
SOCIAL DEVELOPMENT IN THE BALTIC SEA REGION

SPATIAL STRUCTURE AND THE DEVELOPMENT OF SETTLEMENTS IN THE SAINT PETERSBURG AGGLOMERATION

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This article explores the spatial structure and development of settlements comprising the Saint Petersburg agglomeration. Previous studies and database sources, which were never used before (the Federal Tax Service [FTS] database and SPARK-Interfax), are analysed to reveal factors in the economic development of metropolitan areas as well as to understand how settlements develop in Russia's second-largest city agglomeration. The borders and composition of the Saint Petersburg agglomeration are brought up to date. Examining the population size of the settlements helps locate the 'growth belt' of the agglomeration. Lists of major enterprises of the city and the region make it possible to identify patterns in the economic development of the study area. The SPARK-Interfax database aids in clarifying relationships between spatial elements of the agglomeration (its core and satellites) in the distribution of revenues of economic agents. Data on the location of the largest retail stores — shopping malls and hypermarkets — are used to identify the main centres of commerce in the Saint Petersburg agglomeration. A map chart has been drawn using 2GIS and Yandex Maps geoinformation services. An important step in agglomeration analysis is the identification of residential development hotspots. FTS data on property tax base are the main source of relevant information. FTS reports contain data on the number of residential buildings and units covered by the database. Further, FTS statistics is employed to trace income and job distribution across the study area. The current functions of settlement in the Saint Petersburg agglomeration have been determined. According to the findings, the spatial structure of the agglomeration has three groups of 'backbone centres'. The agglomeration includes a core, a population growth area ('growth belt'), commuting sources and recipients, and 'backbone centres'.

Keywords:

Saint Petersburg agglomeration, city, spatial structure, backbone centres, economic security

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Previous research and problem statement

This study is devoted to assessing the role and place of urban settlements in the settlement system of the second largest urban agglomeration in Russia — the St. Petersburg agglomeration. Its determinant features include monocentrism in the spatial structure, seaside and ‘metropolitan’ position, ‘loose’ transport structure, rudiments of Soviet industrialization as the basis for the formation of large urban settlements, the expansion of suburbia due to multi-storey housing areas and cottage settlements, new industrialization in the 2000s due to the rapid influx of foreign investment.

Two concepts lie in the foundation of this research, *economic security* and *self-development of settlements*. And while the former is described in sufficient detail [1–2], the latter is a more vague and indefinite term. Self-development is often understood as development primarily through internal resources [3–6]. Some researchers^{1,2} consider the issues of self-development in a broader spatial aspect in the context of self-organisation, self-sufficiency, self-realization [7]. In regional economy, *self-development* at the regional level [8–9] is linked to the ability of the region to ensure expanded reproduction with its own income sources, to the achievement of a stable state of the economy and its structural elements.

Within systemic approach, self-development of a municipality is seen as the fullest possible use of mainly local, but also external resources in order to create favorable living conditions for the population of a given territory in short- and long-term periods [10–11].

Under self-development of urban settlements within the framework of an agglomeration, we understand such socio-economic development that leads to the full use of internal and external resources in order to create favorable living conditions for a population, taking place in the circumstances of steady population growth, based on the multi-sectoral structure of the economy and several backbone enterprises.

Urban agglomerations are a very long-living research topic. It is believed that the term *agglomeration* was first used by the French geographer Rouget (1973) in the following meaning: “A group of suburbs merged with a main city or several small cities merged.” The author believed that an agglomeration occurs when “the concentration of urban activities goes beyond the administrative boundaries and spreads to neighboring settlements” [12].

¹ China’s Population and Development in the 21st Century, 2020, China.Org.Cn, available at: <http://www.china.org.cn/e-white/21st/index.htm> (accessed 20.04.2020).

² Lorenzo, G.B. 2011, *Development and Development Paradigms. A (Reasoned) Review of Prevailing Visions*, available at: <http://www.fao.org/3/a-ap255e.pdf> (accessed 02.04.2020).

In the 1970s and 1980s, when the concept of agglomeration was firmly entrenched in the scientific world, a number of studies gave a definition of urban agglomeration. In 1987, Lappo wrote that an agglomeration is “a compact territorial grouping of urban and rural settlements, united into a complex dynamic local system by diverse intensive connections — communal-economic, labour, cultural and household, recreational, as well as the joint use of this area and its resources” [14].

Basically, most of researchers identify the same elements of an urban agglomeration: the city-centre, its zones of influence (most often there are three: near, middle and distant), satellite settlements, various connections of settlements within the agglomeration with the city-centre. Similarities in the development of the settlement system in socialist countries and countries of “free entrepreneurship” were noted by the French scientist Beaujeu-Garnier [15]. This indicates that agglomeration is an objective process.

Territorial growth and rising power of cities made researchers pay more attention to the functional and spatial urban structure. In the context of suburbanization phenomenon, the suburbs of large cities got broader functions. The most common way to describe the spatial structure of an urban agglomeration is to divide the territory into belts, depending on the distance from the centre. This concept became so widespread in Russia that it formed the basis for a number of strategic planning documents, for example, The Concept of Socio-Economic Development of the Leningrad Region for the period up to 2025 [17]. The approach is based on the identification of the agglomeration core, which has high building and population density, concentrating significant or even prevailing share of jobs, service organisations, cultural and leisure institutions of the agglomeration. Several belts around the core can be detected (usually two or three), the inhabitants of which have the opportunity to regularly visit the core for labour or recreational purposes. Researchers believe that 75—80% of regular commutations are locked within these boundaries [18].

For a long time, suburbs of large cities performed mainly housing and recreational functions. However, in the 1970s and 1980s suburbanization affected office, business, research and production activities [19]. It soon became apparent that suburban areas (satellite metropolitan area) were taking on more and more functions that had previously been inherent to the city centres. Centres of trade, business activity, research institutions and industrial enterprises moved to the periphery of agglomerations. This led to the decline of traditionally powerful central business districts of large cities. Similar processes of unloading agglomeration centres and shifting some functions to the outskirts were observed for the post-Soviet spaces [16, 20]³. At present, the development of agglomerations is

³ Housing market and settlement patterns in the Moscow region, 2020, *Demoscope*, available at: <http://www.demoscope.ru/weekly/2006/0247/tema06.php> (accessed 12.03.2020).

transitioning from suburbanization to post-suburbanization, with suburbs (satellite zones) increasing their functional diversity [19]. All this has set a new task for researchers: to characterize the territorial-functional structure of urban agglomerations.

In the early 1990s, the American scientist and journalist Joel Garreau introduced the concept of an *edge city*. Garreau described his idea in his 1991 book, *Edge City: Life on the New Frontier*. Edge cities are located on the periphery of urban agglomerations and provide for the neighboring residents some functions of the core, which the former cannot regularly reach. The author considered the emergence and development of such edge cities to be a symbol of a new stage in urbanization.

Soviet researchers also paid attention to the development of large local centres within urban agglomerations. In the early 1970s, when analyzing development trends of Moscow agglomeration, Lappo introduced the concept of *second-order agglomeration* [21]. Later, this concept was developed both in the works of Lappo himself and in those of Pertsik and Makhrova [22].

Second-order agglomerations are structural subdivisions of first-order agglomerations (main agglomerations). They are characterized by a developed system of functional connections both within the second-order area and with the core of the main agglomeration. Such agglomerations have their own centre (core), to which all other settlements gravitate, but at the same time the entire agglomeration of the second order acts as a satellite zone of the main agglomeration core.

The centre of second-order agglomeration should differ from the surrounding settlements by a high number and density of population, well-developed and stable functional structure, well-developed transport, industrial and engineering infrastructure. Pertsik and Makhrova believed that the population of second-order agglomeration centres should be at least 50 thousand inhabitants, and the boundaries of the agglomeration should correspond to a 1.5 hour isochron of transport accessibility [22].

Today new methods for studying spatial structure of agglomerations, and second-order centres in particular, have become widespread. The use of data on the movements of customers from mobile network operators provides researchers with many opportunities [37]. It is now possible not only to determine the boundaries of the largest Moscow agglomeration in Russia, but also to identify local centres of attraction on its territory that receive pendulum migrants from the surrounding territories [38; 39]. The role of such centres in the socio-economic development of agglomerations has not yet been fully determined, but research data once again confirms the presence of local *key centres* (*backbone centres*) in large urban agglomerations, which take on some functions of the original core.

It is no coincidence that in most of the classical works of Western researchers, centres of attraction (or centres of activity) are understood as territories characterized by high concentration of jobs [25]. One of the latest works by European researchers studying cities in France and the Netherlands [31] indicates that satellite cities or sub-centres are rapidly transforming from 'business-only' areas into multifunctional places with residential, office, commercial, industrial and storage areas.

Research methodology

This paper presents the results of a study of socio-economic development heterogeneity of the St. Petersburg agglomeration territory. The following indicators have been selected for the analysis: population size and its dynamics, number of backbone enterprises, revenue of enterprises, number of large retail facilities (shopping and entertainment centres and hypermarkets), housing construction, number of workplaces.

The databases of the Federal Tax Service and the SPARK-Interfax database, as well as regional lists of backbone organisations, have been used for this study. The SPARK-Interfax database has made it possible to show the share of spatial elements of agglomeration (the core and the satellite zone) in revenue distribution. Data from the geoinformation services 2GIS and Yandex. Maps has been used in schematic map of the largest retail facilities location: shopping and entertainment centres (SEC) and hypermarkets. Housing construction areas have been identified using data from the Federal Tax Service on property tax of individuals. In addition, with the help of the Federal Tax Service statistics the features of population income and workplaces distribution have been analysed.

Population dynamics analysis allows to identify municipalities with high rates of population growth, localized at the boundaries of an agglomeration core forming a "growth belt".

To study the features of pendulum migration the authors have used data on the number of jobs from the Federal Tax Service of the Russian Federation and data on the size of the population from the Federal State Statistics Service. Donors and recipients of pendulum migration were identified among the municipalities that make up the St. Petersburg agglomeration.

The allocation of agglomeration's key centres has been carried out taking into account all the indicators mentioned, including the calculated jobs to population ratio.

Composition and boundaries of the St. Petersburg agglomeration

St. Petersburg agglomeration is located on the territory of two federal subjects — the federal city of Saint Petersburg and the Leningrad region. As for the city of St. Petersburg, most researchers agree that its entire territory constitutes a part of the agglomeration; yet there are several approaches to defining agglomeration boundaries on the territory of Leningrad region.

A fundamental study on agglomeration boundaries was carried out during the preparation of the General Plan of St. Petersburg from 2002 to 2005, as well as in 2012 for The Concept of Socio-economic Development of the Leningrad Region for the Period until 2025 [17]. Another noteworthy study is that by Reznikov, published in 2017 [35].

For the purposes of this research, we believe that it is correct to consider the districts of the Leningrad region (Vyborgsky, Vsevolozhsky, Kirovsky, Tosnensky, Gatchinsky, Lomonosovsky) and Sosnovoborsky urban district adjacent to St. Petersburg as part of agglomeration; our approach being helpful for a number of reasons. Firstly, it allows access to a number of statistical indicators that are not available at the lower level of administrative division. Secondly, while some previous studies focused on individual types of public transportation (buses, suburban commuter rail), at the moment there is no study describing pendulum migration using all modes of transport between the satellite zone and the core of the agglomeration.

It is precisely the high share of pendulum migrants in the total number of those employed that makes it possible to classify the territory as an urban agglomeration. Without this indicator, it is impossible to unambiguously judge which parts of the Leningrad region adjacent to St. Petersburg are part of the agglomeration and which are not. In order to fully cover the potential territory of the St. Petersburg urban agglomeration, we consider it necessary to include the areas described above in their entirety.

Now, it is necessary to identify the agglomeration core on the territory of the federal city of Saint Petersburg. The federal city includes three types of municipalities: municipal districts, cities and settlements. All cities that are part of St. Petersburg can be considered independent satellite cities. All urban settlements are located on the periphery of St. Petersburg, within the Kurortny, Petrodvortsovy, Pushkinsky, Kolpinsky, Vyborgsky and Primorsky districts and have poor transport connection with the core. Therefore, within the framework of this study we propose to consider the aggregate of municipal districts of the federal city of St. Petersburg as the agglomeration core.

Some necessary indicators (data from the SPARK-Interfax database) are available only for the level of municipal districts of the Leningrad region and districts of St. Petersburg. When using such indicators, it is necessary to revise the composition of the agglomeration core and the satellite zone. Agglomeration boundaries in the Leningrad region will remain unchanged. In St. Petersburg, the core zone of agglomeration includes the territory of 13 municipal districts: Admiralteisky, Vasileostrovsky, Vyborgsky, Kalininsky, Kirovsky, Krasnogvardeisky, Krasnoselsky, Moskovsky, Nevsky, Petrogradsky, Primorsky, Frunzensky, and the Central district. At the same time, on the territory of Krasnoselsky district there is the city of Krasnoe Selo, which belongs to the satellite zone of agglomeration; on the territory of Primorsky district there is the settlement of Lisiy Nos; on the territory of Vyborg district — settlements of Pargolovo and Levashovo. Total population of these municipalities is 145 thousand inhabitants (7.3% of the satellite zone population). Unfortunately, these municipalities have to be counted as the core of agglomeration.

Thus, the agglomeration core includes 13 previously mentioned districts. The satellite zone consists of five districts of St. Petersburg (Kolpinsky, Kronstadtsky, Kurortny, Petrodvortsovy and Pushkinsky), six districts of the Leningrad region (Vyborgsky, Vsevolozhsky, Kirovsky, Tosnensky, Gatchinsky, Lomonosovsky), and one urban district of the Leningrad region — Sosnovoborsky.

Population dynamics of the agglomeration

In 2019, the total population of the area under consideration was 6.6 million people. The core is home to about 70% of the agglomeration's population. From 2010 to 2019, the population of the St. Petersburg agglomeration increased by 11.2% (660 thousand people). However, the growth had been uneven.

Population growth is mainly concentrated around the agglomeration core. The fastest growing territories are located close to St. Petersburg. For clarity, we can divide the municipalities into those that have grown by more than 11.2% (average population growth in the agglomeration), and those where the population has decreased or increased by less than 11.2%. Thus, we can identify a conditional 'growth belt'.

The population 'growth belt' is rather monolithic — it is a belt of municipalities around the agglomeration core (fig. 1). The total 'growth belt' population in 2019 was 997 thousand people (about half of the satellite zone population), having grown by 330 thousand (about a third) compared to 2010.

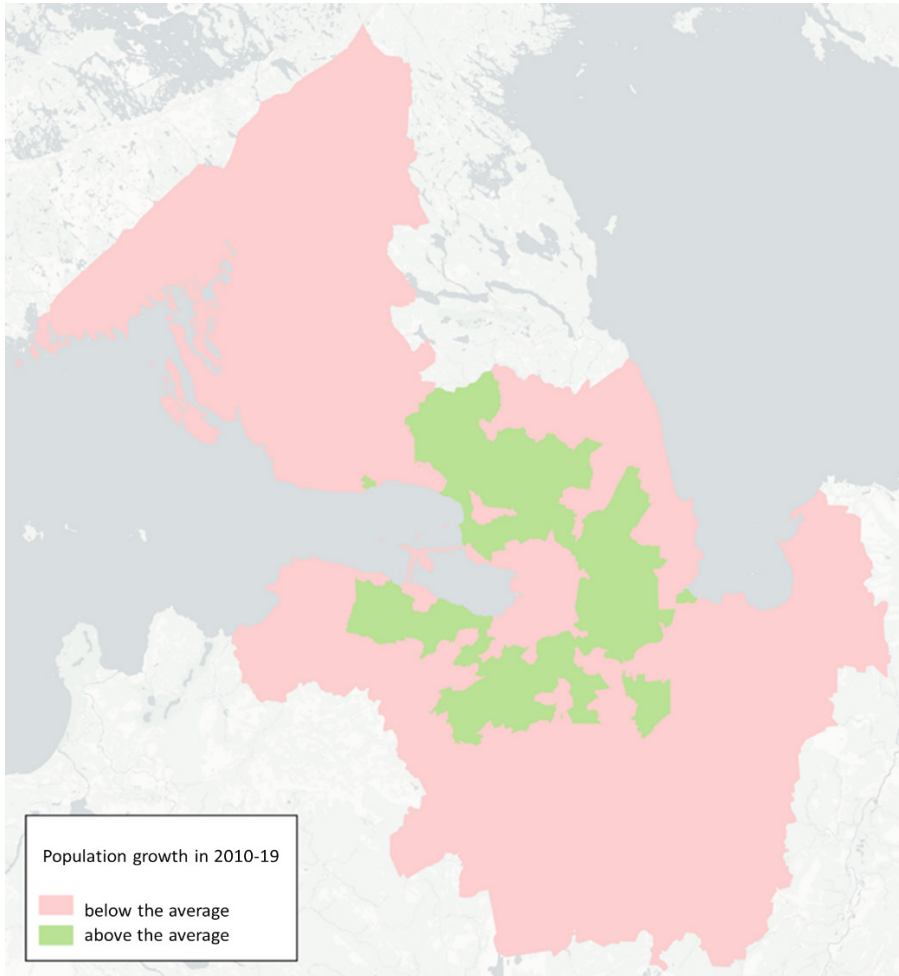


Fig. 1. Population ‘growth belt’ of the St. Petersburg agglomeration (compiled by the author using Municipal statistics database⁴)

Backbone enterprises of the agglomeration

In April 2020, the administration of St. Petersburg and the government of the Leningrad region compiled lists of ‘system-forming’ (*backbone*) enterprises. System-forming enterprises, according to the definition of regional authorities, are organisations of regional importance with a significant impact on the employment of the population and social stability in the region. 154 enterprises were classified as backbone in St. Petersburg⁵, and 79 in the Leningrad region.⁶

⁴ Municipal statistics database, 2020, Rosstat, available at: rosstat.gov.ru/storage/mediabank/munst.htm (accessed 02.05.2020).

⁵ List of Backbone Enterprises Defined, 2020, *St Petersburg Administration*, available at: www.gov.spb.ru/gov/admin/elin-ei/news/186855/ (accessed 08.05.2020).

⁶ List of Backbone Enterprises of the Leningrad region, 2020, *The government of the Leningrad region*, available at: lenobl.ru/ru/informaciya/perechen-sistemoobrazuyushih-organizacij-leningradskoj-oblasti/ (accessed 07.05.2020).

Consider the location of backbone enterprises of St. Petersburg and the Leningrad Region within the St. Petersburg agglomeration. Of all the organisations listed, 193 are located within the agglomeration. Of these, 129 are located within the agglomeration core. 64 organisations are located within the satellite area. They are unevenly distributed over the satellite zone, mostly near the agglomeration core (fig. 2). The largest number of such organisations can be found in the cities of Vsevolozhsk, Gatchina, Kolpino, Kommunar, Otradnoye, the settlement of Sverdlov and the settlement of Pargolovo.

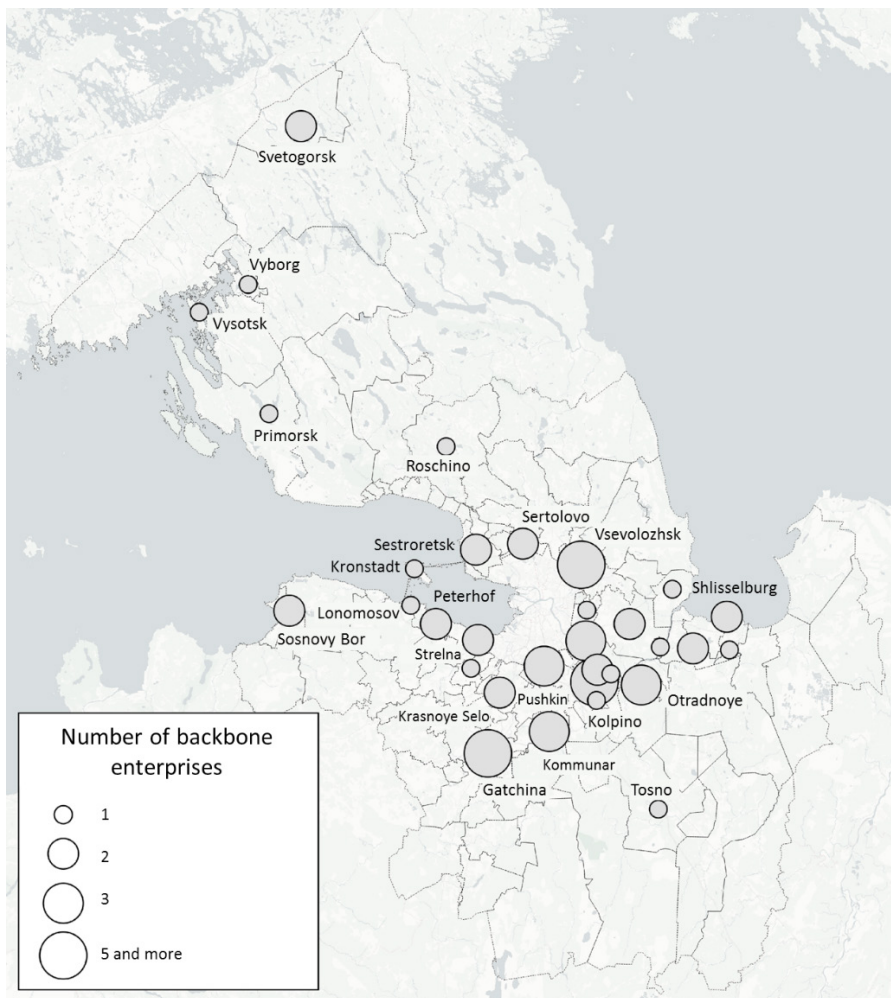


Fig. 2. Distribution of backbone enterprises of St. Petersburg and the Leningrad region over the St. Petersburg urban agglomeration satellite zone (compiled by the author⁷)

⁷ List of Backbone Enterprises, 2020, *St Petersburg Administration*, available at://www.gov.spb.ru/gov/admin/elin-ei/news/186855/ (accessed 08.05.2020).

List of Backbone Enterprises of the Leningrad region, 2020, *The government of the Leningrad region*, available at: lenobl.ru/ru/informaciya/perechen-sistemoobrazuyushih-organizacij-leningradskoj-oblasti/ (accessed 07.05.2020).

Most of economic indicators in the municipal statistics database are available only at district level. Therefore, it is the data of municipal districts and urban districts of the Leningrad Region and districts of St. Petersburg that has been used to characterize economic development. This level of detail only makes it possible to assess the differences between the agglomeration core and the satellite area, but not to describe the heterogeneity within the satellite area, as it has been done for the previous section.

The SPARK-Interfax database publishes its own statistics on the revenue of organisations. The data is available for the federal subjects of Russian Federation, as well as for municipal districts. Urban and rural settlements, as well as municipalities of St. Petersburg are not considered in this case. The boundaries of the core and the satellite zone when using such data turn out to be somewhat different, which is described in detail in the section Composition and Boundaries of the St. Petersburg Agglomeration.

In 2018, the total revenue of organisations in the St. Petersburg agglomeration amounted to 23.7 trillion roubles. According to SPARK, this constituted 10.6% of the total revenue of all organisations in Russia. The share of agglomeration core in organisations revenue was 90.2%. On average for the period from 2014 to 2018, the share was 90.1%.

Table 1

**Total revenue of organisations, billion roubles in 2018 prices
(according to the SPARK database)⁸**

Year	2014	2015	2016	2017	2018
Agglomeration total	22390,5	23582,3	23692,7	23398,1	23666,0
Core ¹	20235,7	21271,2	21265,7	21005,5	21338,6
Satellite zone	2154,8	2311,2	2427,0	2392,6	2327,5
Share of the core, %	90,4	90,2	89,8	89,8	90,2

Retail

Retail is an important component of urban economy. Moreover, large volume of retail space in the city can attract pendulum migrants from the suburbs to make purchases. In his concept of the *edge city*, Joel Garreau emphasized that such city should have a large volume of retail space and be a retail centre for the surrounding areas.

To identify the most important shopping areas in the St. Petersburg agglomeration, we have used data on the location of the largest retail facilities: shopping and entertainment centres (SEC) and hypermarkets.

Researchers note that such retail facilities have a wide service area with a radius of 10—15 kilometers (about half an hour transport accessibility) [36]. Settlements where such shopping facilities are located can be local points of attraction serving the needs of surrounding territories.

⁸ SPARK database, 2020, available at: www.spark-interfax.ru/ru/statistics (accessed 07.05.2020).

There are 104 hypermarkets and 63 shopping and entertainment centres in St. Petersburg urban agglomeration. Of these, 79 hypermarkets and 44 shopping centres are located in the agglomeration core, 25 hypermarkets and 19 shopping and entertainment centres are located in the satellite zone. Shopping facilities are concentrated in several cities (fig. 3). The major shopping locations are Vyborg, Gatchina, Vsevolozhsk, Kolpino, Krasnoe Selo, Peterhof, Zanevskoe and Bugrovskoe settlements and Pargolovo.

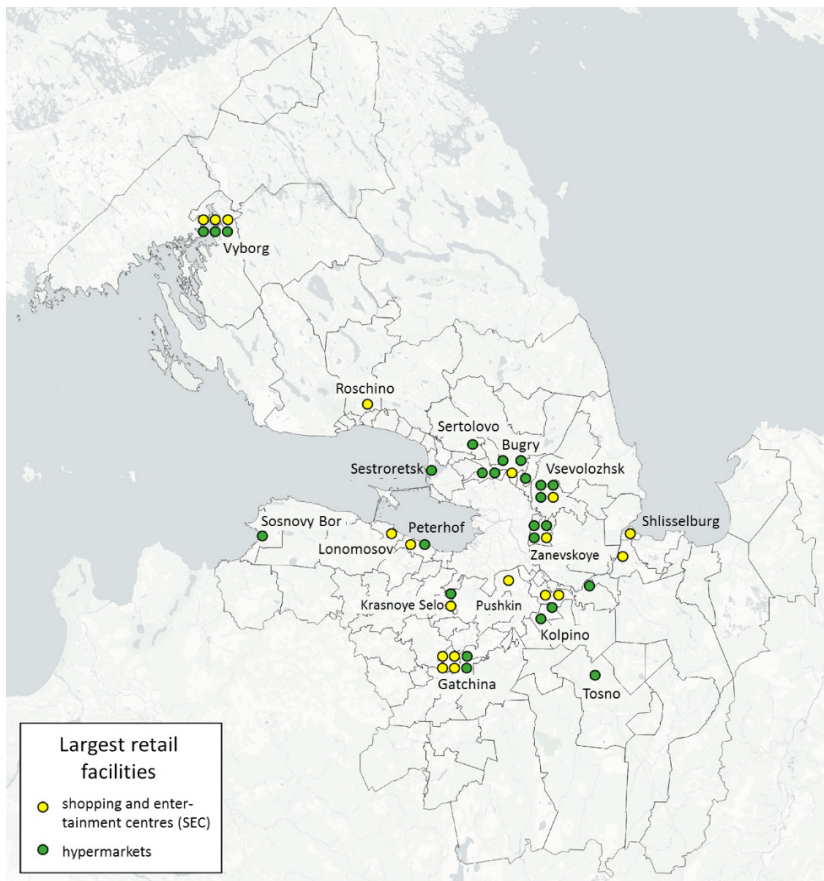


Fig. 3. The largest retail facilities in the St. Petersburg agglomeration (compiled using 2GIS and Yandex.Maps map services)

Housing construction

Another important indicator is housing construction in the agglomeration. The main source of information has been the Federal Tax Service data on the property tax of individuals. The Federal Tax Service reports provide data on the number of residential buildings and residential premises (apartments, rooms), their data is available for the period from 2015 to 2018.

In 2018, the share of the agglomeration core in residential buildings amounted to 71.4% in apartments and 2.6% in houses. In the period from 2015 to 2018, the share of the agglomeration core was decreasing, which points to more intensive housing construction in the satellite zone.

According to the Federal Tax Service, in the period from 2015 to 2018 the agglomeration core accounted for 46.7% of new housing. Since the share of the core in population of agglomeration is about 70%, it may be that significant part of new housing in the satellite zone was constructed for the residents of the core.

We have been able to determine the locations where housing construction exceeded the internal needs of municipalities. For this, the number of new residential properties (apartments, houses) built in the period from 2015 to 2018 has been divided by the average population of municipalities in the same period (fig. 4). For example, in Murinsky rural settlement and Zanevsky urban settlement there were built more than two housing objects per inhabitant.

High rates (from 0.5 to 1 object per inhabitant) are also typical for Vilozzsky, Ropsha, Penikovsky and Yukkovsky settlements located directly near the agglomeration, as well as for Trubnikoborsky settlement, which is located at a fairly large distance.

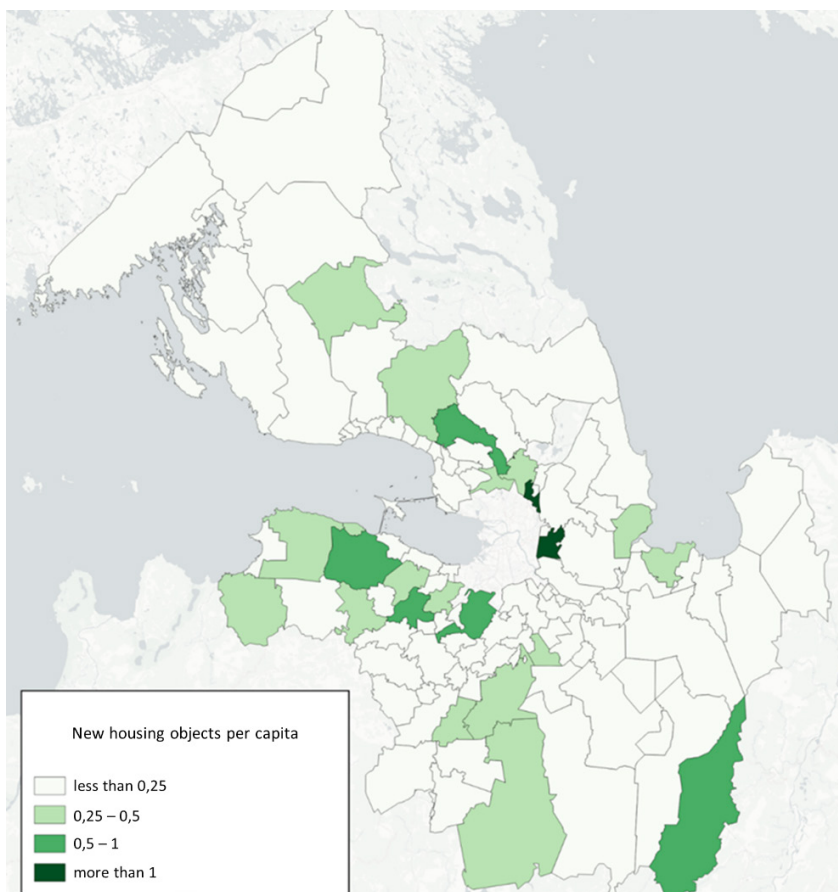


Fig. 4. Housing construction per capita in the period from 2015 to 2018 in the satellite zone municipalities of the St. Petersburg agglomeration (compiled by the author using data of the Federal Tax Service⁹ and Municipal statistics database¹⁰)

⁹ *Federal Tax Service (FTS)*, 2020, available at: <https://www.nalog.ru/rn78/> (accessed 25.05.2020).

¹⁰ *Municipal statistics database*, 2020, available at: rosstat.gov.ru/storage/mediabank/munst.htm (accessed 02.05.2020).

Population income and jobs

As mentioned above, data on the population income in Municipal statistics database is available only for municipal districts (in the Leningrad region), which makes it impossible to assess differences within the agglomeration at a lower level. There is also no information on the number of employees in the organisations in this database.

The Federal Tax Service provides data on the calculation and collection of personal income tax (PIT) on its official website. Data on the PIT base (actually the income of individuals) is available, broken down by “income codes” (sources of income, including salaries).

Within the framework of this study, the authors have used the data on the number of filed PIT declarations (number of *personal income files*) to substitute the missing data on the number of employees of organisations.

In 2018, 4.2 million personal income files were registered on the territory of the agglomeration (table 2). Of these, 3.3 million were in the core and 0.8 million in the satellite zone. If we assume that this indicator reflects the number of jobs and compare it to the Federal State Statistics Service data (according to which working age population of St. Petersburg is about 3 million) this estimate looks overstated.

Table 2

**Number of personal income files
in St. Petersburg agglomeration, thousand roubles¹¹**

Year	2012	2013	2014	2015	2016	2017	2018
Agglomeration total	4,280.0	4,298.9	4,214.8	4,075.3	4,054.6	4,129.8	4,155.7
Core	3,481.5	3,498.3	3,413.4	3,328.6	3,292.1	3,348.1	3,346.5
Sattelite zone	798.6	800.6	801.4	746.7	762.4	781.7	809.2
Share of the core, %	81.3	81.4	81.0	81.7	81.2	81.1	80.5

The number of personal income files in the satellite zone of agglomeration in 2018 amounted to 809.2 thousand. Compared to 2012, the number remained almost unchanged (798.6 thousand roubles). Thus, about 80% of personal income files, which we interpret as the number of jobs, is concentrated in the agglomeration core. On average, for 2014—2018, this share was 81.1%. This is significantly higher than the share of the core in population (averaged 70.7%) over the same period.

Another important indicator by the Federal Tax Service is the income of individuals (personal income tax base). In 2018, individuals’ income in the St. Petersburg agglomeration amounted to 2.1 trillion roubles. Of these, the core accounted for 1.8 trillion roubles, the satellite zone — 363 billion roubles. Thus, the share of the core in the income of individuals was 83.1%, which corresponds to the share

¹¹ Federal Tax Service (FTS), 2020, available at: <https://www.nalog.ru/rn78/> (accessed 25.05.2020).

of the core in the estimated number of jobs. On average, for the period from 2014 to 2018, the share of the core in the income of individuals was 83.1%. Compared to 2012, the amount of individuals income in the satellite zone had grown significantly: from 284.9 to 365.8 billion roubles (+28%).

Table 3

**Personal income tax base (income of individuals)
in the St. Petersburg agglomeration, billion roubles in 2018 prices¹²**

Year	2012	2013	2014	2015	2016	2017	2018
Agglomeration total	2068.5	2102.9	1978.6	1828.8	1972.7	2104.2	2141.8
Core	1783.6	1800.4	1655.4	1526.2	1634.4	1738.5	1779.0
Satellite zone	284.9	302.5	323.2	302.6	338.3	365.7	362.8
Share of the core	86.2%	85.6%	83.7%	83.5%	82.9%	82.6%	83.1%

Pendulum labour migration

There is no data on the number of jobs in municipalities in the Municipal statistics database. Instead, we can use the data of the Federal Tax Service on the personal income tax base. About 80% of jobs in the agglomeration are located in the core (while the share of the core in the agglomeration population is about 70%). It is obvious that part of the jobs in the core are occupied by pendulum migrants from the satellite zone.

The total number of jobs in the agglomeration is 4.1 million with 6.4 million inhabitants (0.65 jobs per inhabitant). According to the official data, there are about 60% of working-age population in the population of the St. Petersburg agglomeration. The ratio of the number of jobs to the population can vary significantly between municipalities. In most cases, this ratio is not higher than 0.5, but in some municipalities, it exceeds 1 job per capita. In the agglomeration core it is 0.74.

We have divided municipalities within the agglomeration into five groups (fig. 5). Two groups with a value of less than 0.5 jobs per capita (highlighted in shades of red) have been classified as *donors* of pendulum migrants (where residents perform commuting labour migrations to other municipalities). Two groups with a value of the indicator higher than in the core (more than 1 and 0.75-1 jobs per capita) and one with a value approximately equal to the core (0.5-0.75 jobs per capita) have been classified as *recipients* of pendulum migrants. This means that they provide jobs not only for their residents, but also attract labour migrants. These municipalities are highlighted in white and shades of blue on the map.

¹² Federal Tax Service (FTS), 2020, available at: <https://www.nalog.ru/rn78/> (accessed 25.05.2020)

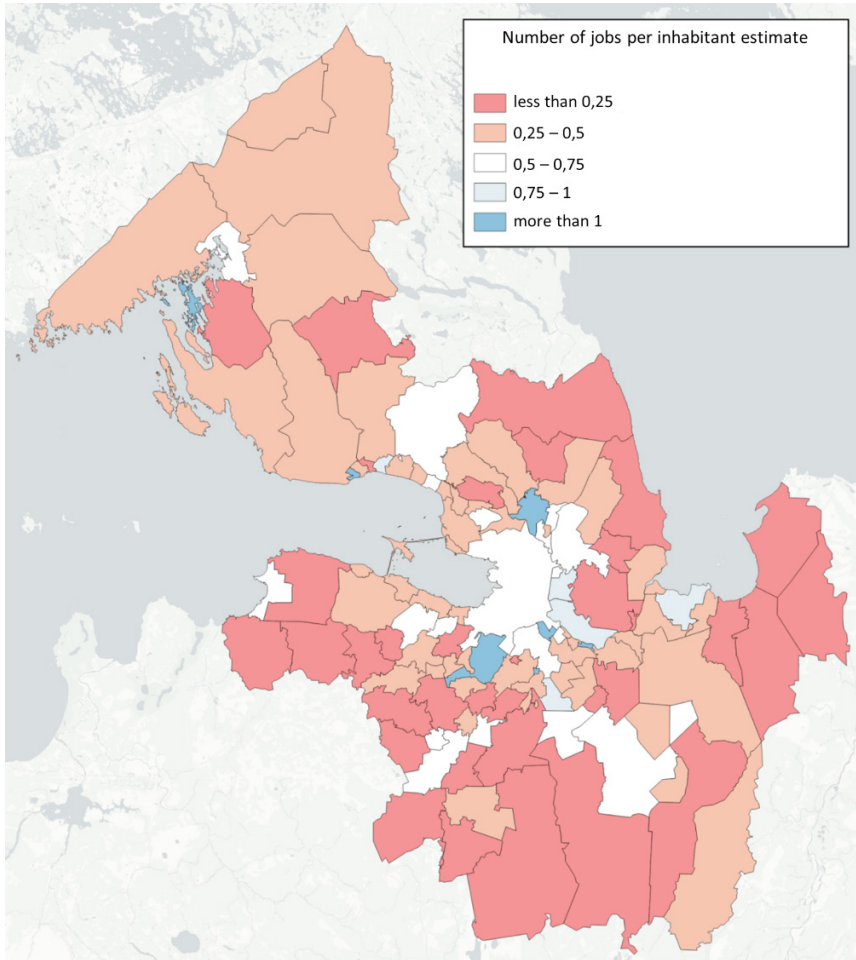


Fig. 5. The ratio of the number of personal income files to the population in the St.Petersburg agglomeration municipalities (compiled by the author using Federal Tax Service¹⁵ and Municipal statistics database¹⁴)

Thus, in addition to the core of the agglomeration, other municipalities with a total population of about 500 thousand people and 320 thousand jobs are possible recipients of pendulum migrants.

Key centres of the agglomeration

In the satellite zone of the agglomeration, there are several large cities with a number of central functions. They act as local centres for the surrounding areas meeting the needs of residents in workplaces, education, retail, medical services

¹⁵ Federal Tax Service (FTS), 2020, available at: <https://www.nalog.ru/rn78/> (accessed 25.05.2020).

¹⁴ Municipal statistics database, 2020, available at: rosstat.gov.ru/storage/mediabank/munst.htm (accessed 25.05.2020).

etc. These cities make it possible to bridge the gap in the level of development between the core and the satellite zone and take the load off the core. They can be considered as the key centres of agglomeration.

Researchers of agglomerations (Lappo, Makhrova, Pertsik and others) believed that the population of the second order centre of agglomerations should exceed 50 thousand inhabitants. To study key centres (potential second order centres of agglomerations), it would also be correct to define the minimum population size.

Making allowances for the smaller population of the St. Petersburg agglomeration in comparison with the Moscow one, as well as for a smaller number of large cities, we suggest that the size of key centres should be at least 40 thousand inhabitants (table 4).

Zanevskoe and Murinskoe settlements, as well as Pargolovo and Shushary deserve special attention. These municipalities are located on the borders of the agglomeration core. They are engaged in large-scale housing construction, mainly for residents of the core, but they do not have a developed economy or social infrastructure. At present, they cannot claim the status of key centres of the agglomeration.

Another group includes the cities of Pushkin, Peterhof, Krasnoe Selo, Sertolovo, Kronstadt and Lomonosov. These can be characterized as comfortable 'sleeping' satellite cities for life. They have well-developed social and service sectors, but a weak economic base, which forces most of the population to pendulum labour migrations. Usually people settle here for 'peace and quiet', ready to make daily commute to the core of the agglomeration for the sake of a comfortable life in a small city.

These cities can be considered key centres of agglomeration as local centres of education, retail and social services, but they do not attract a large number of labour migrants. Probably their 'daytime' population is smaller than the 'night-time' one.

The next group includes the cities of Kolpino, Gatchina and Sestroretsk. These have a well-developed economic base (2–5 backbone enterprises), they are centres of education, retail and healthcare. They have the potential to attract a large number of pendulum labour migrants. At the same time, the ratio of the number of jobs to the population here does not reach the average level (0.3–0.5). Probably, these are the cities with the mixed type of pendulum migration, being both donors and recipients. They are located close to the core, and local residents regularly commute to the centre. At the same time, pendulum migrants from the surrounding territories can come to the city for labour, educational, medical and retail purposes. Some researchers call this phenomenon "replacement migration". These cities are in close interaction with both the core and surrounding territories and can be considered as key centres of agglomeration.

Table 4

**Main characteristics of the largest cities and municipalities
in the St. Petersburg agglomeration satellite zone**

Area	Population, thousand people (2019)	Ratio of workplaces to population size	Number of backbone enterprises ¹²	Number of retail facilities ¹³	New housing (objects per capita in 2015–18)
Kolpino	148	0.34	5	3	0.02
Pushkin	111.2	0.45	0	0	0.04
Gatchina	93.7	0.49	5	6	0.03
Vyborg	76.4	0.59	1	6	0.04
Peterhof	85.2	0.35	2	2	0.04
Vsevolozhsk	74.5	0.65	6	4	0.08
Sosnovy Bor	68.3	0.58	2	1	0.06
Shushary	85	0.53	3	1	0.2
Krasnoye Selo	58.1	0.26	0	2	0.02
Sertolovo	55	0.22	0	1	0.1
Murinskoe	49.7	0.51	0	0	2.5
Tosno	42.5	0.51	1	1	0.04
Kronstadt	44.3	0.36	1	0	0.01
Zanevskoe	43.1	0.90	1	4	2.1
Pargolovo	67.5	0.36	2	2	0.3
Lomonosov	43	0.29	1	1	0.01
Sestroretsk	42.2	0.48	2	1	0.07

The last group is formed by the cities of Vyborg, Vsevolozhsk, Sosnovy Bor, Tosno. They have a well-developed economic base, are centres of retail, education and healthcare. The ratio of jobs to population is at the average level or exceeds it (0.5–0.7). Vyborg, Sosnovy Bor and Tosno are located at a fairly large distance from the agglomeration core. So they can serve as a local core for the neighboring residents, for whom the road to St. Petersburg takes too much time. These cities can be considered as full-fledged key centres of the agglomeration, providing “central” functions to residents of the surrounding territories, being local centres of industry, trade, healthcare and education.

Thus, the key centres of agglomeration can be divided into three groups (fig. 6):

— **Key centres of the first type.** Comfortable livable cities near the core of agglomeration. These cities have close ties with the core, relatively low number of jobs and active pendulum labour migration. At the same time, they have well-developed social and service sectors and potentially can serve as local cores for the surrounding territories as centres of retail, education and healthcare.

— **Key centres of the second type.** Cities with relatively large number of enterprises and jobs, well-developed service, social and commercial spheres. These

cities have close ties to the core. Residents are engaged in pendulum labour migration to the core while replaced by commuters from the neighboring areas. Potentially, these can serve as local cores for the surrounding territories — as business centres (commuting for labour purposes), centres of retail, education and medical services.

— **Key centres of the third type.** Mature local agglomeration cores. These cities have lower intensity of connections with the main core compared to the previous two types. They have a large number of jobs, where both local residents and pendulum migrants from the neighboring areas work. Retail, service and social sectors are well-developed. Potentially they can serve as important business centres, centres of retail, education and medical services for the surrounding areas.

Spatial structure of the agglomeration

Based on all of the above, several spatial structure elements of the St. Petersburg agglomeration can be distinguished (fig. 6).

1. The core and the satellite zone. The all-round dominance of the core has been revealed. Its share in the population is about 70%, in the number of jobs — 80%, in the income of individuals — 83%, in the revenue of organisations — more than 90%.

2. Population ‘growth belt’. Despite the dominance of the core at present time (in the 2010s) we have detected outpacing population growth in the territories of satellite zone bordering the agglomeration core. The share of the satellite zone in the population is constantly increasing mostly due to these core-adjacent areas.

3. Donors and recipients of pendulum labour migration. Various authors and public authorities (e.g., the Labour Committee) have repeatedly announced the large volumes of pendulum labour migration to St. Petersburg from the satellite zone of the agglomeration. This study has not only proven that the core is a recipient of pendulum migrants, but also identified donor municipalities for pendulum migration.

4. Key centres of agglomeration. Potentially, they can be local second-order cores for the surrounding territories. They provide a greater degree of core-functions accessibility for residents and more even development of the agglomeration.

It should be especially noted that in order to confirm or deny the status of key centres and the reliability of our dividing municipalities into donors and recipients of pendulum migrants, it is necessary to conduct additional research on migration flows.

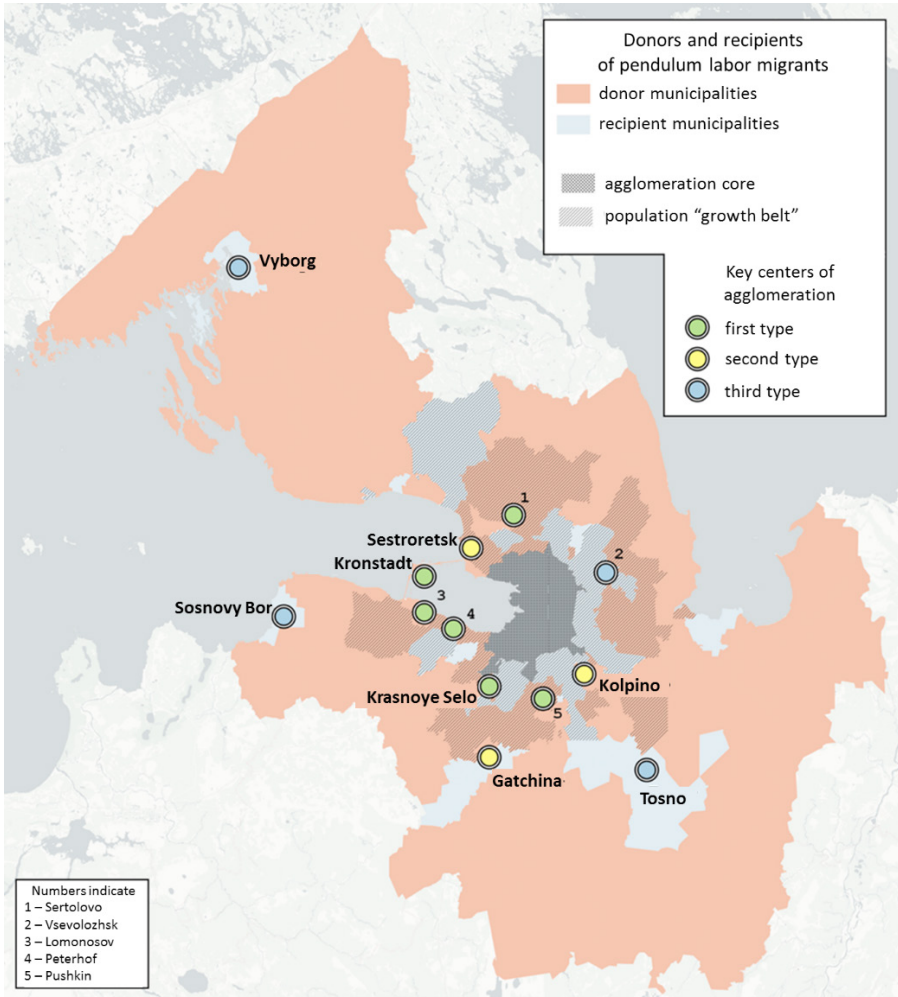


Fig. 6. Spatial structure of the St. Petersburg agglomeration

Results and conclusions

New approaches to studying spatial structure of the St. Petersburg agglomeration have been developed and tested for the purposes of this research. As a result, strong imbalances in the development of the agglomeration core and the satellite zone have been revealed, as well as the peculiarities of the satellite zone spatial development. The main elements of the agglomeration spatial structure have been highlighted: the core and the satellite zone, the conditional population "growth belt", donor and recipient territories of pendulum labour migrants. Since we used only publicly available data in our research, we believe our approach can be replicated to study any other metropolitan area in Russia.

At present, the development of St. Petersburg agglomeration is uneven. The congested agglomeration centre cannot accommodate new residents, which leads to a rapid population growth in the contact zone of the core and the satellite area

of the agglomeration. Large-scale construction is underway on this territory, but it predominantly retains a residential function. In the nearest future, these territories may become an integral part of St. Petersburg 'sleeping areas', but only in case of rapid transport and social infrastructure development. There are also mainly "sleeping" key centres of agglomeration of the first and second types. At the same time, most developed key centres of the third type are located at a relatively large distance from the core and, with the exception of Vsevolozhsk, retain their own path of development.

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