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CENTRAL BUSINESS DISTRICT OF ST. PETERSBURG 1869–2017:

FROM A MARKET ECONOMY TO A CENTRALLY PLANNED ONE AND BACK AGAIN[1]

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Abstract

The city center is at the core of urban and housing economics. Many models crucially depend on it. In a market economy, the location of urban amenities, especially eating establishments, closely correlates with that of the city center and, more generally, with the Central Business District (CBD). In a centrally planned economy, the spatial distribution of those amenities is determined by the central planner and can differ significantly from a market-based distribution. Using the case of St. Petersburg (Russia), we investigate changes in the spatial distribution of eating establishments resulting from the transition from a market economy to a centrally planned one and then again to a market economy. In addition, we explore the shifts of the city center between 1895 and 2017 using eating establishments as a proxy. The spatial distribution is analyzed using a 2-D kernel density estimation. We find evidence for a substantial reduction and dispersion of eating establishments during the Soviet period. We also establish that after the October 1917 Revolution the city center of St. Petersburg moved several kilometers to the north-east.

Key words: St. Petersburg; urban amenities; 2-D kernel density estimation; restaurants; centrally planned economy

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Introduction

The city center, and, more generally, central business district (CBD),[2] are at the core of urban and housing economics. Many models crucially depend on the notion of the city center, where all workplaces are located. In a market economy, the location of urban amenities, especially eating establishments, closely correlate to that of the city center. In a centrally planned economy, the spatial distribution of those amenities is determined by the central planner and can differ significantly from a market-based distribution. In particular, the central planner tends to favor a more even distribution of eating amenities.

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2 The notions of the *city center* and *central business district* as well as employment center are interchangeable. The city center is probably more appropriate, since it describes rather a point than a region, which corresponds better to the exercise undertaken in this study.

Bertaud and Renaud *[1997]* examine the consequences of the shift from a centrally planned economy to a market economy for the spatial structure of Moscow. They find that in the Soviet city, unlike a typical city in a market economy, the population gradient is positive. However, they establish that the transition to a market economy led to a vertiginous adjustment towards a market spatial pattern. In particular, the land price gradient, which was very flat in the beginning of their sample (1st quarter 1992), became much steeper by the 4th quarter of 1992.

This study identifies the location of the city center of St. Petersburg. Typically, this is done using population or employment density. However, for most of the period under investigation, especially the Soviet period, such data are not available. Therefore, we take advantage of the strong correlation between the spatial distribution of eating establishments[3] and the city center, as shown in Lüscher and Weibel *[2013]* and Kolodilin et al. *[2017]* in order to approximate the location of the city center. We also test a hypothesis of the polycentricity of St. Petersburg using employment density data prior to the October 1917 Revolution and for 2015. In addition, we investigate changes in the spatial distribution of eating establishments resulting from the transition from a market economy to a centrally planned one and then again to a market economy. Taking advantage of the GIS methods and a unique geocoded data set of eating establishments in St. Petersburg (Russia) between 1894 and 2017, we explore the changes in the spatial distribution of these establishments and, hence, the shifts of the city center. Eating establishments are not a perfect substitute for employment density, but they can be considered as the best proxy, given their correlation with business activities and the large number of observations. Their spatial distribution is analyzed using a 2-D kernel density estimation. We find evidence for a substantial reduction and dispersion of eating establishments during the Soviet period. We also establish that after the October 1917 Revolution the city center of St. Petersburg moved several kilometers to the north-east.

The paper has the following structure. Second section describes the historical evolution of the legal framework of eating establishments in Russia, in general, and in St. Petersburg, in particular. Third section gives the approaches to identifying the location of the city center, which is the main employment center of the city, and of employment subcenters. In fourth section the data and methodology used in this study are presented. Fifth section concludes,

Three centuries of eating establishments in St. Petersburg

Prior to 1917, the activities of restaurants were controlled by the market economy, although from the first half of the 18th century the St. Petersburg authorities attempted to impose restrictions both on the number of eating establishments and on their spatial distribution *[Demidenko, 2011]*. St. Petersburg, at that time, was the administrative and military center of the Empire and an important industrial city. Therefore, the majority of the population were male. In 1890, for example, the share of males was about 54%.

The proportion of unmarried men was high resulting in a large demand for food services outside of home, as many of them could not afford to have their own cooks. The number of eating establishments was large and growing with the population of the city.

In 1917, immediately after the October Revolution, the Bolshevik government issued a decree that empowered the municipalities to open public canteens.[4] In August 1918, the Bolsheviks abolished private ownership of real estate, which made the existence of private eating establishments problematic. According to an order of the local authorities of St. Petersburg,[5] from November 15, 1918 such establishments were to be liquidated *[Lebina, 2016, p. 19]*. Additionally, the widespread use of food stamps, which originated during World War I, forced the majority of the population to take advantage of communal catering.

During the New Economic Policy, 1921–27, private restaurants were allowed again. Some of them were returned to their owners under long-term leases. However, communists and the working class were not supposed to visit restaurants, which were seen as bourgeois and incompatible with the proletariat.

3 In this study, we include in the category of *eating establishments* all types of fixed places where food and drinks are served for payment. Hence, it encompasses every establishment varying from cafeterias to restaurants.

4 Act of the Council of People's Commissars of the Russian Soviet Federated Socialist Republic of November 28, 1917 "Decree on extending the rights of the municipal government in the area of food service" *[Dekret o rasshirenii prav..., 1917]*.

5 St. Petersburg's name has changed throughout its history; for simplicity we refer to the city as St. Petersburg throughout this paper.

In 1928, the New Economic Policy was replaced by a policy of forced industrialization. This meant the proscription of private economic initiatives. By the early 1930s, private restaurants had entirely disappeared *[Chaus, 2010]*. The state set a target of serving at least 50% of the industrial workers and their families in public eating establishments.[6]

The declared purpose was to "free" women from their cooking responsibilities in order to increase their work participation rate. Given the increasing housing shortage due to a rise in the immigration of workers to the cities, an additional purpose was to reduce the need for new migrants who would demand more living space by involving instead in the productive activities of women already living in urban areas. In 1928–35, a system of food stamps was introduced due to the mass collectivization of agriculture, which disrupted the supply of staple foods from rural areas. As a result, the main place where employees could obtain food were the canteens of their enterprises. This affected the spatial distribution of eating establishments as they were located mainly on the sites of factories and offices *[Tverdyukova, 2006, p. 40]*. Access to these canteens was limited to the employees of the respective organizations. Needless to say, in the absence of competition the quality of food and service in such establishments was very low.

After the cancellation of food stamps in 1935, a renaissance of independent restaurants began. However, very soon the entry of the Soviet Union into World War II led to a drastic reduction of food supplies. In 1941–47, the food stamp system was again reactivated. Eating establishments, especially canteens, were used to administratively distribute food rations, differentiated according to the "social value" of each person (see for example, *[Druzhinina-Zaitseva, 2011]*). The canteens served only those listed and denied access to unauthorized persons. During the war, the share of food distributed via eating establishments in the overall retail distribution more than doubled *[Orlov, 2010, p. 39]*. From 1944 restaurants started to serve people without food stamps but for higher ("commercial") prices *[Smirnova, 2014, p. 68]*.

The state, recognizing issues related to public catering (such as insufficient coverage and the low quality of food and service), tried to improve the situation. For example, in 1959 a joint ordinance of the Communist party and the government of the USSR was published that strove, among other things, to expand the number of eating establishments.[7] It became obligatory to equip each newly built factory and educational establishment with a canteen. Thus, the spatial distribution of eating establishments became more diverse. For instance, factories located on the fringe of the historical center made a "gray stripe" separating the city center from residential areas. Schools were more or less evenly distributed across the city. Unlike schools, universities were more concentrated. Overall, the central government policy should have led to a less centralized distribution of public catering.

Perestroika, launched in the Soviet Union in 1985, gave a huge impetus to the development of eating establishments. In 1987, an act was issued that allowed the founding of eating establishments in form of cooperatives.[8] Initially, the cooperatives had to be created by private persons and the local Soviet authorities, and act within the framework of state trade. However, they were free to set prices and production plans. This act led to a proliferation of cooperative restaurants.

In the 1990s, the during transition from a centrally planned to a market economy, the spatial distribution of consumer amenities changed significantly in Russian cities. This was a consequence of giving up the Soviet system of a centralized distribution of jobs, a surge in the services sector, a tremendous rise in the amount of privately owned real estate, and the rapidly increasing motorization of the population.

Approaches to delineating the city center

There are various approaches to determining the location of the city center (see a literature overview in *[Kolodilin et al., 2017]*). This literature can be split in two unequal parts. One of them (e.g., *[Alperovich, Deutsch, 1994]*) takes advantage of the declining function of the population and employment density

6 Act of the Council of People's Commissars of the USSR of July 18, 1930 "On developing public catering" *[O razvitii obshchestvennogo pitaniya, 1930]*.

7 Act of the Central Committee of the Communist Party of the USSR and the Council of Ministers of the USSR of February 20, 1959, no 182 "On the further development and improvement of public catering" *[O dal'nejshem razvitii..., 1959]*.

8 Act of the Council of Ministers of the USSR of February 5, 1987, no 160 "On creation of the food service cooperatives" *[O sozdanii kooperativov..., 1987]*.

as the distance from the city center increases, postulated by urban economics. The other (e.g., *[Thurstain-Goodwin, Unwin, 2000; Lüscher, Weibel, 2013]*) looks at the spatial distribution of various amenities and identifies the city center as the point, where their concentration is highest.

While the overview of Kolodilin et al. *[2017]* concentrates on monocentric city models, there is a large strand of literature focusing on polycentric cities. McDonald *[1987]* defines an employment subcenter as a secondary peak in a variable characterizing employment or population density (gross employment density, net employment density, employment-population ratio, gross population density, and net population density). His favored indicators for a subcenter are the gross employment density and the employment-population ratio. The city center is implicitly defined as the global maximum of the spatial distribution of these two indicators. The indicators are computed for administrative regions (e.g., zones and rings in Chicago) or census tracts. Following McDonald *[1987]*, Giuliano and Small *[1991]* come up with a more elaborate definition of the employment center. They define the center as "a continuous set of zones, each with density above some cutoff $\bar{D}$, that together have at least $\bar{E}$ total employment and for which all the immediately adjacent zones outside the subcenter have density below $\bar{D}$." They set $\bar{D}$ = 10 persons per acre and $\bar{E}$ = 10,000 employees. In addition, in order to be classified as adjacent, the zones must have at least 0.25 miles of common boundary. According to Giuliano and Small *[1991]*, the choice of the cutoff values is dictated by their desire to match as closely as possible the theory while keeping the statistical analysis manageable. Similarly, McMillen and McDonald *[1998]* require potential employment centers to satisfy two criteria: to have an employment density of at least 10 employees per acre and total employment of 10,000.

The choice of the thresholds suggested in these two studies to identify employment subcenters is rather ad hoc and can be very city-specific. Therefore, alternative approaches emerged that look for the location of subcenters using non-parametric approaches. For example, McMillen *[2001]* uses such an approach and analyzes zones of employment density by transportation in order to identify employment subcenters in six US cities. Craig and Ng *[2001]* apply a method of non-parametric employment density quantile splines to the employment density data at census tract level in order to locate the subcenters of Harrison County.

Models, data, and results

Gradient method

First, we use the approach suggested in Alperovich and Deutsch *[1994]*. For this purpose the following regression is estimated using the method of maximum likelihood:

$$p_i = \alpha e^{-\gamma d((\theta_1,\theta_2),(c_{i1},c_{i2}))+\varepsilon_i}, \quad (1)$$

where p_i is the population or employment density in the i-th municipal district (MD); α is a parameter measuring the population or employment density in the city center; γ is the density gradient that describes the diminishing population or employment density as the distance from the city center increases; λ is the non-linearity parameter in the Box-Cox specification; $d((\theta_1, \theta_2), (c_{i1}, c_{i2}))$ is the distance in km between the city center and the centroid of district i (θ_1 and θ_2 are the longitude and latitude of the city center, while c_{i1} and c_{i2} are the coordinates of the centroid of the i-th MD); ε_i is the error term.

In order to estimate the gradient regressions data on population and employment densities are needed. Data sources and the number of observations are reported in *Table 1*.

For the period 1869–1910, the data referring to 2015 are available at the level of the 38 police subdistricts (*politseiskie uchastki*). The latest data are available at the level of 111 MD. These data are taken from the database of MD indicators of St. Petersburg's statistical office Petrostat.[9] The size of the municipal districts is comparable to that of the former police subdistricts.

The distributions of the population and employment densities 1869–1910 by police subdistricts are shown in *Fig. 1* and *Fig. 2*, respectively. The distribution of the population and employment densities in 2015 by MD is shown in *Fig. 3*. The darker the shading, the higher the density. The highest employment density is observed in the historical center of the city and gradually declines toward the

9 http://petrostat.gks.ru/wps/wcm/connect/rosstat_ts/petrostat/ru/statistics/Sant_Petersburg/db/

city periphery. For the population, the picture is not that clear cut, for there are some MD with high population densities that are relatively far from the city center.

Table 1. Data sources

Variable	Year	Description	Source
Population, employment	1869, 1881, 1890, 1900, 1910	38 police subdistricts	Population census
Population, employment	2015	111 subdistricts	Petrostat; http://petrostat.gks.ru
Eating establishments	1894, 1905, 1915, 1917, 1923, 1935	individual establishments	Address books of St. Petersburg, Petrograd, and Leningrad
Eating establishments	1973, 1982	individual establishments	Telephone books
Eating establishments	2005	individual establishments	Yellow pages
Eating establishments	2017	individual establishments	www.restoclub.ru

The results of the estimation of model (1) for population and employment are reported in Table 2. In all cases, the density gradient is negative and statistically significant, which implies that the population and employment densities decay as the distance from the city center increases.

Table 2. Employment and population density estimation results

Coefficient	Dependent variable:			
	population density		employment density	
	Specification:			
	exponential	Box-Cox	exponential	Box-Cox
	(1)	(2)	(3)	(4)
α	5.280*** (0.154)	8.531*** (1.391)	4.045*** (0.189)	4.879*** (0.350)
γ	−0.115*** (0.008)	−0.191*** (0.036)	−0.140*** (0.010)	−0.163*** (0.014)
σ	1.051*** (0.071)	1.991*** (0.449)	1.278*** (0.086)	1.491*** (0.136)
θ_1	30.348*** (0.029)	30.352*** (0.031)	30.324*** (0.016)	30.321*** (0.016)
θ_2	59.926*** (0.013)	59.933*** (0.014)	59.934*** (0.008)	59.935*** (0.008)
λ		0.190*** (0.059)		0.105*** (0.029)
Observations	111			

Notes. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.
Numbers in parentheses are standard errors of the estimated parameters.

The gradient varies between –0.12 and –0.19. The estimated nonlinearity parameter λ is 0.190 for population and 0.105 for employment. The parameters θ_1 and θ_2 are the longitude and latitude of the city center, respectively.

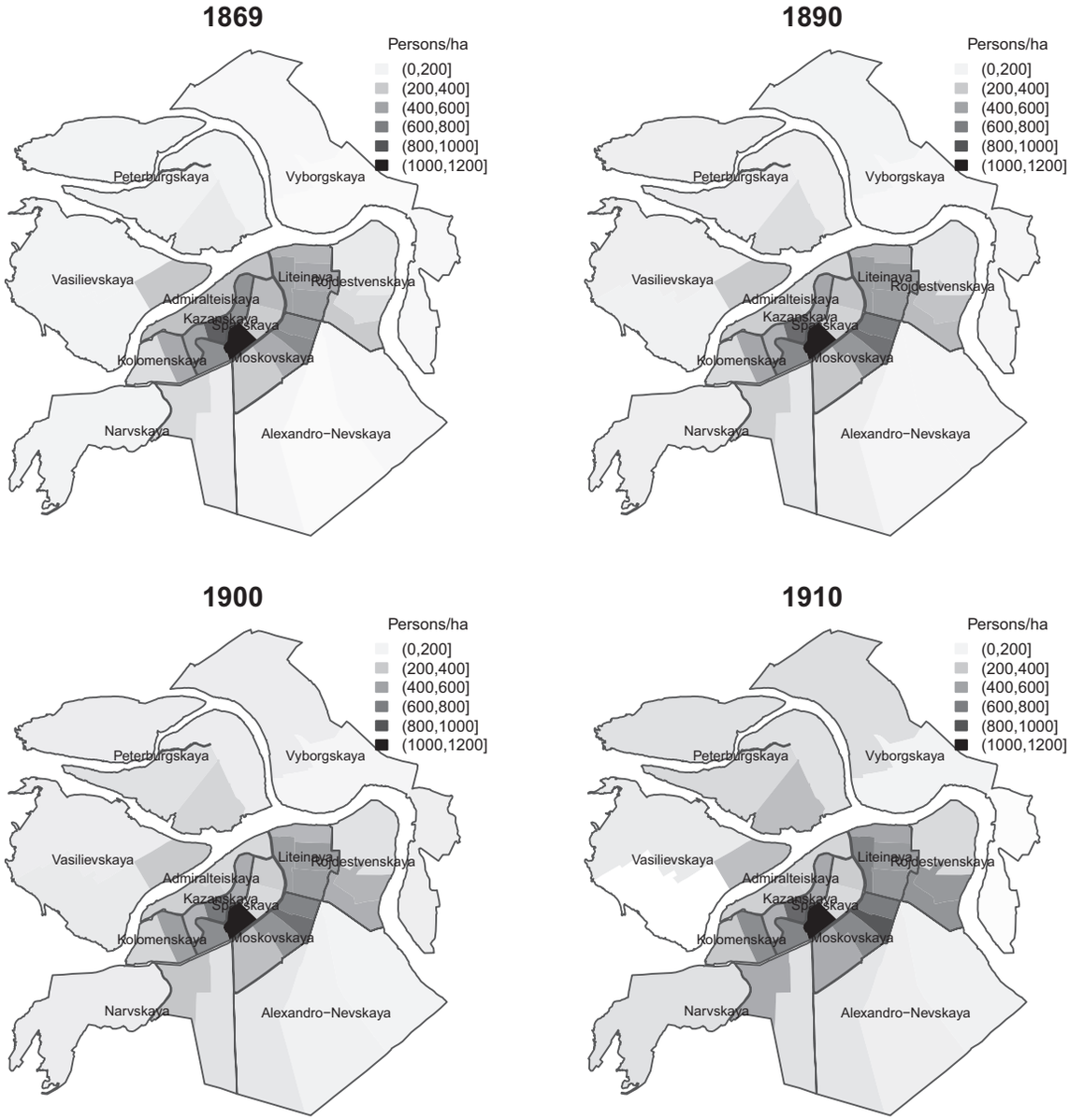


Fig. 1. Population density in St. Petersburg, 1869–1910

Spatial density of urban amenities

In order to estimate the spatial density of an urban amenity, we take advantage of the 2-D kernel density estimation method.[10] Following Borruso and Porceddu *[2009]*, we split the city into square cells approximately 200 m per side and obtained a grid with 127,500 cells (375 × 340). The window size, BW, was determined separately for each coordinate using the following rule:[11]

$$BW = 4 \times 1.06 \times \min\left\{s_x, h\right\} \times N^{-\frac{1}{5}}, \quad (2)$$

10 The spatial smoothing across both coordinates was done using the function *kde2d* from the package MASS of the statistical and graphical programming language R.

11 See Venables and Ripley *[2002, p. 130]*, equation (5.5).

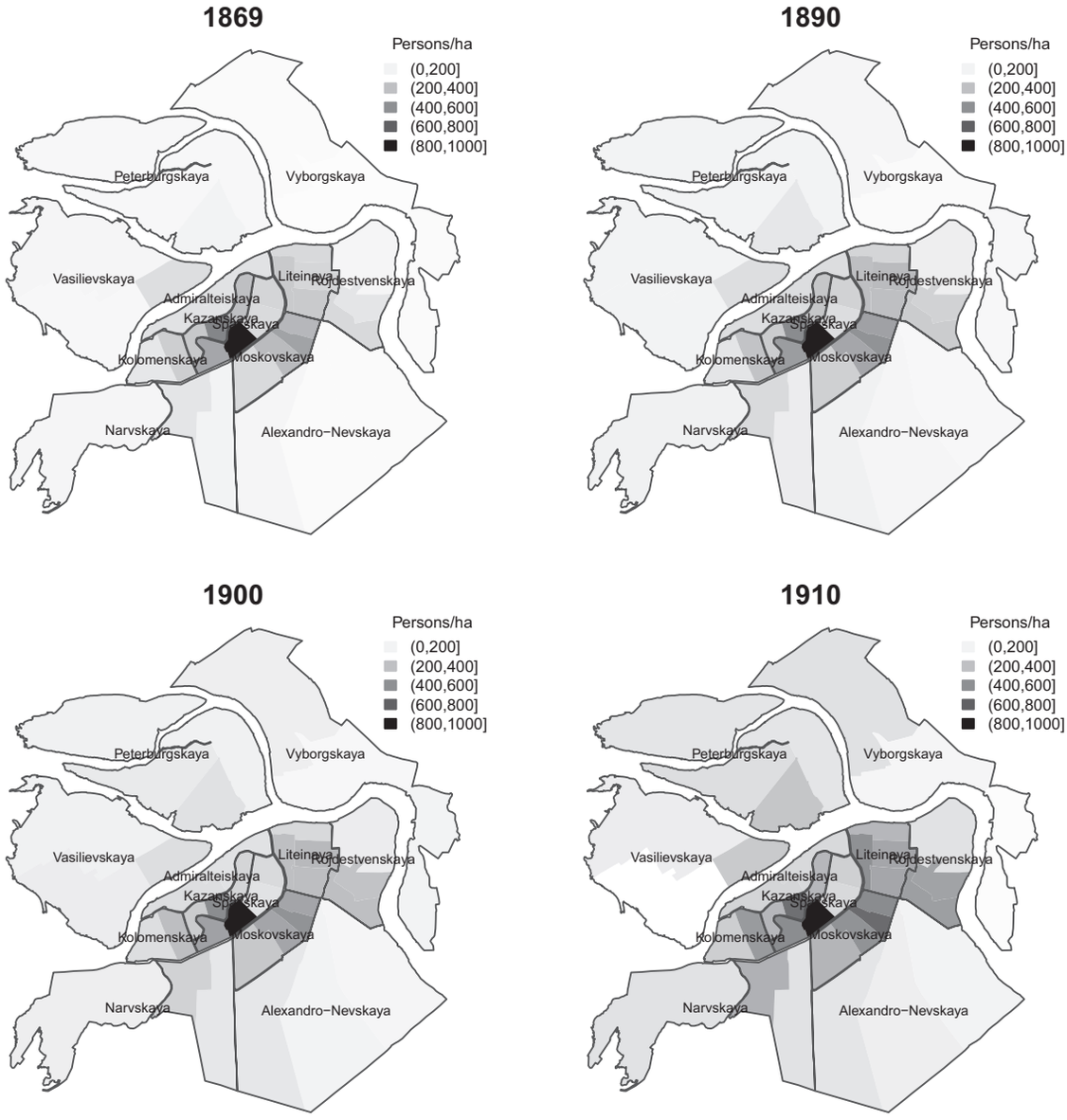


Fig. 2. Employment density in St. Petersburg, 1869–1910

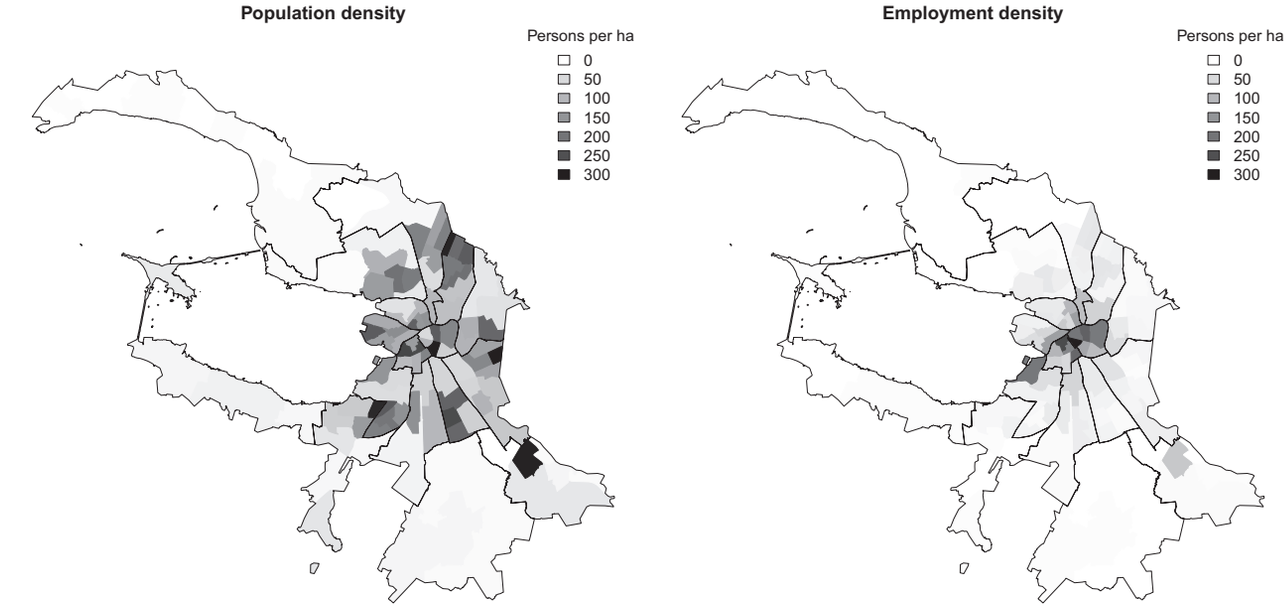
where σ_x is the standard deviation of the variable x (in this case, the variable is either the longitude or latitude of individual objects); N is the number of observations of variable x.

$$h = \frac{Q_3 - Q_1}{1.34}, \tag{3}$$

where Q_1 and Q_3 are the first and third quartiles of variable x, respectively.

The identification of the city center using the 2-D kernel density estimation was done based solely on the data on eating establishments.

There are three advantages of using eating establishments as a proxy for the city center. First, they are closely correlated with city centers. As survey results of Lüscher and Weibel *[2013]* and Kolodilin et al. *[2017]* indicate, people tend to associate them with downtown. Second, the functionality and the form of eating establishments has not changed radically over the last 150 years, unlike, for example, banking services which are now provided by automatic teller machines



a) Population **b) Employment**

Fig. 3. Population and employment density, 2015

(or online), which did not exist one hundred years ago. In addition, the switch of the role of St. Petersburg from the capital of Russia to a city with regional importance dramatically changed its political landscape. Nowadays, it no longer has the attributes of a capital city, such as ministries, the central bank, or the national parliament. Third, eating establishments are very numerous, producing more reliable estimates of the spatial distribution.

The data on eating establishments are obtained from different sources. Between 1894 and 1935, they are taken from the address directories that were published 1894–1940: Ignatov *[1894]*, Suvorin *[1905; 1917]*, Hessen and Livshits *[1923]*, and The whole of Leningrad *[1935]*. The addresses of eating establishments for 1956 and 1962 are taken from Ministry of Communications of the RSFSR *[1956, 1962]*. For 1973 and 1982, telephone directories Lapin *[1973]* and Manuylova *[1982]*, respectively, are used. For 2005, we took advantage of the Yellow pages for St. Petersburg Pavlov *[1995]*; Yakovlev *[2005]*. Finally, for 2017, the data are taken from the all-Russia Internet restaurant registry *Restoclub* (www.restoclub.ru). An important issue is the completeness of data. Unfortunately, it is impossible to guarantee that an address or telephone book contain the entire list of eating establishments. It can be assumed, however, that the information is missing non-systematically.

The original data collected from the majority of these sources represent addresses. The next step was to geocode the establishments, that is, convert the addresses into geographical coordinates. While for 2017, the longitudes and latitudes are downloaded together with other characteristics of establishments, for the earlier periods the geocoding was done manually. The task was complicated by the fact that over the last 100 years, many addresses, especially in the former periphery of the city changed quite substantially. New streets emerged, while multiple old streets were merged, split, abolished, or renamed. There were several waves of street renaming. The first one took place after the October Revolution, when the old names, especially if they had a "tsarist flavor", were changed to "revolutionary" ones. In 1944, though, many old names were returned, since the new ones did not become popular. After WWII, quite a few streets were named after war heroes. Finally, after 1990, a wave of returning old, pre-Revolution, names began. Thus, using modern addresses can sometimes lead to false results, two buildings with the same address, but separated by a century, could be kilometers apart. Therefore, determining the correct coordinates corresponding to the addresses was quite a time consuming exercise.[12] In some cases, only approximate coordinates could be obtained,

12 Unlike, for example, Berlin, which had 28 streets named Bahnhofstraße and 25 named Berliner Straße *[Kholodilin, 2016]*, St. Petersburg has relatively few duplicated street names, the most frequent being Alexeevskaya ulitsa and Novaya ulitsa both occurring six times in 1917. This simplifies the otherwise tedious task of geocoding.

especially when the old streets had disappeared. The spatial distribution of eating establishments in St. Petersburg between 1894 and 2017 is shown in *Fig. 4*.

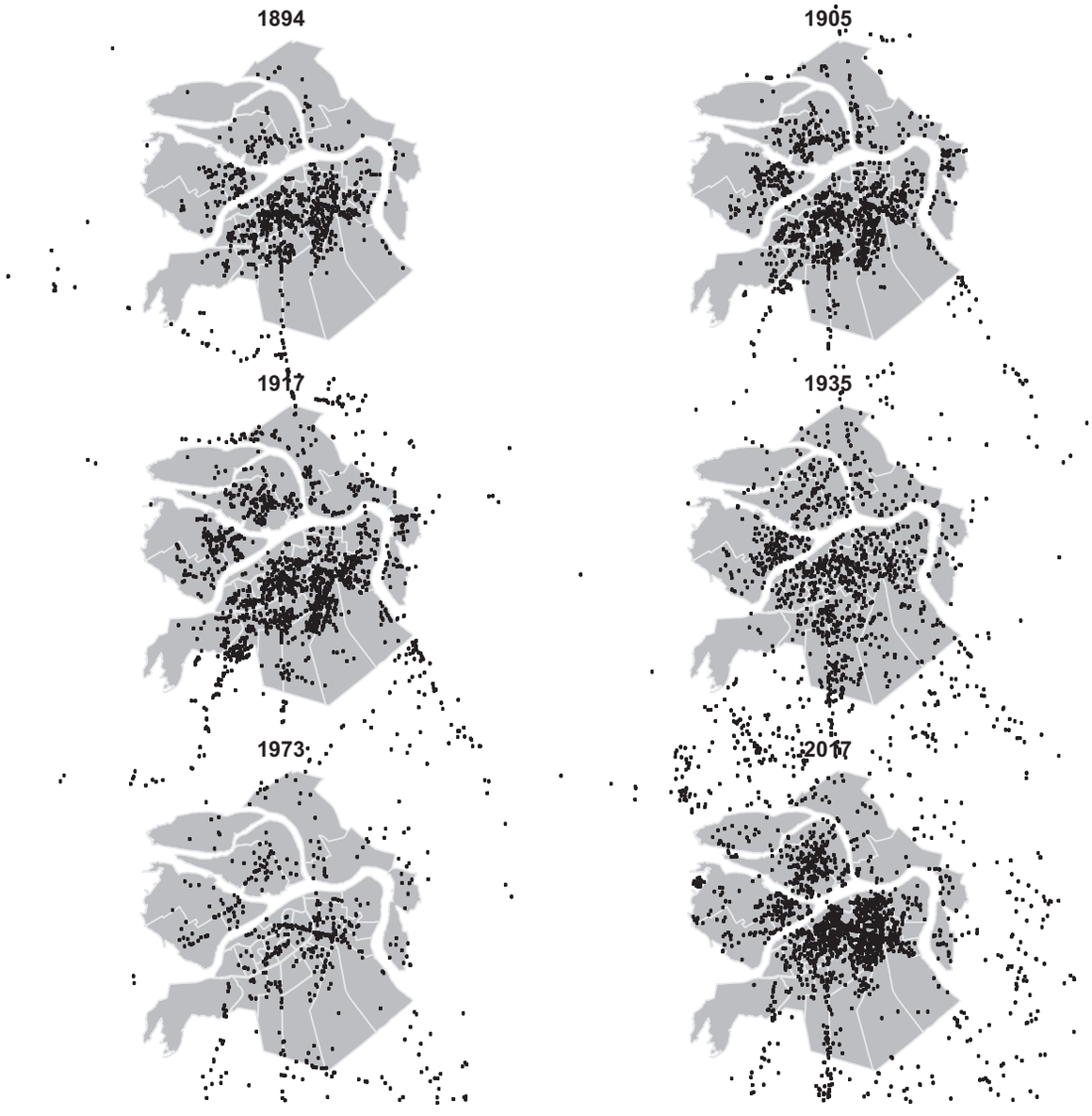


Fig. 4. Spatial distribution of eating establishments in St. Petersburg, 1894–2017

Figure 5 displays the shifts in the location of the St. Petersburg's city center over more than one century. The two upper panels show the population and employment centers, whose coordinates were obtained by the gradient method, while the lower panel shows the eating establishments (consumer) center calculated using the 2-D kernel density estimation. It can be seen that in the beginning of the period under inspection the population, employment, and consumer center were located next to each other, between Fontanka river and canal of Griboyedov, near to the Sennaya square. However, within the following 100 years all these three centers diverged from each other. Whereas the population center moved several kilometers to the South-East and is located now at the inflection of Vladimirskiy prospekt, the employment center shifted to the North, close to Nevskiy prospekt. The eating center experienced even stronger shifts. First, it went to the North-East, toward Liteinyi prospekt, where it remained until the October 1917 Revolution. Later, it moved to the North, close to the intersection of Liteinyi and Nevskiy prospekts, where it currently remains.

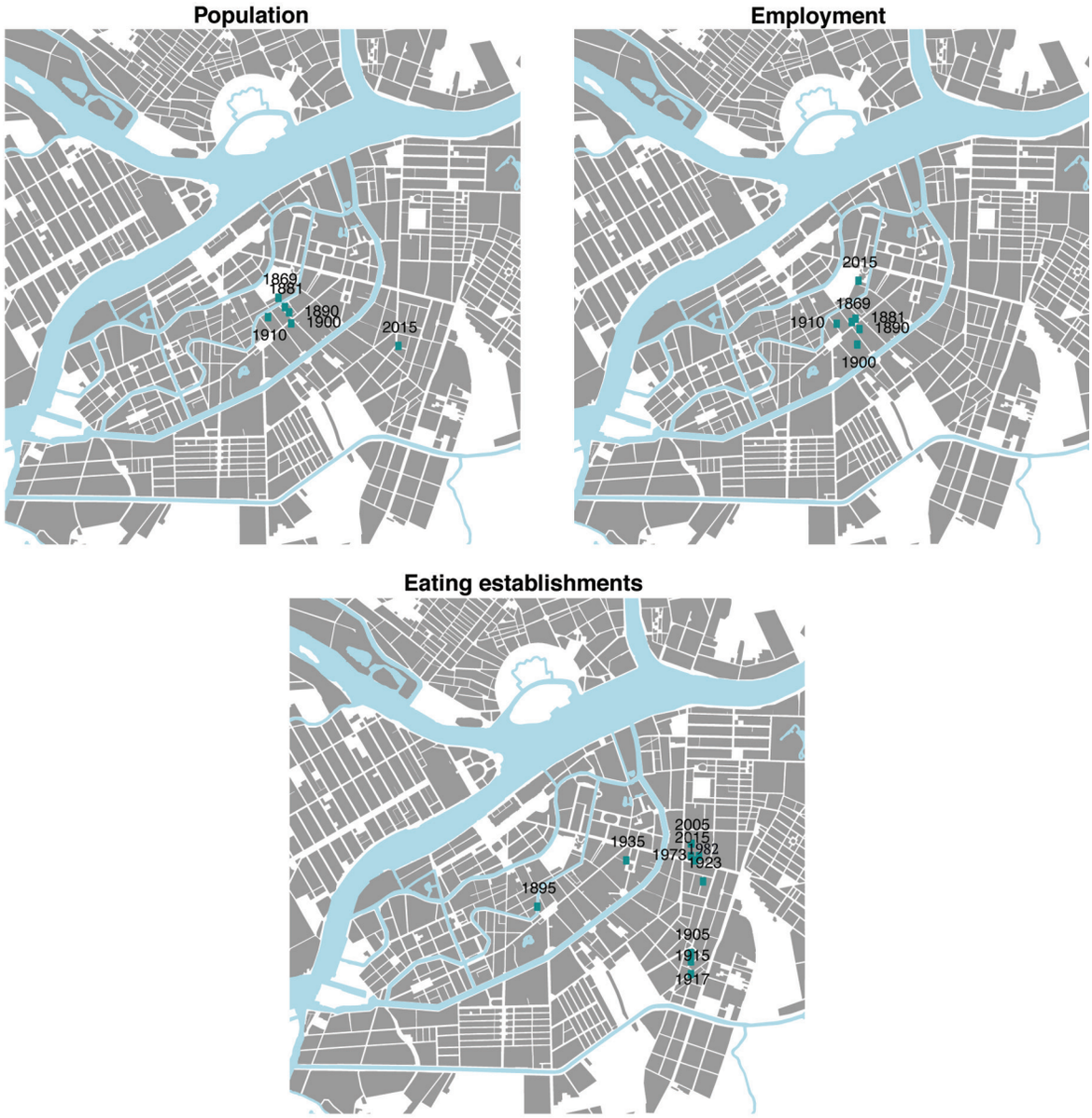


Fig. 5. Displacement of the city center of St. Petersburg, 1869–2017

Table 3 shows that the number of eating establishments increased from 1895 to 1915. By 1917, due to war time difficulties and the dry law introduced after the outbreak of World War I, the number of establishments had declined. The Russian Civil war caused a significant reduction in the number of eating establishments in St. Petersburg. The earliest figure available after the end of the Russian Civil war was for 1923. According to these data, the number of establishments had decreased by two thirds, while the population of the city had halved. As a result, the number of eating establishments per 100,000 persons decreased from 73 to 46. By the mid-1930s, a substantial reduction of the number of eating establishments, both totally and per capita, had occurred. By 1973, despite a large increase in the population the number of eating establishments decreased to less than 600. The number of establishments per head of population went down to 17 per 100,000 persons. The re-introduction of the market economy in the 1990s led to a surge in the number of eating establishments, although the per-capita numbers are still well below the pre-1917 level.

Table 3. Descriptive statistics of eating establishments, 1894–2017

Year	Coefficient of variation	Number of establishments	Population 1000 persons	Establishments per 10^5 persons
1894	1.87	836	1098[a]	76
1905	1.43	1283	1635	78
1915	1.23	1784	2315	77
1917	1.30	1671	2300	73
1923	1.98	506	1093	46
1935	1.25	970	2716	36
1973	1.47	595	4220	14
1982	1.18	1155	4711	25
2005	1.22	2050	4581	45
2017	1.83	2992	5226[b]	57

[a] Due to the data availability issues, for the eating establishments in 1894 the population figure of 1895 is used.

[b] Population figure for 2015 is used.

Sources: address directories, Petrostat, and own calculations.

We calculated the degree of the spatial concentration of eating establishments as the coefficient of the variation of the smoothed distribution for the city boundaries as of 1917. The first column of *Table 3* shows the concentration was highest at the beginning of our sample, meaning that the vast majority of establishments were clustered in the center. By 1923, the spatial concentration surged. This can be explained by the reduction of the population, the forced displacement of workers from the periphery of the city to its central districts, and the fact that St. Petersburg became a city near the border of Finland, Estonia, and Latvia. Therefore, many establishments located on the roads leading to these former Russian provinces (now independent states) were closed. Afterward, the degree of spatial concentration of eating establishments decreased. In 1935, it attained its minimum pointing to the substantial decentralization of public catering, which was mainly organized in the form of canteens at factories, schools and offices. Since 1973, the coefficient of variation has been increasing and by 2017 it attained its 1894 level.

Density of bilateral distances between establishments

Related to the approach in the preceding subsection is the method used by Duranton and Overman *[2005]*. In order to evaluate the localization of various industries, they compute the $\frac{N(N-1)}{2}$ pairwise Euclidean distances between the establishments of each industry and then calculate the densities of the distances using a Gaussian kernel:

$$\hat{K}(d) = \frac{1}{N(N-1)h}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} f\left(\frac{d-d_{ij}}{h}\right), \quad (4)$$

where h is the bandwidth; $f(\bullet)$ is the kernel function; and d_{ij} is the distance between the i-th and j-th establishments.

Figure 6 shows the empirical density of the pairwise distances between restaurants computed using the approach of Duranton and Overman *[2005]*. Each curve corresponds to a different year. Between 1894 and 1917, the modes moved rightward. During the 1920s, the mode returned to the left, while in 1935 it shifted rightward again. By 1973, the distribution became bimodal: the highest mode was

at approximately 4 km and the second one at 23 km. In 2017, the distribution of distances remained bimodal, but both modes shifted leftward. The highest mode is now at around 2 km, while the second mode is at about 9 km. The right tail of the distribution became longer but also lower. Interestingly, this finding is similar to the results obtained by Bertaud *[2006]* for St. Petersburg and displayed in *Fig. 2*, which depicts the built-up density profile of some CEE and western European cities. The second peak in Bertaud's study is located a bit farther than in our case — about 14 km from the city center. However, it starts at approximately 9 km and represents a plateau stretching until 15 km. The similarity can be explained by the fact that eating establishments follow the population density, which in the case of large former socialist cities increases toward the city periphery due to an increased proportion of densely populated high-rise residential buildings constructed there since 1960s. Today the pattern remains; it becomes even more accentuated, for newly built residential buildings are much higher than their Soviet counterparts and contain smaller dwellings. Therefore, it is to be expected that the built-up density peak at 14 km from the city center will persist and will most probably move even farther away.

Employment subcenters

In subsection "Gradient method," we identified the population and employment center of St. Petersburg. Here, we test the hypothesis of the monocentricity of St. Petersburg. We focus on the modern city for two reasons. First, prior to 1917, the employment density is available for 31 subdistricts, which is a small number of observations. For example, in McMillen *[2001]* the smallest sample size is 498 for New Orleans. Second, *Fig. 1* implies the existence of a single center. In order to check for the existence of secondary employment centers, we opt for the approach of McMillen *[2001]*, as being the most intuitive of those suggested in the literature. This is a two-step procedure. At the first stage, candidate subcenters are chosen using a locally weighted regression (LWR)[13] for the logarithm of the employment density, p_i. The candidate subcenters are such that they meet the following criterion: $\frac{p_i - \hat{p}_i}{\hat{\sigma}} > 1.96$, where $\hat{p}_i$ is the fitted value of the LWR for subdistrict i and $\hat{\sigma}$ is the estimated standard error for the prediction. At this stage, a single subcenter candidate is found, namely Metallostroi, which is a subdistrict in the south-east of the city, where 20 manufacturing factories and a research institute are located, see the darker area in *Fig. 3*.[14]

At the second stage, the potential subcenter is tested for significance. The second stage consists in estimating the following semiparametric regression:

$$p_i = \alpha + \beta g(DCBD_i) + \sum_{s=1}^{S} (\delta_1 d_{is}^{-1} + \delta_2 d_{is}) + u_i \,, \tag{5}$$

where g(DCBDi) is a proxy for the density gradient with respect to the city center, which is estimated below, in Equation 6, and d_{ij} is the distance between the centroid of subdistrict i and a candidate subcenter s. In our case, the maximum number of potential subcenters is 1.

$$g(DCBD_i) \approx \lambda_0 + \lambda_1 z_i + \lambda_2 z_i^2 + \sum_{q=1}^{Q} (\beta_q \cos(qz_i) + \gamma_q \sin(qz_i)) \,, \tag{6}$$

where z_i is the distance from subdistrict i to the city center transformed such that it varies between 0 and 2π (as coordinates of the city center we use those obtained using the Alperovich and Deutsch *[1994]* approach for employment density) and Q is determined using the Schwartz information criterion. *Table 4* reports the estimation results of Equation 5. None of the distance coefficients is significant at conventional confidence levels. Only the direct distance to Metallostoroi is significant at 20%, which is used in McMillen *[2001]*. However, both coefficients are negative. Hence, the hypothesis of Metallostroi being a secondary employment center of St. Petersburg cannot be accepted. Interestingly the centroid of Metallostroi is located at 20 km from the employment city center that we identified in this paper and approximately at the same distance from the eating

13 For this purpose, we use the loess function of the statistical and graphical programming language R.
14 The subdistrict to the west of the central area of the city, Morskie vorota, where the seaport is located, is not identified by the LWR as a potential employment subcenter.

center, which roughly corresponds to the farthest local maxima of the empirical density curve of the pairwise distances between restaurants obtained for 2017; see *Fig. 6*.

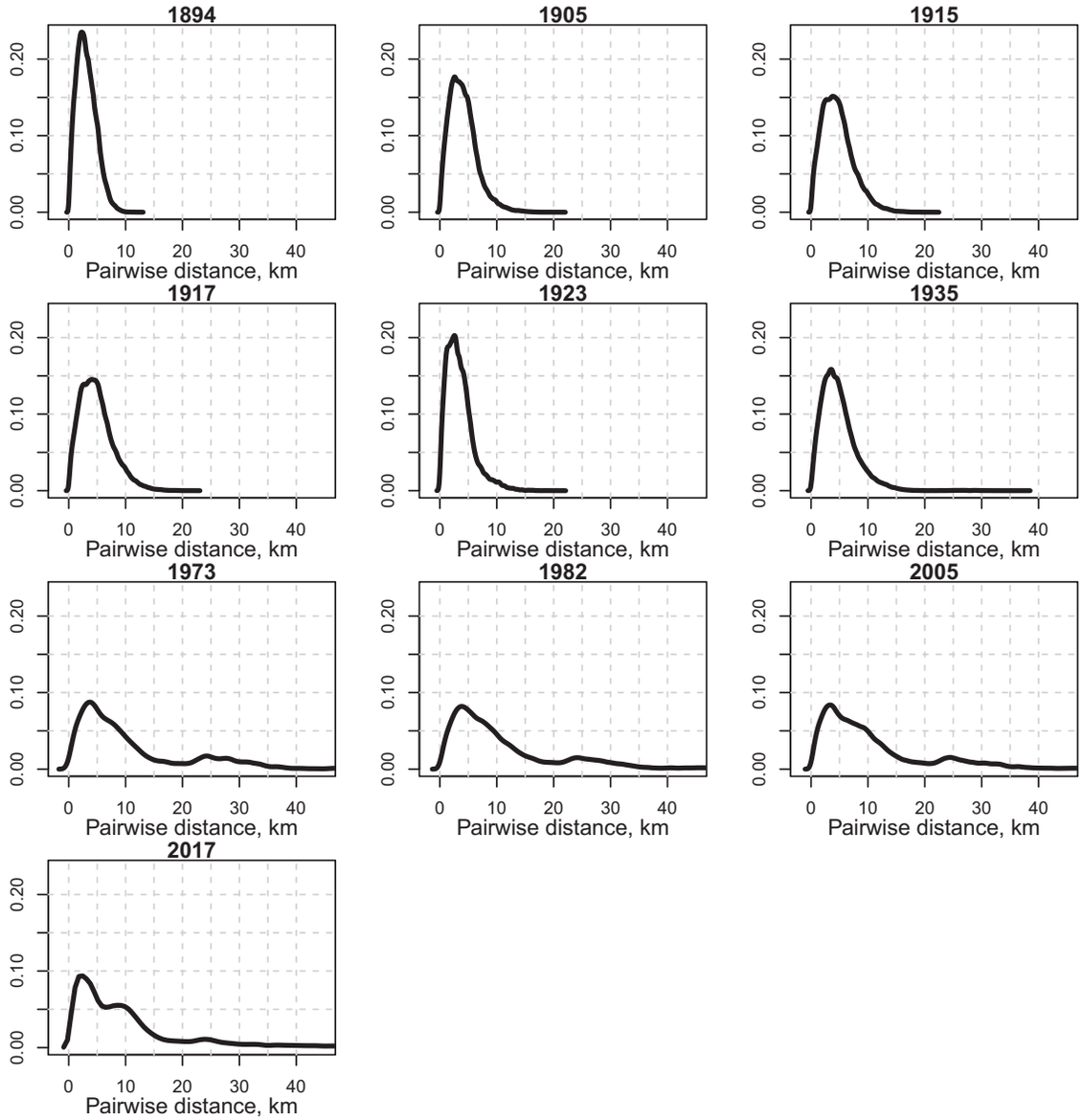


Fig. 6. Empirical density of the pairwise distances between restaurants, 1894–2017

Table 4. Estimation results of the semiparametric regression for employment subcenters

Variable	**Coefficient (t-value)**
Constant	0.661
	(0.551)
gDCBD	0.941^***
	(0.081)
Distance to subcenter	–0.015
	(0.012)

Variable	Coefficient (t-value)
Inverse distance to subcenter	–3.223
	(2.585)
Observations	110
R^2	0.742
Adjusted R^2	0.734
Residual Std. Error	1.088 (df = 106)
F Statistic	101.367^*** (df = 3; 106)

Note. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Conclusion

This paper examined the changes in the spatial distribution of eating establishments in St. Petersburg between 1894 and 2017. We claim that the location of the maximum spatial density of eating establishments can approximate the city center.

The period under consideration was characterized by large shifts in the shape of the spatial distribution. Its center, and the concentration and localization of eating establishments substantially changed. The main factors behind these developments are the expansion of the city and the transitions from a market economy to a centrally planned one in the 1920s and then again to a market economy in the 1990s.

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К.А. ХОЛОДИЛИН, Л.Э. ЛИМОНОВ

ЦЕНТРАЛЬНЫЙ ДЕЛОВОЙ РАЙОН САНКТ-ПЕТЕРБУРГА 1869–2017 гг.:

ОТ РЫНОЧНОЙ ЭКОНОМИКИ ДО ЦЕНТРАЛИЗОВАННО ПЛАНИРУЕМОЙ И ОБРАТНО

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Деловой центр города играет ключевую роль в городской и жилищной экономике. Многие теоретические модели завязаны на этом понятии. В условиях рыночной экономики размещение городских прелестей, в особенности заведений общественного питания, тесно коррелирует с местоположением делового центра. В централизованно планируемой экономике пространственное распределение этих прелестей задается центральным планирующим органом и может существенно отличаться от распределения, возникающего в условиях рыночной экономики. На примере Санкт-Петербурга мы исследовали изменения пространственного распределения заведений общепита в результате перехода от рыночной экономики к централизованно планируемой и обратно к рыночной экономике. Кроме того, мы проанализировали перемещение центра города с 1895 по 2017 г., используя заведения общественного питания как показатель делового центра. Пространственное распределение этих заведений было измерено с помощью метода двухмерного ядерного сглаживания. Мы обнаружили, что в советский период количество и пространственный разброс заведений общепита существенно уменьшились. Также мы установили, что после Октябрьской революции 1917 г. центр Санкт-Петербурга сместился на несколько километров к северо-востоку. Наконец, мы протестировали гипотезу о полицентричности Санкт-Петербурга и опровергли ее.

Ключевые слова: Санкт-Петербург; городские прелести; городские услуги; двухмерное ядерное сглаживание; рестораны; централизованно планируемая экономика

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