Chapter 2
Urban Spatial Structure as a Factor of Travel Behavior

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Abstract Urban spatial structure is considered to be one of the determining factors of the transport demand volume and structure. Russian cities are traditionally characterized by high levels of public transport ridership, compared to the Western cities. Thus, it can be assumed that the spatial structure of Russian cities is a perfect illustration of the Transit Oriented Development (TOD). However, the spatial structure of the majority of the Russian cities, which has been developing during the rapid urbanization in the 20th century, currently preserves and reproduces the specific extensive models peculiar to the cities in the socialist countries. The authors analyze the spatial development patterns of 13 Russian cities in order to assess the current situation and the prospects for transit oriented development in the Russian Federation. A brief history of urban spatial development during the Soviet period is provided. Fundamental differences between TOD and Soviet Style Development (SSD) and their impact on transport demand are discussed.

2.1 Soviet Style Development Versus Transit Oriented Development

At the first glance, the spatial structure of Russian cities (as well as the spatial structure of the majority of the former USSR cities) seems to be a perfect illustration of the concept of transit-oriented development (TOD) as formulated by the American architect Peter Calthorpe in his book "*The New American metropolis*" (Calthorpe 1993), published two years after the end of the Soviet era. In fact, the parameters used in planning and development of the Soviet cities were thoroughly oriented at intensive public transportation usage. However, some fundamental differences between TOD and the Soviet Style of development (SSD) do exist.

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Firstly, TOD became a historical antithesis to the tradition of car-oriented development paradigm (COD), longstanding in the cities in the US, Canada, Australia, and other parts of the Western world and was based on the extremely high motorization rate and, accordingly, on the transport self-sufficiency of households, particularly of those living on the periphery of cities and in the suburbs. The attention to urban spatial development as a factor of travel behavior in the countries of the Western world originated in response to the problem of urban sprawl in the second half of the 20th century which caused numerous social problems such as congestion, environmental degradation, and slow social and spatial integration. This issue has been closely associated with the phenomenon of car dependency (Schiller et al. 2010; Newman and Kenworthy 2006). Both problems became more critical in North America and Australia in comparison to Europe and Asia. The overall situation was a consequence of the post-war growth in the sales of cars and individual houses in the suburbs, that is, the phenomenon of the "*exodus of the middle class to the suburbs*" (Jones 1981). This fact explains the great contribution of the North American and Australian scientists to the research of this issue. At the same time, the adoption of TOD paradigm does not (even theoretically) imply the reduction of the motorization rate to the limits determined by the standards of the Soviet times. In the Western cities, the usage of public transportation can be encouraged, but it is impossible to limit the motor vehicle production and sales. The first studies on spatial planning and the influence of land use on travel behavior appeared in the 1970s (Handy 2005) when scientists noticed the interrelation between urban population density and public transport usage. The scholarly debate on the issue intensified in the early 1990s after the publication (Newman and Kenworthy 1989) which examined the interrelation between population density and fuel consumption in large cities. To date, TOD model has been tested in many cities around the world as a tool to reduce the popularity of private cars and make public transportation more attractive. The concept has been taken into account in urban spatial development management in North America, Australia, and Europe. The most developed countries and territories in Asia (Japan, South Korea, Singapore, and Hong Kong) have also reached great success in this field. The concept of TOD is being widely introduced in China, India, and Latin America. Nowadays, the development focused on public transportation is seen as the most sustainable form of urban spatial development (Cervero and Murakami 2008).

One of the major features of socialist cities as opposed to those in the West was the low motorization rate. The motorization rate in Russia remained extremely low throughout the Soviet era: by the end of it, in 1990, there were 80 vehicles per 1000 residents in the USSR, including no more than 50 personal cars. In the USSR, the low motorization rate was achieved with the simplest of means: national production of cars was severely restricted (the only plant intended for mass production of cars more or less advanced by the standards of the time (FIAT) was built in 1970 in Togliatti[1]); import of cars was banned; the price of a new car was equal to 3–5

[1]Before the construction of the plant the motorization rate was less than 10 cars per 1000 residents.

annual salaries of a qualified engineer. Thus, in the Soviet Union, car-oriented suburbs had never developed. Prosperous citizens would have two homes: a small apartment in an apartment building and a "dacha" (a modest country house) located on a 0.06 ha lot in the suburbs, usually with a small garden and without urban amenities. The less affluent citizens lived in communal apartments with a kitchen and a bathroom shared by several families. The housing stock in large cities was totally dominated by multifamily houses. In the 1950s and 1960s, 5-storey residential buildings were typical while since the 1970s and until the end of the Soviet era, buildings with 8, 12 or more stories prevailed. The share of the built-up area in a city reserved for urban street and road network was exceptionally low. It is necessary to mention that the term "*share of built up area in streets and roads*" was already used by Russian urbanists at the beginning of the 20th century. For example, Greg Dubelir, the Russian pioneer of urban studies stated in his monograph written in 1910:

> … if the value ε implies only the share in streets and roads and does not include parks, large open areas, etc., it can be assumed that the coefficient ε is equal to:
>
> – for tall buildings and wide streets with estates with small lots – 0.40,
> – for average conditions – 0.30,
> – for a rational plan with narrow streets and small houses with estates with relatively large lots – 0.20-0.25 (Dubelir 1910).

According to the recommendations of the USSR Academy of Architecture, the share of area in streets and roads had to vary from 15 % (in small towns) to 25 % of the total area of a residential zone (Levchenko 1947). The book by the acknowledged Soviet specialist in transport studies, A. Polyakov (1953) presents the data on the percentage of built up area in streets and roads for 111 cities in Russia as of 1946, according to which the average value of the indicator was 25.2 % of the total residential area, varying from 32.5 % in urban centers and 27.7 % in the intermediate zone to 23.0 % in the peripheral zone. Noting that all these values conform to the strictest requirements of the recommended design standards, A. Polyakov argued that the standards were insufficient rather than redundant. At the same time, the scientist was convinced that "*a significant saturation of cities with motor vehicles would entail an increase of this relative indicator*". Unfortunately, the optimistic forecast by A. Polyakov has only been fulfilled halfway through: the predicted "*significant saturation of cities with motor vehicles*" came true, but it only happened in the post-Soviet period. However, it was by no means accompanied by "*an increase of this relative indicator*". It does not exceed 8–12 % in any city in the Russian Federation. Thus, the cities in the USSR, unlike their Western counterparts, had not been shaped by private cars in the course of the 20th century; rather than that, they had been shaped by total absence of private cars.

Secondly, and perhaps most importantly, TOD, as well as COD (and all the other spatial development models applied in the Western cities), is based on the private ownership of land and unconditional freedom of choice available to the citizens. Neither the former nor the latter was present in the USSR. The TOD researchers focus mainly on factors such as housing density (density), land use diversity

(diversity), and designing pedestrian-friendly urban spaces (design). This set of factors is referred to in the academic literature as 3-D (Cervero and Kockelman 1997). Some publications also mention two additional factors: the distance to public transit stations (distance to transit) and travel time to the destination (destination accessibility), resulting in 5-D group of factors (Ewing et al. 2007; Hamin and Gurran 2009; Cervero and Murakami 2008). The importance of these factors transpires in the greater efficiency of TOD development in comparison with the traditional high density development near public transit stations (Cervero and Murakami 2009; Lin and Shin 2008; Loo et al. 2010). These characteristics enable the stimulation of public transport usage and reduction of private car usage by local residents and people visiting the area (Boarnet and Crane 1997). The distinctive features of the TOD such as high density, diversity of uses, and focus on pedestrians have a lot of influence on travel behavior and often encourage people to stop using a personal motor vehicle (Kenworthy and Laube 1999; Ewing and Cervero 2001): the generalized cost of travelling by public transport becomes much lower. These details, characteristic of TOD, seem quite alien to the realities of SSD. The Soviet housing estates were territories used exclusively for residential purposes, and mixed-use development was not practiced. Considering the low level of car ownership that was typical for Soviet cities, the residents had no choice whatsoever with regard to the transport mode. The Soviet people used the overcrowded public transport without thinking about the dubious convenience of such trips. Public spaces near subway and suburban railway stations were physically present, but the issue of their convenience and attractiveness was hardly relevant, as the service and trade sector was notoriously underdeveloped during the Soviet period. Within the limits of the development strategy implemented in the country there was no room for urban land markets. The absolute imperatives were the growth of industrial production. As to the housing construction, according to the observation by the same author, it was dominated by "*a kind of super-large villages near the factories*" (Glazychev 2008).

According to the classical models, the attractiveness of land intended for development dwindles moving away from the urban core, which leads to a decrease in density and development. In case of the cities that have developed in the countries with free market economy, this process is controlled mainly by the market forces. The result is a city where the maximal housing and population density occurs in the center while being most sparse at the outskirts. If the current density of economic activity does not correspond to the actual land value for any reason, effective mechanisms of renovation and redevelopment are launched, eventually forming a decreasing density profile. Under the free market conditions, developers aim at maximizing the value of the final product, but in the conditions of the administrative command system oriented at a proposal, the task of providing new housing is solved by simply adding square meters. Therefore, in the urban areas which have been actively developing for a long time in the conditions of planned economy the described decreasing density profile is not observed. According to the contemporary studies dedicated to the spatial structure of the post-socialist cities, particularly the works of Bertaud (Bertaud and Renaud 1995; Bertaud 2004), the

cause for this dissimilarity is the rejection of private property and the absence of land markets in cities. In socialist countries, the types of land use were determined based on the perception of public importance of various objects.

The exotic Soviet urban development conditions have had a huge impact on the present day urban spatial structure, as rapid urbanization occurred namely during the Soviet period (the share of the urban population had grown from about 17 % in 1917 to about the current degree of 70 % in half a century). The development flaws of the Soviet cities such as the low values of the parameter ε were not critical while the transportation demand was almost entirely met by public transport (even though the latter was often of very low quality). Problems emerged with the rapid growth of motorization rate since the mid-1990s and in the 2000–2010s.

2.2 A Brief History of the Soviet Style Development

There are three important milestones in Russian history that triggered significant changes in urban spatial structures: (1) the abolition of the institute of private real estate ownership after the events of 1917, (2) The "*Khrushchev thaw*" and the beginning of the industrial housing construction era in 1957, and (3) the collapse of the Soviet Union and restoration of market economy and private property institutions in 1991.

The development of Russian cities before 1917 was progressive but, due to objective historical reasons, rather slow. The country's economy was actually an agrarian one and the level of urbanization was low. Typical FAR for cities in that period ranged from 1.3 to 1.8 in provincial cities (and even in some of the central neighborhoods in Moscow) to 3–4 in St. Petersburg; i.e. there was a fairly high-dense development similar to that in the European cities. The share of the area in streets and roads in the central part of a city was fully consistent with the contemporary European trends and amounted to 25–35 %.

The 1920–1930s saw intensive industrialization of the Soviet type, focused on the development of heavy and defense industries. This process led to the concentration of economic activity (and people) in cities. Production plants, including industrial giants, designed for tens of thousands of workers were usually built at the outskirts of cities. Later, many of them turned into vast brownfields.

Inadequate housing construction volumes were made up for either by constructing low quality temporary dwellings (e.g. barracks near big factories—the problem that still exists today) or (which was more common) by multiple densification of the existing housing stock. At that time, the dwelling area allotted for one person could be 3–5 m^2. Figure 2.1 shows a significant increase in population density in the central part of Moscow between 1907 and 1935, despite the fact that housing density had not changed much.

Since the mid-1930s, due to the development and enforcement of the Moscow General Plan and general plans of other major Soviet cities, fairly reasonable development and land use requirements were introduced along with standards for

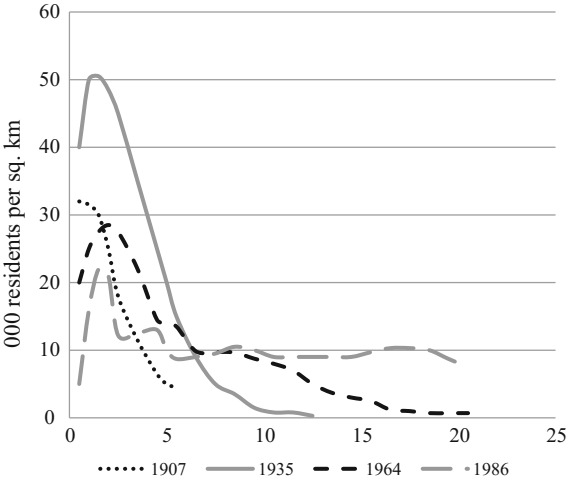

Fig. 2.1 Moscow density profiles in different years [*Source* Reproduced by authors from (Petrov 1988)]

insolation, green areas, and various urban infrastructure utilities. These new rules were obviously declarative (not to say, propagandistic) in nature. In reality, the high-quality housing construction in that period was concentrated almost exclusively in the elite segment, available solely to the higher strata of the Soviet bureaucracy as well as the cultural and academic elite (Khan-Magomedov 2006). The houses built during that period are located in what are the central areas of the respective cities today and are still perceived as high end real estate, which increases their price. Obviously, such kind of housing did nothing to solve the housing problem in general.

The era of cheap and rapid industrial housing construction started in 1957 with the construction of a pilot Cheryomushki neighborhood in Moscow. It was a real breakthrough, as millions of citizens were granted the previously unavailable comfort of living in a single-family apartment (Khan-Magomedov 2006). Per capita dwelling area in cities began to grow rapidly. Undoubtedly, mass housing construction required significant space, so the cities grew actively. Evolving cities overstepped the industrial zones, which led to mass construction at peripheral areas beyond the industrial areas.

Thereby a W-shaped urban structure height configuration, unique in the world, was created in the Soviet cities:

- multistoried (some of them historical) buildings in urban cores;
- "flat" industrial areas on yesterday's periphery which evolved into intermediate urban zones by the 1950s;
- high-rise housing estates on the new periphery that were even more distant from urban centers.

The minimal personal freedoms granted by the government in the 1960s ("Khrushchev thaw"), which included, in particular, the relatively free choice of a working place combined with the preservation of the ban on private housing

ownership, thereby preserving an extremely low residential mobility level. Citizens could now select their workplace, but it was still very difficult to move from one residential area to another. This circumstance had caused obvious problems and extremely high demand for public transportation in the Soviet cities.

At the same time, in the 1960–1970s, a package of regulations, quite advanced from a humanitarian point of view, was proposed, defining, inter alia, the required subdivision of urban areas into residential, green and industrial zones as well as the level of transportation infrastructure development.

In practice, these regulations resulted in the proliferation of neighborhoods that usually consisted of 5-storey apartment buildings accompanied by large green areas, with a typical FAR (Floor Area Ratio) value close to 1. The implementation of more advanced building techniques brought about the growth in the number of stories: while the BCA (Built Coverage Area) remained unchanged, the FAR value increased greatly and exceeded 10.

Obviously, these new high-rise housing estates were built on greenfield land, usually at a considerable distance from the city center and/or major concentrations of employment opportunities. In many cases, these neighborhoods were dominated by "*departmental housing stock*", i.e. houses designed exclusively for the employees of certain large industrial enterprises.

From a humanitarian point of view, these remote neighborhoods were a huge step forward compared to the barracks around the factories. At the same time, this type of development created demand for high capacity public transportation systems. In many cities, the initiative of developing such systems came from large industrial enterprises, the actual owners of the new residential areas who were required to ensure transportation of their employees from the place of residence to the production plant entrance.

In any case, local authorities and managers of the production plants (combined under the leadership of the Party bodies) were primarily concerned with the issue of commuting. The employment concentration at such enterprises was so high that it made quite effective the organization of regular bus routes (high-capacity buses) and even the construction of tram lines (with multi-car trams), designed exclusively to provide transportation links between a production plant and the housing estates associated with it. The most striking illustrations of this transportation policy were Samara and Nizhny Novgorod where the function of transporting workers between the production plants and the associated housing estates was carried out by the local subways. In other words, subways existed in these cities but did not play the role of universal city-wide transport systems. The task of subway extension to the historic downtown area, that is, the transformation of the underground transport system from a departmental to a city-wide was only addressed with the arrival of the new economic reality in the early 2000s.[2]

[2]It is worth noting that the opening of "*Gorkovskaya*" station in the central part of Nizhny Novgorod led to a sharp increase in ridership: from around 30 to 40 million passengers per year. For the reasons discussed below, this short-term growth could not reverse the trend of an overall decrease in ridership: the following year saw the restoration of the downward trend.

Another aspect, important for understanding the spatial structure of Russian cities, was the proposed motorization level, provision of parking spaces, and road network. The Soviet planning regulations (Gosstroy SSSR 1985) were based on the following directive hypothesis: "… *when calculating the capacity of the network of streets, roads and transport hubs, as well as the distribution of parking spaces, the level of motorization for the planning horizon should be assumed to be 150–180 cars per 1000 inhabitants*". These regulations were actually implemented: the citizens kept their personal cars either in the garages located in the specially allotted zones (for example, in the sanitary areas of railways and high-voltage power lines) or in microrayons,[3] beside high-rise apartment buildings. The actual level of motorization being 50 (maximum 80), this practice did not cause major problems, and there was no need for any parking restrictions. Today, with the level of motorization at 2–3 times higher than prescribed by the norms cited above, the psychological stereotypes of the citizens create acute problems when the authorities try to introduce appropriate parking regulations.

Planning regulations for microrayons presumed total exclusion of all transit-related traffic from a planning unit. For example, the planning regulations cited above required providing a local road network in multi-story residential areas based on a single 3.0 m wide lane. Given the extremely low level of motorization in 1970–1980s, such parameters were relatively harmless. Today, when 1000 residents of the same residential neighborhoods have 300–400 or more cars, such thoroughfares became a real obstacle not only for the residents departing their residential area but even for the passage of emergency vehicles and public services.

In the conditions when transportation demand was supposed to be met by public transport with almost no alternatives, the only parameter limiting the growth of planning units was the radius of access to public transport stations. Given this, the distance between the adjacent streets in the residential areas built at that time can exceed 1 km (Fig. 2.2). Such distances make it almost impossible to implement any kind of coordinated traffic control.

Moreover, in Soviet cities there was no segregation of urban network into urban streets and urban roads that has been present in the developed countries since the middle of the 20th century. The need for such segregation was appreciated by professional Soviet planners. A.A. Polyakov stated that "*when the saturation of the US cities with cars reached 200 cars per 1000 residents, construction of high class urban roads was launched in the largest cities. Those were urban highways, and usually they did not intersect with streets and roads at the same level*" (Polyakov 1967). He was confident that with the motorization in the USSR reaching the same level, the implementation of a hierarchical transport network subdivided into roads and streets will become inevitable. Unfortunately, this optimistic forecast has not come true. The preference was given to the so-called "*high street of continuous traffic flow*". This is a hybrid type of a street combining multi-lane carriageway and

[3]A microrayon is the main structural element of the Soviet residential areas that can be described as a collection of extremely large housing blocks without any typical block configuration.

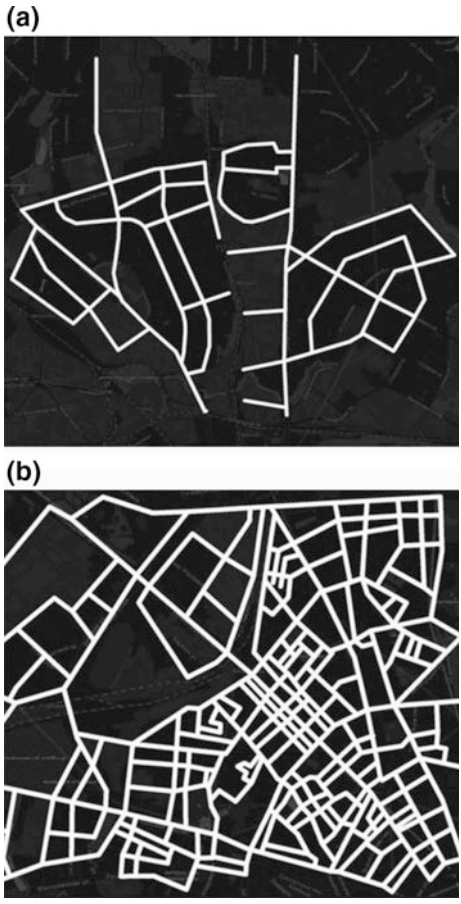

Fig. 2.2 Typical configuration of the road network in Moscow districts built (**a**) in late XIX–early 20th century (**b**) in 1970s. The illustrations are to scale. (*Source* Created by authors)

multi-level junctions with direct access to houses and intensive public transport traffic, which is not present in the planning requirements in the developed countries and in the World Road Association (PIARC) recommendations (Mikhailov and Golovnykh 2004).

As noted above, by the end of the Soviet period, the share of the built-up area dedicated to the transport network (ε) had not exceeded 8–12 % in any of the Russian cities. The decline of this index compared with the value of 25 % recorded in 1946 happened primarily due to the increase in housing density which took place without either heeding the recommendations by scientists or evaluating perspectives of the motorization rate growth. However, based on the Soviet motorization rate, the road network of so modest density was sufficient to meet any potential transportation demand. Phenomena such as heavy traffic or traffic jams were a rarity that would only occur due to a force majeure.

The problem can be explained using the following simple formula:

$$s_v = 10^7 * \frac{\varepsilon}{d * m}$$

$$s_v - \textit{area in square meters of streets \& roads per } 1 \textit{ vehicle}$$

$$\varepsilon - \textit{share of built up area in streets \& roads}$$

$$d - \textit{population density, people per } 1 \textit{ ha of built up area}$$

$$m - \textit{motorisation level, vehicles per } 1,000 \textit{ inhabitants}$$

Given m ≈ 80, at the end of the Soviet period, there were about 200–250 m^2 of streets and roads per 1 vehicle, even though ε was equal to 0.08 and population density was 40–50 inhabitants per hectare. The same situation is characteristic of modern cities in the US, Canada or Australia where motorization rate is several times higher but the same value of $s_v \approx$ 200–250 m^2 is being reached at the expense of fundamentally higher road density (ε ≈ 0.35) and lower average population density.

By now, when the motorization rate in the largest Russian cities crossed the mark of m ≈ 40 with the same road network density (ε ≈ 0.08–0.1) and growing population density (d ≈ 60–80), the average road network area per vehicle became extremely low. In Moscow (despite the active road construction during the last 20 years), the value s_v is close to 28 m^2, while in other large cities it is between 25 and 40 m^2.

Thus, the distinctive structure of Russian cities (SSD) was shaped by the 1990s, and is characterized by:

- W-shaped height configuration (high density city center and peripheral territories along with ineffective land use in the intermediate zone) (Bertaud and Renaud 1995);
- Extremely low share of built-up area in streets and roads.

2.3 Transformation of SSD During the Post-Soviet Period

The analysis of the spatial development in post-socialist cities was conducted based on the example of housing construction in the largest Russian cities, with the exception of Moscow and St. Petersburg. The source of information was the database of the State Corporation "*Fund for assistance to reforming housing and communal services*" (Reforma ZHKKH 2016). Moscow and St. Petersburg were excluded from the study because of their special status (these cities are also the subjects of the Russian Federation), as well as a significant difference in demographic, social and economic indicators and especially, in budgetary possibilities.

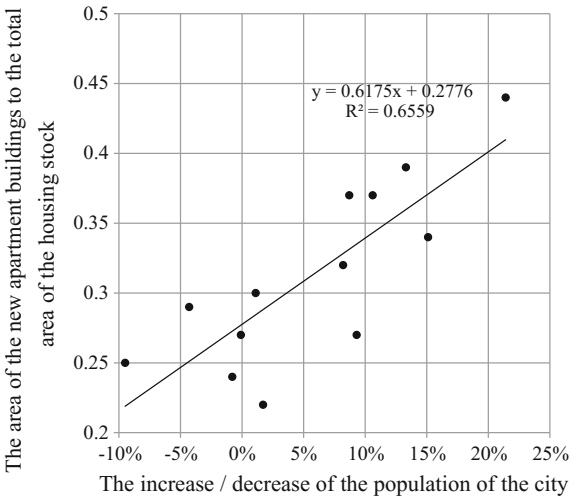

Fig. 2.3 The relationship of the change in the population and the volume of construction of new apartment houses, % by 1991 (*Source* Created by authors using data from Fund for assistance to reforming housing and communal services Reforma ZHKKH 2016)

Thus, 13 other cities with population over 1 million people were included in the study. The study analyzes information on residential buildings constructed in 1992–2015 in terms of their distance from the city center and public transport stations.

The total area of the houses built after 1991 comprises about one third of the total volume of the housing stock in the studied cities. This parameter is found to be in strong correlation with the dynamics of the city population growth during 1992–2015 (Fig. 2.3). The highest value of the indicator, 44 %, can be observed in Krasnoyarsk which experienced significant population growth in 1991–2015 (over 20 %) (Table 2.1).

Even in the cities where population decreased (Nizhny Novgorod, Samara) or remained essentially unchanged (Perm, Omsk, Volgograd) in 1992–2015, the share of the houses built after 1991 in the total area of the housing stock is 22–30 %. It can be argued that the construction of new apartment buildings in 1992–2015 reflects, on the one hand, the ongoing improvement of the standard of living within the financially prosperous stratum of the "settled" urban population, and on the other, the strong demand for high-quality new housing by the new, economically successful residents of Russia's largest cities.

Based on the available data on these cities it is possible to appreciate the degree to which housing construction in post-Soviet Russia has been able to change the spatial structure of its cities and influence the supply/demand of transportation services.

Creating the density profiles of residential development has shown that in all the cities on which data was provided the maximal density is registered in the central areas (Fig. 2.4). The density of residential buildings within the radius of about 1 km around the center is between 170 and 405 thousand square meters per 1 km^2.

Table 2.1 The characteristics of the housing stock changes in the largest Russian cities during the post-Soviet period

No	City	The share of the total area of the apartment buildings constructed after 1991 in the total area of housing stock (%)	Population, 2015 (thousands)	Population growth, 1991–2015 (%)
1	Novosibirsk	32	1548	8.2
2	Yekaterinburg	37	1446	10.6
3	Nizhniy Novgorod	25	1273	−9.5
4	Kazan	37	1191	8.7
5	Samara	29	1172	−4.3
6	Chelyabinsk	34	1169	15.1
7	Omsk	27	1166	−0.1
8	Rostov-on-Don	27	1110	9.3
9	Ufa	30	1107	1.1
10	Krasnoyarsk	44	1067	21.4
11	Perm	24	1042	−0.8
12	Volgograd	22	1018	1.7
13	Voronezh	39	1014	13.3

Source Created by authors using data from Fund for assistance to reforming housing and communal services and Russian Federation Federal State Statistics Service (Reforma ZHKKH 2016 and Russian Federation Federal State Statistics Service 2016)

The most distinguishable centers (335,000–405,000 m^2 per 1 km^2) are found in Samara, Novosibirsk and Yekaterinburg. Mean values of the indicator (303,000–324,000 m^2 per 1 km^2) are characteristic of Rostov-on-Don, Chelyabinsk, Voronezh, and Nizhniy Novgorod. The lowest density of residential buildings (168,000–275,000 m^2 per 1 km^2) is typical for the central areas of Kazan[4], Omsk, Ufa, Krasnoyarsk, Perm, and Volgograd.

All the cities except for Omsk are characterized by one or more (Ufa, Chelyabinsk) density peaks at various distances from the city center (Table 2.2). In most cities, these peaks can be registered using the density profile of residential development in general, but it is more convenient for this purpose to use the density profile of residential development only within the residential areas. The additional peaks of density (density of residential development within a residential area of 150,000 m^2 per 1 km^2 and more) at the distance of 5–7 km from the city center are observed in Ufa, Krasnoyarsk, Yekaterinburg, Voronezh, Rostov-on-Don, Kazan, and Chelyabinsk. Additional density peaks at the distance of 9–11 km from the city center are characteristic of Chelyabinsk, Ufa, Samara, and Nizhny Novgorod. In

[4]For Kazan, it is reasonable to use the density at 1–2 km from the city center, as the center of the city is clearly distinguishable, but the area within the radius of 1 km around the center has low density of residential buildings due to a number of reasons.

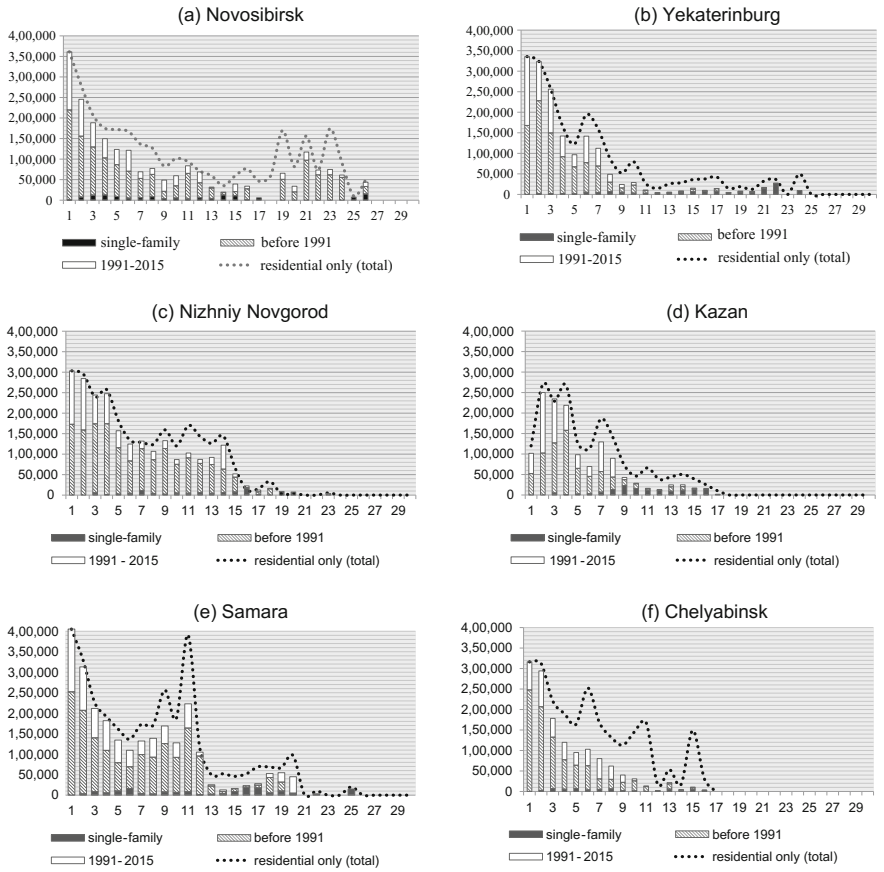

Fig. 2.4 **a–m** Residential housing density profiles of Russian cities [*Source* Created by authors using data from Fund for assistance to reforming housing and communal services (Reforma ZHKKH 2016)]

Perm and Chelyabinsk, additional peaks are located at the distance of 15–17 km from the city center. The presence of additional peaks at the largest distance from the city center (20–25 km) is typical of Volgograd and Novosibirsk. In such cities as Samara, Volgograd, and Ufa the density of residential buildings in residential areas within the peaks is comparable with the values of the corresponding figure in the central parts of the city.

The analysis of changes in density profiles has revealed that to varying degrees, the tendency of density growth in the central areas occurred in 1992–2015 in all the cities chosen for the study. The density of residential development within the radius of 1 km around the city center has increased by two and a half times in Kazan; by two times in Yekaterinburg; by more than one and a half times in Novosibirsk, Nizhny Novgorod, Ufa, Voronezh, and Samara; by 1.3–1.4 times in Omsk,

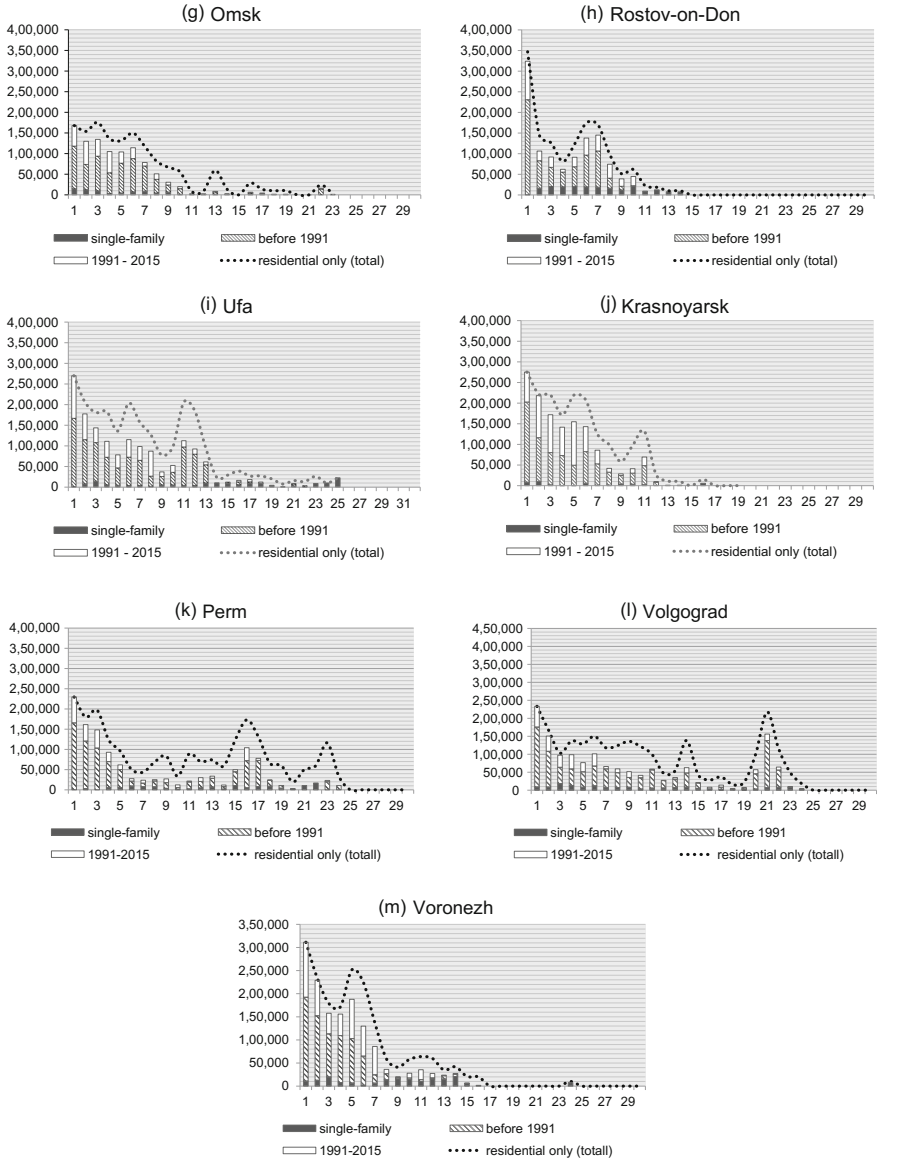

Fig. 2.4 (continued)

Rostov-on-Don, Perm, Krasnoyarsk, Chelyabinsk and Volgograd. Within the "*closest*" peaks in the cities, there is also a tendency of housing density increasing by 1.5–2 times. In some of the cities, the "*closest peaks*" appeared or became much more pronounced as a result of large-scale construction in the post-Soviet period

Table 2.2 Density peaks

City	Closest peak	Medium peak		Remote peak
Distance from the city center	5–7 km	9–11 km	15–17 km	20–25 km
Novosibirsk				+
Yekaterinburg	+			
Nizhniy Novgorod		+		
Kazan	+			
Samara		+		
Chelyabinsk	+	+	+	
Omsk				
Rostov-on-Don	+			
Ufa	+	+		
Krasnoyarsk	+			
Perm			+	
Volgograd				+
Voronezh	+			

Source Created by authors using data from Fund for assistance to reforming housing and communal services (Reforma ZHKKH 2016)

(for example, in Yekaterinburg and Voronezh). The "*medium*" and "*remote*" peaks have not seen such intensive growth of housing density.

Figure 2.5 shows the distribution of housing construction in the post-Soviet period in each city by zone at varying distances from the city center. As opposed to the general volume of housing construction, the share of the area of residential buildings in the studied cities within the radius of 3 km around the city center ranges from 15 % (Omsk, Krasnoyarsk) to 29 % (Perm). This kind of a zone is not leading in terms of the volume of housing construction in the post-Soviet period in any of the studied city. In some cities (Yekaterinburg, Nizhny Novgorod, Omsk,

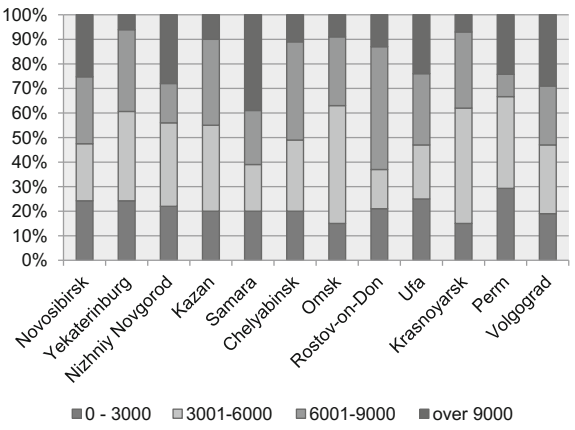

Fig. 2.5 Allocation of housing construction in the post-Soviet period by zone at the varying distances from the city center [*Source* Created by author using data from Fund for assistance to reforming housing and communal services (Reforma ZHKKH 2016)]

Krasnoyarsk, Perm), the largest volume of housing construction (34–48 %) is concentrated in the area of 3–6 km around the city center. In Novosibirsk, Kazan, Chelyabinsk, Rostov-on-Don and Ufa, the main volume of constructed housing (27–50 %) is situated in a zone of 6–9 km around the city center. Housing construction took place mainly at the distance of 9 km and farther from the city center in Samara (39 %) and Volgograd (29 %).

Thus, it is possible to discern two counterpoised trends. Both trends are illustrated by the example of the city of Yekaterinburg (Fig. 2.6).

The first trend shows that all the cities chosen for the study have seen an essential increase in housing density within their central areas. This trend prevailed in the early post-Soviet years, i.e. during the initial formation of the housing construction market.

The second trend is the continuation of the Soviet urban planning practice of the so-called integrated development of greenfield areas at the outskirts of cities (Kosareva et al. 2015). This trend prevailed during the housing construction boom induced by the high oil prices in the 2000s. The Russian model of the sprawl, contrary to its Western counterpart, is focused on dense multi-story development. In addition, development of new territories was only formally integrated: in fact, residential areas of the Soviet type were built with a minimal number of jobs nearby. Meeting the transportation demand in those areas (regardless of the level of motorization) is extremely difficult. Major housing construction projects in downtown areas are quite rare, but can still be found. Examples include the residential

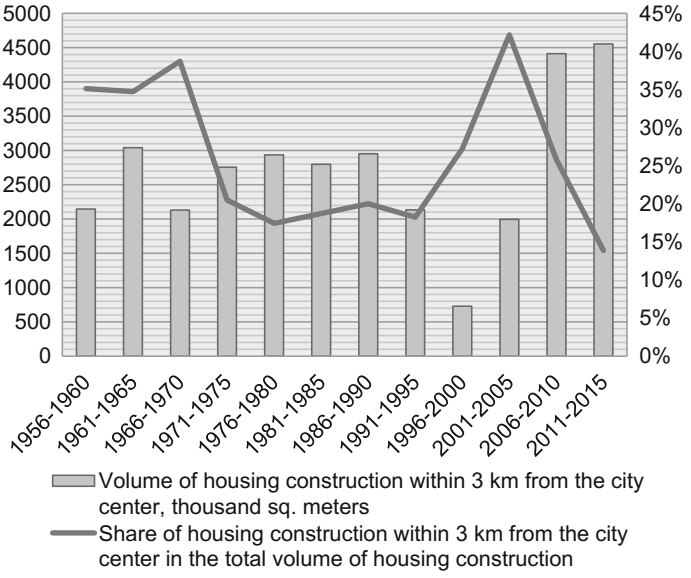

Fig. 2.6 The dynamics of housing construction in the central area of Yekaterinburg [*Source* Created by author using data from Fund for assistance to reforming housing and communal services (Reforma ZHKKH 2016)]

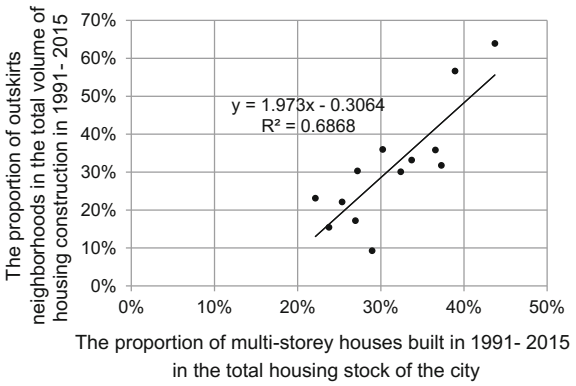

Fig. 2.7 The share of peripheral neighborhoods in the total volume of housing construction in the post-Soviet period [*Source* Created by authors using data from Fund for assistance to reforming housing and communal services (Reforma ZHKKH 2016)]

complex in Nizhny Novgorod (in the center of the city on the river Volga near the 2018 World Cup buildings) and new residential complexes in the district of New Savinovsky in Kazan (also in the city center and near the 2018 World Cup buildings, with the area of approximately 2000,000 m^2).

The share of the area of apartment houses built as part of the peripheral development of urban areas in the total amount of housing construction in various cities also confirms the notion that the large-scale construction in major Russian cities is associated with the sprawl. The biggest share of peripheral neighborhoods in the total volume of housing construction in the post-Soviet period is characteristic of the cities that have experienced the most significant growth of the housing stock (Fig. 2.7): Krasnoyarsk (64 %) and Voronezh (57 %). In some cities, the value of this indicator is significantly lower: Samara, 9 %, Perm, 15 %. In most cities, the value of the indicator is about 20–30 %.

The share of the total area of buildings constructed during the post-Soviet period within a walking distance (800 m) from subway stations in the cities where this transport mode is present amounts to 12–24 % (Fig. 2.8). The highest value (24 %) is registered in Novosibirsk where the subway network is moderately well-developed (2 lines, 16 km, 13 stations). In Nizhny Novgorod, which has a subway network comparable to that of Novosibirsk (2 lines, 19 km, 14 stations) the share of housing built in the post-Soviet period within the limits of normative accessibility is only 13 %. In Samara, Kazan, and Yekaterinburg there is only one subway line (10 stations in Samara and Kazan, 9 stations in Yekaterinburg). Among these cities, the leader in terms of the share of housing built in the post-Soviet period within a normative distance from subway stations is Yekaterinburg: 19 % versus 12 % in Kazan and Samara.

The proximity of the post-Soviet housing to tram stations varies greatly between the cities. In Samara, the share of the post-Soviet housing located within a walking distance from tram stops (400 m) is 60 %; in Krasnoyarsk, it is only 5 %. It should be noted that the factor of pedestrian access to subway stations has been and remains very important: in all these cities, subways operate with due frequency and capacity.

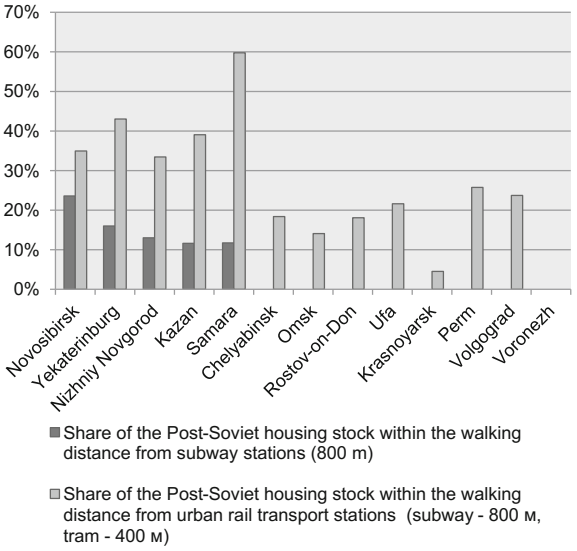

Fig. 2.8 The share of the total area of housing constructed during the post-Soviet period within a normative distance to subway and tram stations (*Source* Created by authors using data from Fund for assistance to reforming housing and communal services Reforma ZHKKH 2016)

At the same time, pedestrian access to tram lines is becoming an increasingly nominal factor: as shown in Chap. 3, tram lines in most Russian cities are currently in deep stagnation.

Another problem is providing transport services to the neighborhoods built on city outskirts. Usually the development of transport network is unable to catch up with housing construction in such areas: many of those, designed in the Soviet period, have been only recently provided with competitive public transport. Examples include the Botanicheskiy neighborhood in Yekaterinburg and the neighborhoods of Azino-1 and Azino-2 in Kazan.

The *Botanicheskiy* neighborhood is located in the southern part of Yekaterinburg at about 5 km from the city center. In fact, it is the last Soviet residential district in the city, as it was designed during the Soviet period: the development of the area became possible after the removal of the airport in 1985. The major part of the construction was carried out in the 1990s. The total area of residential buildings in the neighborhood is about 0.7 million square meters. The neighborhood is mainly built up with 10–16-story buildings. Jobs in the area are available only in the consumer services sector. Currently, the neighborhood is connected to the city center by the subway ("*Botanicheskaya*" station opened in 2011 but was designed back in the Soviet times). The part of the neighborhood that is most remote from the subway station is served by a tram line (no priority) connecting to the subway closer to the city center.

The neighborhoods of *Azino-1* and *Azino-2* are located to the east of the center of Kazan at a distance of about 8 km. The total area of residential buildings in these two neighborhoods is more than 2 million square meters. Similar to the *Botanicheskiy* neighborhood in Yekaterinburg, the development took place mainly in the 1990s. The area is located close to the Big Kazan Ring where light rail was

launched after reconstruction in 2012. It provides access to the center of the city and to the southern subway station "*Prospect Pobedy*" (built in 2008).

In the more recently constructed peripheral neighborhoods there is currently no public transport which is able to compete with a private car in terms of convenience for the residents. At the same time, these neighborhoods are being built according to the Soviet planning regulations, for the most part. The residents willing to commute to the city center and back in their private cars will have to make use of the substandard road network built in the 1960–1980s. Competitive alternatives to private transport simply do not exist in most of the cases. The examples of such neighborhoods are *Krutye Kluchi* in Samara and *Akademicheskiy* in Yekaterinburg.

The neighborhood of *Krutye Kluchi* is being built at 21 km north-east of Samara city center. The construction began in the early 2010s; the project is expected to be completed by 2025. It is planned to build 5 million square meters of housing. Transport services in the area are currently provided by municipal buses and private bus operators with high frequency (with intervals less than 5 min) but without dedicated lanes.

The neighborhood of *Akademicheskiy* located at 7 km south-west of Yekaterinburg city center. The construction in the area began in the late 2000s, it is planned to build 9 million square meters of residential real estate and 4.2 million square meters of office and commercial real estate. The transport situation in the area today is similar to the situation in *Krutye Kluchi*. The construction of the planned tram line is using extra-budgetary sources, but the issue is not yet settled. In general, the involvement of developers and owners of commercial properties in the financing of public transport projects in Russia is extremely rare and limited to just a few cases.

Thus, in the spatial development of large Russian cities during the post-Soviet period, two key ambivalent trends can be indicated. On the one hand, there is a considerable density increase of residential development in downtown areas as well as in the areas properly served by public transport; on the other hand, extensive high-density development continues in suburban areas. These trends are evident in each individual city: it is possible to find positive examples of efficient land use in the urban centers characterized by high levels of transportation services and cases of large-scale greenfield development anywhere. The two trends in question are also characteristic of Russian capital cities, Moscow and St. Petersburg, which are not included in our study.

The first trend is a direct result of the transition to land and real estate market and is a very positive factor in terms of providing transportation services and reducing the need for travel. Many cities have public transport systems of quite a good quality in their centers, either inherited from the Soviet period and subsequently expanded or developed in the post-Soviet years. The development of the areas served by public transport can improve economic sustainability of public transport operators and help prevent the growth of car use. In the cities where, for some reasons, public transport systems have been underdeveloped for some time, the trend for density increase will significantly simplify the task of providing transportation services in the future.

The second trend, on the other hand, has a negative impact on transportation services. Only in rare cases cities manage to keep pace with housing construction and provide new areas with public transport of reasonable speed and capacity. New neighborhoods are served by bus operators at regular routes and schedules or by "jitneys". In both cases, the buses move in the general flow of vehicles, that is, have ROW-C.

The commuters—the residents of new neighborhoods—are usually private car owners, often in the first generation. It is very difficult to persuade them to use even high quality modes of public transport, and they are unlikely to opt for a bus route with ROW-C.

These circumstances lead to extensive use of private cars as means of commuting and, accordingly, to the further growth of private car ownership, including the addition of a second or third car in a household. Meanwhile, the new neighborhoods continue being unsuited for this kind of a situation. There is a chronic shortage of parking spaces as well as the obvious inconsistency between the adjacent road network capacity and the demand for it, triggered by widespread motorization.

Mass housing construction in remote areas is often combined with inefficient land use within the urban core which is properly served by public transport. An example is the *Ametevo* neighborhood in Kazan, located in close proximity to the subway station built in 2005. Here, despite the availability of transport resources sufficient for transit-oriented development, the low-density individual buildings constructed 40 or more years ago continue to prevail. The more typical examples of ineffective land use are disused industrial zones located in the intermediate areas of many Russian cities.

The described negative trends can be explained, in the first place, by the low quality of land use regulation, characteristic of the majority of Russian cities.

Currently, the governing territorial planning documents in a typical city include a "*general plan*" (the analogue of a master plan) as well as land use and development rules (zoning regulations). The quality of these documents and, moreover, the integrity of their enforcement have been fairly low throughout the post-Soviet period.

Moreover, huge parts of urban land remain the municipal property. As might be expected, the abolition of the planned economy and of the state monopoly on urban development did not immediately result in the creation of a fully-fledged land market. The administration received the right to grant land to private investors and developers and accept money and other sorts of compensation such as the construction of apartment buildings in return (Trutnev 2011). This kind of a situation increases a municipality's interest in the development of new territories. A similar problem can be observed in Chinese cities where land resources are also concentrated in the hands of municipalities. The cities of Central and Eastern Europe also experienced difficulties in formulating a clear policy of spatial development in the context of choosing between the development of peripheral areas in response to the demand for new construction and the need to make urban core denser (Bertaud 2004).

In Russian cities, things are being made worse by factors such as monocentricity and low residential mobility. With the increase of the share of the service sector in the economy, the employment is naturally concentrated in urban cores, which is evident in all Russian cities. On the other hand, the level of residential mobility remains very low, which does not allow citizens to optimize their transport needs by changing their place of residence. According to the estimates based on the level of prices and mortgage lending rates, in 2014, only 30 % of the Russian population had the opportunity to purchase an apartment or a house, and even that is the highest figure in a decade. In the first quarter of 2015, due to the decrease in income and increase in bank interest rates, the value fell to 24.7 % (Kosareva et al. 2015).

2.4 The Impact of Urban Spatial Structure on Travel Behavior (the Case of Moscow)

It is interesting to analyze the travel behavior in a post-socialist city, in areas with different levels of public transport availability. Our analysis is based on the data from surveys conducted in 2013 and 2015 by the Moscow Institute for Social and Cultural Programmes (Moscow Institute for Social and Cultural Programmes 2016). The study covers seven aspects of urban life, one of which is transport, and covers all the 146 districts of Moscow.

In 2015, the following questions were included in the group of questions concerning the transport sector:

1. Which of the following problems in your district are most critical to you?
   (a) poor thoroughfare situation (poor quality of roads, traffic jams)
   (b) public transport does not operate properly (few routes, overcrowding, low frequency)
   (c) not enough parking spaces
2. How do you usually get to work/place of study?
   (a) by private operator bus (jitney)
   (b) by bus
   (c) by taxi
   (d) by subway
   (e) by private car
   (f) by bicycle, scooter, roller skates
   (g) by tram
   (h) by trolleybus
   (i) on foot

   Each respondent could choose more than one answer.

The results of the study present, in particular, the information on the distribution of respondents in each district based on the selected answers and, accordingly, on the modal split. This data can be used for aggregated analysis of the relationship between the transport behavior and a spatial structure and the urban features of an area.

The share of residents who use subway was chosen as a typical indicator of travel behavior. In order to describe the spatial structure of a region the following factors were chosen: the physical distance from the district to the city center (Red Square) and the weighted average distance from the housing stock to subway stations. Increased distance from the city center greatly impacts the attractiveness of subway in comparison to other public transport modes; for short-distance travel, land transport is often more convenient because of the more frequent stop locations, while the low (compared to the subway) speed of the land transport is not critical. The weighted average distance from the housing stock in a neighborhood to the subway stations shows the ease of access to subway stations for the residents of each particular area. In order to calculate this indicator, the data published by State Corporation "*Fund for assistance to reforming housing and communal services*" (Reforma ZHKKH 2016) was used. The study includes the districts of Moscow within the Ring Road or adjacent to it as well as the areas that are not adjacent to the Ring Road but are served by the subway (Yuzhnoye Butovo). The analysis results show that the increase of the average distance to a subway station by 100 m reduces the proportion of residents using subway by 0.7 %. The increase of the distance from the city center by 1 km prompts the increase of the number of residents using the subway by 0.8 %.

Given the high (more than 400 cars per 1000 inhabitants) motorization rate in Moscow and referring to the foreign research data (Ewing and Cervero 2001), one would expect a very large (up to 25–30 percentage points) difference between the number of car trips by the residents of the districts with the largest and, respectively, the smallest distance from the housing stock to the subway stations. This hypothesis is also supported by the fact that the Muscovites are very critical of the land public transport quality of service: according to the same survey, the residents of the districts served exclusively by land public transport are more likely to be worried by drawbacks of public transport such as low density of the route network, low frequency, and overcrowding. However, the analysis of empirical data on the modal split for the residents of the districts located between the Third Ring Road and the Moscow Ring Road has clearly illustrated that the hypothesis is not entirely correct.

Figure 2.9 shows the popularity of various transport modes among the inhabitants of the districts located between the Third Ring Road and the Moscow Ring Road with the maximum and minimum average distance from the housing stock to the subway stations.

Table 2.3 presents the average values of modal split for two typologically different sets of neighborhoods. The sum of all modal shares exceeds 100 % because of the accounting for multimodal trips.

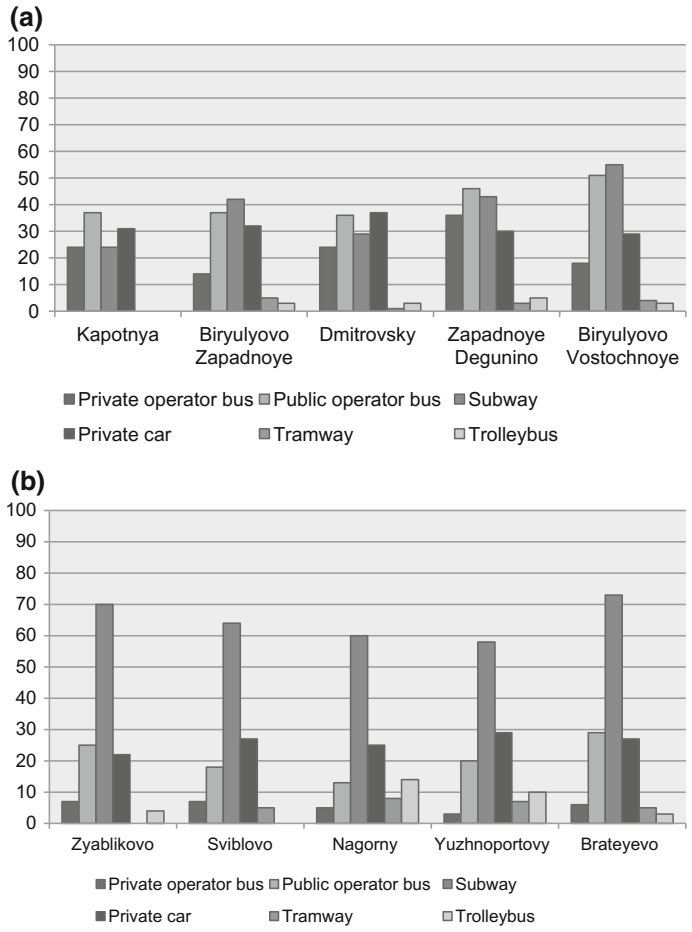

Fig. 2.9 The popularity of various transport modes among the inhabitants of the districts between the Third Ring Road and the Moscow Ring Road with (**a**) minimum average distance from the housing stock to the subway stations (**b**) maximum average distance from the housing stock to the subway stations (*Source* Created by authors using data from Moscow Institute for Social and Cultural Programmes 2016)

Thus, the residents of the neighborhoods not served by subway are more likely to use land public transport than private cars instead of subway (or in addition to it). This situation can be explained by the comparative analysis of modal split and motorization level of world cities.

Figure 2.10 presents the regression line based on a sample of 42 cities in the world and connecting between the motorization level and the share of car trips. Moscow's point on this graph is located substantially below the regression line, which means that the share of car trips in Moscow is significantly lower than in foreign cities with a similar level of motorization.

Table 2.3 Modal split in the neighborhoods located between the Third Ring Road and the Moscow Ring Road with minimum and maximum average distance from the housing stock to the subway stations

Neighborhoods by average housing stock distance from the subway stations	Modal Split		
	Subway (%)	Private car (%)	Land transport (%)
Minimum average distance	58–73	22–27	30–40
Maximum average distance	24–55	29–37	61–89

Source Created by author using data from (Moscow Institute for Social and Cultural Programmes 2016)

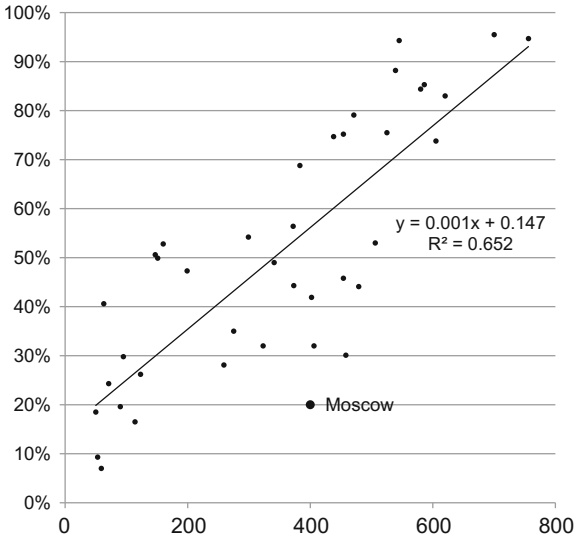

Fig. 2.10 The nominal level of car ownership and the share of car trips [*Source* Created by author using data from Institute for Mobility Research (2013)]

The cause of this phenomenon is likely to be explained by the extremely low area ratio of road network for one car, which is typical for Russian cities. In order to clarify the merits of the case, we have used the formula introduced above:

$$s_v = 10^7 * \frac{\varepsilon}{d * m}$$

This will help us to see that the real impact on the modal split is not produced by the nominal level of car ownership per se but rather by an adjusted value based on the parameter s_v.

For this purpose, we introduce a new indicator—"*real*" motorization level:

$$m_{real} = 10^7 * \frac{\varepsilon}{d * sr}$$

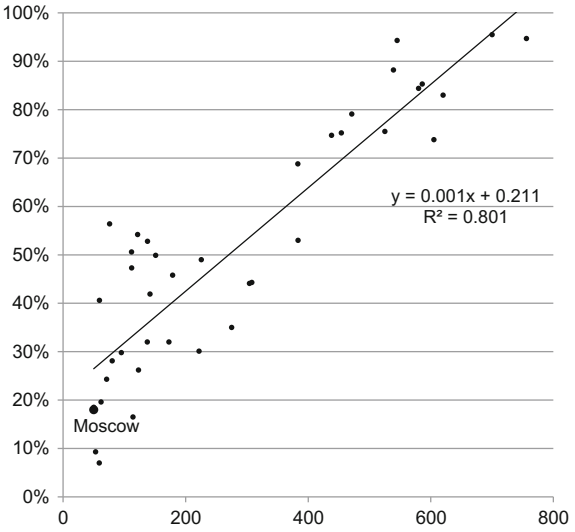

Fig. 2.11 The level of "real" car ownership and the share of car trips [*Source* Created by author using data from Institute for Mobility Research (2013)]

where *sr* is the road area, which maximizes the correlation of m_{real} with the share of car trips. In fact, m_{real} shows the number of cars (per 1000 inhabitants), which can be used on a daily basis, considering the actual values of population density and the road network development in the city.

The calculation shows that *sr* is about 200 m^2, and certainly, when switching from the nominal motorization level (m) to the real motorization level (m_{real}) the regression line becomes more valid ($R^2 = 0.801$ against $R^2 = 0.662$ in the previous case), and Moscow's point moves closer to the trend line (Fig. 2.11).

These results can explain the patterns of travel behavior in the neighborhoods not served by subway, presented above. Each car owner living in such district would probably use his or her private car for commuting. However, the road network deficit makes this choice either irrational in terms of generalized cost or physically impossible.

2.5 Conclusion

The main features of the spatial development of Russian cities by the beginning of the 1990s were as follows: (1) the W-shaped height and density configuration comprised of a high dense city center and peripheral territories and low-dense industrial areas in the intermediate zone; (2) extremely low share of built-up area used for transport network. During the post-Soviet period, there have been two key ambivalent trends in the spatial development of large Russian cities. On the one hand, there has been a considerable density increase of residential development in downtown areas and in the areas properly served by public transport; on the other

hand, there is a continuation of extensive high-density development in suburban areas. A combination of factors such as the high-density development of peripheral areas, the low share of built-up area used for urban road network, and high (and growing) motorization rate have led to a very specific variety of the traditional "clash of cities and cars": private cars are increasingly becoming a part of urban landscape rather than merely serving as vehicles for everyday use. Cars continue to occupy ever more space within the residential areas, but are used for commuting to a very limited degree.

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