

DYNAMICS OF THE SIZE DISTRIBUTION OF THE RUSSIAN NON-CAPITAL CITIES IN THE POST-SOVIET PERIOD¹

The urban system and its diversity are essential resources for economic development. At the intra-regional level, cities that do not have the status of the regional administrative centre shape the structure and diversity of the urban system. The article presents the results of the study on the distribution of non-capital Russian cities (depending on their size) as well as on the mobility patterns that influence their dynamics in the post-Soviet period. Based on data about the population of the Russian cities in the period 1991–2016, the study uses the method for analysing the dynamics of the distribution with the application of Markov chains. The study has demonstrated the predominance of downward mobility of non-capital cities within the city size distribution, which results in their considerable concentration at the left side of the distribution and the decrease in the diversity of city size. Simultaneously, the mobility of cities is more intense in the eastern part of the country, as the mobility patterns contribute to the preservation of greater diversity of city size (compared to the western part). It is possible to identify three groups of non-capital cities that differ in mobility patterns and distribution directions. The first group includes cities belonging to agglomerations of large regional capitals, whose dynamics of distribution are opposite to the dynamics of the distribution of the totality of non-capital cities. The second group comprises cities belonging to the agglomeration shadow with the most unfavourable dynamics of the distribution. The third group contains remote cities located in the periphery, which show a slight tendency towards the formation of a bimodal distribution. The scale of these groups differs in the eastern and western parts of Russia. The findings complement the results of other studies, expand knowledge about the modern dynamics of regional settlement systems, as well as determine further research areas. The revealed negative trends in the evolution of the city size distribution substantiate the need for a transition to the regulated development of the urban system. Such an approach should consider the consequences of the spatial development policy for different groups of cities and should strive to maintain the diversity of settlement systems.

Keywords: city, city size, population size, diversity, concentration, city size distribution, transition probability matrix, ergodic distribution, mobility, regional capital, non-capital city

Acknowledgements

The article has been prepared with the support of the Russian Foundation for Basic Research, the project No. 19-010-00094 “Spatial development of contemporary Russia: tendencies, factors, mechanisms”.

For citation: Bufetova, A. N. (2020). Dynamics of the Size Distribution of the Russian Non-Capital Cities in the Post-Soviet Period. *Ekonomika regiona [Economy of region]*, 16(3), xx-xx, <https://doi.org/10.17059/ekon.reg.2020-3-x>

Introduction

Cities, being centres of population concentration, economic activity, innovation, play a special and important role in the socio-economic development of the country. The structure of the urban system determines the efficiency of the use of resources, which include space.

By concentrating economic activity, large cities take advantage of internal economies of scale, localisation and urbanisation effects. This makes them attractive to business and people. Therefore, large cities develop not only due to internal sources, but also due to the attraction of resources of the surrounding periphery (smaller cities and villages), reducing their dynamics or even causing a decline. Ultimately, this one-sided interaction between a large city and its periphery leads to the exhaustion of external resources for the development of both.

However, large cities can also have a positive impact on the dynamics of the surrounding settlements. The population of the nearest neighbouring cities can participate in the labour supply in the market of a large city, and high competition in this labour market stimulates an increase in the level of education and skills. A large city is a market for products manufactured in peripheral towns. Simultaneously, various firms that could not withstand the competition in a large city move to these towns and take

¹ © Bufetova A. N. Text. 2020.

advantage of their cheaper labour and land. The relocation of firms and circular migration of workers contribute to the spread of new ideas, knowledge and technologies.

Depending on the dominant effects, the proximity to a large city can be both a driver and an impediment to the development of other settlements.

The largest cities of the regions of the Russian Federation are, with few exceptions, their capitals, and the non-capital cities are the periphery. On the one hand, these non-capital cities are a source of resources for the development of regional capitals; on the other hand, they are primarily affected by growth impulses generated by regional centres. Non-capital cities, their diversity and interaction ensure the connectivity of the urban system, regional space, and influence the efficiency of regional economies.

The rapid growth in the number and size of Russian cities coincided with the period of administrative regulation of the economy. More than half of modern Russian cities received their urban status in the 20th century [1], and 80 % of the existing cities in Siberia and the Far East appeared in the post-revolutionary period [2]. After the abolition of centralised regulation of the spatial distribution of economic activity and population, the Russian urban system began to change.

Studies on Russian cities in the post-Soviet period are diverse. Works devoted to the analysis of the differentiation of socio-economic development of cities reveal its persistent inequality [3]. Research is being conducted on the factors influencing the dynamics of the city [4, 5] and the problems of the fiscal capacity of cities [6].

Studies of population changes in Russian cities during the post-Soviet period have shown that the removal of administrative restrictions on urban migration has increased the concentration of the population in large cities [7] and reduced the weight of medium and small cities [8]. The centripetal migration in all regions leads to the concentration of population in regional capitals and their suburbs and the decay and depopulation of cities in the regional periphery [9].

As a result, the diversity of cities in the regions is decreasing. However, according to G. Lappo, the diversity of cities is “an essential prerequisite for further strengthening of the social and economic efficiency of the future settlement and territorial organisation of the country” [10].

E. Kolomak showed that not the concentration of the population (which has already reached a significant degree) but the diversity of city size positively affects the productivity of Russian regional economies. The diversity of city size links the levels of the urban hierarchy, makes it possible to take advantage of economies of different sizes, and allows for flexibility in the location of different industries [4]. Therefore, the crisis in the development of non-capital cities requires close attention and comprehensive research.

However, non-capital cities rarely become an independent object of research. In numerous papers, they are considered alongside and in comparison with regional capitals [3], and their performance is seen as less favourable than those of regional centres. However, the totality of non-capital cities is very heterogeneous, so research focuses on selected groups of non-capital cities, i.e. medium-sized cities, the second cities of regions, single-industry towns [11–13], which reveal the problems of these particular categories of cities.

The closest to the topic of this study are works devoted to the analysis of changes in the population of non-capital cities.

N. Mkrtchyan and L. Karachurina concluded that there is a positive relationship between the remoteness of peripheral administrative-territorial units from regional capitals and the rate of population reduction in them [9]. However, they note that this relationship is not unambiguous, as an increase in a size of non-capital city reduces its dependence on regional capital: the larger the city, the more it has the capacity to maintain or increase its population, irrespective of its remoteness from the regional centre [14].

The vast majority of urban studies is based on the analysis of information through descriptive statistics, which, with all its obvious advantages, leads to conclusions about an average typical object. Regression analysis also does not provide information on the behaviour of objects related to the tails of the distribution. Information on the development of the variety of objects can be obtained by analysing the dynamics of the distribution.

Studies on the city size distribution most often check the correspondence of their actual distribution to the reference (Pareto distribution), i.e., compliance with the rank-size rule. The researchers studying the city size distribution in Russia conclude that it does not correspond to the mentioned rule [4,

15], but note that there have been no significant changes in the shape of distribution in the post-Soviet period [4, 16]. However, empirical and theoretical studies have shown that the compliance with the rank-size rule mainly describes the existing urban system and does not provide grounds for normative judgements. Furthermore, the verification of compliance with this rule does not reveal the characteristics of the processes that shape the distribution and determine its dynamics.

Information on the dynamics of the distribution and mobility patterns can be obtained using the Markov chains, proposed by D. Quah [17]. It allows considering the peculiarities of the dynamics of the variety of examined objects, including those related to the tails of the distribution, as well as assessing both characteristics of the mobility of objects within their distribution and the direction of evolution of the distribution. In research practice, this method has been used to study the processes of regional convergence [18], the spatial distribution of economic activity and the role of spatial externalities in regional dynamics [19, 20]. Additionally, it has been applied in the analysis of the evolution of city size distribution in different countries (e.g., [21, 22]). This method has not been implemented in the studies of the evolution of Russian urban system.

The paper aims to analyse the dynamics of the size distribution of non-capital cities and the mechanisms that form it, namely, the mobility patterns that influence the dynamics in the post-Soviet period.

Considering that the history of urban systems in the eastern and western parts of the country is different, we believe that changes in the distributions of the sizes of non-capital cities in the western and eastern parts of the country can differ and occur with varying intensity.

In addition, we assume that the dynamics of the size distribution of non-capital cities is influenced not only by their size and by distance from the regional capital, but also by the capital's size (determined by its population).

Finally, given that the settlement system in the eastern part of the country is more dispersed and territory is less connected, we expect that the influence of regional centres on the dynamics of the size distribution of non-capital cities there should be weaker than in the western part.

These are the working hypotheses of the study. Based on the aims and hypotheses, it is necessary to identify the direction of the dynamics of the size distribution of non-capital cities and the mobility patterns within the distribution, as well as their differences for the western and eastern parts of the country. Additionally, it is important to compare the dynamics of the city size distribution for groups of cities differing in population size, distance from the regional capital, as well as its size, located in the western and eastern parts of the country. The paper should reveal the features of the mobility of cities within the distribution, which determine its dynamics in these groups.

Methodology and Data

The approach to the study of the distribution dynamics proposed by Quah is focused on the analysis of transition probability matrices (TPM). To estimate TPM, a discrete distribution of objects is constructed, for which a certain number of classes and their bounds are specified. Most often, following the recommendations in Quah [17], class bounds are chosen in such a way that initially the number of objects in each class is approximately the same.

In this study, the entire set of cities was divided into 5 classes in accordance with the relative size of the city or the ratio of the city population to the average city population for the entire set of non-capital cities

$$\bar{n}_i = n_i / \bar{n},$$

where n_i is the population in a non-capital city i ; $\bar{n} = \frac{\sum_{i=1}^N n_i}{N}$ is the average population in a non-capital city; N is the number of cities in the set.

Then, based on information about the transitions of cities between the selected classes during the analysed period, conditional transition probabilities were estimated [23]:

$$p_{ij} = \frac{\sum_{t=1}^T n_{ij}^{t+1}}{\sum_{t=1}^T n_i^t},$$

where n_{ij}^{t+1} is the number of cities that moved from class i to class j in the period $t + 1$; $n_i^t = \sum_{j=1}^N n_{ij}^t$ is the number of cities in the period t in class i .

Thus, each element of the obtained TPM p_{ij} shows the probability that the city entering class i in the current period will move to class j in the next period.

If the resulting TPM is a regular Markov matrix, it is possible to obtain the ergodic distribution α , i.e. a stationary distribution, which will be achieved in the long term, if the transition probabilities remain unchanged. The vector α can be determined from the condition $\alpha = P\alpha$, and is equal to the normalised eigenvector of the transition probability matrix P corresponding to the eigenvalue equal to one.

Due to the long period required to achieve ergodic distribution, the assumption of the permanence of transition probabilities is too strong. Therefore, ergodic distribution is usually considered not as a prediction of the dynamics of the distribution, but as a qualitative characteristic of the evolution direction. For example, if an ergodic distribution has a pronounced positive skew, then most of the objects in the set demonstrate below average dynamics and move to the lower classes. This mobility pattern is aimed at reducing the diversity of the set in the long term and creates a large group of objects with a low indicator. A more even distribution of objects between classes in a long run equilibrium means that mobility is aimed at maintaining a large variety of objects.

To characterise the relative mobility of cities, the unconditional probabilities of upward (p_{up}) and downward (p_{down}) transitions were calculated, showing the probability of a city moving to a higher or lower class, regardless of what class it belongs to in a given period:

$$p_{up} = \frac{\sum_{t=1}^T \sum_{j>i} n_{ij}^{t+1}}{\sum_{t=1}^T \sum_{i,j} n_{ij}^t}, p_{down} = \frac{\sum_{t=1}^T \sum_{j<i} n_{ij}^{t+1}}{\sum_{t=1}^T \sum_{i,j} n_{ij}^t}.$$

Accordingly, the value $p_{const} = 1 - p_{up} - p_{down}$ shows the probability of remaining in the occupied class, regardless of its rank, and can be considered as a characteristic of the distribution stability (hereinafter, the distribution stability coefficient).

To characterise the intensity of the mobility of cities within the distribution, the Shorrocks Index was calculated: $SI = (k - traceP) / (k - 1)$, $SI \in [0; k / (k - 1)]$, where k is the number of classes, $traceP$ is the sum of matrix elements located on the main diagonal (matrix trace). The higher is the SI value, the higher is the mobility.

The analysis of the influence of geographic location on the dynamics of the distribution of non-capital cities was conducted by decomposing the initial TPM (generalisation of the approach proposed by S. Rey [24]). For this purpose, the entire set of cities was divided into groups according to the criterion defined by the influence factor under study. For each group obtained, a discrete distribution was proposed, and then the TPMs were estimated based on the previously identified classes for the totality of non-capital cities. The transition probabilities forming the conditional matrices obtained in this way are comparable, and their comparison with each other and with the transition probabilities of the original TPM allows making conclusions about the influence of the factor under study on the dynamics of relative mobility and evolution of the distribution.

The two types of TPM decomposition are performed in this work. To understand the dynamics of the size distribution of non-capital cities in the western and eastern parts of the country, the decomposition was carried out into two conditional matrices (the location of the city in the eastern or in the western part of the country was used as a decomposition criterion). To examine the influence of regional capitals on the dynamics of the size distribution of non-capital city, the initial TPM was decomposed into five conditional TPMs. For this purpose, all non-capital cities were divided into 5 groups depending on the ratio of their size and the size of the regional capital, considering the distance between them, that is, based on the ratio $n_i^r \cdot d_i^r / n^r$, where n_i^r is the population of non-capital city i of region r , d_i^r is the distance from city i of region r to the administrative centre of this region², and n^r is the population of the administrative centre of region r . These large groups of non-capital cities were ranked A, B, C, D and E . The element of each conditional matrix k ($k = A, B, C, D, E$) p_{ijk} shows the

² We use information on the distance between cities by road from Autotransinfo (www.ati.su).

probability of transition of a city from class i to class j in terms of relative size, provided that at the beginning of the period it was in k -th group by the ratio of its size and the size of the regional capital, given the distance.

The study used information from the database “Economies of Russian Cities” of the statistical portal Multistat³ and reports of the Federal State Statistics Service⁴ on the population of cities of the Russian Federation that did not have the status of administrative centres in the period 1991–2016. Simultaneously, cities that had the status of rural settlements for at least one year of the period under review, as well as cities with a population less than 12 thousand people throughout the entire period, and cities with incomplete population data were excluded from consideration. As a result, the total number of non-capital cities was 825: one fifth is located in the eastern part of the country and the rest is in the western part of the country⁵. This value is just over 80 % of the total number of non-capital cities of the Russian Federation. However, micro-cities excluded from consideration do not demonstrate intensive mobility within the distribution and do not substantially affect its evolution; therefore, the analysed sample is representative.

Results

The TPM obtained for the totality of non-capital cities (Table 1) shows a high degree of distribution stability: the diagonal elements of the matrix are high; the significant elements are concentrated around the main diagonal (standard errors⁶ are mentioned in parenthesis). The distribution stability coefficient is almost 97 %; downward mobility prevails, i.e., the unconditional probability of a downward transition (1.8 %) exceeds the unconditional probability of an upward transition (1.3 %). The probability of leaving the first class, which includes cities, the size of which is not more than 34.7 % of the average (not more than 18,000 people in 1991–2016), is just over 1 %. Thus, these cities are unlikely to have development prospects. As a result, this class accounts for 40 % of non-capital cities in the ergodic distribution; the share of cities in other classes does not exceed 17.6 % and decreases with class rank, so the ergodic distribution is positively skewed.

While the distributions of cities in the western and eastern parts of the country are also characterised by the predominance of downward mobility and positive skewness of the ergodic distributions, there are some distinctive features.

As expected, the mobility of cities in the eastern part of the country is relatively higher than in the western part of the country: the Shorrocks index is higher and the stability coefficient is lower. The probability of leaving the first class is lower in the East (0.9 %) than in the West (1.1 %), but the probability of getting into this trap class is slightly lower in the East: the probability of moving from any class to a higher class in the East is twice as high as in the West, and the probability of moving to a lower class is comparable. As a result, positive skewness of the ergodic distribution for cities in the eastern part of the country is less pronounced than for those in the western part: only 34.9 % of all cities in the eastern part are in the first class, while in the ergodic distribution of western cities, the share of the first class is 45.9 %. The shares of other classes in the ergodic distribution are higher in the East than in the West, and they increase as the rank of the class increases (Table 1). Thus, the existing mobility patterns of eastern cities allow for the preservation of a more diverse urban system.

What is the role of regional centres in the dynamics of the size distribution of non-capital cities? To answer this question, the initial transition matrix was decomposed into five conditional TPMs. Each of them shows the transition probabilities and allows the assessment of the distribution dynamics for groups of cities that differ in population size, distance from the regional capital, and its size (Fig.).

First, the dynamics of the distributions of groups B , C , D , and E , and the distributions of the totality of non-capital cities are similar: they are dominated by downward mobility, the ergodic distributions are positively skewed to varying degrees (Table 2). However, the dynamics of the city size distribution

³ *Ekonomika gorodov Rossii / GMTS Rosstata* [Economies of Russian cities. Rosstat]. Retrieved from: http://www.multistat.ru/?menu_id=9310014 (Date of access: 10.25/2015).

⁴ *Federalnaya sluzhba gosudarstvennoy statistiki Rossii* [Federal State Statistics Service of the Russian Federation]. Retrieved from: www.gks.ru. (Date of access: 08.02.2019).

⁵ The eastern part of the country in this study includes the cities of the Siberian Federal District, the Far Eastern Federal District, as well as Tyumen Oblast, Khanty-Mansi Autonomous Okrug and Yamalo-Nenets Autonomous Okrug.

⁶ The standard errors of the transition probability estimates were calculated as follows: $\sqrt{\frac{p_{ij}(1-p_{ij})}{N_i}}$, where $N_i = \sum_{t=1}^{T-1} n_i^t$ [25].

Table 1

Transition probability matrices for the distribution of non-capital cities

Class number	Class number					Distribution of cities (number of cities in class, % of the total)		
	1	2	3	4	5	1991	2016	ergodic
The set of non-capital cities $p_{up} = 0.012, p_{down} = 0.02, P_{const} = 0.968, SI = 0.041$								
1	0.988 (0.002)	0.011 (0.001)	0.001 (0.000)	0	0	20.1	26.7	40.0
2	0.028 (0.003)	0.953 (0.004)	0.018 (0.002)	0.001 (0.001)	0	19.5	15.7	17.6
3	0.001 (0.000)	0.021 (0.002)	0.961 (0.003)	0.017 (0.002)	0	20.1	19.7	17.0
4	0	0.001 (0.000)	0.023 (0.002)	0.961 (0.003)	0.015 (0.002)	20.1	18.8	13.7
5	0	0.001 (0.000)	0	0.017 (0.002)	0.982 (0.002)	20.2	19.1	11.7
Non-capital cities in the western part of the country $p_{up} = 0.008, p_{down} = 0.017, P_{const} = 0.975, SI = 0.038$								
1	0.989 (0.002)	0.01 (0.002)	0.001 (0.000)	0	0	19.3	28.3	45.9
2	0.028 (0.003)	0.958 (0.004)	0.013 (0.002)	0.001 (0.000)	0	20.6	16.7	16.8
3	0.002 (0.000)	0.019 (0.003)	0.962 (0.004)	0.016 (0.002)	0	19.3	19.6	14.8
4	0	0.001 (0.001)	0.024 (0.003)	0.956 (0.004)	0.019 (0.002)	20.7	16.7	11.4
5	0	0	0	0.02 (0.002)	0.98 (0.003)	20.1	18.7	11.1
Non-capital cities in the eastern part of the country $p_{up} = 0.016, p_{down} = 0.018, P_{const} = 0.966, SI = 0.045$								
1	0.991 (0.003)	0.009 (0.003)	0	0	0	22.1	27.9	34.9
2	0.021 (0.005)	0.953 (0.008)	0.025 (0.009)	0.001 (0.001)	0	18.6	16.2	14.8
3	0	0.023 (0.005)	0.952 (0.008)	0.025 (0.006)	0	21.0	16.8	15.9
4	0	0.001 (0.001)	0.023 (0.006)	0.952 (0.008)	0.024 (0.005)	20.3	18.9	16.9
5	0	0	0	0.024 (0.005)	0.976 (0.005)	18.0	20.1	17.5

Note. Upper bounds of classes are city size as a percentage of the average: first class — 34.7; second class — 51.3; third class — 79.2; fourth class — 131.1; fifth class ∞ .

Source: author's calculations based on "Economies of Russian cities" of Rosstat. Retrieved from: http://www.multistat.ru/?menu_id=9310014 (Date of access: 10.25.2015); Federal State Statistics Service of the Russian Federation. Retrieved from: www.gks.ru (Date of access: 08.02.2019).

in group A is opposite: upward mobility prevails, and in the long run equilibrium 40 % of cities end up in the fifth class. The share of the fourth class is also higher than in other groups and in TPM for the entire set of non-capital cities. Therefore, in general, the ergodic distribution has a pronounced negative skew, as the size of 62.3 % of cities in group A is average or above average.

This means that a sufficient number of cities in the group are either shrinking more slowly than the average, or even increasing, thus moving to higher classes.

What is the reason for the opposite direction of the evolution of the city size distribution in group A? The population of more than 70 % of cities in this group is less than 50 thousand people, while 70 % of all cities in the group are located at a distance of no more than 100 km from the regional centre, and for another 20 % the distance is no more than 150 km. The average distance from a city to the regional

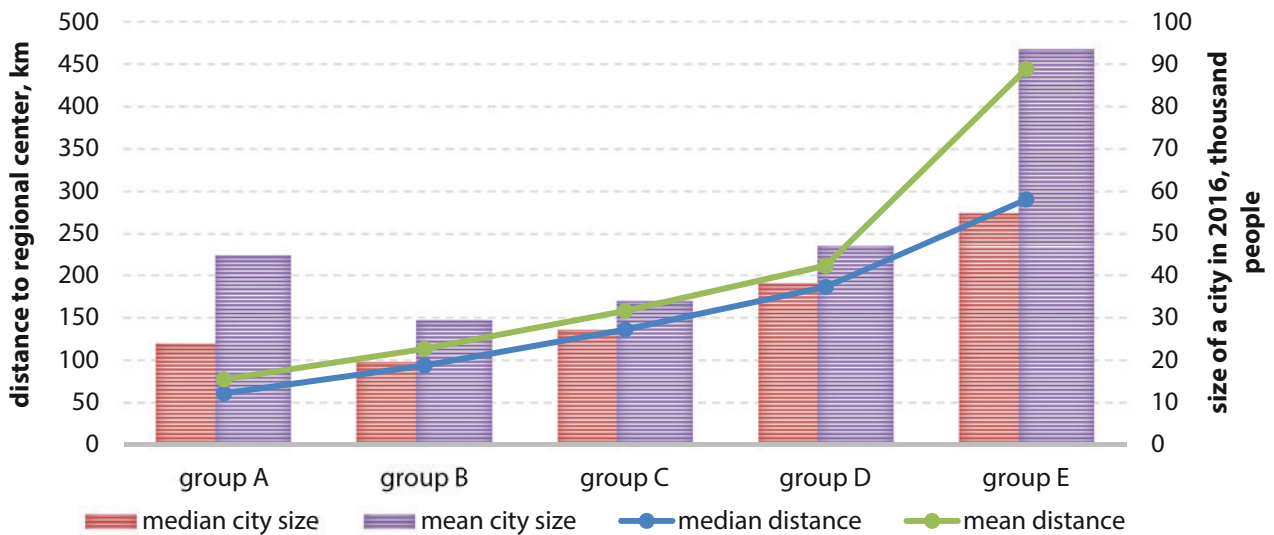


Fig. Distance to a regional centre and city size

centre is 76.7 km, and the median is 60 km. This is the nearest periphery of regional capitals, two-thirds of which are the largest cities with a population of more than 500,000 people, including million-plus cities.

In the analysed period, almost half of the cities in group A (48 %) increased their size (no more than a third in other groups) on average by 26 % for the entire period, which is higher than in other groups. The growing cities of the group are located in 19 regions of the western part and only in 3 regions of the eastern part of the country (in the regions of the Siberian Federal District). By the number of growing cities, the undoubted leader is Moscow Oblast. The second place takes Leningrad Oblast followed by Nizhny Novgorod, Sverdlovsk and Kaliningrad oblasts.

However, there is also bimodality in ergodic distribution: the combined share of cities of the first and second classes is 28.1 %, and only 8.3 % of cities are in the third class. That is, not all cities in the immediate periphery experience the positive spatial externalities generated by regional centres.

Other groups include cities that are, on average, larger and more distant from regional capitals. In group B, almost 90 % of cities have a population of no more than 50 thousand people, half of which are located at a distance of no more than 100 km from the regional centre, and a quarter of which are at a distance of more than 150 km. The positive skewness of the ergodic distribution of this group is most pronounced: 65 % of the cities belong to the first class, 82.4 % of the cities are in the first and second classes, 5 % in the fourth class and only 2.5 % in the fifth class. This means that the dynamics of a significant part of the cities in the group is below average, that is, their sizes are shrinking faster than the average size of a non-capital city. The most important reasons for the rapid deterioration of the distribution dynamics in this case are the small size of the cities of the group and the increase in the distance to the regional capital. Based on the latter, while such non-capital cities do not belong to agglomerations, they are still under the influence of regional capitals, which becomes negative outside the agglomeration area.

Thus, regional capitals have a predominantly positive impact on the dynamics of the size of cities only in the immediate periphery. The more remote non-capital cities suffer negative influence (population loss, desertification of territories).

In groups C, D, and E, the dynamics of the distribution is qualitatively similar, but quantitatively different due to the growth of the size of the cities belonging to the groups, as the size of a city is an independent factor of its stability and development. In addition, the protective function of a distance manifests itself more clearly at a larger distance from the regional centre.

Group E deserves special attention. In this group, the shares of the fourth and fifth classes in the ergodic distribution are roughly equal (22.7 % total), which is significantly higher than in groups B, C and D. The group includes cities, 85 % of which are more than 150 km away from the regional centre; the average distance is 444 km, and the median distance is 290 km. The proportion of small towns (population below 50,000) is the lowest of all groups (43.6 %), while only this group has cities with more than 250,000 inhabitants (8.4 %), including more than 500,000 people. The share of growing

Table 2

Conditional transition probability matrices

Class number	1	2	3	4	5	Distribution of cities (number of cities in class, % of the total)		
						1991	2016	ergodic
Group A ($p_{up} = 1.4\%$, $p_{down} = 0.8\%$)								
1	0.987 (0.003)	0.011 (0.003)	0	0.002 (0.001)	0	30	33.0	16.9
2	0.014 (0.004)	0.972 (0.006)	0.012 (0.003)	0.001 (0.001)	0.001 (0.001)	20.6	20.5	11.9
3	0.002 (0.002)	0.011 (0.004)	0.973 (0.006)	0.012 (0.004)	0.002 (0.000)	16.2	15.3	8.9
4	0.001 (0.002)	0	0.004 (0.002)	0.964 (0.008)	0.031 (0.007)	14.4	10.8	22.2
5	0	0.001 (0.002)	0	0.017 (0.005)	0.982 (0.005)	18.8	20.4	40.1
Group B ($p_{up} = 1.3\%$, $p_{down} = 2\%$)								
1	0.991 (0.002)	0.009 (0.002)	0	0	0	34.0	44.8	65.1
2	0.032 (0.005)	0.950 (0.007)	0.018 (0.004)	0	0	27.7	18.0	17.3
3	0	0.030 (0.006)	0.954 (0.008)	0.016 (0.005)	0	18.2	18.6	10
4	0	0	0.030 (0.007)	0.949 (0.009)	0.021 (0.006)	13.2	13.1	5
5	0	0.004 (0.004)	0	0.037 (0.012)	0.959 (0.013)	6.9	5.5	2.6
Group C ($p_{up} = 1.5\%$, $p_{down} = 2.4\%$)								
1	0.985 (0.004)	0.01 (0.004)	0.005 (0.002)	0	0	17.4	25	41.6
2	0.03 (0.006)	0.947 (0.008)	0.021 (0.005)	0.002 (0.002)	0	27.1	19.4	18.5
3	0.002 (0.001)	0.024 (0.005)	0.955 (0.006)	0.019 (0.004)	0	27.1	32.5	24
4	0.001 (0.001)	0	0.035 (0.006)	0.957 (0.007)	0.007 (0.003)	21.3	17.5	13.7
5	0	0	0	0.04 (0.012)	0.960 (0.012)	7.1	5.6	2.2
Group D ($p_{up} = 1.2\%$, $p_{down} = 2.1\%$)								
1	0.982 (0.007)	0.018 (0.007)	0	0	0	0.174	16.7	51.8
2	0.037 (0.012)	0.951 (0.014)	0.012 (0.007)	0	0	0.116	11.1	23.8
3	0.002 (0.002)	0.022 (0.007)	0.959 (0.01)	0.017 (0.006)	0	0.256	23.6	11.3
4	0	0.002 (0.002)	0.019 (0.006)	0.968 (0.008)	0.011 (0.004)	0.244	29.2	9.4
5	0	0	0	0.028 (0.009)	0.972 (0.009)	0.210	19.4	3.7
Group E ($p_{up} = 0.9\%$, $p_{down} = 1.7\%$)								
1	0.989 (0.006)	0.011 (0.006)	0	0	0	5	8.6	50.8

The end Table 2 on next page

2	0.035 (0.011)	0.951 (0.013)	0.014 (0.007)	0	0	11.1	8.6	16.2
3	0	0.018 (0.006)	0.952 (0.009)	0.030 (0.007)	0	13.7	13.6	10.3
4	0	0.004 (0.002)	0.024 (0.005)	0.962 (0.007)	0.011 (0.004)	23	22.8	11.2
5	0	0	0	0.010 (0.003)	0.990 (0.003)	47.2	46.4	11.5

Note: upper bounds of groups are the ratio of the size of a non-capital city and a regional capital, considering the distance between them: group *A* — 1.869; group *B* — 4.451; group *C* — 9.245; group *D* — 21.705; group *E* ∞ . The upper bounds of classes remain the same.

Source: author's calculations based on "Economies of Russian cities" of Rosstat. Retrieved from: http://www.multistat.ru/?menu_id=9310014 (Date of access: 10.25.2015); Federal State Statistics Service of the Russian Federation. Retrieved from: www.gks.ru (Date of access: 08.02.2019).

cities in group *E* is 33.9 %, which is also higher than in groups *B*, *C* and *D*, where population growth is observed in no more than a quarter of the cities in the group.

Just over half of the cities in group *E* are located in the eastern part of the country. However, the share of growing cities among them is slightly smaller: 35 % versus 45 % in the western part. In the East, mainly the cities of Khanty-Mansi and Yamalo-Nenets Autonomous Okrugs are growing. The regions with the concentration of growing cities in group *E* in the western part of the country are Stavropol Krai, Republic of Tatarstan, Republic of Bashkortostan, Krasnodar Krai, and Belgorod Oblast.

The positive dynamics of these cities does not depend on regional centres due to various reasons. The oil and gas cities of Khanty-Mansi and Yamalo-Nenets Autonomous Okrugs and the metallurgical centre Sary Oskol, as well as federal resort cities of Stavropol Krai are growing due to their specialisation. Large cities of Bashkortostan and Tatarstan are developing, rather, due to the considerable distance from regional capitals, which allows them to maintain their own periphery and turns them into regional sub-centres. Large and far removed from regional centres non-capital cities of Krasnodar Krai such as Novorossiysk, Armavir, and Sochi are also growing.

Thus, increase in the distance weakens the negative influence of regional capital. There are remote cities whose performance is above average, whose growth depends on other factors, primarily, specialisation and size.

The conditional TPMs obtained for the totality of cities in the West and East reflect both general trends and particular characteristics of the dynamics of the size distribution of non-capital cities in these parts.

Table 3

Ergodic distribution and mobility characteristics for conditional transition probability matrices in the western and eastern parts of the country (%)

Group rank	Class number					P_{up}	P_{down}
	1	2	3	4	5		
For the western part of the country							
<i>A</i>	21.7	12.1	10.6	17.2	38.4	1.5	1.1
<i>B</i>	73.3	15.2	7.6	3.1	9	1.1	2.1
<i>C</i>	40.8	17.3	23.2	15.3	3.3	1.3	2.2
<i>D</i>	63.2	24.7	8.8	2.2	1	0.9	2.2
<i>E</i>	76.7	2.8	5.3	5.2	10	0.8	1.6
For the eastern part of the country							
<i>A</i>	25	0	50	0	25	0.7	0
<i>B</i>	51.4	25.6	8	0	1.5	1.6	1.2
<i>C</i>	35.7	23.6	40.7	0	0	1.1	1.6
<i>D</i>	18.6	14.5	12.4	35.9	18.5	1.5	0.9
<i>E</i>	3.5	11.1	12.1	21.2	20.6	2.0	2.2

Source: author's calculations based on "Economies of Russian cities" of Rosstat. Retrieved from: http://www.multistat.ru/?menu_id=9310014 (Date of access: 10.25.2015); Federal State Statistics Service of the Russian Federation. Retrieved from: www.gks.ru (Date of access: 08.02.2019).

For group *A* of both the eastern and western parts, the probability of an upward transition exceeds the probability of a downward transition, and for the cities of the eastern part, the latter is absent at all. In the ergodic distribution, the size of 55.6 % of the cities in the western part is average or above the average (the fourth and fifth classes) (Table 3).

In groups *B* and *C*, as well as for the totality of non-capital cities, the ergodic distribution is positively skewed. The cities of group *D* in the eastern part are characterised by a predominance of upward mobility, in contrast to the similar group in the western part. Therefore, the shape of the ergodic distribution is significantly different: 36 % of cities in the long run end up in the fourth class while maintaining the identified mobility patterns.

Finally, group *E* of cities in the eastern part in the long run equilibrium exhibits a much higher degree of bimodality and a higher proportion of cities belonging to the fifth class than the similar group of cities in the western part of the country. The small share of cities in the fifth class of the ergodic distribution for western cities is explained by the characteristics of the distribution dynamics, namely, the strong dominance of downward mobility. Here, the probability of a downward transition is twice as high as the probability of an upward transition.

Conclusion

The current mobility patterns of non-capital cities within the city size distribution are aimed at the concentration on the left side of the distribution, that is, at a further increase of the share of small towns in their total number and a decrease in the diversity of sizes of non-capital cities. However, the intensity of transformation of the distribution of cities varies between the western and eastern parts of the country. In the East, the mobility of cities is higher, and its patterns are aimed at maintaining a slightly greater diversity of their sizes than in the West.

A study of the impact of regional capitals on the dynamics of the distribution of non-capital cities revealed its limitations and ambiguity: the characteristics of the mobility of non-capital cities and the dynamics of their size distribution depend on the ratio of market potentials of a non-capital city and regional capital. Three groups of non-capital cities were identified, with different mobility patterns and different directions of the distribution dynamics.

The dynamics of the size distribution of non-capital cities of the immediate periphery of the largest regional centres is fundamentally different from that of other cities as well as of the totality of non-capital cities. Only in this group of cities located in the agglomeration areas of regional capitals, upward mobility within the distribution prevails; cities are gradually concentrated on the right part of the distribution, which means an accelerated growth of a significant part of them. In the context of the predominance of downward mobility and the accelerated decline of most other non-capital cities, this fact indicates that regional urban systems are more monocentric. However, the positive influence of proximity to regional capitals on the dynamics of the city size distribution is more significant in the regions of the western part of the country. In the East, the influence appears to be much weaker because of the smaller number of satellite cities of regional centres and poor transport infrastructure.

The second group consists of cities located directly outside the immediate periphery, in the shadow of the largest regional capitals and their agglomerations, which, in contrast, demonstrate an accelerated decline in size, a significant predominance of downward mobility, and a significant increase in the proportion of small towns.

A further increase in the distance from regional centres turns distance into a protective barrier and mitigates negative effects of a downward mobility in the dynamics of the city size distribution, typical for non-capital cities located in the agglomeration shadow. Simultaneously, in the eastern part of the country characterised by long distances and poor infrastructure development, the distance barrier manifests itself even when non-capital cities are less remote from regional centres.

The current mobility patterns of non-capital cities of the remote periphery, which form the third group, are aimed at the formation of two poles. On the one hand, cities that are shrinking faster than the average non-capital city are concentrated on the left side of the distribution. On the other hand, some of the cities maintained and developed through specialisation, size, their own periphery, and simultaneously protected by distance from the influence of regional capitals, are gradually concentrating on the right side of the distribution (however, the right pole is markedly weaker than the left pole). The revealed tendency for the formation of a bimodal city size distribution is much more pronounced in the eastern part of the country, with its different history, dispersed settlement system and weak space

connectivity, where the agglomeration effect is weaker and the distance barrier is stronger than in the more developed western part of the country.

The revealed negative trends in the dynamics of the city size distribution (increasing concentration on the left side of the distribution, a decrease in the diversity of sizes) are the result of an unregulated transformation of the Russian urban system. This is another strong argument for the need to move towards managed development and elaborate an urban development policy (based on science) aimed at preserving the diversity of the urban system and improving its social and economic efficiency. In addition, these trends point to the need for thorough study of policies for the development of large agglomerations and the assessment of their possible effects, which are ambiguous for non-capital cities of different groups and parts of the country, the lack of which can threaten the urban periphery in the context of demographic insufficiency.

The obtained results determine further areas of research, which are important for a better understanding of the state and trends of the urban system and for determining directions and ways of its regulation. These include the identification of the factors and risks of urban development in the agglomerations and their shadows, the characteristics of the factors and risks of the development of the urban system in the eastern part of the country, etc.

References

1. Lappo, G. & Polyak, P. (1999). Results of urbanization in Russia by the end of the XX century]. *Mir Rossii. Sotsiologiya. Etnologiya [Universe of Russia. Sociology. Ethnology]*, 8(4), 35–46. (In Russ.)
2. Isupov, V. A. (2018) Urbanization of the Western Siberia: in the Eyes of an Historian. *EKO [ECO]*, 7, 7–22. DOI: 10.30680/ECO0131-7652-2018-7-7-22 (In Russ.)
3. Zubarevich, N. V. & Safronov, S. G. (2019). Russia largest cities development in 2010s. *Regionalnye Issledovaniya [Regional Research]*, 1, 39–51. (In Russ.)
4. Kolomak, E. A. (2018). *Gorodskaya sistema sovremennoy Rossii [The urban system of modern Russia]*. Novosibirsk: IEIE SB RAS, 143. (In Russ.)
5. Golubchikov, O. Yu. & Makhrova, A. G. (2013). Factors of unequal development of Russian cities. *Vestnik Moskovskogo universiteta. Seriya 5. Geografiya [Moscow University Bulletin. Series 5. Geography]*, 2, 56–60. (In Russ.)
6. Povarova, A. I. (2016). Why Is the Self-Sufficiency of Urban Districts Budgets Not Growing. *Ekonomicheskie i sotsialnye peremeny. Fakty, tendentsii, prognoz [Economic and Social Changes: Facts, Trends, Forecast]*, 1(43), 108–121. DOI: 10.15838/esc/2016.1.43.7 (In Russ.)
7. Kolomak, E. A. (2015). Urbanization Resource in Russia. *Prostranstvennaya Ekonomika [Spatial Economics]*, 4, 59–74. DOI: 10.14530/se.2015.4.059-074 (In Russ.)
8. Efimova, E. A. (2014). Regional Aspects of Urbanization in Russia. *Regionalnaya Ekonomika: Teoriya i Praktika [Regional Economics: Theory and Practice]*, 43, 2–12. (In Russ.)
9. Mkrtychyan, N. & Karachurina, L. (2013). The farther from the centers, the greater the population decline. *Demoskop Weekly [Demoscope Weekly]*, 575–576. Retrieved from: <http://www.demoscope.ru/weekly/2013/0575/tema04.php> (Date of access: 10.04.2019) (In Russ.)
10. Lappo, G. M. (2019). Diversity of Cities as a Factor of Russia's Successful Spatial Development. *Izvestiya Rossiyskoy Akademii Nauk. Seriya Geograficheskaya*, 4, 3–23. (In Russ.)
11. Smirnov, I. P. & Fomkina, A. A. (2013). Middle cities are in the system of settlement to Central Russia. *Regionalnye Issledovaniya [Regional Research]*, 4(42), 80–87. (In Russ.)
12. Turgel, I. D. & Vlasova, N. Yu. (2016). The second Urals cities: from the city-pant to the multifunctional centers. *Regionalnye Issledovaniya [Regional Research]*, 2(52), 43–54. (In Russ.)
13. Zamyatina, N. & Pilyasov, A. (2016) Single-Industry Towns of Russia: Lock-In and Drivers of Innovative Search. *Foresight and STI Governance*, 10(3), 53–64. DOI: 10.17323/1995-459X.2016.3.53.64.
14. Mkrtychyan, N. & Karachurina, L. (2013). Does the resilience of the population peripheral cities depend on the size? *Demoskop Weekly [Demoscope Weekly]*, 575–576. Retrieved from: <http://www.demoscope.ru/weekly/2013/0575/tema04.php> (Date of access 10.04.2019) (In Russ.)
15. Iyer, S. D. (2003). Increasing Unevenness in the Distribution of City Sizes in Post-Soviet Russia. *Eurasian Geography and Economics*, 44(5), 348–367. DOI: 10.2747/1538-7216.44.5.348.
16. Fattakhov, R. V., Nizamutdinov, M. M. & Oreshnikov, V. V. (2019). Analysing and modelling of trends in the development of the territorial settlement system in Russia. *Ekonomika regiona [Economy of region]*, 15(2), 436–450. DOI: 10.17059/2019-2-10 (In Russ.)
17. Quah, D. (1993). Empirical cross-section dynamics in economic growth. *European Economic Review*, 37 (2–3), 426–434. DOI: 10.1016/0014-2921(93)90031-5.
18. Carluer, F. (2005). Dynamics of Russian regional clubs: The time of divergence. *Regional Studies*, 39(6), 713–726. DOI: 10.1080/00343400500213564.
19. Bufetova, A. N. (2017) Trends in the concentration of economic activity and disparities in Russia's spatial development. *Regional Research of Russia*, 7(2), 120–126. DOI: 10.1134/S2079970517020022.
20. Bufetova, A. N. (2019). The Study of Spatial Effects in Regional Dynamics of Labor Productivity. *Region: ekonomika i sociologiya [Region: Economics and Sociology]*, 2, 80–100. DOI: 10.15372/REG20190204 (In Russ.)
21. Bosker, E. M., Brakman, S., Garretsen, H. & Schramm, M. (2008). A century of shocks: The evolution of the German city size distribution 1925–1999. *Regional Science and Urban Economics*, 38(4), 330–347. DOI: 10.1016/j.regsciurbeco.2008.04.002.
22. Black, D. & Henderson, V. (2003). Urban Evolution in the USA. *Journal of Economic Geography*, 3(4), 343–372.

23. Bickenbach, F. & Bode, E. (2003). Evaluating the Markov Property in Studies of Economic Convergence. *International Regional Science Review*, 26(3), 363–392. DOI: 10.1177/0160017603253789.
24. Rey, S. J. (2001). Spatial Empirics for Economic Growth and Convergence. *Geographical Analysis*, 33(3), 195–290. DOI: 10.1111/j.1538-4632.2001.tb00444.
25. Bosker, M. (2009). The spatial evolution of regional GDP disparities in the ‘old’ and the ‘new’ Europe. *Papers in Regional Science*, 88(1), 3–27. DOI: 10.1111/j.1435-5957.2008.00183.x.

About the author

Anna N. Bufetova—Cand. Sci. (Econ.), Associate Professor, Senior Research Associate, Institute of Economics and Industrial Engineering of the Siberian Branch of RAS; Associate Professor, Novosibirsk State University; Scopus Author ID: 57194622001; <http://orcid.org/0000-0003-4253-7079> (17, Ak. Lavrentyeva Ave., Novosibirsk, 630090; 2, Pirogova St., Novosibirsk, 630090, Russian Federation; e-mail: Bufetova@gmail.com).