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THE SOVIET LEGACY IN THE URBAN MORPHOLOGY OF MAJOR RUSSIAN CITIES

Abstract: All post-Soviet cities look similar. They also demonstrate similar development trends, have similar issues and like no other illustrate the concept of 'path-dependency'. As a consequence of very specific political and economic conditions for their development, these cities have acquired distinctive features and elements of urban structure, and today's planners have to deal with the imprint left by the Soviet era. Due to the longest history of 'socialist experiment' Russia became the main ground for the implementation of the Soviet urban-planning model and today its cities present a rich empirical base for studying the consequences of the systemic impact of the administrative-command system as a substitute to the market one. The study draws attention to the Russian cities with a population of over 1 million people since the typical problems and the need for the effective urban form are more pronounced there. The author consistently discusses a range of the urban form characteristics of the major Russian cities looking for the similar traits in their morphology. The aspects considered include settlement size and general density along with the spatial distribution of population evaluated by means of three indicators: density profile, density gradient and dispersion index, and also the structural form and the network configuration.
Key Words: post-Soviet, major Russian cities, quantitative indicators of urban form.

Introduction

With the end of the communist era all major constituents of old socio-economic and political order such as single-party system, command economy, state ownership and control over all kinds of resources have ceased existing. The change in politics and economics was relatively sharp and the results of this transition became visible soon after the collapse of the socialist system. The urban space has transformed as well, but in a more evolutionary manner. In his study of post-communist Prague, Sykora (1999:79) noted that "the political change took only a few weeks and the core institutional transformations of economic system were accomplished within a few years, however, the change of settlement structures will take many years or decades".

Due to the longest history of 'socialist experiment' Russia (along with the few other post-Soviet states) became the main ground for the implementation of the Soviet urban-planning model and today its cities present a rich empirical base for studying the consequences of the systemic impact of the administrative-command system as a substitute to the market one.

The Soviet-period legacies adversely affect the development patterns across the post-Soviet cities and create distinctive urban structures. Despite possible regional variations the similarity in general urbanisation trends is often striking.

In the following part of this paper the author will consistently consider a range of the urban form characteristics of the major Russian cities looking for the similar traits in their morphology. A lot of research has been and is now being conducted in Moscow and, to a lesser extent, in St Petersburg, and although these two capitals are definitely important on their own terms, they are more likely to stand out among other cities and cannot serve as prototypes of the post-Soviet city. In this study, the author draws attention to the Russian cities with a population of over 1 million people (excluding Moscow and St Petersburg) since, due to the larger average settlement radius, the need for the effective urban form is more pronounced in major cities.

Measuring the post-Soviet urban form

Settlement size and density (general)

The simplest measure of the urban form is the size of the city comprising its population and area. In terms of population, there are 15 Russian cities that may be considered as major (over 1 million inhabitants) including metropolitan cities Moscow and Saint Petersburg. Figure 1 denotes their location.

Figure 1. Location and population of the studied major cities

Before the Soviet 'urban explosion', that was before 1929, urbanisation in Russia, similarly to many other spheres, was taking place with a great delay (Vishnevsky, 1998). While in Europe and the USA the proportion of the urban population had already exceeded the share of rural residents by 1920 or was close to it, in Russia it accounted for about 15,3%. The 1929 became a turning point and in just 8 years of accelerated industrialization and concomitant, forced and hasty urbanisation, the urban population of Russia more than doubled. Cities were founded and developed to become, in fact, only an appendage of industrial production and today, almost thirty years after the end of the Soviet era, this low-quality environment formed by the means of planned economy is still a home to a large part of the population. Figure 2 shows that similar trend can be observed in the growth of the cities that became the object of interest in this study. In all the large cities, excluding Moscow and St. Petersburg, there is a visible leap in urbanisation between 1930 and 1990.

It is worth noting that during the Soviet period the urban population was not only (often artificially) increased, but also irrationally located. Hill and Gaddy (2003) present a detailed account of the flaws of the Soviet population distribution policy, which resulted in geographical remoteness and severe climatic conditions for the unprecedented share of population.

Consider, for example, Perm, the city with the population just above 1 million people and one of the Russia's "frozen dinosaurs" (Hill and Gaddy, 2003:56). By the early 20th century, Perm was Russia's thirty-first largest city with a population of 67,000. In only 10 years, the city's population more than tripled due to the rapid industrialisation and its area was expanded by including the suburbs into the city limits. Administrative boundaries have been shifted, so that a number of the surrounding villages became the city's new remote areas while the space between them and the old centre remained vacant and often not developed. Noteworthy that such a "leapfrog" fashion of the urban growth was not exclusive for Perm, and many other Russian cities employed the same methods in

their climb to the million people milestone[1] . At that period the city adapted its current linear shape, stretching along the river for 60-70 km. One can see in the Figure 3 that most of the city's development took place during the Soviet era or rather after the 1940s.
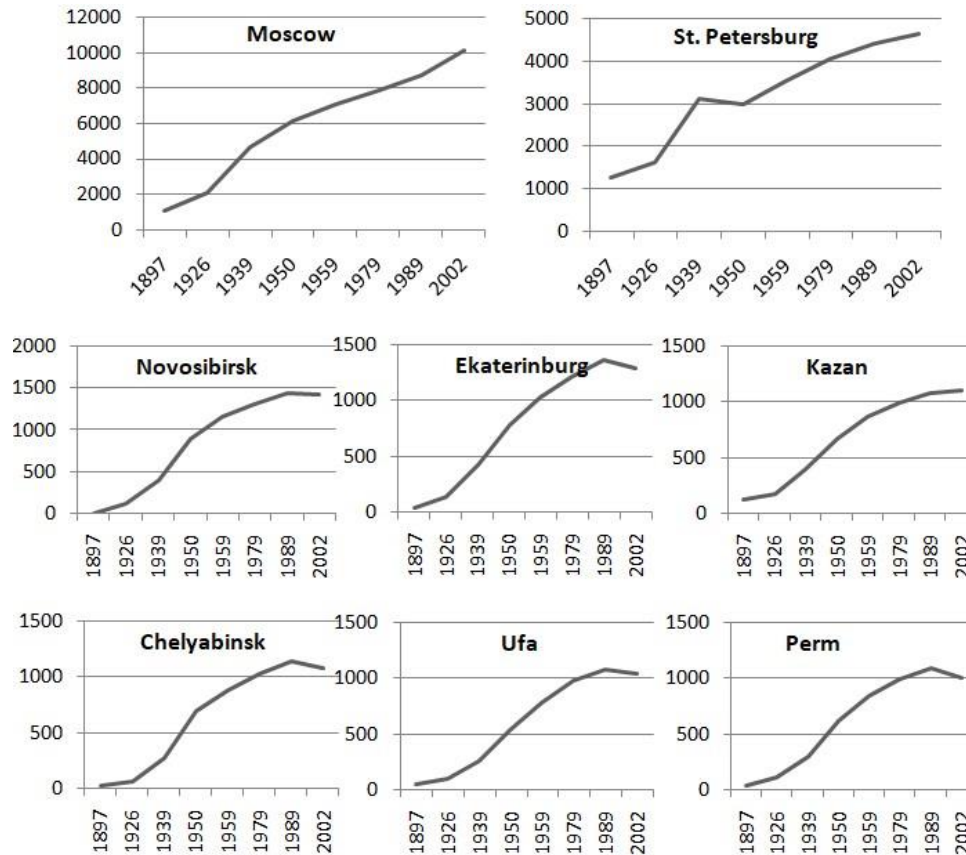

Figure 2. Population change in some of the major Russian cities
during the 20th century. Source: Census data

In 1929-1937 (the first and the second five-year plans) the rate of housing construction slowed down sharply, which, coupled with the ongoing labour-intensive industrialization, resulted in the prolonged housing crisis. The problem of housing shortage was overcome only in the 1960s due to the mass construction of "Khrushchyovkas" – standard residential buildings constructed of low-cost panels or bricks under the rule of Khrushchev (hence the name).

Proceeding to the consideration of the city size on the basis of its territory, it makes sense to take into account the size of the built-up area (and not the area within the administrative boundaries), since, along with the population, it determines the most important indicator of the urban form – density. Generally, city's average density is calculated simply as the ratio of the total population of the city to its total land area. Yet these figures appear to be practically meaningless seeing the unknown amount of rural and any other kind of undevelopable land included into the city limits. The built-up area hereby is a better denominator for calculating density than the total land area (Galster et al, 2001).

In this study the built-up area does not include extensive recreational areas (occupied by urban forests or large parks), physical obstacles to land use such as rivers or ponds, agricultural lands and any undeveloped territories. At the same time, adjacent territories outside the

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[1] During the USSR, the status of a city with a million inhabitants allowed to qualify for the construction of the metro and a privileged position in the allocation of centrally distributed resources. In the post-Soviet period "million-plus cities" are also distinguished by a special attitude from the authorities and the population.

administrative boundary of the city that, in fact, function as a part of it, are included. The general densities were calculated for all the major cities studied, Figure 4 shows the position of the major Russian cities relative to other cities in the international sample. The data are derived from land use maps, territorial planning documents, satellite imagery, etc.
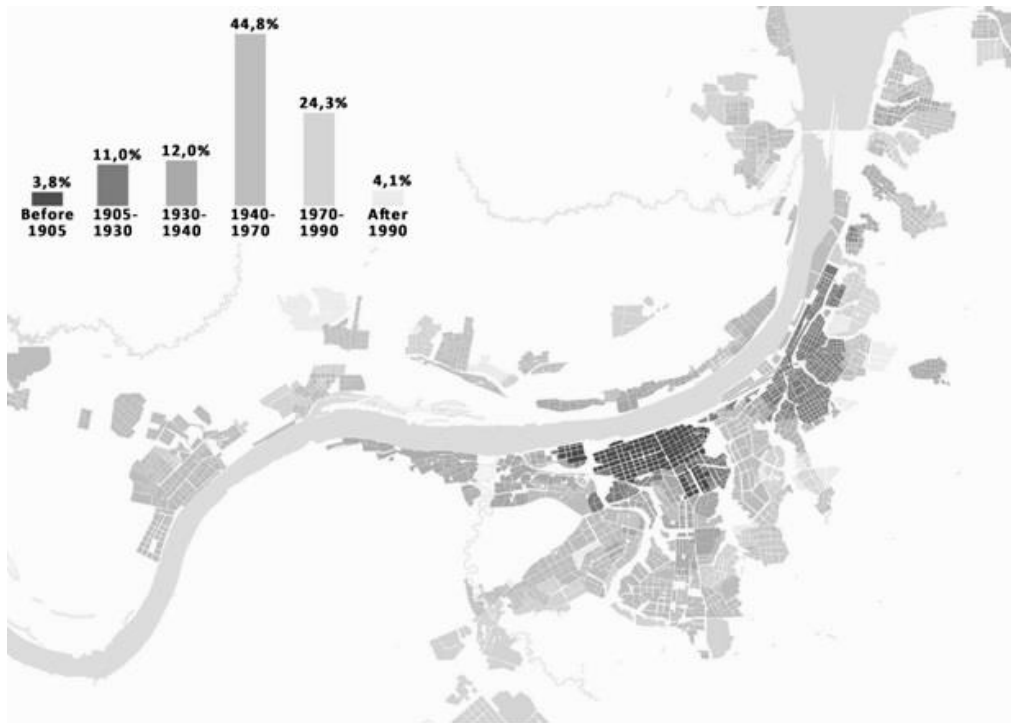

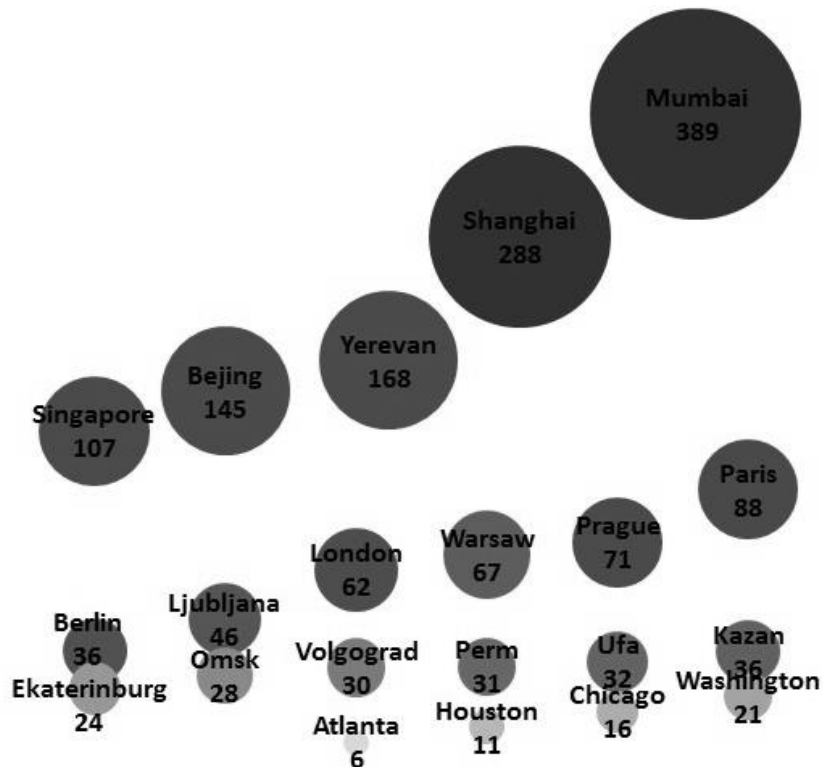Figure 3. Perm growth during the 20th century

Figure 4. Comparative population densities in built-up areas (people/hectare)
of major Russian cities and selected cities around the world. Source of the data
for non-Russian cities: Bertaud, 2003

Although general density is a useful characteristic for some basic analysis of the urban form, since it is the most widely used indicator of sprawl, much greater interest lies in how this density is distributed across the city. For instance, Moscow's reasonably high population density does not make it compact in the ordinary sense. Given Moscow's centralized pattern of employment location, the concentration of population on the periphery puts enormous demands on commuting (Bertaud and Malpezzi, 2003). The following part of the paper looks at the ways the population density is distributed within the built-up areas of the major Russian cities.

Population distribution

The spatial distribution of the population is another primary urban form characteristic. There are three indicators of population distribution widely used in the urban planning field: density profile, density gradient and dispersion index.

The graphs in Figure 5 show the density distribution in the four large cities around the world, three of them follow approximately the same pattern. The most common type of density profile includes a 'density crater' in the centre with a peak density immediately after it and the gradual decrease towards the periphery. These empirical observations appear to be in line with the theoretical approach developed by urban economists Alonso, Muth and Mills, which predicts the fall of the density from the CBD to the fringe with the rise of commuting costs. One striking exception from the relatively uniform picture of spatial distribution of densities observed in most of the world cities is the case of Moscow: its density profile is a rising graph with a considerable leap upwards outside the central areas.
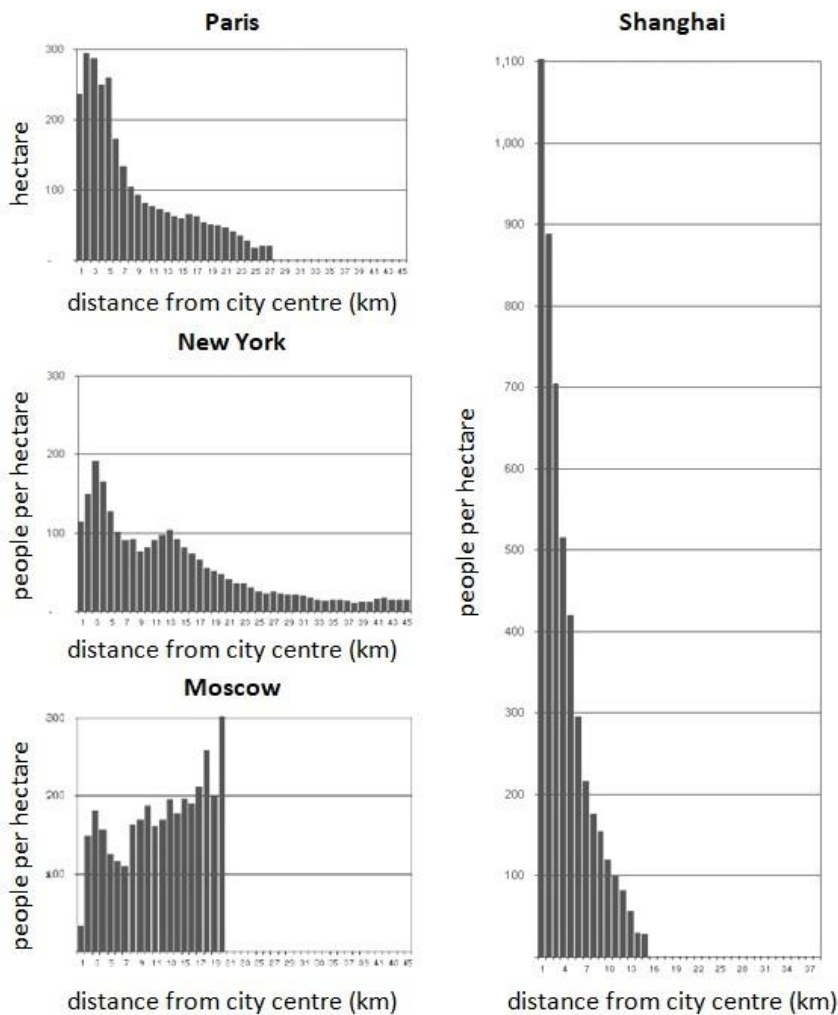

Figure 5. Density profiles of selected cities. Source: Bertaud, 2001

Although Moscow is rather an extreme case, the density profiles of the other major Russian cities also digress from the 'normal' one. Figure 6 shows the density profiles of Perm, Ekaterinburg and Samara.
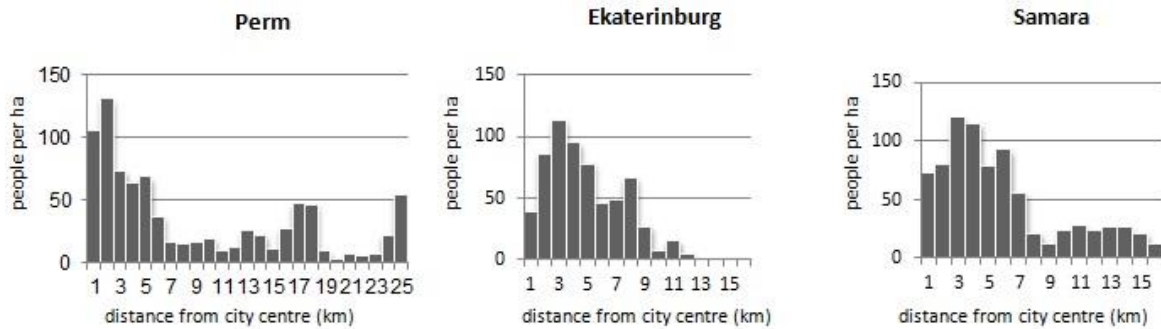

Figure 6. Density profiles of some major Russian cities

Although the basic visual analysis of these graphs already allows making some general conclusions on the pattern of the population distribution in the post-Soviet cities, it is possible to go further and to estimate it quantitatively with the help of such characteristic as a *density gradient*.

The term is believed to be introduced into a wide circulation by urban geographer Colin Clark (1951), who studied twenty cities to prove that the density distribution generally presents a negatively sloped exponential curve. Mathematically the relation between the residential density and the distance from the city centre may be expressed in the following function:

$$D(r) = D_0 e^{-br}$$

where D_0 is density in the city centre; r is the distance from the city centre; b is an exponential decay parameter called Population Density Gradient.

Using simple regression methods, it is possible to interpret the variation of population density with the distance from the city centre by estimating the parameters of the negative exponential function. Transforming the above equation into the linear form by taking the log of both sides leads to the following expression:

$$ln(D) = lnD_0 - bx$$

While most of the research dedicated to the density gradient was carried out in the USA, various cities around the world were studied in a series of comprehensive studies by Alain Bertaud and his colleagues (Bertaud and Renaud, 1997, Bertaud, 2001, Bertaud and Malpezzi, 2003) based on the data collected during his work as an adviser to municipalities. The findings of these studies show that the population density gradients (PDG) of a large number of cities around the world do follow the standard model of negative exponential decline with high values of the coefficient of determination R^2 (see Figure 7). The relationship between the PDG values and transportation costs, noted by Bertaud and Malpezzi (2003), becomes apparent when comparing the data from around the world: the population gradients tend to flatten with the rise of the transportation costs.

As for major Russian cities, some of them, like Ekaterinburg, fit the 'classic' model quite well while others, like Perm or Novosibirsk, digress substantially or even have an inverted gradient, like Rostov-on-Don (see Figure 8). In general, the current values of the Russian cities' PDG are at the level of European cities, that is between typical Asian cities, where prevalent mode choice is walking and cycling and the gradients are usually the steepest, and automobile dependent American cities with flatter gradients. In order to obtain the quantitatively expressed sprawl trend of the post-Soviet development in the major Russian cities it would be useful to analyse these graphs in time, which constitutes a wide field for further research, provided that the data from the Soviet period are available.
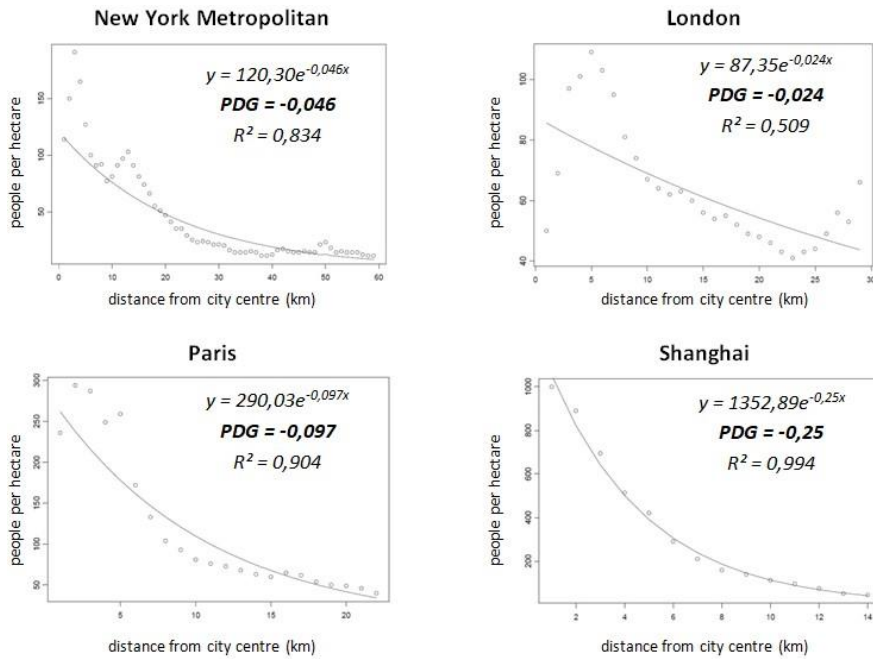
New York Metropolitan

$$y = 120,30e^{-0,046x}$$
PDG = -0,046
$R^2 = 0,834$

people per hectare

distance from city centre (km)

London

$$y = 87,35e^{-0,024x}$$
PDG = -0,024
$R^2 = 0,509$

people per hectare

distance from city centre (km)

Paris

$$y = 290,03e^{-0,097x}$$
PDG = -0,097
$R^2 = 0,904$

people per hectare

distance from city centre (km)

Shanghai

$$y = 1352,89e^{-0,25x}$$
PDG = -0,25
$R^2 = 0,994$

people per hectare

distance from city centre (km)

Figure 7. Density gradients of selected cities. Adapted from Bertaud and Malpezzi, 2003

Novosibirsk

$$y = 106,4e{-0,06x}$$
PDG = -0,06
$R^2 = 0,313$

people per ha

distance from city centre (km)

Samara

$$y = 120,9e{-0,13x}$$
PDG =-0,13
$R^2 = 0,679$

people per ha

distance from city centre (km)

Ekaterinburg

$$y = 265,6e{-0,33x}$$
PDG = -0,33
$R^2 = 0,759$

people per ha

distance from city centre (km)

Perm

$$y = 61,63e{-0,07x}$$
PDG = -0,07
$R^2 = 0,339$

people per ha

distance from city centre (km)

Rostov-on-Don

$$y = 54,26e0,031x$$
PDG = 0,031
$R^2 = 0,057$

people per ha

distance from city centre (km)

Omsk

$$y = 64,12e{-0,12x}$$
PDG = -0,12
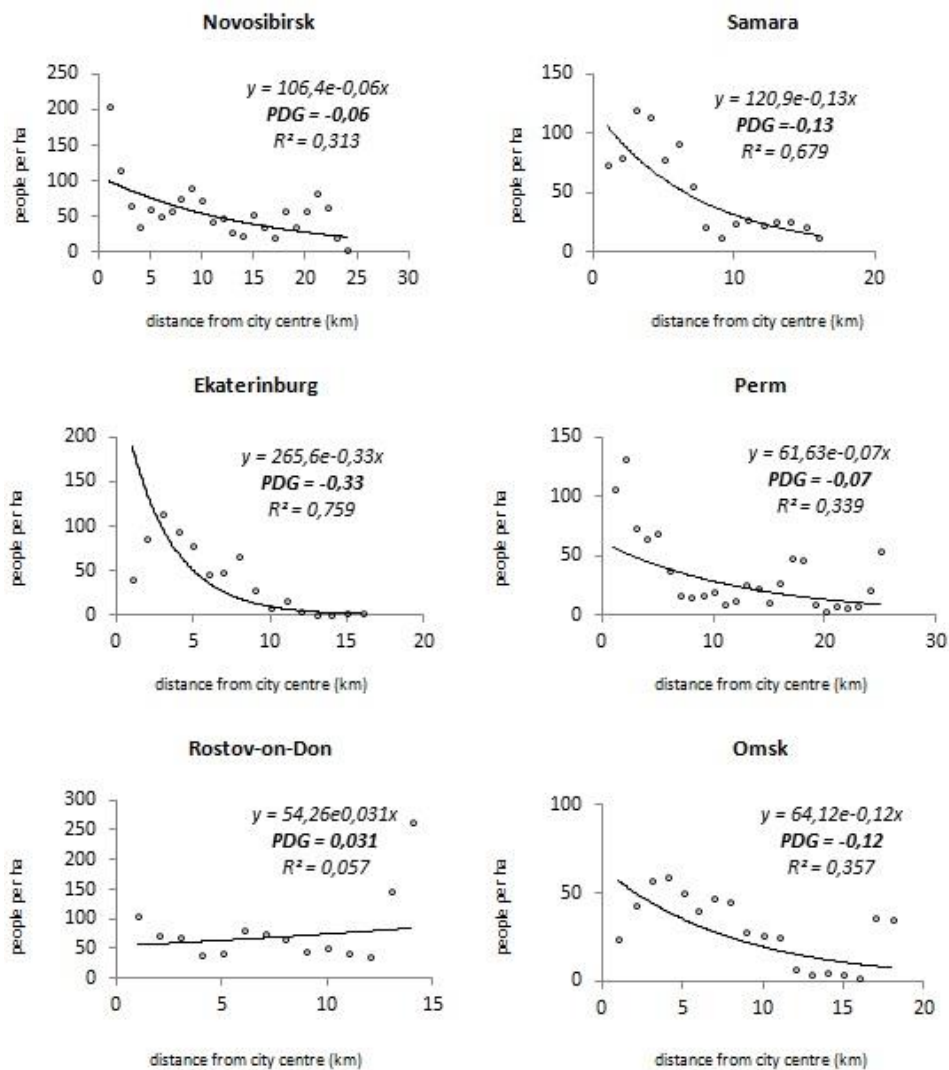$R^2 = 0,357$

people per ha

distance from city centre (km)

Figure 8. Density gradients of selected major Russian cities

Another way of measuring the population distribution is the dispersion index – the ratio between the median distance to the centre per person and the average distance to the centre of gravity of a cylindrical city with the area equal to the built-up area:

$$\rho = \frac{\sum d_i w_i}{\frac{2}{3}\sqrt{\frac{A}{\pi}}}$$

where d_i is the distance of the ith tract/circle from the CBD, weighted by the share of the population in this tract/circle w_i, A is the built-up area (Bertaud and Malpezzi, 2003).

Dispersion index is a useful spatial indicator for comparative purposes since regardless of the size of the city it shows the effectiveness of the established distribution of population across the territory of the city i.e. the effectiveness of 'shape performance'.

The threshold between compactness and dispersion is considered to be the value of 1. Most major Russian cities have the dispersion index greater than 1, which indicates reduced concentration of population around the city centre (see Figure 9). Such situation is not favourable since higher concentration of the population reduces the distance between the objects of departure and arrival, reduces the average range of travel and reduces the workload of transport and the associated investment.
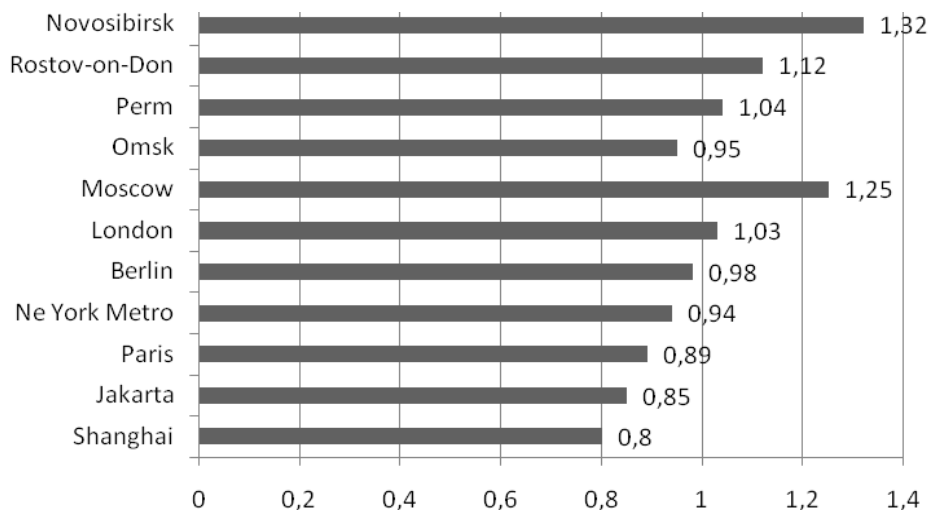

Figure 9. Comparative dispersion indexes of selected major Russian cities and cities around the world. Source of the data for world cities including Moscow: Bertaud, 2001

Thus, density profile, density gradient and dispersion index of Russian cities present a general image of a sprawling city with relatively dispersed population and sudden peaks of population concentrations on the periphery. Figure 10 offers a clear representation of this type of spatial structure in 3D form.
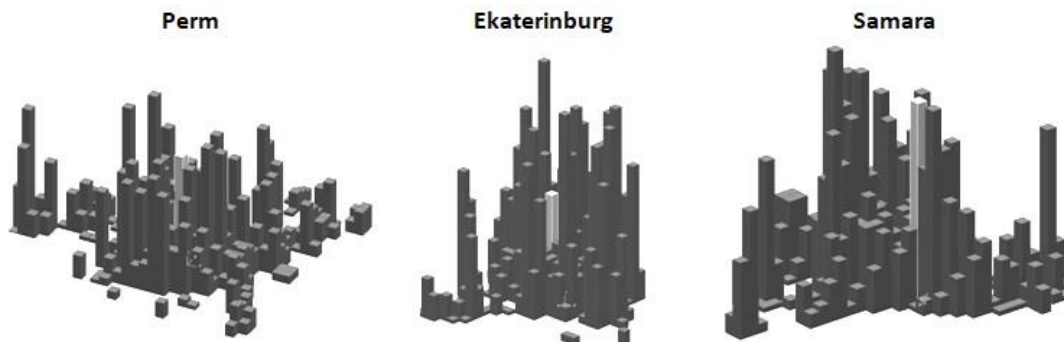

Figure 10. The spatial structure of three major Russian cities

In 1997 work Bertaud and Renaud conducted an empirical analysis of the 'spatial anomalies and urban inefficiencies' typical for cities with the socialist past based on findings from Russia, Poland and China. The typical Russian city structure according to Bertaud and Renaud (1997) represents four distinct concentric zones:

- The pre-socialist historical core with high population densities.
- The industrial belt, giving a sudden drop in the density of residential development in close proximity to the city centre.
- The "socialist" residential belt.
- Fringe suburban areas with the mix of individual housing, dachas and low-rise apartment blocks.

Of all the Russian cities only Ekaterinburg does follow this concentric circles model, other cities do not show this model distinctively. Yet the belt of manufactures (often perishing) can be found in every industrialised city in Russia. Plots in prime locations are occupied with unattractive buildings which, in addition, are often inefficient in terms of employment creation. The ratio of jobs per unit of land in these industrial zones is relatively low.

The "socialist" residential ring, although often distorted, is also an indispensable part of any post-Soviet city. It mostly consists of microrayons – high-density residential settlements, each housing about ten thousand people. According to Stanilov (2007a), over half of the population in post-socialist cities lives in these large housing estates of poor and rapidly degrading quality. According to the survey by Brade et al (2009), these socialist prefabricated dwellings are ranked very low in the desired housing preferences of the post-socialist cities' population. However, the current residents of such housing have little intention to move, which means this type still shows a wide acceptance among its in-dwellers. Moreover, in large Russian cities the newly built multi-storied housing on the outskirts is very popular both among developers and among customers. In the absence of a proper regulation by the authorities, the real estate market tends to develop following the path of least resistance. In order to avoid difficulties associated with construction in the existing urban environment, developers opt for green-field development at the outskirts with cheaper land. Maintaining the Soviet tradition of multi-storey residential development on the periphery, the cities take the path of further extensive growth or sprawl.

Structural form

Another important urban form-related phenomenon that may be assessed at the macro-scale (city) level is the degree of jobs concentration in the city centre, i.e. monocentricity. Many cities in the world demonstrate predominantly monocentric model, others are predominantly polycentric, and a lot are in between, either having a composite structure with different parts of the city tending to one side or another or being in the process of transition from monocentric to polycentric model. Factors contributing to this transition process may include both circumstances characteristic of the whole country (or even of the region) like high private car ownership, affordable land prices and city-specific conditions like the low range of employment options, attractions and facilities in the city centre, flat topography and grid street layout. In such circumstances, the historically formed CBD starts losing its primary importance and its functions are partially picked up by the newly formed suburban subcentres.

That was the case with the former socialist cities in Central and Eastern Europe. Most efforts of post-1990s developers in CEE cities were directed towards the urban fringe with new residential (single-family houses) and commercial (shopping, offices and warehouses) construction (Sykora, 2007) and previously high-density and monocentric settlements rapidly mutated into sprawling and multi-nodal metropolitan areas (Stanilov, 2007b). The dynamism of the suburbanisation allowed Stanilov and Sykora (2014) to call this process "the post-socialist suburban revolution". Yet, in Russia similar trends in the development of suburbs are visible mostly in Moscow (and to the much lesser extent in St Petersburg), where the number of private low-rise residential development on the periphery has been growing in the last 10-15 years with simultaneous formation of peripheral subcentres through private business megaprojects of high-

density residential development (Makhrova, 2013). New centres of commercial activity (warehousing and trading complexes) have also appeared in the territories adjacent to the Moscow Ring Road and arterial roads contributing to the partial shift of business activity to the outskirts of the agglomeration. Compared to Moscow other major cities continue to be highly monocentric and often lack any significant suburbs or satellite cities (Becker et al, 2012). What remains common for all the cities in Russia is its specific 'seasonal' suburbanization expressed in the growth of population in cottage settlements ('dachas') during spring and summer.

Although many cities in Russia, like St. Petersburg (Government of St. Petersburg, 2017) or Kazan (Hadiullina, Ivanov, 2017), consider polycentric development as a way out of the transportation issues, their current urban structure is far from polycentric, but close to 'dismembered' or fragmented. While polycentric structure implies that many trip-generating activities are spread in clusters within the built-up area, in the Russian cities the strong centre still attracts most of the population during the daytime and most of the subcentres are presented by the old industrial enterprises survived from the Soviet period. These subcentres, however, continue to provide jobs only for the population within a relatively short radius, for those living in the housing purposely built for the industry workers at the time.

For instance, Perm, due to the above-mentioned historical reasons and difficult topography preventing communication between peripheral areas, still in many ways presents several autonomous settlements. In some areas subcentres of business activity were initially not formed, in others they ceased existing as the Soviet large enterprises lost their importance or even collapsed in the new economic conditions (see Figure 11). Thus, the historically fragmented urban structure is now coupled by the high degree of monocentricity, which creates considerable transportation problems.
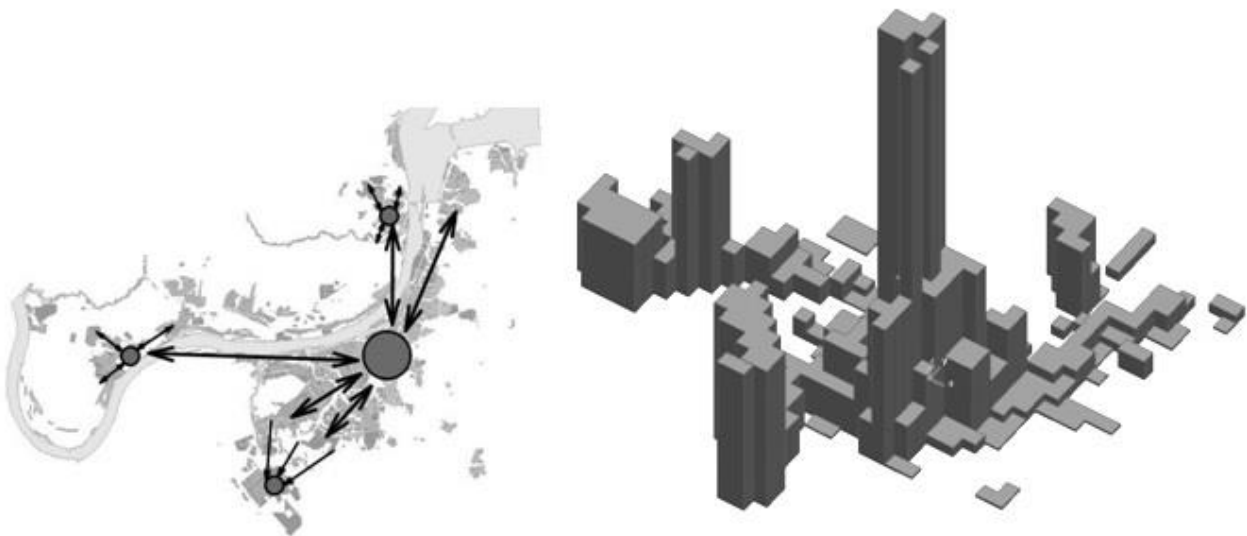

Figure 11. Main labour migration flows and 3D job density in Perm

Transportation network

To measure the network density two indicators were calculated and analysed: the road network density per capita and the road network density per urbanised (built-up) area, the result is displayed in Figure 12. At first sight, it becomes apparent that overall values of densities per built-up area in the major Russian cities are significantly lower in comparison with their 'western' counterparts (see Figure 13). This indicator evaluates the degree of the city's permeability and implicitly the accessibility enjoyed by its inhabitants. Low values of road density in Russian cities indicate excessive, unreasonably big urbanised areas, which simply cannot be sustained by cities' budgets given the low average densities. Less road length per person, on the contrary, is usually a sign of more sustainable urban form, subject to the

prevalence of non-motorized modes of transport or public transport. Thus, dense Asian cities (for instance, Hong Kong, Seoul, Jakarta, Singapore) generally show high levels of road length per built-up areas with low levels of road length per capita relative to cities in other regions (Barter, 2000). Otherwise, in case of reliance on private modes, low values of road density per capita only enhance congestion levels. To sum up, preferable combination of these two indictors consists of higher network density per hectare of urbanised area and lower network density per capita. In this respect, such cities as Krasnoyarsk, Samara, Chelyabinsk and Novosibirsk seem to perform slightly better among other major Russian cities.
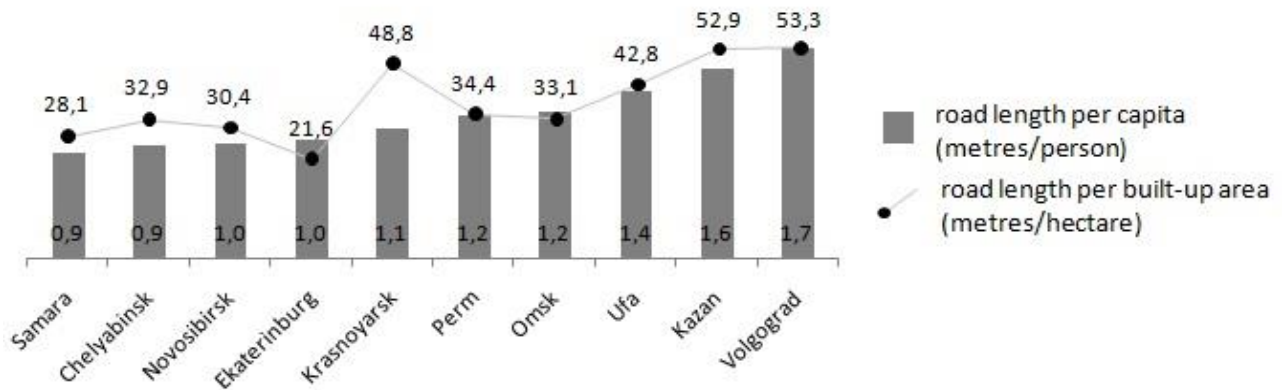

Figure 12. Network density for major Russian cities.
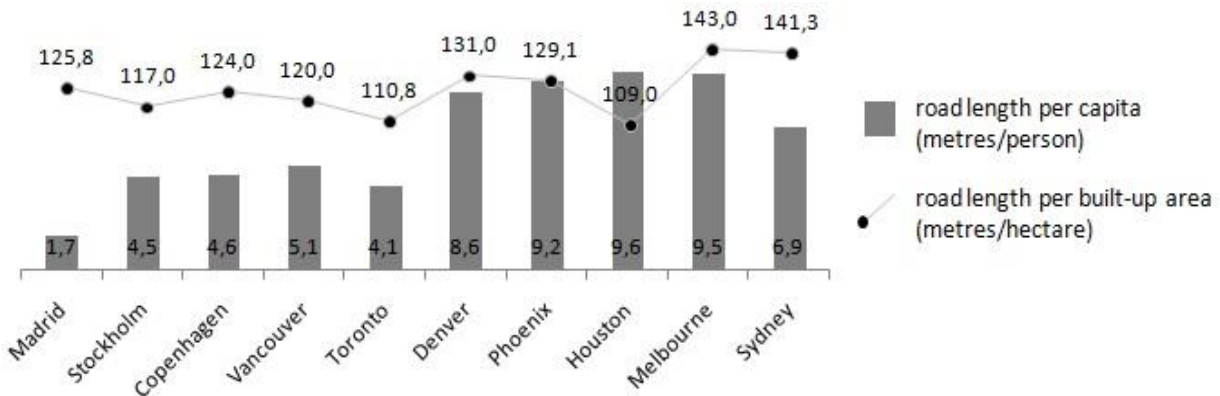Data source: Census 2010

Figure 13. Network density for selected world cities.
Data source: Sorensen and Hess, 2007

Yet the high network density does not automatically make it effective and convenient. In order to assess the efficiency of the network configuration a coefficient of network indirectness may be calculated (Sosnovskih, Rusakova, 2006):

$$\gamma_i(n) = \frac{\sum_i n_i l_i}{\sum_i n_i d_i}$$

where l_i is the distance measured along the roads of the kilometre zone i from the CBD, weighted by the share of the population in this zone n_i, and d_i is the aerial beeline (shortest) distance of the ith circle from the CBD, weighted by the share of the population in this circle n_i.

Various constraints of topography, rivers and railways coupled with low number of bridges and overpasses often do not allow forming a solid system of streets. The network indirectness affects not only the accessibility of the remote areas, but also the amount of unproductive urban

transportation associated with reruns. High coefficient of indirectness indicates that the places of residence are not rationally distributed across the territory. While a considerable share of the built-up area outside the core is occupied by low-density residential development or industrial sites, there are often remote densely populated areas with an unsatisfactory level of communication with the city centre.
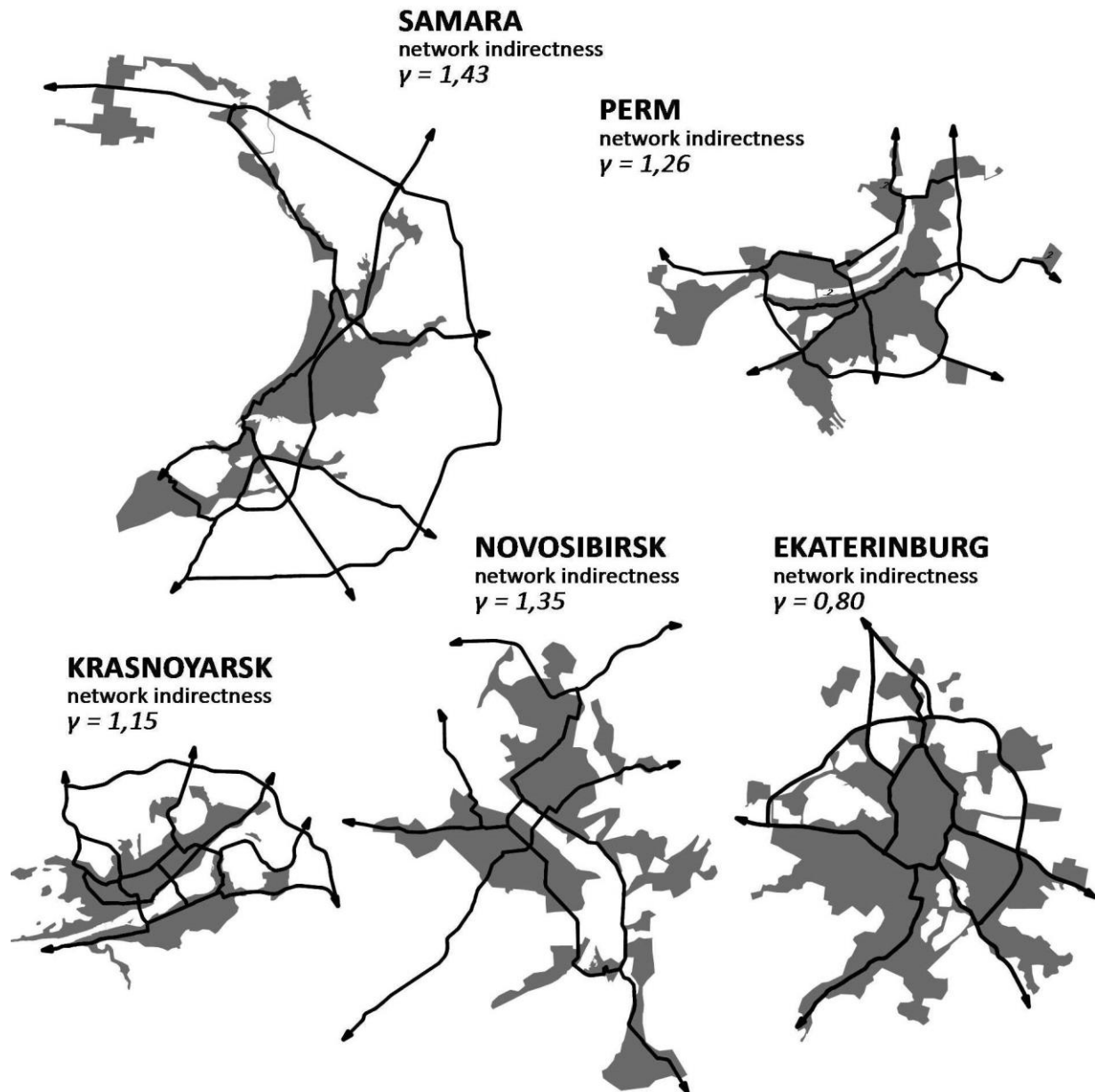

SAMARA
network indirectness
$\gamma = 1,43$

PERM
network indirectness
$\gamma = 1,26$

NOVOSIBIRSK
network indirectness
$\gamma = 1,35$

EKATERINBURG
network indirectness
$\gamma = 0,80$

KRASNOYARSK
network indirectness
$\gamma = 1,15$

Figure 14. Transportation network of selected major Russian cities

Conclusion

Based on the analysis carried out in this study it may be concluded that Soviet-period legacies continue to determine Russian cities' current development patterns in many respects. Most of the development in the major cities took place during the 20th century in accordance with the principles adopted in Soviet planning. Today's cities, unreasonably stretched or fragmented, are the product of the long-standing tradition of expansive development and focus on urban growth.

The communist 'big-is-beautiful' mentality' combined with the rejection of private property and land market, that left Soviet planners 'without market benchmarks' for urban investment decisions, resulted in the deficient urban structure. Thus, most major cities presently have the population density gradients that are distorted or even inverse, and the dispersion indexes that are not even close to those of the compact cities.

One debasing element of the post-Soviet urban form is the array of extensive industrial sites scattered over the cities' core. The two options available here is the relocation of the existing enterprises from the city core or the reconstruction and modernisation of them on the existing sites with simultaneous integration into the urban environment. The first option is less preferable as it is fraught with further extensive territorial growth of the city. Another Soviet legacy left to age is the belt of high-density housing generated over the years of intensive housing construction in the peripheral areas. Such housing constitutes a significant share of the housing stock and, therefore, needs to be preserved and somehow maintained. The experience of the Baltic countries, East Germany, Poland and other countries, which faced the post-war housing crisis and, just like the Soviet Union, solved this problem via large-scale residential development of low quality, suggests many ways of renovation in accordance with modern demands: from facade reconstruction or various extensions, depending on the design system of the building to placing commercial premises on the ground floor. The gigantic renovation project currently taking place in Moscow cannot be accomplished by any of the other Russian cities with much more modest budgets and, besides, loses its credibility against the background of ongoing perverse practice of the green-field development on the Moscow periphery.

There is a pronounced need to mitigate the deficiencies of the post-Soviet urban form in the major Russian cities since it leads to the unnecessary increase in distances between people and places, in time spent on commuting, in the length of the city infrastructure network and therefore in its capital and operating costs. Urban form cannot be changed in a blinking of an eye but better understanding of the spatial organization of the major Russian cities will allow influencing it in a way consistent with city's long-term development aims. The combined effect of municipalities' instruments at hand – land use regulations and infrastructure investments – can shape the spatial development trends making post-Soviet urban structure more efficient and, in the long term, may support solving many of the pressing problems, and above all, the ones related to the urban transportation.

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