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DEVELOPMENT OF MUNICIPAL DISTRICTS OF SAINT PETERSBURG OVER THE LAST DECADE: AN ECONOMIC AND SPATIAL ANALYSIS

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The article analyses economic and spatial indicators to produce a typology of the economic development levels of St. Petersburg municipal districts. To normalise the city's development, it is vital to understand which territories have contributed more to the process and which have inhibited it. It is also essential to analyse the principal economic indicators of each municipal district and assess transport accessibility, street activity and transit. The study demonstrates the connection between the economy and space, which gives the answer to the question about the causes of economic growth. An economic analysis of the districts is carried out by ranking ten leading indicators obtained from the municipal databases and geoinformation services, whilst a spatial analysis is performed based on testing the Space Syntax methodology. The study made it possible to describe the city's spatial development, improve the methodology and provide recommendations for municipal administrators. The findings will enhance strategic urban planning in St. Petersburg.

Keywords:

economic development, spatial analysis, St. Petersburg, municipal district, Space Syntax

Introduction

Today, economy and space are inextricably linked in urban studies. The degree of development of urban space determines the value of the economic product. People gravitate to cities offering unique urban solutions. The success of a city depends on and is measured by the quality of urban space. The higher the quality, the better the needs of people are satisfied — housing is more convenient, transport is more accessible, and places of attraction are more varied. This directly affects labour productivity and this is how space shapes the urban economy.

Megapolises offer their residents a special quality of space. These territories have higher economic and resource potential. Over the past decade, the contribution of these cities to Russia's GDP has been 30—32% [1]. In such cities, the demand for spatial changes is supported by financial opportunities to implement these changes. Hence, a large number of various ongoing projects and increased interest in them in recent years.

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Moscow and St. Petersburg play an important role owing to their administratively privileged position. While Moscow's development is largely facilitated by its capital status, St. Petersburg has been developing along similar lines to other megacities. However, in the last decade, St. Petersburg has been following the global urban development trend, being a place of attraction for the population [2]. According to the data for 2016 in [3], among other Russian regions, the city ranked first in the number of enterprises per 100 thousand inhabitants, second in turnover per capita and third in the number of people employed in small businesses. In the past unstable decade, the city's economy showed a high degree of sustainability [4]. As a result, much of the research on the spatial development of St. Petersburg has appeared because of its social and economic success.

The basis of the modern study of this topic is formed by several bodies of literature. The first one is connected with the study of the St. Petersburg agglomeration, the relationship between the city and the region. Today, in the spatial structure of the agglomeration, there are three groups of 'vertebral' centres [5], a core, a population growth zone, switching sources and recipients, as well as 'backbone' centres. The influence of the agglomeration extends far beyond the administrative boundaries of the city [6], capturing most of the Leningrad region. Such a connection prompts the need for the cooperation between administrative subjects in the implementation of spatial projects [7]. The key prerequisite for the development of a dialogue between the city and the region is a single economic system [8]. The city needs to expand its spheres of influence, and the region needs investments [9]. The St. Petersburg agglomeration is characterized by a monocentric urban structure [10]. Today, there are both transport problems, hindering mobility [11] and housing problems related to the structure and location of housing [12]. This block of studies also includes works devoted mainly to the imperial period of the city's development [13; 14].

The second body of literature focuses on the study of the post-Soviet socio-spatial transformations of St. Petersburg. It is noted in [15] that the city has gone through seven key stages of development over the past period of transformation. In another work [16], when interpreting the main trends in the transformation of St. Petersburg, special attention is paid to the preserved old post-Soviet features. In [17], the calculation of indicators of well-being in the regions was carried out to identify the spatial patterns of post-Soviet differentiation. In [18], it is noted that the transformation of the city is still ongoing and separate differentiation is observed in various post-transformation urban areas. This is especially visible, for example, in retail trade, when Soviet districts now perform new functions [19].

The third body of literature is the study of the problems of the development of municipal districts, and boroughs of the city. For example, a team of researchers [20] divided St. Petersburg into subareas, examining each in detail for existing spatial problems. Similarly, they studied urban development [21] through the analysis of municipal districts, showing the existing differentiation of municipalities in terms of population well-being. In other cases, a comprehensive analysis of municipal districts and boroughs was not carried out. Many articles are of a

topic-specific nature [22]. They identify prospects for the development of the primary spatial zones of the Petrodvorets district, or present a retrospective analysis of the socio-economic development of the Kolpinsky district.

The prerequisites of this study follow from the analysis of this literature. Firstly, only a few articles attempt to comprehensively analyze the economic situation in the municipal districts of the city. Secondly, the topic of the spatial development of municipal districts has not been researched enough. There are only a few studies designed to evaluate spatial indicators in certain areas of the city. This work aims to overcome these shortcomings. The study will show the level of economic development of each administrative unit of the city, as well as touch upon the topic of how urban space could affect this development.

In this paper, it is important not only to present which of the 111 districts contribute more to the development of the city but also to identify the reasons for it. As part of the hypothesis, it is argued that the structure of space directly affects economic growth — the development of municipal districts and is conditioned by their high transport connectivity, accessibility and integration into the city. Many researchers have already tried to explain the urban economy through space [24]. They identified a possible relationship between transport accessibility and economic development, a positive relationship between the polycentric structure and the level of economic development [25], and established a correlation between spatial coefficients and GRP [26]. Probably, following this logic, it will be possible to normalize the development of the city. Further research will help to propose recommendations for the future development of St. Petersburg.

Materials and methods

The material of the study was obtained from two sources. The first source is open data for the period from 2014 to 2019 for ten economic variables. The rationale for these variables is presented in Table 1. It shows indicators reflecting the economic development of a single municipality.

Table 1

Economic indicators used in the paper

Indicators	Rationale
Population	These indicators reflect the demographic potential of the territory (obtained from Rosstat)
Population density	
Salary	These are open data of economic municipal statistics. The data are used to compare the standard of living, budgetary resources, and the volume of economic activity of organisations. The data of Rosstat and reports of heads of administrations are used. Recalculated per capita for comparison
Own budget revenues	
Budget expenditures	
Volume of trade turnover	
Volume of investments	
Business profit	
Real estate, price per sq. m.,	Measure the demand for a territory. The price of real estate is taken according to CIAN. Points of interest reflect socio-economic objects — a total of 8,867 pcs. OSM data is used.
Number of points of interest	

Source: compiled by the author.

Variables used to test the claim that spatial indicators affect economic development is the second source of the material analyzed. Spatial indicators are assessed using Space Syntax. This method originated in a study of the London area [27] and, after a long period of criticism [28–30], it has become a universal tool for urban researchers. It is proposed to calculate several Space Syntax metrics — Integration, Choice and Accessibility using the QGIS geographic information system. The description of the indicators is presented in Table 2.

Table 2

Space Syntax spatial indicators used in the paper

Indicators	Description	Rationale
Integration	Reflects the number of optimal routes between streets. The busiest and most convenient streets for residents	Selected as universal in Space Syntax — reflect the economic movement of resources and population
Choice	Shows the intensity of transit traffic and the location of the most «pass-through» areas of the city	
Accessibility	Represents accessibility to points of interest located within a 30-minute walk	

Source: compiled by the author.

The methodological basis of the study is built around the transformation of economic variables into three general indicators: the Grand Total, the Grand Change, and the Grand Stability. The Grand Total (GT) is the arithmetic mean of the ranked values of the individual observation variables (1.1):

$$GT = \frac{1}{n} \sum_i^n RVV_i \quad (1.1)$$

where is RVV_i the ranked value of an individual observation variable. Calculation by formula (1.2):

$$RVV = \frac{VV_i - 0}{VV_{\max} - 0} \quad (1.2)$$

where VV_i is the average value of a single observation variable. It is taken as the average for all calendar years.

Grand Change (GC) is the arithmetic mean of the ranked dynamics of all variables of a single observation (2.1):

$$GC = \frac{1}{n} \sum_i^n RDV_i \quad (2.1)$$

where RDV_i is the ranked dynamics of an individual observation variable. It is calculated according to the formula (2.2):

$$RDV = \frac{DV_i - 0}{DV_{\max} - 0} \quad (2.2)$$

where DV_i is dynamics of an individual observation variable. It is calculated using the formula (2.3):

$$DV = \frac{1}{n} \sum_i^n \left(\frac{x_t - x_{t-1}}{|x_{t-1}|} \right)_i \quad (2.3)$$

where x_t is the value of a single variable in the current calendar year and x_{t-1} is the value of a single variable in the base (previous) calendar year.

Grand Stability (GS) is the arithmetic mean of the ranked differences in the values of the unstable and stable periods of the individual observation variables (3.1):

$$GS = \frac{1}{n} \sum_i^n RSV_i \quad (3.1)$$

where RSV_i is the ranked difference between the values of the unstable and stable periods of an individual observation variable. It is calculated according to the formula (3.2):

$$RSV = \frac{SV_i - 0}{SV_{\max} - 0} \quad (3.2)$$

where SV_i is the difference in the values of an individual observation variable. It is taken as the difference between the average unstable (2014–2016) and stable (2017–2018) periods.

To determine the general level of economic development of the district, each grand value is assigned its own level from 1 to 3 points: for GT — developed, medium, backward; for GC — active, moderate, inactive; for GS — stable, restrained, unstable. In total, the district can score a minimum score of 3 points, and a maximum score of 9. Each district is then assigned a similar score for the boroughs to which it belongs. The boroughs score from 1 to 3 points according to the three overall scores. As a result, the final score of the district is in the range from 6 to 18 points. The subsequent division occurs according to 5 developmental indicators: advanced (18–16 points), high (15–13 points), average (12–10 points), acceptable (9–7 points), and weak (6 points).

Results

The drivers of the city's development were the districts of Admiralteisky (5 units) and Petrogradsky boroughs (4 units). These are advanced (= 18 – 16) territories of the centre. In addition to them, this group also included several districts of Kurortny (2 units), Vasileostrovsky (1 unit) and Kolpinsky (1 unit) boroughs — a total of 13 districts (11.7%) moved to the advanced group. In turn, the group of districts with a low level of development (= 6) is not numerous. It includes the remote Kronstadt borough with the centre in the city of Kronstadt, which can be accessed via the city dam (only 1 municipal district (0.9%)).

The remaining groups dispersed almost evenly throughout the remaining urban areas. Thus, districts of the acceptable (= 9 – 7) level are located in Kalininsky (5 units), Krasnogvardeisky (4 units), Kirov (2 units), Krasnoselsky (2 units), Moscow (2 units), Nevsky (2 units), Petrodvortsovy (2 units), Primorsky (2 units) and Frunzensky (2 units) boroughs — a total of 23 districts (20.7%). Municipal districts of the medium development level (= 12 – 10) are also assigned to different boroughs — Primorsky (6 units), Krasnoselsky (5 units), Kirov (4 units), Nevsky (4 units), Frunzensky (3 units), Vyborgsky (2 units), Kalininsky (2 units), Kurortny (2 units), Moscow (2 units), Central (1 unit), Kolpinsky (1 unit), Krasnogvardeisky (1 unit), Petrodvorets (1 unit), Pushkin (1 unit). In total, 35 municipal districts (31.5%) belong to the group of middle-level districts. The remaining group of districts of a high (= 15 – 13) level is concentrated in Kurortny (7 units), Vyborgsky (6 units), Centralny (5 units), Vasileostrovsky (4 units), Kolpinsky (4 units), Pushkinsky (4 units), Nevsky (3 units), Petrogradsky (2 units), Admiralty (1 unit), Kirov (1 unit), Moscow (1 unit), Frunzensky (1 unit) boroughs — 39 in total units (35.1%) of municipal districts.

In this sample, 21.6% of the districts are the least economically developed among the others — these are the districts of Yuntolovo, Kolomyagi, Gagarinskoye, Pulkovsky meridian, Finlandsky, Severny, Piskarevka, Prometheus, district No. 21, Avtovo, Krasnenkaya Rechka, Polyustrovo, Bolshaya Okhta, Powder, Rzhevka, Uritsk, Gorelovo, Nevskaya Zastava, Rybatskoye, Peterhof, Strelna, Kupchino, District No. 75, Kronstadt. In terms of boroughs, about 22% of such districts are located in Nevsky, 25% — Primorsky, 28.5% — Krasnoselsky, 28.5% — Kirovsky, 33% — Frunzensky, 40% — Moscow, 66% — Petrodvortsovoe, 71.4% — Kalininsky, 80% — Krasnogvardeisky, 100% — Kronstadt boroughs.

If we project economic indicators on the map, then several patterns will be found (Fig. 1). First of all, it is possible to identify densely located and most economically developed municipal districts. Being located in such an area enhances the effect of spatial connectivity, allowing municipal districts to use each other's resources and infrastructure more efficiently.

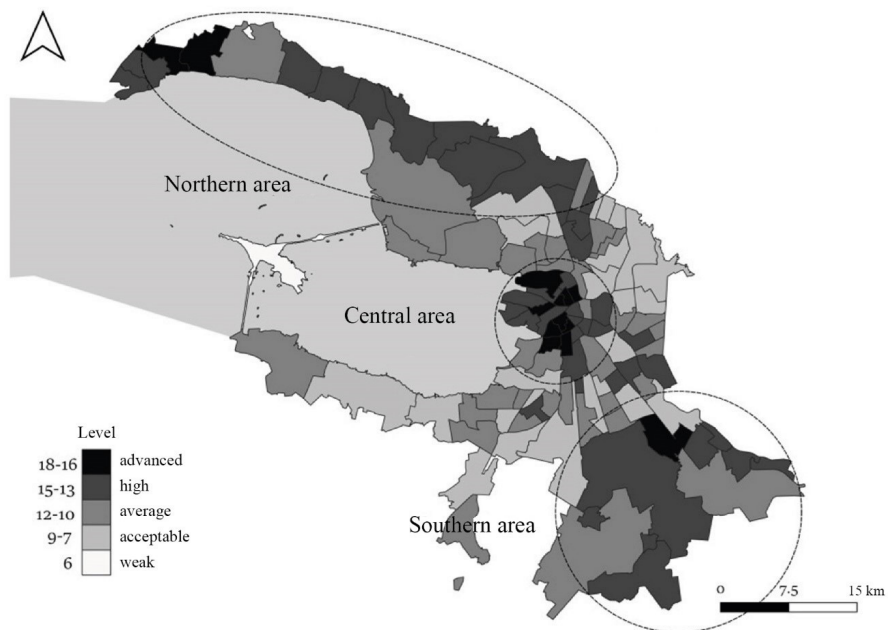


Fig. 1. The level of economic development of the districts of St. Petersburg

Source: compiled by the author.

There are three development areas in St. Petersburg. The first area — the central one — attracts more people by the number and variety of functions and interactions per square meter. The second area — the northern one — is characterized by the presence of highly developed municipal districts-settlements located away from the city centre. The reason for their high level of economic development lies in their location on the Baltic Sea and the positioning of the area as an urban resort. Hence, one of the highest land prices in the city and the smallest number of residents in municipal districts. The third area — the southern one — is now at the stage of its active development. The high potential of this area is due to the low price of real estate which could potentially ensure the accelerated growth of its municipal districts.

Street activity in each area also differs (Fig. 2). The density of roads in the south of the central area attracts attention. It will be more convenient for the consumer to move along it, among others, to meet his needs. As for the northern area, the street activity here is one of the minimal in the city, which seems justified given the presence of a single highway passing through all municipal districts. An intermediate position is occupied by the southern area, which is characterized by a rather low degree of street activity. The transport structure here is also formed

around a single highway and diverges towards municipal districts, however, the street network of microdistricts introduces relative diversity. In general, we can state “peripheral growth” — a situation where former territories, previously considered backward outskirts, today have taken on a semi-peripheral function and created an effective transport framework.

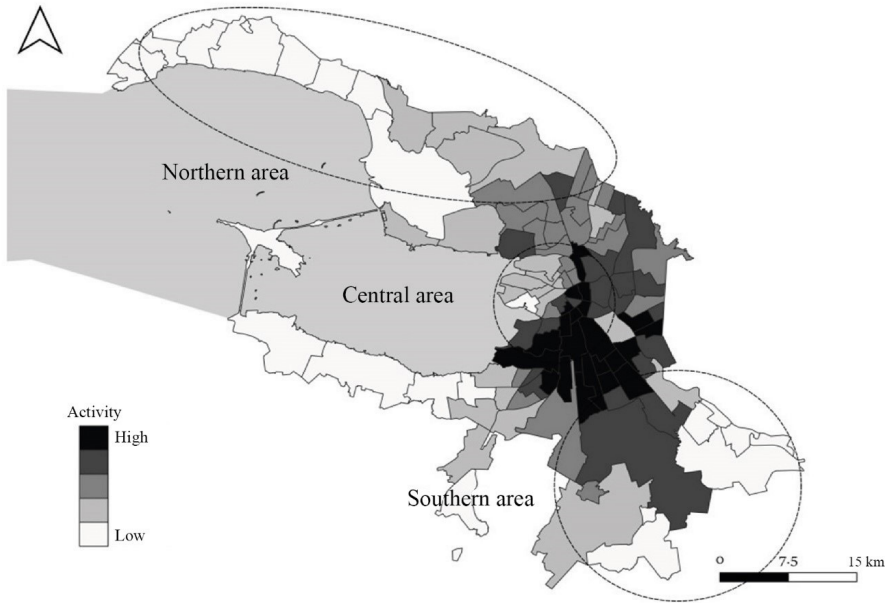


Fig. 2. Street activity by municipal districts of St. Petersburg

Source: compiled by the author.

The functionality of the city territories can be analysed by the level of urban transit activity (Fig. 3). In the northern area, the only route performs only one function — that of transporting people. No street activity can be provided for by such a road. In the central area, there are places of attraction for the key roads and streets of the city — here their flows intersect, which makes it possible to arrange the infrastructure in such a way to attract a large number of people from other districts. In the southern area, the high transit of the main streets does not make it possible to realize the likely potential due to the lack of additional connections between these streets. So, if in the centre, the lack of street transit is picked up by the density of connections and the natural high street activity of the territory, then in the south the average level of transit is not linked to density — today these are long routes along which there is no urban environment, that is, these territories are not included in the economic turnover.

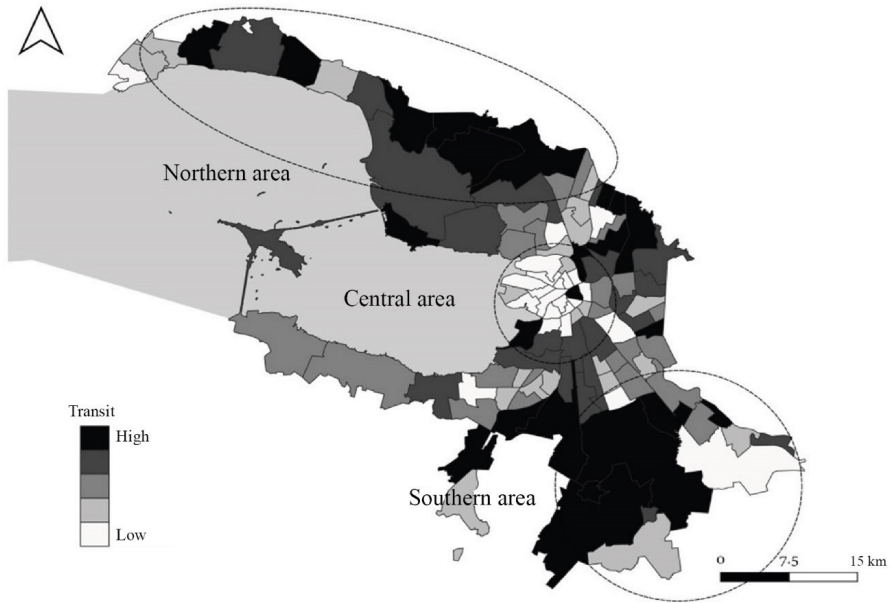


Fig. 3. Map of the transit of streets by municipal districts of St. Petersburg

Source: compiled by the author.

The result associated with the availability of points of interest is also logical (Fig. 4). If the northern and southern areas, due to their poorly developed network of streets and high transit, are characterized by the absence of a large number of points of interest and access to them, then the central area acts as the most accessible territory for visiting and maintaining activities. At the same time, one should not forget about the population of the areas under consideration. For the northern area, everything that was said earlier applies in full — the absence of people does not imply a developed grid of streets. In the southern area, the situation is reversed — more people live here than in the central area, however, the development of the road network is minimal and in some cases even comparable to the northern area. On the other hand, the infrastructure is simply not keeping up with the increase in population, which causes such results. At least now it is possible to detect accessibility cores within the southern range, which cannot be said about the northern one. It depends on the subsequent actions in what capacity it will be possible to develop the future centre in the south of the city, create new points of activity there and improve their transport links.

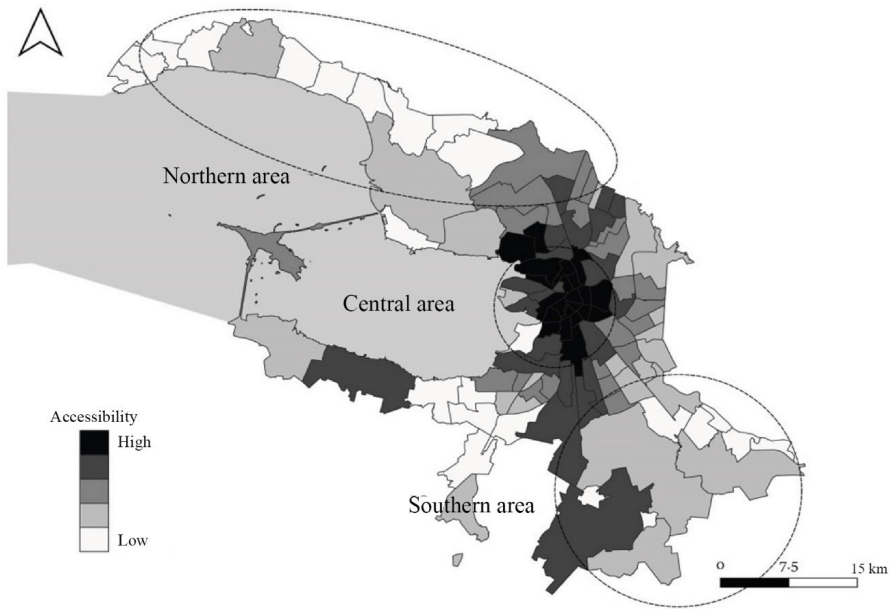


Fig. 4. Map of accessibility of objects by districts of St. Petersburg

Source: compiled by the author.

Discussion

The logic of the economic development of St. Petersburg over the past decade has been subordinated to the development of its administrative units. Only 13 districts out of 111 made a significant contribution to the development of the city. 76.9% (or 10 out of 13) of these territories are municipal districts of the city centre — the Admiralteisky and Petrogradsky districts. Therefore, the monocentric nature of urban development should be affirmed, that is, the city's economy directly depends on the activity of the centre. On the one hand, this makes it possible to unify economic processes, and increase the agglomeration effect from each district. On the other hand, the territory of these districts is much more limited in the economic sense than the periphery.

First of all, there are practically speaking no weak districts in the city. The exception is the Kronstadt borough having only one administrative unit. At the same time, other districts that conditionally pull the economic development of the city down much more today are 23 districts that are acceptable in terms of development, that is, about 12 (52.2%) peripheral (located directly at the edge of the administrative boundaries of the city) and 11 (47.8%) semi-peripheral districts (between peripheral districts and the centre). In other words, 100% of the districts

that contribute one of the most negative values of economic development are on the periphery and semi-periphery. As expected, the central municipal districts of St. Petersburg turned out to be the most cost-effective, while the periphery and semi-periphery ranked last in terms of economic development — they made the least contribution to the city's economy.

As a result, when planning the future development of the city, the process of decentralization of economic resources to the urban periphery or semi-periphery begins. Given the annual population growth, the pressure on the centre is also increasing and is likely to reach its limit in the near future. A logical solution is polycentric development, that is, the dispersal of economic resources from the centre to the semi-periphery, as the place of the largest number of inhabitants, and reducing the load on the central districts of the city.

Of course, here it should be taken into account that the functional roles of different boroughs in the life of the city differ markedly — it is not entirely correct to compare “bedroom” boroughs, administrative boroughs and business boroughs, therefore the results obtained should not be considered a universal typology of St. Petersburg boroughs and this should be taken into account when making strategic planning decisions for the development of the city.

As far as spatial analysis is concerned, the situation here is not so unambiguous. Firstly, the division of St. Petersburg into three separate spatial blocks is visually traced, which were called the northern, central and southern areas within the framework of the study. The first is a place of concentration of municipal districts with high economic development, the basis of the economy of which is the provision of guest services and recreation for residents. The second area is the basis of the economic framework, the place of concentration of goods and services. In turn, the third area is a new actively developing part of the city. All three areas today are territories that are economically separated from each other, that is, there is a certain dysfunction of between WHSD and the Ring Road, which do not involve many exits to most of the underdeveloped districts. The unification of areas with additional transport links, the modernization and compaction of the street grid, would probably allow semi-peripheral districts to achieve high growth rates and increase the number of districts in the areas.

Secondly, the results obtained were not unambiguous, and there is an explanation for this — here the relationship between the studied variables should be taken into account (Table 3). First of all, the length to the centre (LC) is only significant in determining the most active streets (INT) and the accessibility of the district (ACC). The dependencies are direct — the smaller the length from the district to the centre, the greater the accessibility and activity. This does not affect economic performance. A comparison of the general level of economic development (GL)

and the Grand Total (GT) of the districts showed no significant results — there is only a weak correlation between the Grand Change (GC) and Grand Stability (GS). In turn, all of them are also not associated with spatial indicators.

Table 3

Correlations of spatial and economic indicators

Indicator	LC	GL	GT	GC	GS	POI	INT	CHO	ACC	POP
LC	1.00	—	—	—	—	—	—	—	—	—
GL	0.04	1.00	—	—	—	—	—	—	—	—
GT	0.30	0.09	1.00	—	—	—	—	—	—	—
GC	0.02	0.46	0.00	1.00	—	—	—	—	—	—
GS	0.04	0.47	0.00	0.87	1.00	—	—	—	—	—
POI	0.40	0.03	0.23	0.04	0.09	1.00	—	—	—	—
INT	0.75	0.06	0.06	0.03	0.06	0.28	1.00	—	—	—
CHO	0.12	0.05	0.05	0.00	0.00	0.13	0.00	1.00	—	—
ACC	0.69	0.01	0.35	0.01	0.03	0.85	0.40	0.20	1.00	—
POP	0.11	0.19	0.00	0.18	0.18	0.52	0.37	0.10	0.41	1.00

Source: compiled by the author.

In a situation with the number of points of interest (POIs), there is a direct correlation: the more there are, the higher the accessibility of the territory (ACC) and its population (POP). At the same time, accessibility (ACC) is also likely to be directly related to the size of the population — the larger it is, the more people live in this area. It should be argued that indicators of economic development are in no way interconnected with spatial indicators — transit, street activity, and accessibility. In other words, the thesis that the economic development of territories determines, first of all, their integration, transit and accessibility turns out to be incorrect in the framework of the study of the economy and space of St. Petersburg.

The thesis is also refuted that the most active and accessible territories of municipal districts for residents are at the same time the most economically developed of all. As part of the search for relationships, it turns out that these coincidences are random. On the contrary, most of the semi-periphery areas have more street activity than the centre. Probably, the potential for the future development of the city is associated with it, and these territories require an integrated approach if there is an interest in the development of urban space.

Conclusions

The study resulted in the following empirical data on the districts: firstly, 21.6 % of the city's districts are poorly developed economically. These are mainly peripheral and semi-peripheral territories, and it is they that are pulling urban development down. Secondly, 11.7 % of districts are highly developed; 76.9 %

of them are located in the central boroughs of the city. If, in addition, high-level developed districts (35.1 %) are added to them, then about half (46.8 %) of the city's districts should be considered economically developed territories. Thirdly, there are several spatial areas — the northern, central and southern, which are economically isolated from each other.

The study has identified several characteristic features of the spatial development of the city in the last decade, which is characterized by monocentricity (the development of the city directly depends on economic activity in the central districts); centralization of resources (economic activity decreases from the centre) to the periphery and semi-periphery of the city, which also confirms the thesis of monocentricity; discontinuity of space (economic areas of the city are separated from each other by semi-peripheral districts, which weakens the agglomeration effect); the growth of the periphery (territories that decades ago were considered backward outskirts now perform a semi-peripheral function and their further development will lessen the discontinuity of space). Finally, semi-periphery is becoming more active; the highest street activity has been registered in the areas bordering on the centre. It is obvious that St. Petersburg's economic activity is clearly moving from the central districts towards the southern, which is a clear sign of decentralization.

The Space Syntax methodology made it possible to identify the interdependencies of indicators. Firstly, there are no links between the selected economic and spatial indicators — transit, activity and accessibility do not affect the economic development of the territory and vice versa. Secondly, the study has shown that the number of people and points of interest does not affect economic performance. There is only a non-significant correlation between the level of economic development and population numbers. Thirdly, the correlation between some of the spatial indicators shows that the shorter the distance from the territory to the centre, the higher its activity and accessibility, the more points of interest, the higher the availability of services and the higher the population numbers. Accessibility, with a small probability, is interconnected with the number of population — the larger it is, the more people live in the territory.

The main recommendation of this study is to ensure the economic connectivity of the central parts of the city with those located in the north and south. Is it also essential to identify common economic interests to better integrate different areas of the city. As of today, some areas are poorly integrated into the urban system since semi-periphery territories are still weak. Measures are already being taken to rapidly develop them. In this matter, special attention should be paid to the formation of several nuclei in the city — future centres of activity. The highest economic indicators are typical of the southern part of the city. However, a full-fledged urban infrastructure has not yet been created there. In this sense, given the identified potential of these territories, it seems appropriate to continue the development of infrastructure. Another important finding is that the periphery

becomes the most geographically advantageous place for residents to live, while other areas perform production, trade, office and cultural functions. It is also important to enhance this trend.

The city authorities are well aware of the problem of the connectivity of areas — the recommendation is consistent with the idea of polarized development set out in strategic documents. For example, the Strategy for the Spatial Development of St. Petersburg adopted for the period until 2030 presupposes the formation of territorial economic zones (TEZ). An important aspect of the implementation of the idea of TEZ is their connection with the Master Plan of the Development of the City, Regulations for Land Use and Development, and Regional Urban Planning Standards, which, however, do not emphasize the importance and functions of particular areas of the city. At the same time, the results of the study demonstrate that in the spatial development of the city emphasis should be placed on three areas — Kurortnaya, Central and Southern TEZ.

The results of the study raise questions that need further research. There is a discrepancy between the selected economic indicators and the spatial features of the territory, although in the studies mentioned in this paper their interdependence is obvious. In addition to the selection of indicators, this result is associated with their generalization and ranking — there is no doubt that with each separate comparison of all the individual variables that make up the overall economic indicators, it will be possible to find connections. In this study, there was a need for more generalization, which at the same time, could be its main drawback. In addition, the identified intracity differences should not be absolutized and the proposed typology of districts is still disputable.

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