	74.6	70.9	64.9	n/a	n/a
Number of cases of recurrent alcoholism and alcohol-induced psychosis per 100,000 people	1155.4	1076.2	984	n/a	n/a
Percentage of adult non-drinkers, %	n/a	n/a	n/a	39	40

Compiled by the authors by using the data of the Unified Interdepartmental Statistical Information System. Retrieved from: https://gks.ru/emiss (Accessed: 11.04.2020).

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Table 3

Ranking of Russian regions in terms of alcohol-related deterioration of human capital

Regions	RHC_1	RHC_2	RCH_4	RCH_5	∑RCH	R ∑RCH
Central Federal District						
Belgorod region	9	15	18	18	60	9
Bryansk region	47	47	64	81	239	61
Vladimir region	79	52	42	74	247	65
Voronezh region	67	18	70	58	213	49
Ivanovo region	85	37	68	86	276	72
Kaluga region	57	33	41	38	169	35
Kostroma region	48	46	43	78	215	51
Kursk region	24	45	62	52	183	41
Lipetsk region	80	22	48	75	225	56
Moscow region	49	11	19	40	119	21
Orel region	50	32	60	67	209	47
Ryazan region	33	19	32	66	150	28
Smolensk region	54	41	50	65	210	48
Tambov region	62	26	24	80	192	44
Tver region	72	43	28	71	214	50
Tula region	83	17	47	72	219	53
Yaroslavl region	82	27	49	43	201	45
City of Moscow	12	6	8	6	32	5
North-Western Federal District						
Republic of Karelia	61	72	81	77	291	74
Republic of Komi	84	86	55	44	269	69
Arkhangelsk region	73	67	46	57	243	63
Nenets Autonomous District	53	70	82	68	273	70
Arkhangelsk region without autonomous districts	75	66	46	56	243	63
Vologda region	37	76	30	32	175	38
Kaliningrad region	76	35	44	33	188	42
Leningrad region	70	16	10	17	113	19
Murmansk region	56	42	59	15	172	36
Novgorod region	86	54	54	79	273	70
Pskov region	51	40	61	64	216	52
City of St. Petersburg	18	4	4	4	30	4
Southern Federal District						
Republic of Adygea	46	21	25	73	165	33
Republic of Kalmykia	22	20	13	31	86	14
Republic of Crimea	38	12	67	36	153	29
Krasnodar region	11	14	9	8	42	7
Astrakhan region	23	30	15	30	98	16
Volgograd region	28	31	27	19	105	17
Rostov region	5	9	12	34	60	9
City of Sevastopol	19	10	75	16	120	22
North Caucasian Federal District						
Republic of Dagestan	3	3	3	3	12	3
Republic of Ingushetia	1	2	1	1	5	1
Kabardino-Balkarian Republic	16	7	29	12	64	11
Karachay-Cherkess Republic	7	8	7	29	51	8
Republic of North Ossetia	4	5	17	7	33	6
Chechen Republic	2	1	2	2	7	2
Stavropol region	21	13	6	23	63	10

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End of Table 3

Regions	RHC_1	RHC_2	RCH_4	RCH_5	∑RCH	R ∑RCH
Volga Federal District						
Republic of Bashkortostan	26	56	38	35	155	30
Mari El Republic	65	49	56	70	240	62
Republic of Mordovia	42	24	45	46	157	31
Republic of Tatarstan	20	23	22	14	79	12
Udmurt Republic	78	78	66	53	275	71
Chuvash Republic	52	51	69	76	248	66
Perm region	68	73	74	63	278	73
Kirov region	43	79	31	60	213	49
Nizhny Novgorod region	71	29	33	82	215	51
Orenburg region	39	53	76	22	190	43
Penza region	41	34	77	54	206	46
Samara region	6	28	23	24	81	13
Saratov region	29	25	35	50	139	24
Ulyanovsk region	58	44	72	55	229	57
Ural Federal District						
Kurgan region	77	85	63	42	267	68
Sverdlovsk region	60	58	40	9	167	34
Tyumen region	15	62	34	27	138	23
Khanty-Mansiysk Autonomous District (Yugra)	10	50	36	20	116	20
Yamalo-Nenetsk Autonomous District	27	65	79	62	233	59
Tyumen region without autonomous districts	14	71	34	26	145	27
Chelyabinsk region	74	68	51	39	232	58
Siberian Federal District						
Republic of Altai	44	87	26	25	182	40
Republic of Buryatia	69	84	16	11	180	39
Republic of Tyva	32	81	5	45	163	32
Republic of Khakassia	36	83	53	48	220	54
Altai region	13	77	73	47	210	48
Zabaikalye region	63	82	57	41	243	63
Krasnoyarsk region	30	64	65	21	180	39
Irkutsk region	31	59	71	49	210	48
Kemerovo region	59	80	21	13	173	37
Novosibirsk region	34	36	11	10	91	15
Omsk region	64	38	14	28	144	26
Tomsk region	25	55	20	5	105	18
Far Eastern Federal District						
Republic of Sakha (Yakutia)	35	60	84	59	238	60
Kamchatka region	45	39	52	85	221	55
Primorye region	8	57	39	37	141	25
Khabarovsk region	17	61	80	61	219	53
Amur region	66	69	58	51	244	64
Magadan region	81	75	85	84	325	75
Sakhalin region	40	63	83	83	269	69
Jewish Autonomous District	55	48	78	69	250	67
Chukotka Autonomous District	87	74	86	87	334	76

Successful regions Lagging regions

Compiled by the authors by using the data of the Unified Interdepartmental Statistical Information System. Retrieved from: https://gks.ru/emiss (Accessed:12.02 2020).

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Regions of the North-Caucasian Federal District – Dagestan, Ingushetia, Kabardino-Balkaria, Karachay-Cherkessya, North Ossetia, Chechnya and Stavropol region – are in the top of the regions that drink the least alcohol. It may seem surprising that the cities St.Petersburg and Moscow, Krasnodar and Belgorod regions are also at the top despite their relatively high alcohol consumption levels. Their results can be explained by greater efficiency of regional health care and law enforcement agencies. The cities Moscow and St. Petersburg and Krasnodar region have comparatively low alcohol-related crime rates and fewer cases of alcohol-induced disorders and alcoholism. Another driver of these regions' performance is the higher income level, which means that their inhabitants can afford to consume more expensive and, therefore, less toxic alcohol.

The heaviest drinking regions are Chukotka Autonomous District, Karelia, Perm, Magadan and Ivanovo regions, Udmurtia, Nenets Autonomous District, Novgorod region, the Komi Republic, Sakhalin and Kurgan regions, and Jewish Autonomous District. Chukotka Autonomous District and Magadan region have the highest rates of deaths due to alcohol poisoning, alcohol-related crime and the number of cases of alcoholism and alcohol-induced psychosis. Karelia has a high incidence of alcohol-related crime and high rates of alcoholism and alcohol-induced disorders. Perm region also has to struggle with high rates of alcohol-related crime and newly diagnosed cases of alcoholism and alcohol-induced psychosis. Ivanovo region has the highest rate of deaths caused by alcohol poisoning and also the largest number of cases of recurrent alcoholism and alcohol-induced psychosis. In Udmurtia and Kurgan region, there are high rates of deaths caused by alcohol poisoning and alcohol-related crimes. The level of the latter is also high in Nenets Autonomous District, which also suffers from a high incidence of alcoholism and alcohol-induced psychosis. In Novgorod region, the alcohol-related death rate is one of the highest in Russia (in this indicator, Novgorod region is preceded by Chukotka Autonomous District) and a high rate of alcoholism (number of cases of recurrent alcoholism and alcohol-induced psychosis). The Republic of Komi has an extremely high level of alcohol-related violence and rate of deaths caused by alcohol poisoning. Both Sakhalin region and Jewish Autonomous District have high rates of alcoholism (reflected by the two indicators – the number of newly diagnosed cases of alcoholism and alcohol-induced psychosis and the number of cases of recurrent alcoholism and alcohol-induced psychosis).

In this case, it is evident that the high level of deterioration of human capital is closely linked to the general state of economic depression in some regions and the low level of per capita income. Another important characteristic shared by the lagging regions is that they are located remotely from large economic centres.

Conclusion

The results of our study have lead us to the following conclusions:

1. As the addiction progresses, consumption of addictive goods entails more and more severe deterioration of human capital of consumers. There is an inverse relationship between the value of the human capital and the costs incurred by the alcohol consumer.

2. Consumption of addictive goods and its negative consequences is determined by a range of economic, social, psychological, cultural and other factors, which vary considerably across regions and countries. Such regional variation of factors shapes the regional consumption patterns.

3. There is a great variety of indicators that can be used for assessment of the degree of human capital deterioration resulting from alcohol consumption. Their choice depends on the research goals and availability of reliable statistical data. For our study we chose a set of indicators that are regularly monitored on the national and regional level in Russia and that reflect the direct influence of alcohol consumption on human capital.

4. Our analysis based on the proposed set of indicators has shown that there are considerable regional variations in terms of human capital deterioration. Regions with higher income levels and those where religion plays an important role tend to be in a more favorable position than others. What causes more serious concern is that the group of lagging regions is quite large and includes 12 regions. The highest concentration of such regions is found in the Far Eastern and North-Western federal districts. These are peripheral, economically disadvantaged areas.

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5. Our findings can be useful for devising and implementing regional policies aimed to curb consumption of goods with health risks. Such policies should focus on alcoholism prevention at the stages of family and community socialization and socialization in the schooling process. It should be noted, however, that, to achieve a long-term effect, such policies require stable macro-economic conditions and equalization of regional disparities.

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