UMEÅ UNIVERSITY

Modeling Income-Based Residential Segregation in Moscow, Russian Federation

by

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A THESIS

SUBMITTED TO THE DEPARTMENT OF GEOGRAPHY AND ECONOMIC HISTORY

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

MASTER'S PROGRAM IN SPATIAL PLANNING AND DEVELOPMENT

UMEÅ, SWEDEN

JUNE, 2015

Abstract

This thesis investigates spatial patterns of income-based residential segregation at the neighborhood level in the Russian capital city Moscow within new administrative boundaries, which have received relatively little attention in prior studies. It is argued that Moscow faces high levels of income inequality exacerbated by growing levels of spatial segregation between the affluent and prestigious Center – South-West and poor industrial South – South-East. Applying a whole set of quantitative methods complemented with computer mapping techniques, based on the latest 2013 data by the City of Moscow Territorial Branch of the Federal State Statistics and 2010 Census data, this study provides new insights into spatial differentiation processes and elaborates policy solutions aimed at addressing economic disparities in the city. A key finding of this thesis is that income segregation in the study area has been driven to a larger extent by the isolation of very poor neighborhoods from middle- and upper-income areas.

Keywords: Moscow, income, residential segregation, spatial analysis, poverty, affluence, inequality

Acknowledgements

I would like to express my sincere gratitude to my thesis supervisor, Senior Lecturer, Associate Professor Olle Stjernström for his excellent teaching, patient guidance, assistance and considerable contribution to the overall improvement of this study. I have the great admiration for his sense of the analytical mind and inexhaustible creativity. His absolute passion for geography which he entirely shares with all students is truly inspiring. With his encouragement and support, I have been able to cope with difficulties throughout the entire process of writing my master thesis.

In addition, I wish to thank the Student Counsellor Håkan Appelblad, Senior Lecturer at Center for Population Studies Erika Sandow, Professor Urban Lindgren and all other teachers at the Department of Geography and Economic History at Umeå University for generously sharing their expertise and for their valuable suggestions during my studies. I would also like to extend my thanks to Administrator at the Student Office Fredrik Gärling and International Coordinator Wasif Ali for their help in offering me the resources in running the program. I am grateful to my groupmates encouraged me in their own ways: Anna, Erika, Eva-Lena, Hampus, Hanna, Julian, Konstantin, Krista, Marcin, Oskar, Rebecka, Simon, Therese, and fellow students from Master's Program in Tourism: Angyrette, Hannelene, Jakub, Tomoya, Vasileios, and all others.

My studies would not have been possible without financial support from Swedish Institute (SI) providing me with a two-year scholarship for studying the Master's Program in Sweden. I am particularly grateful to the Professor, Doctor of Political Science, Head of Department of Sociology, Politology, and Management at Kazan State Technical University Vladimir Alexandrovich Belyaev for his kind references and SI coordinators Markus Boman and Rita Wikander.

Heartfelt thanks go to the closest members of my family: my parents Gulfia and Ravil and grandmother Radima for their uninterrupted confidence, care and love during all these years. I would especially like to thank my fiance Erik who has always believed in me and helped me overcoming all the obstacles. Finally, I would like to dedicate this thesis to the loving memory of my early passed away grandfathers Rafkhat and Gousman and grandmother Kadria. R.I.P.

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CHAPTER ONE: INTRODUCTION

1.1 Research Needs and Relevance

Currently, it is widely acknowledged that the residential segregation by income, which is a large-scale multidimensional urban phenomenon assuming the uneven geographical distribution of income groups within a certain area, has become one of the key issues in spatial planning policies across Western cities and especially post-socialist regions. The transition process from a state socialist system to a capitalist market economy made the income factor of crucial importance as the main criterion for personal rewards and social status of the individual in present Russian society (Ester *et al.* 1997). Since the 2000s, despite significant economic growth and decreases in poverty levels, income polarization has remained persistently high and has even increased further, fueling substantial disproportions in living standards. The study area corresponds to Moscow, the capital city and the most populous federal subject of the Russian Federation capturing about 10 per cent of the country's total population, but more than 29 per cent of all retail sales, 16 per cent of GDP, almost 53 per cent of financial assets and close to 30 per cent of all direct foreign investments and tax revenues (Department of Economic Policy and Development of Moscow 2014). Moscow is unique in many ways, both in the global sense and within Russia, which makes its study both challenging and interesting because the city's experiences are being repeated in many former Soviet cities and across Russia, although at a smaller scale and with a considerable time lag. Central position and well-developed transportation network has allowed Moscow to take advantage as a major political, economic, cultural, scientific and logistical hub within the country (Urban Land Institute 2011). It is the largest city in Europe and the sixth largest city in the world by population size, close to approximately 12,197,596 inhabitants, and one of the world's largest urban economies (Goskomstat 2015). In addition, Moscow is the northernmost and coldest megacity and metropolis on Earth, with less than 190 frost-free days. In 2012, due to the ambitious expansion project called «New Moscow», the city's territory was increased by 148 thousand hectares of land in the south-west suburbs and by 235 thousand people (Moscow Department of Urban Policy and Construction 2015). The main factors that caused the sprawl of the city are the centripetal development of Moscow, difficult traffic situation and extremely growing population because of intensive labor migration from adjoining regions and former Soviet republics.

It is worth emphasizing that in spite of the fact that Moscow is much wealthier than the rest of the country, with per capita incomes of Muscovites almost 4-6 times greater than that of the national average, the city is characterized by the highest income disparity because of unequal access to its enormous concentration of financial resources. During the last decade, incomes rose significantly in already affluent communities and simultaneously fell on a widespread basis within poor communities. In particular, Moscow has moved from extensive to intensive model of urban development, with more clearly marked urban segregation that reveals prestigious and non-prestigious urban districts, reduction of public spaces, and appearance of isolated gated communities (Zotova 2012). Some elements of territorial segregation based only on socio-professional characteristics in Moscow existed in Soviet times, but the natural process of segregation was restrained due to the Soviet government's commitment to egalitarianism. Since the beginning of housing privatization, the city has spontaneously formed three major sectors: the

prestigious and expensive Center and South-West, industrial and poor South and South-East and intermediate by characteristics North.

Given the potential socio-economic consequences of residential income segregation, it is thus relevant to study the main drivers of this rise in segregation by income in order to provide insights into the circumstances under which segregation evolved and which trends in the economy are most likely to explain the changes in income concentration. However, existing studies concerning segregation issue in Moscow are limited by relatively little attention to the spatial configuration of income segregation across multiple dimensions mainly because of computational difficulties and data limitations and focused rather on the ethnic aspect of residential sorting. Taking Moscow's perspective, this thesis contributes to expanding the knowledge about the main income drivers and assesses the segregation preferences of affluent and poor neighborhoods within new administrative boundaries of the city, which have not been examined before in relation to the chosen research area. Understanding the intensity of social exclusion among the poor and the degree of social closure by the affluent will help to elaborate policy measures that effectively address the processes reinforcing economic disparities in Moscow.

1.2 Aim and Research Questions

The aim of this thesis is to analyze the spatial patterns and underlying processes of residential income segregation at the neighborhood level in the city of Moscow.

To achieve this aim, this thesis is structured around the following research questions:

1. What explicit factors affect income and how these income-affecting factors are interrelated?

2. Are differences in income segregation related to proximity to the centers of activity, as hypothesized by theory?

3. How is segregation of poor and affluent neighborhoods spatially expressed in the study area and how has it changed over time?

4. What are the income segregation levels across five classical dimensions of residential segregation and what impact does ethnicity have on socio-economic patterns?

1.3 Description of Research Methodology and Design

The data necessary for the present study were retrieved from a variety of sources. Substantial amount of socio-economic information (average income per capita, population size, population density, industrial and occupational composition of the economically active population) was taken from the official population registers available by City of Moscow Territorial Branch of the Federal State Statistics (Mosgorstat) based upon 2013 data by the Russian Federal State Statistics Service (Goskomstat). This information originally comes from the annual form No. 1-MO called «The listing about infrastructure objects of the municipality for December, 31 of the reporting year» provided by the local governments of Moscow municipalities to the territorial bodies of state statistics. Regarding the main demographic variables (average age and ethnic composition of the population, educational attainment), data were obtained from the latest 2010 population Census. Time series maps required information at the neighborhood level from the 2002 and 2010 Census records as well. Moreover, published online data from Open Budget of Moscow (2015) on the structure of budget revenues of Moscow municipalities in 2014 have been used as a source for estimating budget share variable and housing sale prices per square meter have been adopted from 2013 Moscow Real Estate Prices Map (CIAN 2013). Geospatial

digital cartographic file for Moscow was initially derived from GIS-Lab electronic resource (2015), being geographically projected later to accurately determine local autocorrelation. By means of the ESRI ArcGIS 10.2.2 tools, tabular data and GIS shapefile have been joined together to create the analyzed map with complete information, where the examined city is subdivided into 146 community areas. The key calculations were performed for all constituent neighborhoods of Moscow using the spreadsheet application Microsoft Excel 2007, general-purpose statistical software packages Stata 12.0 and IBM SPSS Statistics 19, cross-platform software program GeoDa 1.4.6 intended for spatial data analysis and open-source multi-platform Java software Geo-Segregation Analyzer capable of calculating residential segregation indices.

Deploying quantitative methods, this study consists of four stages. In the first stage, in contrast to conventional global statistical regression analyses, such as logistic regression or Ordinary Least Squares (OLS) analyses assuming the data to be statistically independent and identically distributed, spatial processes are addressed in this study using spatial regression analysis. By applying this kind of analysis, a part of the variance is explained by neighboring values and the spatial dimension is truly an important aspect of modeling. Measuring the spatial pattern of neighboring values is based on the notion that features near each other are more similar than features located far apart (Mitchell 2005). Spatial regression methods capture spatial dependency in regression analysis, providing information on spatial relationships among the variables and avoiding statistical issues such as unstable parameters and unreliable significance tests. In particular, multiple OLS regressions with a contiguity-based spatial weights matrix specification (standard and with spatial variable) and Spatial Error Model have been computed in order to identify relationships between income and related factors influencing its spatial pattern across Moscow and providing a powerful statistical context for a study of the extent, processes and impacts of segregation in the city. The construction of the weights in GeoDa 1.4.6 was chosen in accordance with the rook criterion which defines a location's neighbors as areas with full shared boundaries in contrast to a queen weights matrix which includes both common borders and common corners and proceeds in the similar manner as for the rook (Anselin 2005). A complete match between the data and equivalent contiguity entries in the weights file was provided by variable POLY_ID. Calculations were based on Euclidean distance and required projected data. Maps of residuals were constructed using Equal Intervals method which sets the value ranges in each category equal in size, because it is unbiased in terms of category selection and shows the values that are either over- or underpresented. In addition, measures of spatial autocorrelation such as Moran's *I* and Hot Spot Analysis (Getis-Ord Gi*) frequently ignored in statistical analysis of geographical phenomena have been applied as a basis for measuring between-neighborhood segregation to indicate whether spatial dispersion is random or not and identify areas of neighborhood clustering significantly different from the average situation in the total study area. All twelve variables used in this study will also have an individual Gi* map with the explanation of the trend that was taking place and the clustering pattern of high values (hot spot) and low values (cold spot).

In the second stage, to identify the dominant patterns of income segregation, the agglomerative hierarchical cluster analysis based on Ward's method with squared Euclidean Distance as the distance or similarity measure has been used to reduce the 146 Moscow's neighborhoods into a manageable number of six homogeneous groups in accordance with responses to statistically significant variables. Ward's method is distinct from other methods because it uses an analysis of variance approach to evaluate the distances between clusters

(Rogerson 2001). The advantage of this approach is that it does not depend on relatively arbitrary income categories and there is no need to specify a particular spatial form in advance. Cluster membership was assessed by calculating the total sum of squared deviations from the mean of a cluster. The criterion for fusion was that it should produce the smallest possible increase in the error sum of squares. Because the variables are measured on different scales, which affect the squared Euclidean distance measure, standardized Z-scores have been applied. No restrictions were imposed on the number of clusters that are expected to be optimal.

In the third stage, following the descriptive approach of Kendra Bischoff and Sean Reardon (2013), six relative income categories based on the ratios of neighborhood mean income to the total metropolitan area's mean income have been defined and the share of population living in each neighborhood has been tabulated. Next, two measures of income segregation, in particular, trends in the extent of segregation of poverty and affluence were computed and described by employing the Rank-Order Information Theory index, because they provide a detailed picture of how income segregation varies across the city and how it has changed over the period 2002-2013. This index is measured as a weighted average sum of Theil's (1972) Entropy Index of segregation across percentiles for persons below versus persons above each point of the income distribution. In the final stage, in order to assess the overall levels of socio-economic segregation in the city of Moscow traditional indices of segregation have been calculated according to Massey and Denton's (1988) five dimensions: evenness (Gini index), exposure (isolation index and correlation ratio), concentration (absolute concentration index), clustering (absolute clustering index), and centralization (absolute centralization index). Although the coefficient for the variable of mixed ethnicity remained nonsignificant after the introduction of other predictor variables in the preceding spatial regression analysis, the spatial configuration of income segregation can be substantially reinforced by the intersection of ethnic inequality and requires examining the dissimilarity or segregation indices for ethnic groups. For this purpose, all the ethnicities in Moscow were divided into 10 major groups: Rus (Russians only); Slav (SlavonicBelarusians and Ukrainians); Mid_Volga (Tatars, Chuvash, Mordvinians, Udmurt); Eur_Amer (Europeans and Americans); Caucasus (Georgians, Armenians, Avars, Chechens, Ingush, Abkhazians, Azerbaijanis, etc.); South-East Asia (Chinese, Japanese, Koreans); Siberia (Buryats, Yakuts, Altai, Khakasses, Mansi, Tuvinians, etc.); Middle East (Arabs, Kurds, Yezidi, etc.); Central Asia (Kazakhs, Kyrgyz, Mongols, Turkmens, Uzbeks, Tajiks) and Others (category including national minorities).

Using such a comparative and a multi-method approach (spatial regressions and analysis of spatial autocorrelation, cluster analysis, analysis of segregation of affluence and poverty, calculating segregation indices) not only provides new insights into spatial patterns and processes of the income segregation context in the study area but also enables to understand neighborhood transformations and their effects on the city's socio-spatial framework.

1.4 Data Limitations

One of the major limitations of the derived data is the fact that this study has to be based on the relatively gross 146 districts of Moscow in 2013, which are territorial entities of Moscow with the local governments and own budget, rather than on the more detailed census-tract level data as in the United States. Whereas a census tract typically has only a few thousand people, the populations of the city's districts are not of equal size ranging from roughly 2,800 to over 251,000. However, districts in Moscow are the appropriate spatial units of measurement because

of the larger amount of readily available data (the most important statistical indicators concerning population, population density and socio-economic information) for them than for other geographical units, providing a base for certain comparative analysis. Therefore, although this study apparently suffers from aforementioned geographical unit disadvantages, it is the most that can be carried out at present for the largest city of Russia. It should be mentioned that the analysis is constrained by data availability as well. Due to a lack of relevant data, it is impossible to study neighborhood-level residential patterns by household composition and poverty status. The official statistics only use data that analyze income per capita which comes from occupational wages and do not account for the widely recognized non-wage income that many affluent people do not record as part of their profit. Money earned through corruption or other supplementary activities becomes an undeclared income that is systematically underestimated and hence cannot be accurately incorporated into the statistics. According to Department of Economic Policy and Development of Moscow (2014), wages contribute to 44 per cent of all incomes and still remain the main source of earnings both for low- and high-income groups. Nevertheless, wage differentiation plays an especially prominent role in the rapid growth of income inequality, as wages of the highest 10 per cent of earners exceed wages of the lowest 10 per cent of earners by about 16 times. Additionally, statistics on age, educational level, and ethnic composition of the population necessary for examining the socio-economic structure of the city are only available from censuses and make it possible to detect the general outlines of population restructuring in Moscow. More recent official demographic data will not be available until the next All-Russian Census. Moreover, the data labels are written in Russian and are therefore difficult for non-Russian-speakers to access. Despite these inconsistencies, official statistical data are the most reliable information source and are generally characterized by a pronounced preservation of the center-periphery differentiation trends, providing an important baseline of descriptive information about residential income segregation in different kinds of Moscow neighborhoods.

1.5 Ethical Considerations

Unlike qualitative research which involves data recorded in narrative descriptions, quantitative research analyzes data in the form of numbers and in terms of quantity. Ethical issues in experimental quantitatively oriented social science research focus on protecting individuals who receive an intervention, for instance, fully informing participants in group communication about the subject, obtaining their full consent and their right to discontinue the activities at any time. If the investigator receives consent, the ethical problems will be lessened, although not completely eradicated. Furthermore, ethical issues also occur in conducting nonexperimental quantitative research (surveys, data analysis), but they are frequently less complicated and harmful than experimental studies. Nevertheless, it is important to follow the basic principles of protecting the confidentiality of participants (Gallardo 2012). This study involves accessing only publicly available information aggregated within certain geographical units at the municipal level, so there is no reasonable expectation of privacy rights. A person's identity is not inferred in any way in the process of analyzing the data and examining relationships between variables. This probably improves potential data protection and ensures confidentiality of quantitative data analysis techniques. In regard to integrity, all the results of this study are reported accurately in accordance with the results of collected data, only when it actually showed statistically significant differences. All photographs in this paper were taken by the author in the public places of the study area in April 2015.

1.6 Thesis overview

Chapter One outlines the relevance, aim and research questions, methodology and ethical considerations of this study. Chapter Two reviews the existing literature including the classical models of residential segregation and the five dimensions of segregation (evenness, exposure, clustering, concentration and centralization), underlines theoretical and empirical approaches to income segregation and discusses main contribution to investigating segregation in the Moscow metropolitan area. In Chapter Three emphasis is put on the patterns of income segregation in Moscow by outlining post-socialist peculiarities of spatial structure of Moscow and changes in income separation across the city, exploring main challenges for urban development, and proposing justification of the indicator variables complemented with hot spot analyses in the study area. Chapter Four presents the results of the analysis components of this research study, including the spatial regression analysis, cluster analysis, evaluation of the intensity of income segregation between the affluent and the poor, mapping techniques of income differences allowing to reach a better understanding of what happened to the residential income segregation pattern in Moscow over time, and segregation indices. Finally, Chapter Five summarizes the conclusions of this study by addressing the research questions together with directions for future research and designing the efficient policy instruments to make segregation in the study area a more acceptable option.

CHAPTER TWO: LITERATURE REVIEW

2.1 Classical Models of Residential Segregation

One of the first attempts to formulate a model of spatial segregation was made by the German geographer Kohl in 1841, who confirmed that the city was segregated by the elite in the city center and the poor living on the periphery. In an effort to distinguish and categorize patterns of residential segregation, a set of considerable urban studies emerged in the United States during the first half of the 20th century. The Concentric Zone Model was proposed by a sociologist of the Chicago School Ernest Burgess (1928), who argues that a city radially grows outward from its central point toward the outskirts in a series of rings or five concentric zones. According to Burgess (Figure 1a), the Central Business District Zone focusing financial, recreational, political activities and transportation is located in the inner circle, and then surrounded by the Zone in Transition comprising the slums and colonies of recent immigrants with low living standards, then the Zone of independent Workingmen's Homes inhabited by industrial workers who escaped from the previous zone but wished to live in the close proximity to their work, afterwards the Residential Zone made up of middle class single-family dwellings or high-class apartment buildings, and finally the Commuters' Zone located beyond the city limits in suburban areas or in satellite cities. Appropriate extension zones occur as the city expands and with the growth of its central business district. Therefore, Burgess observed that wealthier families tend to abandon the central business district due to the increasing pollution and violence, thus leading to suburbanization process of high-income classes towards the peripheries, while low-income classes occupy devalued areas in the center close to employment opportunities. However, he underlined that other factors such as situation, prevailing city plan and its system of local transportation can modify this pattern. Some Latin-American and post-socialist cities in Europe exhibit an inverted center-periphery pattern, where wealthier families tend to concentrate in central areas notably in terms of social status supplanting poor families to the outskirts of the city (Harris & Ullman 1945).

In 1939, the American economist Homer Hoyt proposed a second model of spatial segregation, known as the Sector Theory Model, in accordance with which cities grow in star-shaped sectors along a particular axis of main transportation routes rather than rings (Figure 1b). The entire city is considered as a circle with the various sectors extending from the center of that circle towards the periphery. In this model, a low-income housing area located in the southern quadrant would tend to extend outward to the very margin of the city in that sector. Diametrically opposed, high-class residential areas would segregate themselves along established lines of the fastest transportation, best urban infrastructure and largest amenities in the eastern quadrant surrounded by the sectors of the middle-income population. By the mid-1940s, it became evident that the existing models of development of large cities do not reflect the reality, as in many cities the land-use pattern is built not around a single center but around several discrete nuclei. Thus, Chauncy Harris and Edward Ullman (1945) developed Multi-core or Multiple Nuclei Model (Figure 1c). The initial nucleus of the city can be located not obligatorily in a central place, it can arise around the port or railway facilities, or the factory and mine. Harris and Ullman distinguished the following main nuclei: the central business district with retail concentration, financial institutions and government buildings; the wholesale and light-manufacturing district near transportation facilities; the heavy industrial district near the present or former outer edge of the city; minor nuclei including cultural centers, parks, outlying

business districts, and small industrial centers; and finally the residential district. In general, high-class districts are likely to be located on well-drained, high land away from noise, odors, smoke, and railroad lines, and low-class districts are likely to arise near factories and railroad districts, wherever located in the city. Extreme cases are the ethnically segregated groups which cluster together.

Both Burgess' and Hoyt's models describe cities disregarding specific geography, culture or history. Moreover, both models refer exclusively to monocentric cities built upon static landscapes and impose several constraints. In Multiple Core model, the number and the size of nuclei frequently gathered in clusters result from historical development and vary greatly from city to city. However, the basic features of the center-periphery, sector and multiple nuclei models are still commonly used as the basis for any segregation analyses of the urban dynamics.

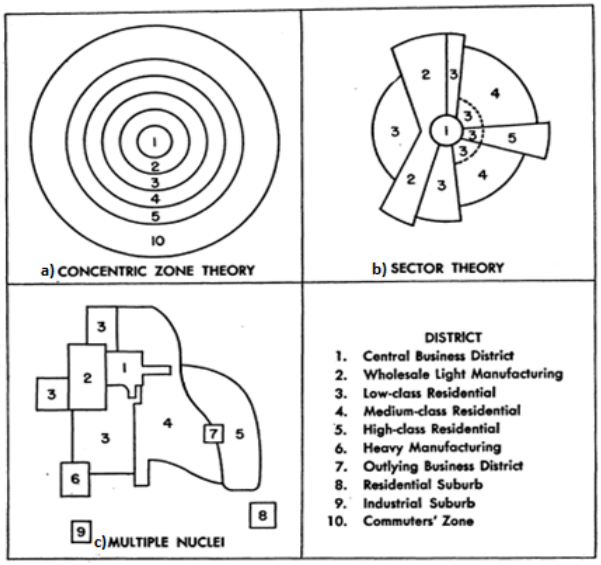


Figure 1. Classical models of residential segregation
(Source: Harris & Ullman 1945, p. 13)

2.2 Dimensions of Residential Segregation

Since aforementioned classical studies, residential segregation has been a prominent topic in social science, provoking numerous disputes about development of an adequate measure of segregation with no consensus on the matter having been reached. In 1955, Otis Dudley Duncan and Beverly Duncan introduced the standard index of residential segregation, so-called Index of Dissimilarity, which can be interpreted as the ratio between the number of households that actually have to move and the maximum number that would have to move to achieve an even distribution and make the city completely desegregated. The importance of the Duncan and Duncan study (1955) is that they have shown that almost all previously suggested indices have a geometrical relationship to the segregation curve. However, having explored the limitations in the use and interpretation of the Index of Dissimilarity, Cortese *et al.* (1976) demonstrated some systematic limitations of this index, since it was affected by the number of households being inflated by random factors, did not include the concept of replacement of the relocated minority in the population and prevented intercity comparisons. As revealed by Green (1994), there are also several problems associated with the measure of Dissimilarity Index, because the expected value of the index will be significantly larger if the spatial unit under consideration and the proportion of the population belonging to the minority group are small. Afterwards, multiplicities of old indices were reintroduced and new were invented. In an effort to classify all the indices, Douglas

Massey and Nancy Denton (1988) from the Chicago School undertook a systematic analysis of twenty existing segregation indices, proposing a systematic classification of five distinct dimensions of residential segregation: evenness, exposure, concentration, clustering, and centralization. The Chicago School used the ecological analogy of invasion and succession to explain changing patterns of residential segregation that finally led to the dominance of one or more socio-economic groups in certain parts of a city. Massey and Denton (1988) thus considered segregation as the degree of separation of two and more groups in the urban environment and argued that a group that is unevenly distributed, minimally exposed to majority members, spatially concentrated, tightly clustered, and highly centralized, is residentially segregated. The multidimensional structure of segregation has been later confirmed by Massey *et al.* (1996) and Wilkes and Iceland (2004). Most indices vary between zero (no segregation) to one (maximum segregation).

The first dimension of segregation, evenness, concerns the unequal distribution of two social groups across units of an urban area. In spite of its imperfections, the Index of Dissimilarity by Duncan and Duncan has been and remains the most widely accepted measure of the evenness dimension. A widely used measure of income inequality, the Gini coefficient, which can be expressed as the mean absolute difference between minority proportions weighted across all pairs of areal units, can serve as another measure of evenness. Unlike the dissimilarity index, the Gini index is less sensitive to deviations from normality, provides a link between income inequality, neighborhood income segregation and patterns of spatial income clustering among adjacent neighborhoods. In addition, James and Taeuber (1985) recommended the Atkinson index (Atkinson 1970) for measuring evenness, but the Atkinson and dissimilarity indices are highly correlated and typically yield the similar conclusions. Moreover, the Atkinson index represents a whole group of indices creating certain difficulties with comparability due to redundant results. Alternatively, Theil (1972) proposed entropy index, also called the information index, measuring departure from evenness by controlling after each unit's departure from the extent of the whole city's diversity. Nevertheless, it fails on the criterion of compositional invariance since its values are determined by the relative number of minority members.

The second dimension of segregation, exposure, refers to the degree of potential interaction or contact between groups within neighborhoods of a city (Massey and Denton 1988). Exposure indices measure the likelihood that members of one group will physically encounter another group (interaction) or members of their own group (isolation) by sharing the same residential area. Taking into account high empirical correlation between indices of exposure and evenness, there are substantial conceptual differences among them, as the former depend on the relative size of the compared groups, while the latter do not. The significance of exposure indices was mentioned by Bell (1954) and Lieberson (1981), who in own turn proposed the P* indices, namely interaction index measuring the probability that members of one group share a neighborhood with members of another group, and the isolation index measuring the probability that one group members share an area with each other. Standardization of the isolation index yields the correlation ratio called Eta2 (White 1986).

The third dimension of segregation is concentration, or the relative amount of physical space occupied by a minority group in the urban environment. The group is ought to be more concentrated if it occupies less of the metropolitan area. The original index of concentration called Delta interpreted as the share of minority members that would have to shift to achieve a uniform density of minority members was first proposed by Hoover (1941) and subsequently adapted by

Duncan *et al.* (1961). However, Massey and Denton (1988) recommended the selection of Relative Concentration Index on the concentration dimension because of being more preferably distributed and having greater variability. Egan *et al.* (1998) showed that caution should be exercised when measuring the concentration of groups with very few members in large areas, because the index takes a negative sign. The fourth dimension of segregation, clustering, refers to the extent to which areas inhabited by minority members spatially adjoin each other. A high degree of clustering assumes a residential structure where minority areas are arranged in the form of one large enclave, whereas a low level of clustering implies that minority areal units are randomly scattered around the urban environment in a checkerboard pattern. The index of clustering chosen by Massey and Denton is White's index of spatial proximity (1983) estimated as a weighted average of the distance between members of the same group and between members of different groups. Although the index has factorial complexities greater than one, it is easier to calculate and interpret. The last dimension of segregation, centralization, reflects the degree to which a group is located near the center of a metropolitan area. According to Massey and Denton (1988), in many cities of developing world, poor groups often inhabit suburban or peripheral areas, and in most industrialized countries, minorities tend to concentrate in the center city areas. Centralization is measured by an absolute index reflecting the degree to which a group is spatially distributed close or far away from the central business district (CBD) by using a formula appropriated from Duncan (1957).

Since Massey and Denton's (1988) analysis, social scientists have generally aspired to measure one or more of the five dimensions, especially relying on Index of Dissimilarity and Isolation Index. Notwithstanding, the most extensively used alternative measure was the entropy index (Fischer *et al.* 2004). Searching for new measures of the degree to which groups are separated from one another residentially, Grannis (1998) applied a new approach to measuring residential segregation by shifting from census tracts to tertiary residential-type streets. He shows that people living in these small communities interact socially in contrast to people living on distant streets that do not have a t-intersection. Nevertheless, t-communities are much more complicated and time consuming to construct as they are not standard units of census geography, requiring schematic street grid maps and their visual inspection. Reardon and O'Sullivan (2004) suggested an alternative view to the Massey and Denton's (1988) conceptual dimensions of residential segregation, allocating only two primary dimensions: spatial exposure, or spatial isolation, and spatial evenness conceptualized as spatial clustering, with centralization and concentration dimensions as only specific subcategories. Despite the existence of a number of new proposed measures of spatial segregation, such measures have not been widely used in residential segregation research and the dimensional conceptualization of segregation developed by Massey and Denton continues to stay a dominant standard. It is worth noting that it is necessary to examine all five indices of segregation simultaneously, as they are all scientifically valid measures capturing different aspects of segregation. For instance, there can be found a pattern called «Hypersegregation» when groups are highly segregated on all five dimensions at once (Massey and Denton 1989). Therefore, grouping segregation indices into five dimensions represents a relevant analytical approach to exploring social, ethnic, age and economic residential segregation in metropolitan areas.

2.3 Income segregation

While much of the debate over segregation in the literature has concentrated basically on racial or ethnic segregation, relatively less attention has been paid to other possible types of neighborhood segregation such as segregation by income. In general, it implies that in a highly segregated urban area, lower-income households will typically reside in neighborhoods with lower average incomes than higher-income households being benefited not only by the accentuated difference in their own incomes but also by the differences in their respective neighbors' incomes. As Musterd and Ostendorf (2012) point out, it is possible to allocate institutional, social polarization, and context-sensitive approaches operationalizing the research of income segregation. The institutional approach appeared in the late 1960s, when Rex and Moore (1967) proved how state interventions could moderate the relationship between income and housing. Economic modeler Thomas Schelling (1971) proposed a space-time model indicating that even if every person tolerated or even preferred integration, the collective interaction of individual preferences will tend to produce segregated neighborhoods. Sassen (1991) in her thesis of social polarization argued that increasing economic inequality and social divisions contribute to decreasing of the middle class acting as a social buffer to prevent the more disadvantaged being socially isolated. However, the polarization approach is criticized because of oversimplification of the global interplay and the role of local contingent factors. Within the limits of the contextual approach, the link between inequality and income segregation is defined by the different characteristics of a city, such as its size, manufacturing base and employment structure (Burgers and Musterd 2002; Brown and Sharma 2010; Reardon and Bischoff 2011), residential housing profile (Galster and Booza 2007), and topography (Meyer 2005).

Reardon and Bischoff (2011) found a robust relationship between income inequality and income segregation along three main dimensions: the spatial segregation of poverty and affluence, race-specific patterns of income segregation, and the geographical scale. Without income inequality inducing the highest-income families to move away from lower-income households, there could be no income segregation, because all neighborhoods would have the same income distribution. The first important dimension of income segregation is that it may produce the segregation of affluence, or the extent to which the highest-income households are isolated from middle- and lower-income households, and the segregation of poverty, or the extent to which the lowest-income households are isolated from middle- and upper-income households. Although most prior research concerning the spatial distribution of income have primarily investigated the effects of concentrated poverty on residents of poor neighborhoods, a better explanation of the effects of affluence highly concentrated spatially and directly influencing the resources available to residents of both poor and lower-income neighborhoods is required as well (Massey 1996; Massey *et al.* 2009). Dwyer (2010, 2012) argues that increasing clustering of the rich in specific metropolitan areas prevents any contacts between the affluent and either middle-income or poor households, further exacerbating negative effects of income segregation. A second important dimension is the relationship between income segregation and patterns of racial or ethnic segregation given the correlation of race/ethnicity and income. Racial segregation taken alone can produce a certain degree of income segregation, implying the necessity of examining income by race or ethnicity. Moreover, the factors affecting income segregation may differ across race/ethnic groups, which have very different residential options even with identical incomes. A third dimension of income segregation is its geographical scale referring to the extent to which the neighborhood sorting by income emerges from large-scale patterns (e.g. when all high-income

households reside in the suburbs and all low-income households live in the city) or from small-scale patterns (when high- and low-income residents are spread in a checkerboard pattern throughout an urban area). Reardon *et al.* (2009) argue that micro-scale residential segregation patterns may cause disparities in the spatial distribution of crucial public facilities with more adverse and potentially inequality-enhancing consequences, especially for children and elderly who spend more time in a particular neighborhood than adults.

Income segregation is important to study because it may lead to inequality in social, economic, political and health-related outcomes (Jencks and Mayer 1990; Sampson *et al.* 1997; Leventhal and Brooks-Gunn 2000; Morenoff 2003). Tiebout (1956) presented a model of residential sorting which predicts income segregation because households with identical preferences and ability to pay tend to organize homogeneous communities by income. Low-income communities are often incapable of generating enough social and human capital resources, whilst high-income households may cluster in a small number of neighborhoods or municipalities and collectively improve own outcomes by isolating themselves in wealthy communities and accumulating extensive financial and social capital. Homogeneous higher-income neighborhoods may possess more green space, better social services and security, better funded schools, and other prestigious amenities and quality public goods. Tiebout's model has been extended by Epple and Platt (1998) and Head *et al.* (2014) confirming that rich households always choose to live in a higher quality and more expensive neighborhoods than poor households. Additionally, housing prices are tightly linked to the cost of nearby housing, leading to a certain degree of residential sorting by income, making the price of housing less affordable to low- and middle-income households (Rothwell and Massey 2010; Reardon and Bischoff 2011). Schill and Wachter (1995) explain the major causes of geographical differentiation by income as a variety of market (mobility of households and their preferences for residential environments with homogeneous economic composition) and nonmarket forces (local government land use regulations and discriminatory practices in the housing market). Following the models of cumulative causation, Meen *et al.* (2005) suggest that observed patterns of segregated communities by income are interrelated outcomes of the restrictions faced by households in terms of available housing, unemployment, the lowest skills, bad physical environments and poor health, when the most deprived low-income households tend to be located in the worst places and are more likely to be spatially and socially excluded, whereas high-income households are able to leave more easily.

A large body of recent research (Rosenbaum and Popkin 1991; Waitzman and Smith 1998; Katz *et al.* 2007; Clampet-Lundquist and Massey 2008; Ludwig *et al.* 2008; Sampson 2008) has undertaken an attempt to investigate neighborhood effects of living in communities with a high poverty rate. Several studies investigating the effects of income segregation (Benabou 1994; Orfield 1994; Mayer 2000; Quillian 2007) show that income segregation within metropolitan areas is associated with greater inequality in school funding and educational attainment between poor and high-income individuals, thereby contributing to long-term economic polarization. Mayer and Sarin (2005) assume that greater income segregation is connected with higher rates of morbidity and infant mortality. Watson (2009) discovered that higher employment rates are associated with lower levels of income segregation, because unemployment stipulates the departure of middle- and upper-income households from central cities, thus increasing income segregation. A related body of research points out that racial segregation presupposes some level of income segregation which is a plausible mechanism leading to racial inequality in health

outcomes and in labor market because of discriminatory conduct, distance from places of residence, and lack of information about possible job opportunities (Clark 1986; Wachter and Weicher 1989; Cutler and Glaeser 1997; Ellen 2000; Ananat 2007; Osypuk and Acevedo-Garcia 2008).

It is important to mention that unlike discrete variables such as race/ethnicity or gender, income is measured on a continuous scale, so measures of segregation that are applicable for categorical groups are inappropriate for measuring income segregation (Jargowsky 1996). Much of the existing research on the subject has focused on measuring overall income segregation by using established measures of racial segregation, such as the index of dissimilarity, tested on a small unrefined set of income categories. Examples of this approach can be found in sociology (Erbe 1975; Massey and Eggers 1993; Massey 1996; Fong and Shibuya 2000; Massey and Fischer 2003), urban planning (Abramson *et al.* 1995; Coulton *et al.* 1996; Pendall and Carruthers 2003), and economics (Jenkins *et al.* 2006). Nonetheless, there are some imperfections associated with this method, such as the substantial loss of information that results from considering income as categorical, choosing a small number of income classes to categorize the continuous data, and monetary equivalent change over time. Coupled with this, the dissimilarity index does not satisfy Pigou-Dalton principle of transfers implying that in the case of neighborhood income segregation a transfer of income from a neighborhood with a higher per capita income to one with a lower per capita income should always result in a decline in the applied measure of income segregation (Sen 1997). The index of dissimilarity satisfies these principles only partially when income is transferred from neighborhoods with per capita incomes that are greater or less than the average for the whole metropolitan area to one that is less than (or greater than) the metro wide average (James and Taeuber 1985). This means that the index will tend to underestimate the impact of transfers among adjacent neighborhoods relative to more distant neighborhoods. Reardon and O'Sullivan (2004) also criticized aspatial segregation measures in the residential income segregation context for their inability to account for the spatial patterning of census tracts leading to two substantial flows: the checkerboard problem and the modifiable areal unit problem.

Another approach to measuring income segregation defines segregation as a ratio of the between-neighborhood variation in mean income to the total population variation in income. Among this type of income segregation measures, Davidoff (2005); Wheeler (2006); Wheeler and La Jeunesse (2006) used the variance of incomes, Jargowsky (1996) explored the standard deviation of incomes, Ioannides (2004) concentrated on the variance of logged incomes, Hardman and Ioannides (2004) on the coefficient of income variations, Ioannides and Seslen (2002) applied Bourguignon's decomposable income inequality index. Paul Jargowsky's (1996) Neighborhood Sorting Index (NSI) defined as the square root of the ratio of the between-unit income variance to the total income variance is most well-known in sociology as it does not rely on arbitrary categorization of income distributions but has limitations for the investigation of the relationship between income inequality and income segregation. The index varies from zero indicating perfect economic integration to one confirming perfect economic segregation. Similarly, Watson (2009) proposed the Centile Gap Index (CGI) measuring segregation as one minus the ratio of within-neighborhood variation in income percentile ranks to the overall variation in percentile ranks, but it does not allow clear comparisons across metropolitan areas and years and consequently cannot take into account geographical scale.

In 2005, Jargowsky and Kim elaborated the modified extension of the NSI and called it the Generalized Neighborhood Sorting Index (GNSI), calculated by means of a spatial weight matrix

that incorporates the spatial structure of the neighborhoods, the extent of which can be transformed by increasing the order of contiguity with two spatial weight matrices (rook and queen criteria). GNSI being equal to zero indicates that all the community mean incomes are the same as the total average, and a value of one shows that all the households reside in strictly homogenous communities, with the each household's income exactly equal to the community's mean income. The key difference between GNSI and NSI is that the GNSI incorporates a flexible technique for the calculation of a neighborhood's economic level which is larger than the neighborhood itself, while NSI does not take full account of the spatial arrangement of the geographical units. Overcoming a number of drawbacks of its predecessor NSI, GNSI is sensitive to the spatial relationships, can measure the degree of segregation at large and small spatial levels, and substantially alleviates the checkerboard problem. However, GNSI assumes data based on geographical boundaries and therefore is not entirely free from MAUP. The main shortcoming of NSI, GNSI and similar measures is that these indices are quite problematic to calculate using commonly available data, as the total variance of household incomes is not published in any census. Alternatively, Jargowsky and Kim (2009) came up with the Information Theory of Segregation, arguing that all measures of inequality can also be used to measure segregation. They developed a Gini Segregation Index for continuous variables and Income Dissimilarity Index indicating the proportion of money that neighborhoods should switch across neighborhoods to achieve equal mean incomes. Reardon and Firebaugh (2002) extended the Gini to polytomous categorical variables and Dawkins (2007) proposed a spatial version of Gini which he called a spatial ordering index less sensitive to the presence of outliers. Extending the Dawkins (2004) standardized spatial Gini index from the context of racial segregation to the case of income segregation, this index represents itself a ratio of two covariances: spatial Gini index calculated from either a nearest neighbor or a monocentric spatial ordering of neighborhood per capita income and a Gini index of between-neighborhood income segregation. Despite its advantages, the spatial ordering index is extremely general and may have different vague interpretations together with many possible spatial ranking schemes.

As revealed by Bischoff & Reardon (2013), more suitable measure of income segregation is classification of neighborhoods into poor and affluent neighborhoods using neighborhood income as base or the rank-order information theory index. Classification of neighborhoods by income requires a ratio of the neighborhood average income to the metropolitan area average income. Income ratio less than 0.67 will define poor, ratio between 0.67 and 0.80 – low income, ratio between 0.80 and 1.0 – low-middle income, ratio between 1.0 and 1.25 – high middle income, ratio between 1.25 and 1.5 – high income and ratio greater than 1.5 – affluent neighborhoods. In a highly segregated urban area, many families will live in poor or affluent neighborhoods and relatively few will reside in middle-income neighborhoods. Summing the proportions of affluent and poor households will result in a measure of income segregation. The advantage of this measure is that it is easily interpretable but uses subjective definitions of neighborhood poverty and affluence. In a similar manner, Fry and Pew (2012) developed a single Residential Income Segregation Index (RISI). The RISI score for a given metropolitan area is estimated by adding the share of low-income residents of that area living in a majority low-income census tract to the share of upper-income residents in that area residing in a majority upper-income census tract. The rank-order information theory index based on Theil's (1972) entropy index estimates the ratio of within-unit income rank variation to overall income rank variation in metropolitan area as a whole and ranges from a minimum of zero in the case of no

income segregation to a maximum of one obtained in the case of complete income segregation. The entropy index easily handles multiple income categories but is subject to shifts in the underlying income distribution (Jargowsky 1996).

Whilst income segregation can be a source of injustice and is frequently considered as an undesirable phenomenon, scholars have only recently started discussing the voluntary self-segregation of the middle class and elites in gated communities and privately governed urban neighborhoods (Blakely and Snyder 1997; Webster *et al.* 2002; Low 2003; Atkinson and Flint 2004; Atkinson and Blandy 2005; Gwyther 2005; Atkinson 2006; Vesselinov *et al.* 2007; Le Goix and Webster 2008; Merriam 2011). There are three main types of gated compounds: lifestyle and prestige communities based on initiatives of developers to sell properties to high-income and affluent customers, and security zones based on residents' initiative to secure their residential area by limiting access to it by means of fences, barricades, monitoring system, etc. From this point of view, the latter may be distinguished from condominiums and secured apartment complexes as behind the gates they include shared amenities and public spaces. Gentile and Sjöberg (2006); Polanska (2010); Marcińczak *et al.* (2015) considered the delayed emergence of gated communities in the post-socialist urban context and discussed the reasons for their increasing popularity. It is argued that the motives for moving to gated communities tightly intersect with the spatial structure of the post-socialist city and strengthening social polarization combined with the weakness of the present spatial plans and the municipalities' unwillingness to hinder the development of gated communities. Besides, it is largely agreed in the literature that the implementation of socialist city planning principles and the administrative allocation of housing made post-socialist cities less segregated and more spatially homogeneous in comparison with their Western capitalist counterparts. Emphasizing the integrative effect of gated communities, Salcedo and Torres (2004); Manzi and Smith-Bowers (2005) argue that without gating these communities would have never been constructed in lower-income neighborhoods. Summing up, the evidence on the segregation effects of gated communities is mixed because on the one hand, they collaterally encourage investment in poor neighborhoods by bringing new sources of employment, better trunk water, sewerage and other utilities and facilitate the functional economic integration between income groups, and on the other hand, in some circumstances may reinforce segregation patterns contributing to territorial fragmentation.

2.4 Research of segregation in the study area

Concepts of social inequality and urban segregation did not exist in the egalitarian sociological models of Soviet society. Issues of social and territorial differentiation of the urban population were unpopular among sociologists and geographers. The territorial differentiation of Moscow's population has been studied only selectively as a historically transient phenomenon and a natural consequence of labor division (Rukavishnikov 1983; Trushkov 1983; Barbash 1986; Shulga 1988). The authors of these studies showed solidarity in their conclusions that social heterogeneity of urban settlement occurs on the basis of social inequality in the capitalist world and as a result of demographic characteristics of the population, land development, and accommodation of employment in the socialist city. In response to major social and economic changes occurring in the aftermath of the Soviet Union's collapse in 1991, authors such as Bater (1994); Mozolin (1994); Trushchenko (1995); Vendina (1997, 2002, 2005); Krasheninnokov (2003); Lentz and Lindner (2003); Makhrova (2006); Nozdrina (2006); Blinnikov (2010); Mazanik (2013) have analyzed the trends of intraurban social segregation in

Moscow, described the historical trends of social resettlement of dominant groups determining the prestige of the city center, and investigated the dynamics of the modern housing market and settlement in the Moscow region. Studies examining the development of gated communities in Moscow metropolitan area and their impact on urban life are not so abundant compared to the amount of research on gated communities in the West (Blinnikov *et al.* 2006; Lentz 2006; Medvedkov and Medvedkov 2007; Zotova 2012). Several researchers, such as Daniell and Struyk (1994); Gritsai (1997); Bater *et al.* (1998); Adams (2008), examined the impact of central Moscow's employment structure, housing stock, locational pattern of business services, and land use, asking the main research questions: «To what extent do the inherited structures of the socialist city make the segregation pattern different from those already described in the scientific literature? Is Moscow close to the traditional monocentric development of the big cities in the developing world? Is it more similar to the European or the American pattern? Who are the people living in the central Moscow?». Cordula (1997); Badyina and Golubchikov (2005) based own studies on the most expensive quarter Ostozhenka of central Moscow as an example of urban segregation and gentrification processes. Scholars Ioffe and Nefedova (1998); Ioffe and Zayonchkovskaya (2011); Makhrova *et al.* (2012) examined suburbanization trends and spatial shifts in the distribution of population within Moscow city and Moscow Region.

After examining the contemporary strategies of urban management in the city of Moscow, Kolossov *et al.* (2002); Kolossov and Loughlin (2004) have drawn a conclusion that modern Moscow is a polarized city that perfectly fits Marcuse's (1997) citadel-ghetto model. Citadel is established by higher-income, higher status group to protect or enhance its dominant position, and ghetto is the result of the involuntary spatial segregation of a group that stands in a subordinate social relationship to surrounding society. Having investigated the Moscow's patterns of socio-economic (1997) and ethnic (2002; 2005) segregation, Olga Vendina concluded that post-Soviet social polarization has led to stronger spatial differentiation and revealed the link between migration processes that contribute to the growth of ethnic diversity of Moscow's population, and socio-economic stratification of society in terms of divergent incomes, educational levels, and social status. It is emphasized that it is necessary to counteract income inequality and focus major efforts on fighting with poverty to avoid increasing ghettoization and emergence of ethnic residential clusters in the Moscow's fragmented urban space. Vendina (2002) also reexamined the Western theory of social polarization for its possible application to post-Soviet Moscow and found that it is not applicable in the full sense because of a partial divergence from Western correlations between social status and material welfare. Increased polarization in Moscow can be explained by emergence of new political elite, new types of postindustrial occupations while old types became less common or disappeared, and high influx of economic migrants in the city (*ibid*).

Differences between the inner and the outer zones of Moscow and the concentration of educated people in the center and the south-west sectors of the city were also considered in the analysis of Timothy Colton (1995). Ester *et al.* (1997) applied Theil-Entropy and Theil-Bernoulli coefficients and found that the gap between the rich and the poor in Moscow is widening because the rich have become richer and the poor have become poorer. Much of the academic research regarding segregation on the subject of residential segregation in Moscow is based upon a variety of qualitative and quantitative methods that do not use or even mention the use of Geographic Information Systems and segregation indices. Richard Rowland (1992, 1998) was the only one scholar who applied segregation indices, in particular, Index of Dissimilarity, to study the degree

of ethnic segregation in the Outer and Inner Zones of Moscow during the 1979-1989 period in the old administrative districts abolished in 1992. His results indicated that there was relatively little segregation between the Moscow's nationalities, with the lowest levels of segregation experienced by the three Slavonic nationalities, namely, Russians, Belarusians and Ukrainians, while the Jews, Chuvash and Kazakhs had the highest levels of segregation. The social-territorial structure of Moscow was rarely properly examined partly because of the lack of reliable statistical data for micro-districts. Therefore, in the existing literature less attention has been given to the issue of the spatial nature of residential segregation by income within the new administrative boundaries of Moscow. Additional research is needed to more fully understand the specific mechanisms underlying segregation of poor and affluent neighborhoods in the study area.

CHAPTER THREE: PATTERNS OF INCOME SEGREGATION IN MOSCOW

3.1 Spatial Structure of Moscow

3.1.1 Post-socialist Peculiarities

Founded in 1147, Moscow has been a capital city several times throughout its history. Since the move of the capital from St. Petersburg to Moscow in 1918, Moscow has been both an industrial and governmental center, first for the Soviet Union in 1922 and for the broader Communist bloc from 1945-1991 (Kolossov *et al.* 2002). Following the Soviet Union's dissolution in 1991, Moscow became the capital of the Russian Federation and since 1993 the country's federal entity. Similar to other East-European cities, the intra-urban geography of Moscow carries incredibly strong imprints of the period of socialist urbanization and is characterized by a certain degree of physical differentiation being sufficient to create significant inequalities, mainly with regard to housing provision, access to public services and jobs, and exposure to negative urban externalities (Gentile and Sjöberg 2006). The relatively low levels of income variation in former Soviet cities reflect not only the egalitarian nature of the former USSR provided all areas with an equal amount of infrastructure facilities, but also housing shortages (Rowland 1998). There was a general absence of a poorer minority-dominated inner city and a richer non-minority outer city, which is more characteristic of American cities. Therefore, it can be argued that horizontal social segregation, which at that time was becoming more pronounced in the spatial organization of Western metropolises, was not typical of Moscow (Mazanik 2013). Naturally, horizontal stratification existed, but it was not expressed in the form of class segregation but rather in the presence or absence of the upper classes, suggesting the existence of a certain degree of vertical segregation.

According to Makhrova *et al.* (2012), the complexity of the spatial structure and the economic functions performed by the Moscow metropolitan area have given rise to a multiplicity of division patterns: monocentrism, radial-concentric and sector-waist agglomeration profile with sharp differences of center and periphery and asymmetry of the western and eastern parts. In contrast to American rectangular urban planning system, Moscow has long been built using a concentric-radial layout with rings starting from the city center to the outskirts and residential neighborhoods having the form of segments of a circle (Insiders Guide 2015). Moscow's road system is centered in a star-like pattern, where territories along the main radial prospects serve as a direct extension of the Moscow Kremlin, seat of the Russian government (Figure 2). The first and innermost major ring, Bulvarnoye Koltso (Boulevard Ring) was built at the former location of the 16th century city wall and is probably the oldest one. The second primary Ring located outside the Boulevard Ring is Sadovoye Koltso (Garden Ring), which is the main driveway of Moscow's center. The Third Transport Ring was completed in 2003 as a high-speed freeway between the Moscow Automobile Ring Road and the city center. Currently being built Fourth Transport Ring aimed at reducing traffic congestion will probably lie between the Third Ring and the Ring Road. The outermost ring within Moscow is the Moscow Automobile Ring Road forming the approximate boundary of the old Moscow.

Moscow's trajectory significantly deviated from other capitalist and its East-European neighbors because it started the process of CBD formation with all types of services and infrastructure from a more initial stage. The radial-concentric structure of the city endowed the center with the highest economic and social potential as an attractive place of residence and job

location (Mazanik 2013). It is possible to allocate two complementary features of socio-spatial segregation taking place in the central Moscow (Trushchenko 1995). The first feature of socio-spatial differentiation was that despite heterogeneous housing fund underclass, marginal elements and lower strata have been consistently replaced by wealthy households from prestigious central areas to a more remote margin. Those early developments gave a start to the well-known core-periphery gradients in the socio-economic differentiation of the urban space in Moscow. According to the second feature, lower strata still living in the center are denied access to all localized benefits advantaged by the privileged strata: luxury residence with the highest real estate prices, elitist schools, clubs, shops, etc. This is unlikely to change in the coming years before at least the infrastructural gap between the central and peripheral areas of Moscow has narrowed. Most of the new clusters of modern economic activities outside the traditional center grow in a few, already privileged directions confirming the specific star-like pattern of centrality rather than indicating a true decentralization (Gritsai 1997).

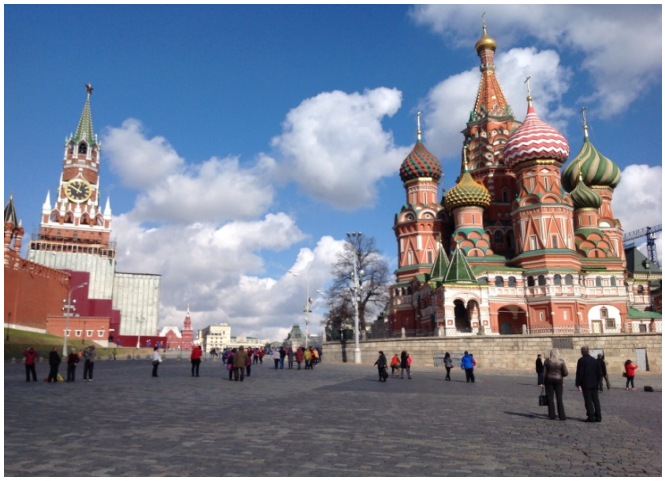


Figure 2. Moscow Kremlin in Tverskoy District (Source: Author 2015)

3.1.2 Functional Zones

Like in the most Russian cities, a few typical districts could be distinguished within Moscow: the historical core; the old periphery; the industrial belt; and sleeping quarters (Blinnikov 2010; Figure 3). The first zone, historical core, houses the Kremlin with government buildings, banks, offices, the most expensive boutiques, and the oldest theaters. The second zone, old periphery area, is located outside the historical core limits and is the most desirable place to live. In contrast to many North American cities, where there is usually a zone of discard between downtown and the residential areas, Moscow has this zone full of well-maintained large residential housing, train stations, markets, and shops. Today much of this area is undergoing rapid construction and gentrification. Perhaps, one of the largest renovations is a high-rise business center «Moskva City» built on the banks of the Moscow River in Presnensky District, with over 2 million square meters (hereafter sq.m) of finished office space (Figure 4). The third zone, industrial belt mainly developed in the 1930s, in the Soviet period accommodated the factories, environmentally harmful industries and related urban settlements which were located rather east, leaving the picturesque western suburbs of Moscow less urbanized. Many of the old industries are now in decline, and city authorities remove the old industrial enterprises replacing them with new residential districts and commercial centers. The fourth zone constitutes sleeping quarters which were built on the former sites of demolished villages (Chertanovo, Biryulyovo, Degunino) or on reclaimed aeration fields (Maryino, Nekrasovka) to accommodate workers from

the industrial belt. One of the main features of the sleeping quarter concept was that services which would be required on a daily basis should be located within each neighborhood: apartment buildings, stores, a school, a clinic, a library or a small stadium surrounded by playgrounds, and tree-covered areas (Gentile and Sjöberg 2006).

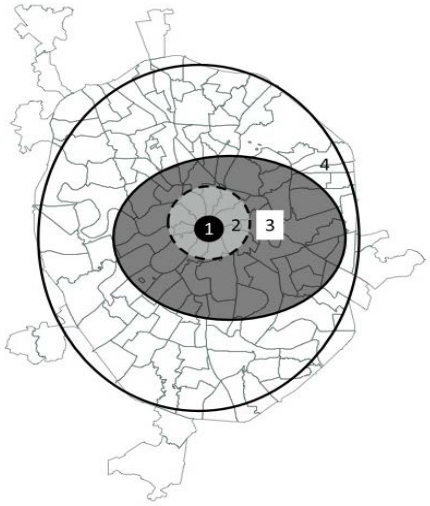


Figure 3. Moscow's functional zones (Source: Blinnikov 2010, p. 158):
1 – the historical core (pre-1800); 2 – the old periphery (19th century);
3 – the industrial belt (1920-1960); 4 – sleeping quarters (post-1960)

Figure 4. «Moskva City» business center (Source: Author 2015)

The Master Plan of Moscow up to 2025 makes provisions for seven major zones (Figure 5). The historical center and the so-called Representation Zone with Stalinesque architecture covering the area around the Moscow State University and the Leninsky Prospect will be defended from any significant demolition and reconstruction. Instead of old abandoned factories, warehouses and garages, it is planned to build social and business centers in Industrial Zone and peripheral centers in the Zones adjacent to the Fourth Transport Ring. The main housing construction is proposed to be on the site with many excreted from the city industrial enterprises between the new Ring Roads (Public Housing Areas). Areas between the Fourth Transport Ring and the Moscow Automobile Ring Road should not be densified as they are considered as the green belt of the capital (Natural Areas). Skyscrapers Zone with 40-45 storey buildings will be built on the outskirts. Demolition of the housing is planned to affect only the most dilapidated

panel 9- and 12-storey buildings located in the Northern, North-Eastern, Southern, and Eastern Administrative Areas.

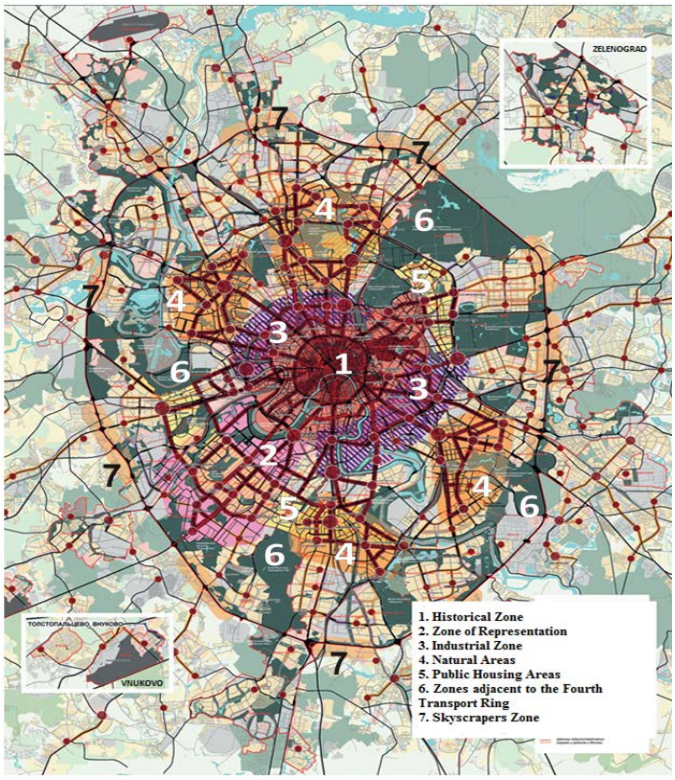


Figure 5. Main map of the Master Plan of Moscow up to 2025 (Source: Adapted from Kulikov 2008)

As Ioffe and Nefedova (1998) point out, instead of suburbanization processes population decompression in Moscow has always been achieved by a frequent expansion of the city's outer limits throughout the period of its urban development. The fact that the city did not fit within the Moscow Ring Road became apparent in the 1970s, therefore integration of Moscow into the Moscow Region was inevitable. The large-scale 2012 project called «New Moscow» increasing the territory of the city in almost 2.5 times provides a revolutionary transformation of the urban territorial structure (Makhrova and Golubchikov 2012). The new project requiring at least 11 trillion roubles for new transport communications, engineering infrastructure, railway construction, water and wastewater systems announces the change in housing policy, e.g. the transition to a low-rise building and creation of civilized suburbs similar to American one, latently involving the construction of gated communities, growth of income segregation and exhaustion of environmental resources. The old boundaries of the city of Moscow had a form of ellipsis with a diameter about 35-40 kilometers; the new city borders expanded to include two towns, Troitsk and Shcherbinka, and 19 urban and rural settlements which earlier were part of the Moscow Region's Leninsky, Naro-Fominsky, and Podolsky Districts (Moscow Department of Urban Policy and Construction 2015). Consequently, the city of Moscow is divided into twelve administrative areas (Central, Northern, North-Eastern, North-Western, Eastern, Southern, South-Eastern, South-Western, Western, satellite Zelenograd, and the newly incorporated Novomoskovsky and Troitsky), which are in turn subdivided into 146 districts and settlements (Figure 6). Map showing the exact location of Moscow neighborhoods is presented in Figure A.1 (Appendix A).

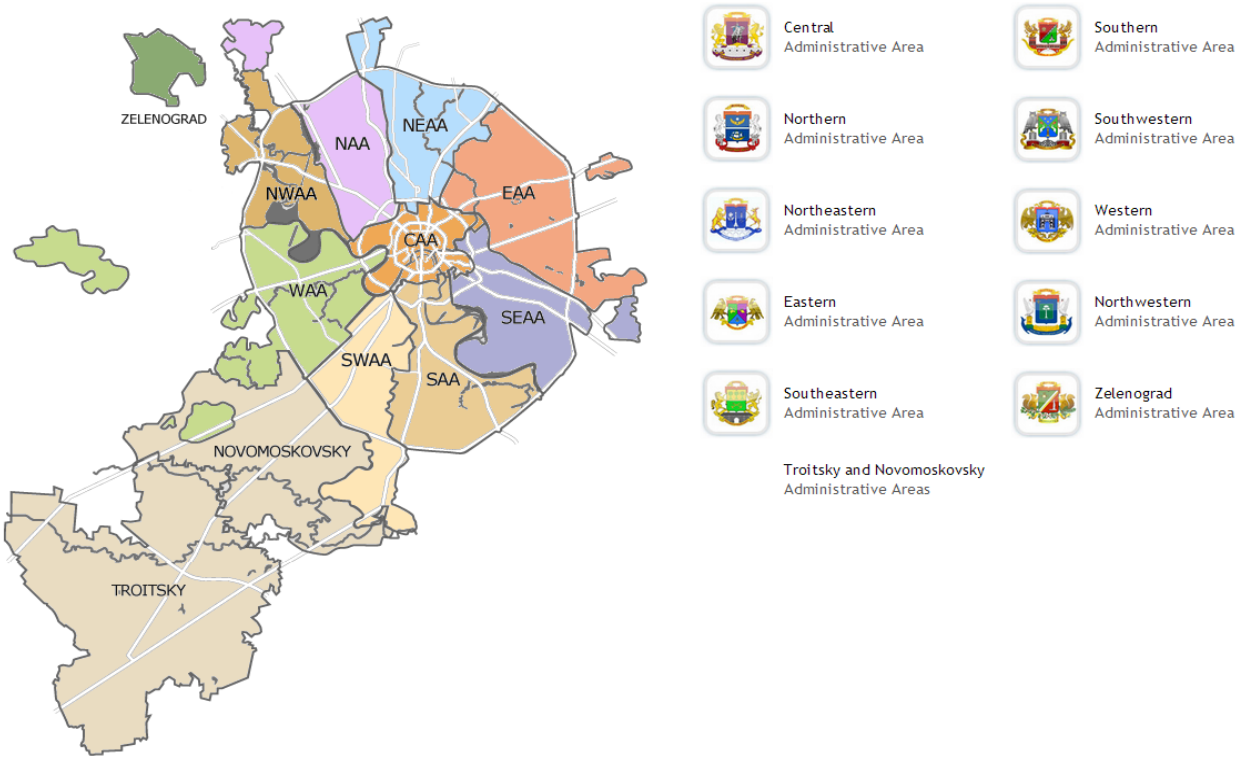


Figure 6. Study area (Source: Moscow City Government 2015)

With the expansion of the geographical boundaries of Moscow and subsequent population growth, residential income segregation manifested itself not only in the fundamental confrontation between prestigious western and industrial eastern parts of the city, but also through the contrast between center and periphery (Trushchenko 1995). Reputation of many Moscow's districts began to create in the Soviet times, depending on where the apartment was given to representatives of different occupations (Zabludovskaya 2014). For instance, Akademichesky and Moskvorechye-Saburovo Districts were historically settled by the scientific community. Aeroport and Sokol Districts received an unofficial status of bohemian residence due to the large amount of writers, actors and artists. Military representatives preferred to live in the north and north-west of Moscow, especially in Khoroshyovsky and Shchukino Districts. Lyublino, Tekstilshchiki, and Maryino in the south-east have the status of working-class districts. However, with the development of the housing market since the mid-1990s and simultaneous deindustrialization in Moscow, it is hard to distinguish purely working-class neighborhoods. With the exception of certain high-priced housing and gated communities, true gilded ghettos have not yet formed. Distinct isolation of high- and low-income groups in the city is hampered by lack of building sites; therefore expensive residential buildings are often located near to low-income housing. Neighborhoods in Pokrovskoye-Streshnevo District and the area around Gazprom's headquarters in Cheryomushki District can be defined as the settlement area of new elite outside the Center of Moscow, concentrating wealthy people, politicians and officials. Homogeneous ethnic ghettos in the Western sense are absent in the Russian capital but there are disadvantaged areas with high proportion of migrants in the south-east, south and part of the north-east of Moscow. Basically, this area close to the Ring Road appeals to migrant workers because of lower cost of housing rent and proximity to large food wholesale markets (*ibid*). Some areas of Moscow have a tendency to turn into true ghetto neighborhoods in the near future, e.g. Biryulyovo, Vykhino-Zhulebino, Tekstilshchiki, Golyanovo, Lyublino, Maryino, and Kapotnya. All of these areas correspond to

several common features: distance from the center, difficulties in transport accessibility, a large number of dilapidated 8-9 storey buildings in poor condition, proximity to industrial enterprises and markets, poorly developed commercial and entertainment infrastructure, lack of greenery, and high percentage of migrants. Because of new zoning of Moscow, shortage of land for construction and housing density standards, social housing will be constructed in the territory acquired from the Moscow Region. In the territory of New Moscow it is planned to construct three main zones. The first zone will include partially urbanized area with a high concentration of administrative and business development. The second zone will incorporate zone of low urbanization with a concentration of educational institutions and health care. Finally, the third zone will introduce a recreation area with low-rise residential development (Moscow Department of Urban Policy and Construction 2015).

3.2 Income Disparities in Moscow

The inequality in income distribution increased greatly after the collapse of the Soviet Union (Blinnikov 2010). Many goods were usually unavailable for money and affluent people were not allowed to publicly boast of their wealth, but all this changed with the beginning of the «perestroika», or the new Russian capitalism. The average monthly work income in Moscow is eight and a half times greater than that in the poorest subjects of the Russian Federation (Figure 7). However, a potential source of social tension in Moscow is a high degree of differentiation in quality and standard of living of its citizens. Although Moscow is still characterized by a strong dispersion of social strata and vague social boundaries within the urban space because of tradition of living in multi-storey apartment buildings which are more resistant to polarization, the weakness of multifamily housing and destruction of the Soviet well-functioning distribution system lead to spatial economic segregation and to occurrence of slums in some cases (Makhrova and Golubchikov 2012).

Figure 7. Dynamics of the average monthly work income in Moscow and Russian Federation (Source: Goskomstat 2015)

Moscow is the center of the concentration of the upper classes in Russia (Figure 8). About 4 per cent of all Moscow households are considered affluent and their incomes are sometimes expressed in the millions of dollars. The presence of these people makes Moscow one of the most expensive cities in the world. Oligarchs made their fortunes in the 1990s, mostly in steel and nonferrous metals, petroleum, telecommunications, and banking by participating in the auctions

that allowed quick privatization of the state assets for a part of the real price (Blinnikov 2010). Moscow's position with more than 79 billionaires indicates a highly uneven post-Soviet distribution of wealth. Upper middle class with household incomes between $20000 and $45000 per year constitutes around 7.7 per cent. This class is characterized by a relatively large proportion of highly-educated and highly paid top managers, business people, and government officials at all levels (members of the parliament, governors, mayors, the highest-ranking police officers), mainly because of widespread corruption. Also among the wealthy there are many professionals who work for the prestigious foreign or Russian companies (British Petroleum-TNK, Gazprom, Alfa Bank, etc.). True middle class (17 per cent) with incomes between $10000 and $20000 per year, averaging $1170 per month, unlike their Western counterparts, cannot afford a private home, but own an apartment with all the modern essentials and one car per family (Blinnikov 2010). The middle classes are mostly employed in the so-called secondary sector of the economy: companies engaged in foreign transactions, commercial activities, and in banking, finance, credit and insurance. Another 29.5 per cent are the low-middle class with incomes of $6000 to $10000 per year averaging $660 per month. These people and those in the true middle class purchase most of the durable goods (refrigerators, TVs, and other appliances).

Around 28.5 per cent of Moscow society belongs to the low-income categories with about $3600 to $4800 available per household per year or $300-400 per month. Adults in such families generally have no tertiary education and are therefore insufficiently competitive in the labor market and tend to hold low-paying and low-prestige jobs. The remaining 13.3 per cent are truly poor people. About one-quarter of these live in acute poverty on $75 per month per household. Many of the truly poor are recent migrants or refugees from the Asian and Caucasian republics, but this category also includes native Russian citizens who are disabled, unemployed, alcoholic/drug addicted, single women with children, and/or pensioners, whose material status is largely determined by the capabilities of government finance and the social security system. At the same time, there is a relatively new category of poor people, the so-called «working poor», who are employed in the public sector of the economy and in depressed industries with an absolutely low level of wages being inadequate to meet the basic needs and have the least opportunities to receive a quality higher education. According to the Human Development Report for the Russian Federation (2003), the specific feature of Moscow is that not the poorest stratum, but the group that occupies an intermediate position on the social scale (the low-middle class) has the most aggravated position without any clear prospects of upward mobility and with risks of falling down into the poverty zone.

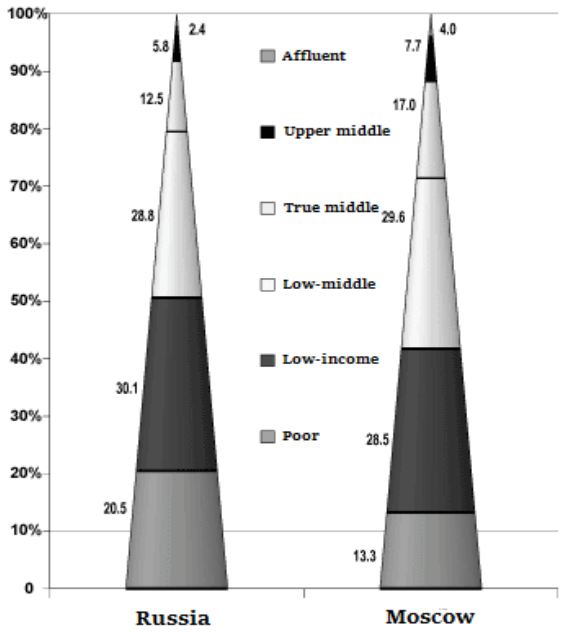


Figure 8. Income classes in Moscow compared to Russia (Source: Zalesskiy 2002)

The results of population survey throughout Moscow in terms of income carried out by Levinson (2014) have shown that the share of wealthy people is about one-tenth among respondents, and almost half of Muscovites have limited income (Figure 9). There is a reason to believe that a significant amount of this population lives within the Third Transport Ring, not on the periphery of Moscow. It is essential that the share of those reporting significant financial difficulties is less than 1/10.

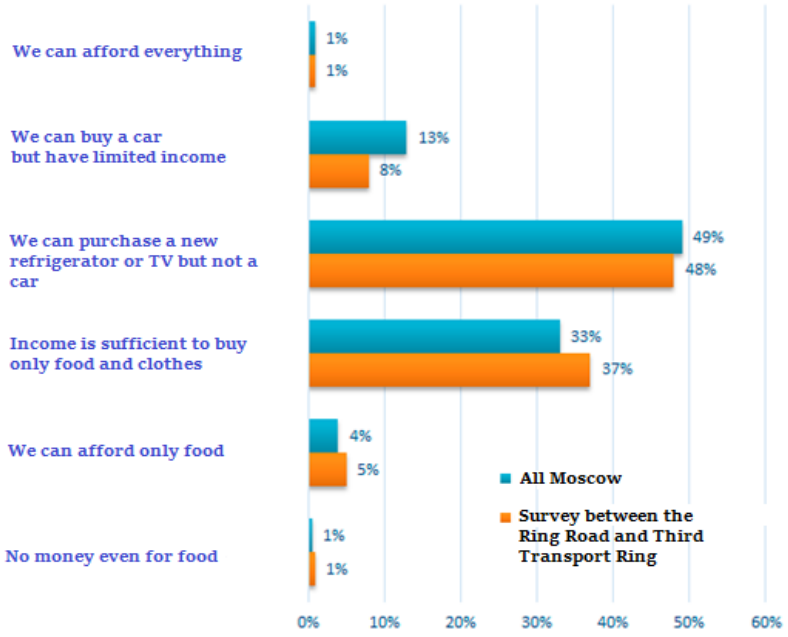


Figure 9. Survey of Muscovites in terms of income (Source: Levinson 2014)

According to the Department of Economic Policy and Development of Moscow (2014), in the structure of income of Muscovites the share of salary (44 per cent) and social payments (12.6 per cent), which today are about two thirds of the total volume of income, is increasing.

Survey results (Figure 10) demonstrate that 77 per cent of Muscovites live on salaries and wages and one-third on retirement pensions.

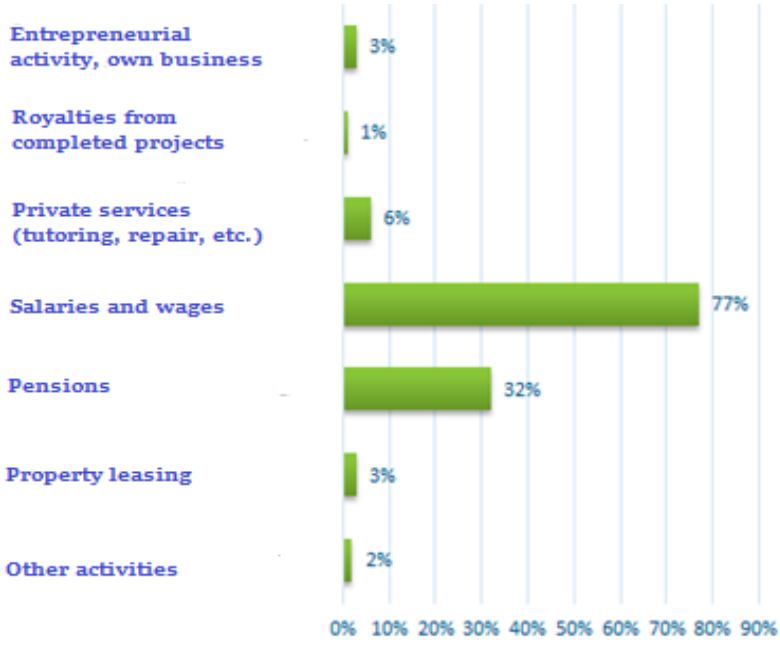


Figure 10. Main income sources of Muscovites (Source: Levinson 2014)

3.3. Main Challenges for Moscow

Income segregation is much less pronounced as a separate issue in Moscow, but since the mid-2000s, a number of policies have been implemented to address the problem of income inequality. In particular, the federal government and Moscow City Hall have been able to slightly decrease inequality in the city by increased social spending (Human Development Report 2006/2007 for the Russian Federation). The Moscow authorities provide salary supplements for employees working in low-paid segments of the public sector and higher retirement pensions. Almost a quarter of the city's budget is spent on subsidies for housing maintenance to socially vulnerable groups whose expenditures on housing utilities exceed 10 per cent of their aggregate income. The measures also include state revenue redistribution to local governments in low-income areas and targeted programs for community development aimed at alleviating the impact of poverty in low-income neighborhoods. Although it is difficult to estimate actual inequality-reduction effect of these policies, it is obvious that they have been insufficient to diminishing current income inequality trends. Creating conditions for mixing of different income groups and reducing the inevitable effects of social inequality constitutes the first serious challenge for Moscow. The second main challenge of Moscow, which cannot be reversed by the construction of transport infrastructure, is a drastic gap between the center containing 40 per cent of all employment workplaces and only 8 per cent of the city's population and periphery. Excessive concentration of commercial and administrative offices in a single city center provokes massive traffic jams, overcrowding, air pollution, and alteration of the historical old core. In the new economic conditions, only wealthy people can afford to purchase an apartment in the prestigious central area, creating a housing market for rich and for poor. New Moscow polycentric scenario involves balanced distribution of several centers of business activity and decentralization of the passenger traffic throughout the city, but plans for large-scale social housing construction in remote areas will only exacerbate the processes of income segregation, leading to excessive population growth, increase in the level of labor migration to the center, exceptional localization

of groups with low incomes, and traffic congestion problems due to slow development of public transportation, and environmental degradation (Urban Land Institute 2011). For instance, the construction of new residential neighborhoods covering about 700 thousand sq.m in Troitsky Administrative Area can lead to doubling of the current population of Moscow and creation of additional enhanced sleeping quarters. These new areas are considered as the least desirable places to live and fail to create new economic value. The expansion decision promoted by the Prime Minister of Russia Dmitry Medvedev, Mayor of Moscow Sergei Sobyanin, lobbyists and owners of suburban areas also contradicts to the principle of creating new growth points in other regions of the country and creates even greater concentration of federal assets within the Moscow metropolitan area.

The third considerable challenge requiring enormous investment is the housing stock, especially the reconstruction of physically obsolete and dilapidated housing, such as the four-story apartment complexes of Khrushchev era constructed in the 1960s (O'Loughlin and Kolossov 2002). Moreover, the city experiences a huge demand for land and empty space to accommodate new housing, so it is necessary to demolish old residential and industrial buildings or to relocate industrial infrastructure. Owing to the strong demand for luxury housing, the formation process of new closed elite neighborhoods in the city of Moscow will continue as well, specifically in the central and western parts. Important questions remain about the impacts of income homogeneity, especially those of closed upper-income enclaves considered socially undesirable. Poverty is strongly linked to housing, and the concentration of poor people in marginalized neighborhoods in the outlying southern, south-eastern and north-eastern districts is deeply problematic. A large number of families in Moscow need to improve their living conditions and are unable to purchase an apartment even on favorable terms of existing city programs. Furthermore, Moscow, as the whole Russia, does not have progressive income tax system with income tax on salaries and rent set at 13 per cent. Despite numerous recommendations regarding change of the income tax scale, the government considers that the tax is appropriate in general and it does not require any adjustment.

The last challenge is increasing dependence on migrant labor in Moscow, requiring additional expenses on the social sphere and active policy of adaptation and integration of migrants accounting for a large share of the new residents in the receiving society for prevention of ethnic segregation. Negative factors are inadequate infrastructure to accommodate higher-density migrant communities and discrimination. Moreover, most working migrants live in Moscow illegally, and that creates tensions in the labor and housing markets. The risk of income and ethnic segregation is significantly higher in the southern, eastern and northern suburbs than in the center or south-west of the city, where a higher standard of living and property filters impede penetration of migrants into those prestigious areas (Vendina 2005).

3.4 Selection of the Variables

Average monthly nominal per capita income of the working age population (16-64 years old) from gainful employment (INCOME) calculated by dividing the overall wage fund to the average number of employees and the number of months in the period has been used as dependent variable. Mean monthly per capita income, adjusted for inflation, more accurately reflects true differentiation and is presented in 2013 US dollars. In addition, a set of the following independent variables was chosen to represent various hypothesized contributory factors explaining spatial differences of income in the Moscow metropolitan area:

a) **POP_DEN** is the population density per square kilometer. This variable is important to study because it concerns the spatial distribution of population and settlement structure. Moreover, Pendall and Carruthers (2003) argue that neighborhoods with very low and very high population densities are almost always associated with higher levels of income segregation. Before 2012, Moscow was one of the most densely populated cities in the world with 10,300 residents per sq.km, but after joining Moscow Region's territories the density characteristics of the population have become one of the lowest (only 4857,66 residents per sq.km) (Kirillov and Makhrova 2012). Population density was logged in the analysis to correct for positive skew in the distribution of population size among neighborhoods in Moscow.

b) **AGE_MEAN** is the average age of population. David Lam (1997) suggests age composition of the population to be one of the most substantial demographic variables affecting the observed distribution of income across time and space. In his point of view, as a result of old-age dependency ratio, older people are among the core groups with a higher-than average poverty risk frequently due to lower income levels, compared to people of working age.

c) **EDUC_SHARE** is the share of population older than 25 years of age with at least a bachelor's degree. Lundberg (2006) has found a strong positive correlation between the initial endowments of human capital measured as the percentage of inhabitants aged 15 and above with at least three years of post-high school studies (educational attainment) and income distribution. Basically, the higher the educational level, the higher the employment income.

d) **MIXED_ETHN** is the mixed ethnicity percentage variable which can be used to understand whether and how income segregation affects ethnic segregation. Income and ethnic segregation are closely interconnected because as a rule, ethnic minorities earn lower incomes and are residentially segregated from majority population (Jargowsky 1996). According to Iceland *et al.* (2002), when measuring residential patterns, there has to be a reference group chosen against which the patterns of other groups can be compared. This paper will determine ethnicity group based on majority (Russians) and minority (non-Russians) group population.

For the ethnic based measurement, the formula used in this study is:

$$MEx = \left(\frac{Nx - Nrx}{Nx}\right) * \mathbf{100}\% \quad (1)$$

where *MEx* is a mixed ethnic percentage in neighborhood *X*, *Nx* is a total number of population in neighborhood *X*, and *Nrx* is a number of Russians in neighborhood *X*.

e) **BUDGET_SHARE** is a percentage of budget execution estimated for each neighborhood. Each budget is generated from tax and non-tax revenues, property income, provision of services, sale of tangible and intangible assets, administrative fees, and other payments (Open Budget of Moscow 2015). Income tax constitutes more than 50 per cent of tax revenues. Exploring the relationship between mean income and the size of the local tax budgets, Boustan *et al.* (2012) found out that rising income inequality is associated with larger increases in tax revenues from state's aid directly supplementing districts with smaller local property tax capacity and faster growth in public expenditures at municipal level.

f) **DWELLING** is the sale dwelling price to income ratio as a summary statistic of over- or undervaluation in the housing market. According to Fox and Finlay (2012), this ratio helps to take account of growth in real incomes and overall inflation, and is an intuitive measure of housing affordability because income is a major determinant of how much a prospective buyer can afford to pay for a dwelling in each neighborhood. The clearest indication of a divergence in the character of Moscow's residential districts and the accelerated development of income segregation can be thus assessed through differentiation of housing prices at the neighborhood

level.

The formula used for calculating price to income ratio in this study is:

$$DWx=\frac{Prx}{INCx} \quad (2)$$

where *DWx* is a dwelling price to income ratio, *Prx* is an average dwelling sale price per square meter in 2013 US dollars in neighborhood *X*, and *INCx* is an average income per capita in 2013 US dollars in neighborhood *X*.

g) industrial variables **AGRI_SHARE** and **MANU_SHARE** calculated as share of employed working in these industries. Krugman (1999) allocates two main industries: immobile, perfectly competitive agriculture which is a constant-returns sector tied to the land, and mobile, imperfectly competitive manufacturing which is an increasing-returns sector.

h) occupational variables for three skill levels calculated as share of employed engaged in the following occupations: managerial positions of companies and enterprises (**MANAGER_SHARE**), financial and insurance services (**FINANCE_SHARE**), and professionals working in the public sector (**PUBLIC_SECTOR**). Bakija *et al.* (2012) explicitly demonstrated that there was a substantial heterogeneity in growth rates of income across occupations with managers, supervisors, and financiers accounting for the top percent of income earners in recent years.

Descriptive statistics displaying the number of observations, mean and median, standard deviation, and range of values for a list of selected variables are shown in Table 1. Income distribution has been very uneven across Moscow with incomes in the affluent communities being more than 16 times higher than incomes within the poor communities.

Table 1. Descriptive statistics of selected variables

Variable	Obs	Mean	Std. Dev.	Median	Min	Max
INCOME	146	1879.185	1254.084	1636.151	733.3697	11807.04
POP_DEN (LOGGED)	146	8.710685	1.644309	9.2699	2.759923	10.31724
AGE_MEAN	146	40.56781	1.84768	40.65	32.9	44.9
EDUC_SHARE	146	0.3893836	0.0934712	0.38	0.18	0.65
MIX_ETHN	146	13.59925	5.501894	12.69274	6.24538	48.65287
BUDGET_SHARE	146	99.46301	15.39911	98.8	62.6	233.3
DWELLING	146	2.975082	0.9073526	3.000892	0.3578815	5.602363
AGRI_SHARE	146	0.186208	1.11006	0	0	11.51766
MANU_SHARE	146	2.889938	4.449429	0.9935437	0	30.0489
MANAGER_SHARE	146	2.522043	12.36947	0.3038228	0	132.661
FINANCE_SHARE	146	3.200736	10.9147	0.0194991	0	88.27309
PUBLIC_SECTOR	146	0.1380706	0.4463437	0.0182125	0.0005059	3.958892

Source: Author's calculations using 2010-2014 data in Stata 12.0

3.5 Variables Hot Spot Analyses

Local maps of statistically significant hot spots and cold spots using the Getis-Ord Gi* statistic in GeoDa 1.4.6 have been created independently for the whole set of variables in Moscow (Figures 11 – 19).

1. Income (Figure 11)

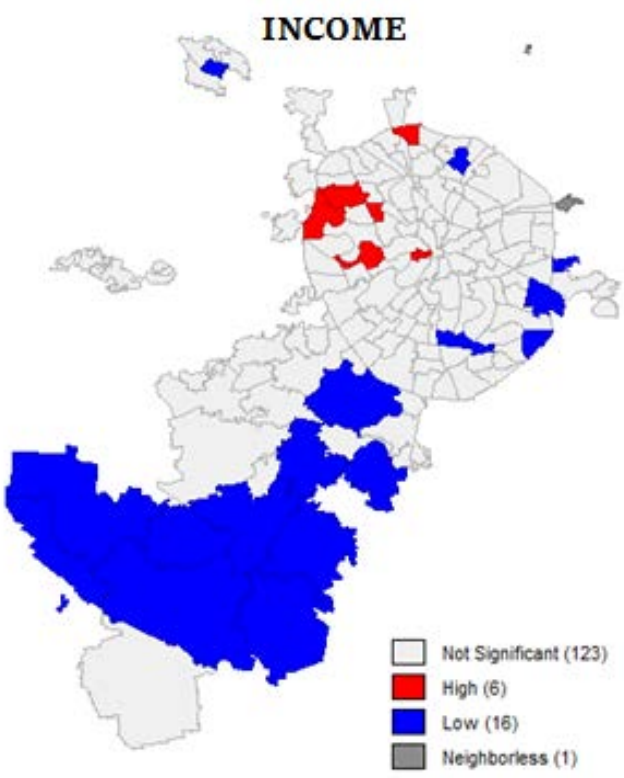


Figure 11. Gi* Cluster Map of variable INCOME (Source: GeoDa 1.4.6):

Affluent and high-income neighborhoods are primarily located in the most privileged central part, west and south-west, while low-income and poor neighborhoods are concentrated on the eastern and south-eastern outskirts of the city, large part of semi-rural New Moscow and former worker-dominated satellite town Zelenograd situated in a suburban zone of the capital that was made part of Moscow after 1960.

2. Population density (Figure 12)

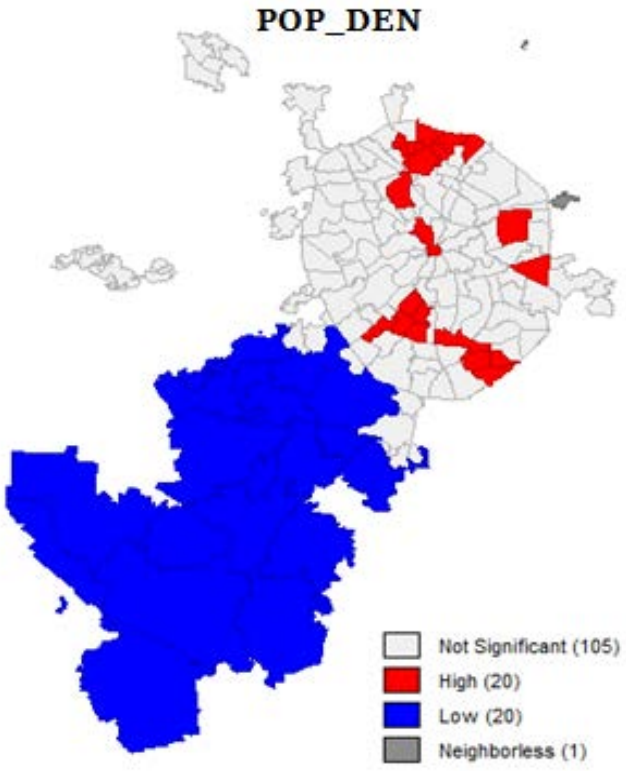


Figure 12. Gi* Cluster Map of logged variable POP_DEN (Source: GeoDa 1.4.6):

The dynamics of average population density has been uneven throughout the city. Population density distribution fits into the general pattern of the significant increase in the area of periphery located on the inner sides of the Moscow Ring Road (south-east, following by south, east and north-east characterized by the highest population density). At the same time, population share in the center is declining but is still higher than in subcentral zone. The new periphery areas located outside the Ring Road (New Moscow) have the lowest population density in the city and have been planned as a primary resource for the future development and associated increase in the proportion of the population.

3. Average age (Figure 13)

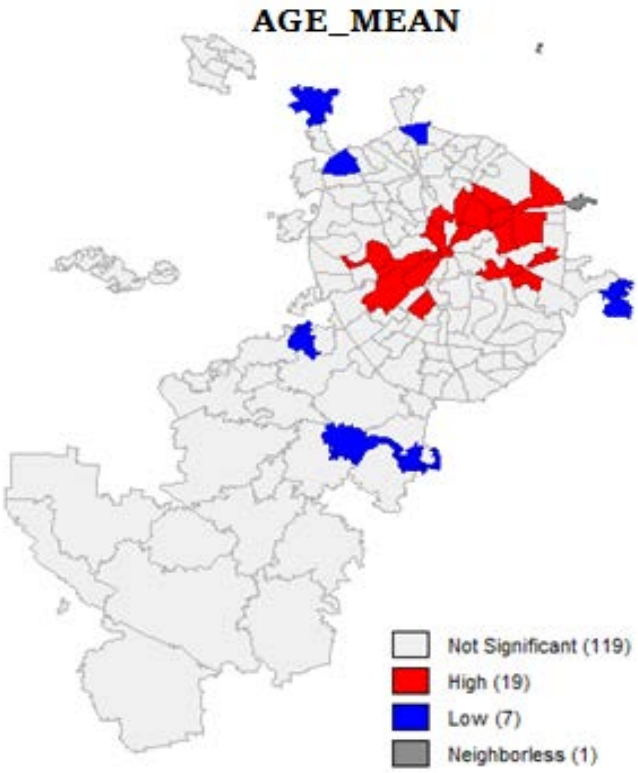


Figure 13. Gi* Cluster Map of variable AGE_MEAN (Source: GeoDa 1.4.6):

Different generations are separated in an urban environment with the higher share of individuals in older ages found in the central and western parts of Moscow and the former working-class dominated industrial outskirts in the east surrounding the central quarters. However, it can be noticed that the center of Moscow has ceased to be the only elderly part of the city because from the mid-1970s there has been an active process of population renewal. Contrastingly, cold spots are especially evident in the new semi-rural territories outside the Ring Road (Novomoskovsky Administrative Area) and northern sector of the city, assuming lower share of inhabitants in older ages and high proportion of younger population.

4. Education (Figure 14)

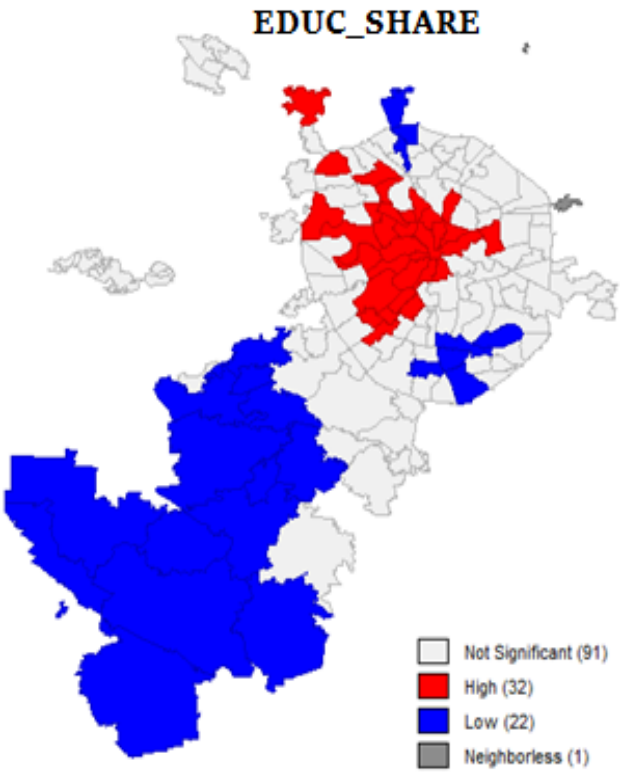


Figure 14. Gi* Cluster Map of variable EDUC_SHARE (Source: GeoDa 1.4.6):

As in the Soviet period, the highest educational level can be found in the center of Moscow with adjacent territories along major highways, south-west, west, north-west and the lowest in the south and north-east of the city including a large part of the new outlying Troitsky Administrative Area (Figure 15). The most educated areas of the city are Sokol, Shchukino, Meschansky, Tverskoy, Presnensky, Arbat, Khamovniki Districts and almost all districts of the South-Western Administrative Area.

5. Mixed ethnicity (Figure 15)

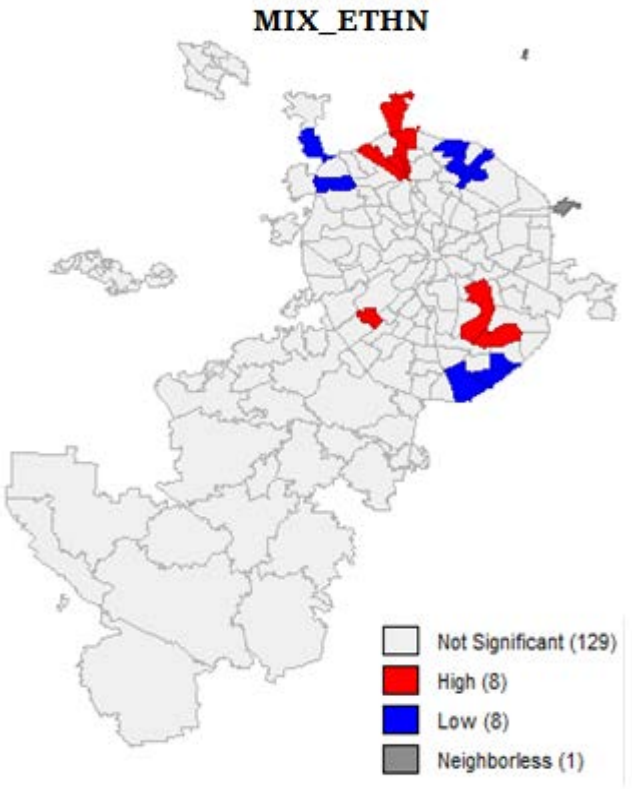


Figure 15. Gi* Cluster Map of variable MIX_ETHN (Source: GeoDa 1.4.6):

The ethnic composition of population in Moscow has changed a lot, as ethnic intolerance and income inequality displace working migrants to the outskirts of Moscow, most notably, in the south-east, on northern and north-eastern outskirts of the city in contrast to the surrounding areas distinguished by relatively homogeneous national composition. These are clearly distinguished areas of increased concentration of ethnic minorities in Moscow, related rather to the social and occupational characteristics than to national differences. Opposite processes can be traced on the north-western outskirts, Maryina roshcha, Otradnoye, Yuzhnoye Tushino and Kurkino Districts. 129 neighborhoods appeared to be nonsignificant because the GIZ-score does not exceed the significant value meaning that these features are dispersed.

6. Budget execution (Figure 16)

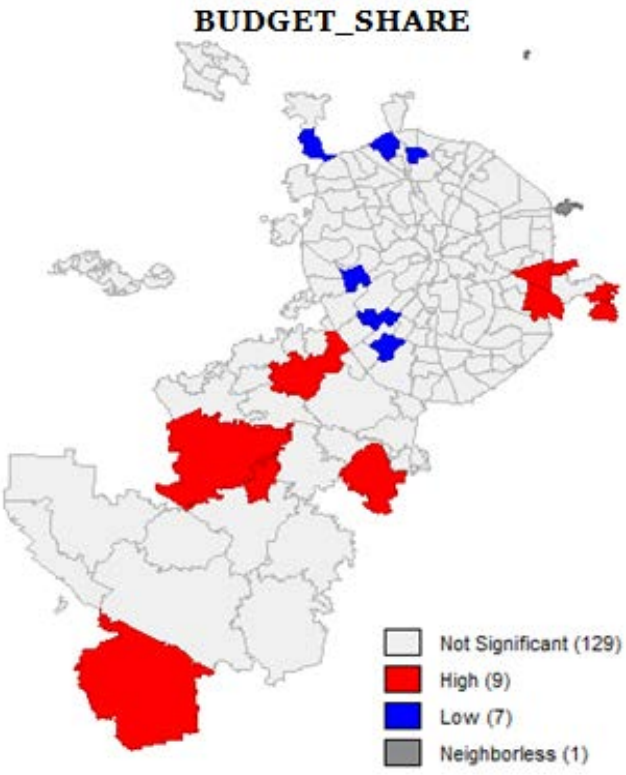


Figure 16. Gi* Cluster Map of variable BUDGET_SHARE (Source: GeoDa 1.4.6):

The areas with the highest budget execution heavily subsidized from the state are located in peripheral areas of the city, particularly in New Moscow, Eastern and South-Eastern Administrative Areas with adverse ecological and social situation (Novokosino, Veshnyaki, Vykhino-Zhulebino, Nekrasovka Districts). On the contrary, Kurkino in the north-west, Dmitrovsky and Timiryazevsky in the north, Fili-Davydkovo and Krylatskoye in the west, Lomonosovsky and Konkovo Districts in the south-west are characterized by budget deficit.

7. Housing sale price to income ratio (Figure 17)

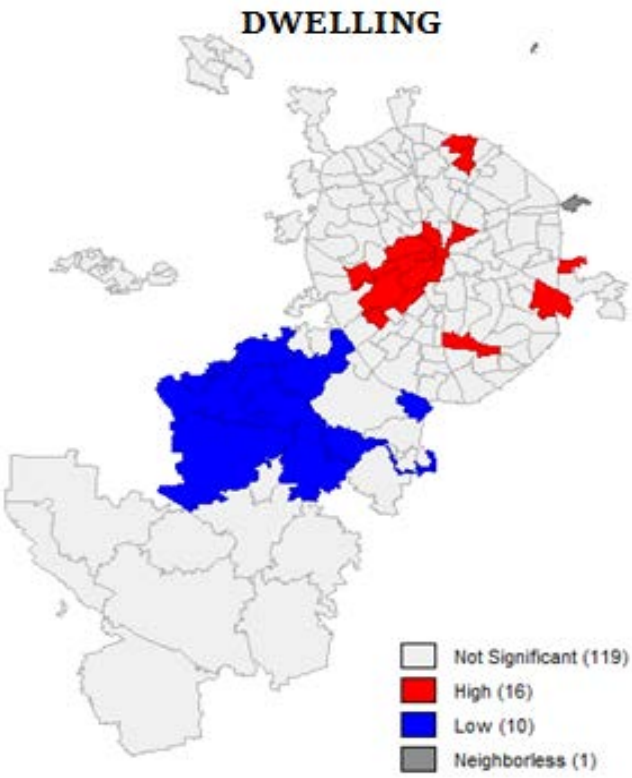


Figure 17. Gi* Cluster Map of variable DWELLING (Source: GeoDa 1.4.6):

The first and most obvious cluster of prestige is the area surrounding the Kremlin within the Garden Ring in the center of the city (Arbat, Tverskoy, Khamovniki, Yakimanka, Presnensky, Meshchansky Districts, where all housing is built mainly on the individual elite and business level projects). The zone of social well-being afterwards extends outward from the center to the west and south-west, e.g. to Gagarinsky, Dorogomilovo, Khoroshevo-Mnevniki, Krylatskoye, Ramenki, and Prospekt Vernadskogo Districts. There also small hot spots in Babushkinsky, Bibirevo, Severnoye Medvedkovo Districts in the north-east because of proximity to the Third Transport Ring and Vykhino-Zhulebino District in the south-east of Moscow. The lowest dwelling ratio can be mentioned in the peripheral suburbs of Novomoskovsky Administrative Area and Severnoye Butovo District beyond the limits of the Moscow Ring Road.

8. Industrial variables (Figure 18)

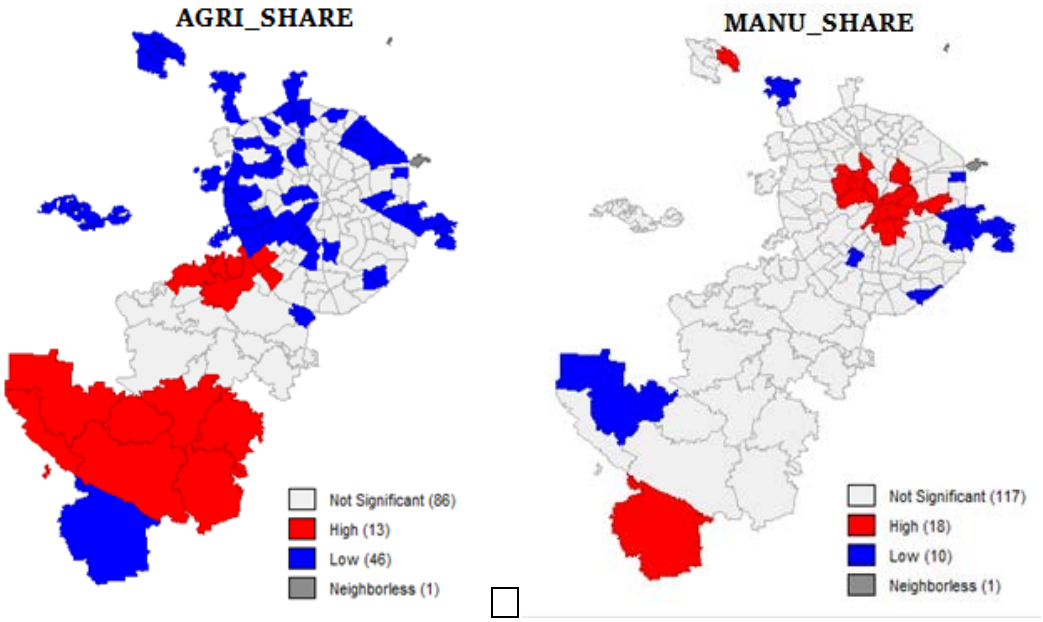


Figure 18. Gi* Cluster Maps of industrial variables (Source: GeoDa 1.4.6):

The higher share of agriculture is spatially expressed in the rural settlements adjoined to the city in 2012 with evident large cold spots in the old Moscow. The percentage of business establishments dedicated to manufacturing reveals the opposite pattern with manufacturing-dependent neighborhoods located in the center and traditional industrial eastern sector of Moscow.

9. Occupational variables (Figure 19)

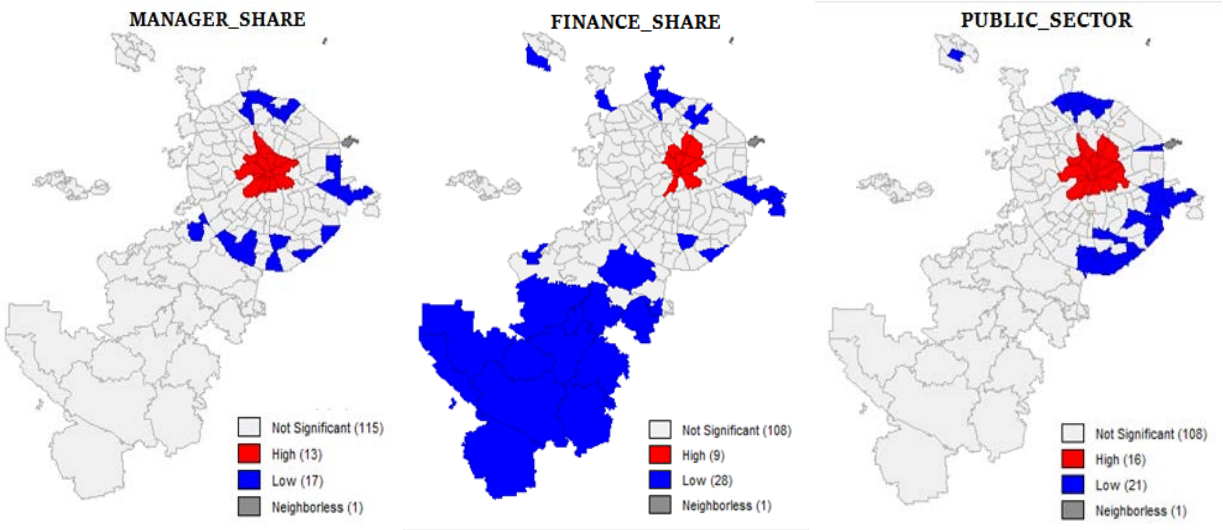


Figure 19. Gi* Cluster Maps of occupational variables (Source: GeoDa 1.4.6):

The highest concentration of managers, financiers and workers engaged in the public sector can be noted in the central part of Moscow as in the most prestigious area characterized by a spatial concentration of business services and market-oriented activities. Executives and managers tend to leave the low-prestige areas to permanently settle in neighborhoods with expensive and decent housing. The distribution of unskilled workers, engineers, technicians and civil servants over the city area is relatively uniform with prevalent spots on the south-eastern, southern and northern outskirts of the city.

CHAPTER FOUR: RESULT

4.1 Regression Analysis of the Determinants of Income

4.1.1 Standard OLS Regression

Answering the first research question requires studying the causal relationship between a dependent variable and a set of independent variables by means of OLS regressions. Results of testing the correlation between variables with one per cent significant level are represented in Table 2 confirming that average age, education share, dwelling-to-income ratio, budget execution share and population density are highly related to income level, whilst industrial and occupational variables together with mixed ethnicity percentage variable are less related to income mainly because of problematic multicollinearity. Preliminary OLS results with all variables showed that the share of workers in agriculture and manufacturing, proportions of managers, financiers and those working in the public sector and mixed ethnicity percentage appeared to be not significant. Nonsignificant variables were re-checked several times and if they were not still significant, they were removed from the analysis.

Table 2. Test of correlations

	INCOME	POP_DEN	AGE_MEAN	EDUC_S~E	BUDGET~E	DWELLING	AGRI_s~e
INCOME	1.0000						
POP_DEN	0.1234	1.0000					
AGE_MEAN	-0.1785	0.2841*	1.0000				
EDUC_SHARE	0.2225*	0.4537*	0.2449*	1.0000			
BUDGET_SHARE	-0.1023	-0.0954	-0.2337*	0.0461	1.0000		
DWELLING	-0.4858*	0.3604*	0.2382*	0.3375*	0.0023	1.0000	
AGRI_share	-0.0988	-0.4025*	-0.0917	-0.1929	-0.0266	-0.0827	1.0000
MANU_share	0.0440	-0.0656	0.0626	0.1420	-0.0613	-0.0696	-0.0278
MANAGER_sh~e	0.0547	0.0436	0.1060	0.3154*	0.0403	0.2281*	-0.0214
FINANCE_sh~e	0.1177	0.0965	0.1932	0.3521*	-0.0289	0.0882	-0.0279
SECTOR_pgt	0.0551	0.0521	0.1501	0.3569*	-0.0038	0.1929	-0.0313
MIX_ETHN	-0.0290	0.0271	0.1012	-0.0611	-0.0159	0.0743	-0.0126

	MANU_s~e	MANAGE~e	FINANC~e	SECTOR~t	MIX_ETHN
MANU_share	1.0000				
MANAGER_sh~e	0.2169*	1.0000			
FINANCE_sh~e	0.3968*	0.2879*	1.0000		
SECTOR_pgt	0.3621*	0.8038*	0.5618*	1.0000	
MIX_ETHN	0.0132	0.0638	0.0935	0.0363	1.0000

In parentheses * p < 0.001

Source: Author's calculations using 2010-2014 data in Stata 12.0

Corresponding to the standard OLS results (Table 3), variables AGE_MEAN, EDUC_SHARE, DWELLING, BUDGET_SHARE, POP_DEN are statistically significant highly related to income level. The null hypothesis that the explanatory variables in the model are not effective can be rejected since the probability is less than the level of significance ($p < 0.05$) and the observed value of F exceeds the critical value. However, the coefficients which reflect the expected change in the dependent variable for every one unit change in the associated explanatory variable for variables AGE_MEAN, DWELLING, BUDGET_SHARE are negative indicating that the larger shares of old population, higher dwelling ratio and higher percentage of budget execution are related to lower income. On the contrary, variables POP_DEN and EDUC_SHARE

demonstrate positive relationship with income. The CONSTANT term or intercept is the expected mean value of income when all the independent variables are equal to zero.

Table 3. Standard OLS Regression

Variable	Coefficient	Std.Error	Probability
CONSTANT	8255.11	1916.82	0.00003***
POP_DEN	170.6124	54.4702	0.00211**
AGE_MEAN	-149.7975	44.91156	0.00109**
EDUC_SHARE	5378.869	944.9408	0.00000***
BUDGET_SHARE	-12.18298	5.127422	0.01885*
DWELLING	-896.7173	92.62695	0.00000***

In parentheses * p < 0.05, ** p < 0.01, *** p < 0.001
Source: Author's calculations using 2010-2014 data in GeoDa 1.4.6

An Adjusted R-Squared value of around 0.47 indicates that the explanatory variables modeled using linear regression explains approximately 47 per cent of the variation in income. By assuming a multivariate normality and the corresponding likelihood function the Log likelihood (-1199.57), the Akaike info criterion (2411.15) and the Schwarz criterion (2429.05) have been applied to compare with the fit of the spatial regression models. Less negative Log likelihood and lower values of the information criteria indicate a closer fit to the data.

A test for non-normality of errors (the Jarque-Bera Statistic) is highly significant, showing non-normality of residuals and biased model predictions which may be the result of model misspecification. Both diagnostics for heteroskedasticity (the Breusch-Pagan and Koenker-Bassett tests) are statistically significant and indicate that the modeled relationships are not consistent owing to heteroskedasticity. Specification robust test for heteroskedasticity (the White test) is also significant and confirms presence of heteroskedasticity provided by the previous two statistics. The final set of model diagnostics includes tests against spatial autocorrelation (Table 4). The Moran's *I* (error) score of 0.126 is positive and significant, indicating strong spatial autocorrelation of the residuals. However, in order to choose the higher order alternative specification, it is more appropriate to use the Lagrange Multiplier test statistics (Anselin 2005). The LM-SARMA statistic in this model is significant and its value is higher than LM-Lag and LM-Error, predicating that it is probably selecting the single alternative rather than a true higher order model. Given that LM-Error statistics are significant and reject the null hypothesis that there is no spatial autocorrelation, the decision is to estimate a spatial error specification model in the next step.

Table 4. Diagnostics for spatial dependence (standard OLS)

TEST	MI/DF	VALUE	PROBABILITY
Moran's I (error)	0.1258	2.6886	0.00718**
Lagrange Multiplier (lag)	1	0.0114	0.91501
Robust LM (lag)	1	7.2407	0.00713**
Lagrange Multiplier (error)	1	5.0648	0.02442*
Robust LM (error)	1	12.2941	0.00045***
Lagrange Multiplier (SARMA)	2	12.3054	0.00213**

In parentheses * p < 0.05, ** p < 0.01, *** p < 0.001
Source: Author's calculations using 2010-2014 data in GeoDa 1.4.6

Figure 20 represents Equal intervals map of the dependent variable suggesting the clustered pattern that similarly colored areas tend to be in similar locations, particularly in the two main prominences Mitino and Severny Districts and in the most prestigious central, western and south-western parts of Moscow.

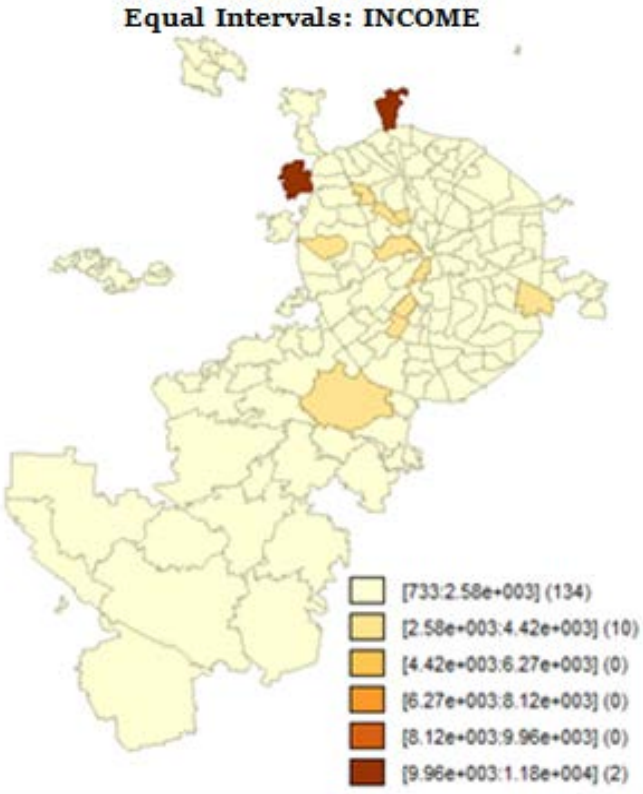


Figure 20. Equal intervals map of the dependent variable Income (rook weights) (Source: GeoDa 1.4.6)

Another important indicator of reliability of the results is the distribution of the residuals. Histogram of the residuals OLS_RESIDU in Figure 21 confirms non-normality and statistically significant biased model. Examination of the model residuals (Figure B.1 (a), Appendix B) also shows under- and overestimated OLS regression model as residuals are not randomly distributed, which could be evidence of spatial autocorrelation. Clustering of residuals indicates model misspecification due to non-stationarity. The Gi* Cluster map of the residuals OLS_RESIDU in GeoDa also reveals a significant clustering of high values (hot spots) being evident in the center of Moscow (Khamovniki district) and in the northern part of the city, and clustering of low values (cold spots) mainly around commuter suburban areas (Figure B.2 (a), Appendix B).

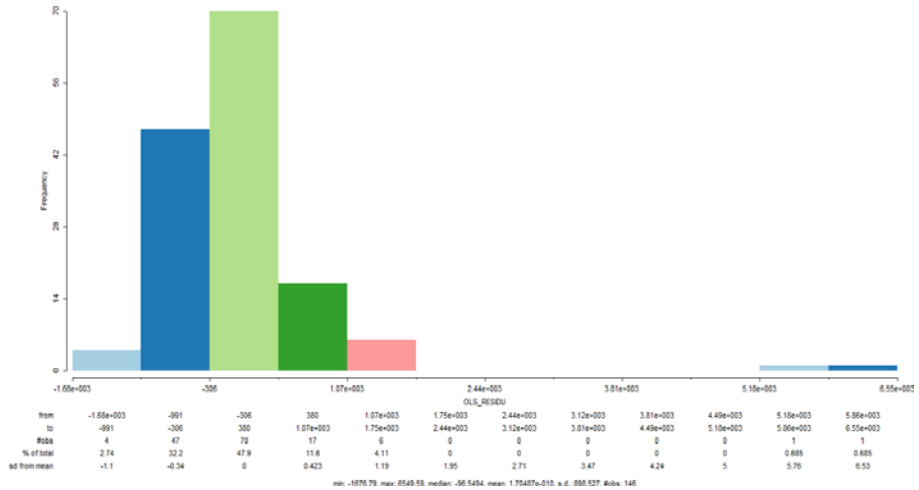


Figure 21. Histogram of Residuals OLS_RESIDU (Source: GeoDa 1.4.6)

For detecting patterns of heteroskedasticity it is relevant to plot the residuals against the predicted values (Figure 22). The spread of the residuals OLS_RESIDU is wider toward the left side of the graph than at the right, where the variability of the residuals is somewhat smaller, suggesting some heteroskedasticity.

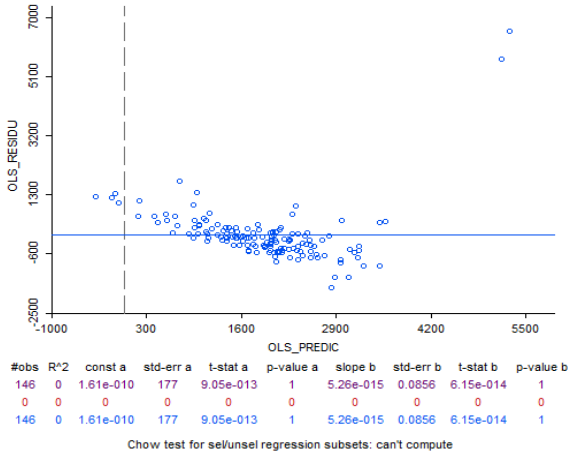


Figure 22. Residuals OLS_RESIDU/predicted value plot (Source: GeoDa 1.4.6)

Instead of the predicted values, other explanatory variables may be selected for the x-axis as well (Figure 23). The plots confirm the existence of several very large residuals. Fluctuating patterns around zero support the evidence of heteroskedasticity.

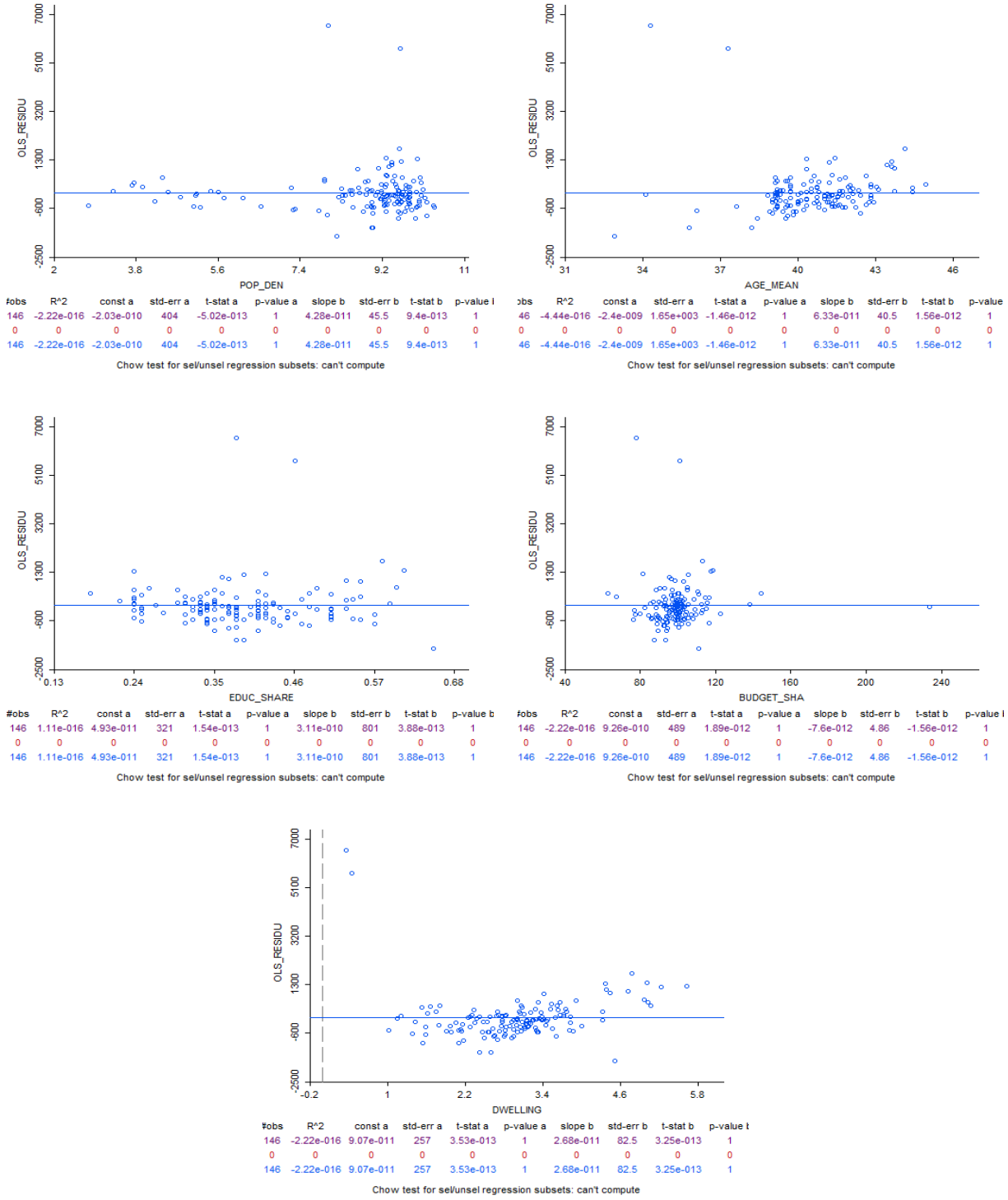


Figure 23. Residuals OLS_RESIDU/predictor variables plots (Source: GeoDa 1.4.6)

Spatial patterns in the residuals can be analyzed more formally by means of a Moran scatter plot (Figure 24). Moran's *I* for the residuals OLS_RESIDU is greater than 0, exhibiting strong positive spatial autocorrelation, as similar high and low values tend to be located near one another.

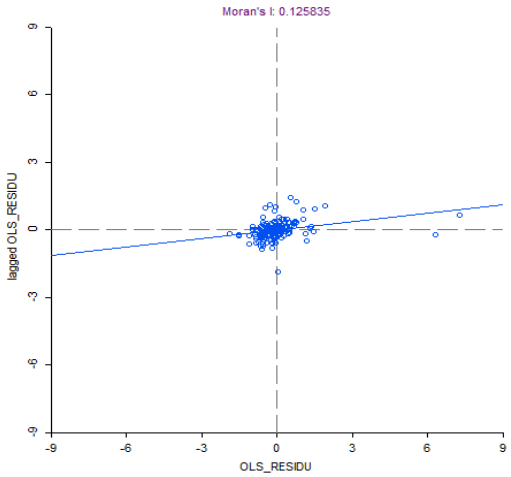
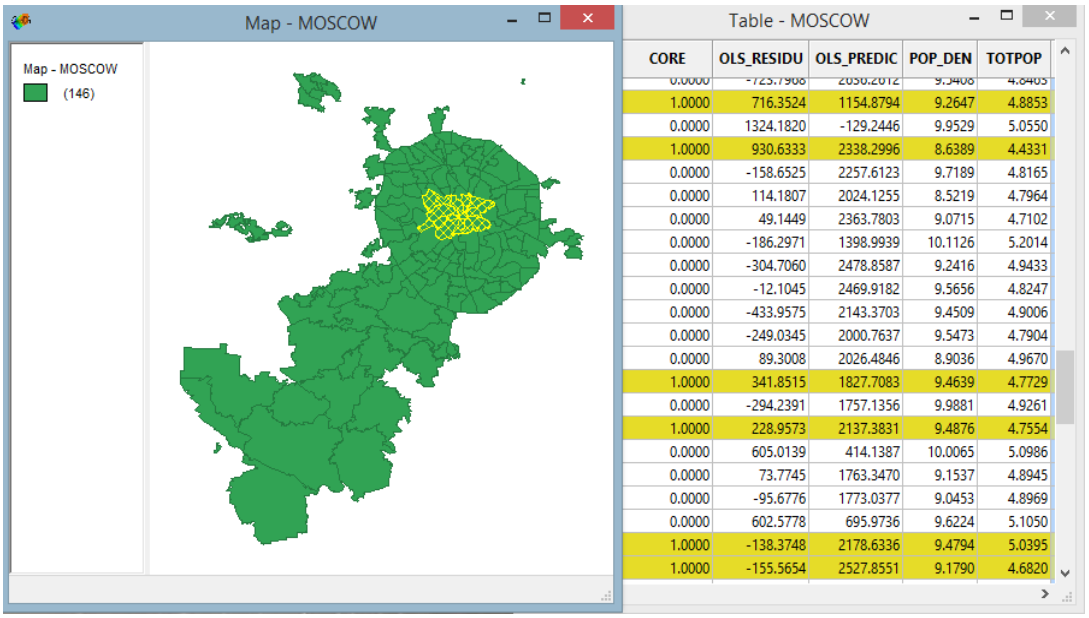


Figure 24. Moran's I scatterplot for residuals OLS_RESIDU (Source: GeoDa 1.4.6)

4.1.2 OLS with Spatial Variable

Rice *et al.* (2006) assume that regional accessibility is a significant determinant for income, although estimates vary considerably with respect to the geographical scope. Employment earnings increase up to a close distance from the center of the urban area, the quantitative impact of population of working age declines with remoteness from the core. Hence, to answer the second research question, an explanatory dummy variable CORE with values 0/1 consequently representing periphery and core has been included into the regression analysis in order to improve the model (Figure 25). The value of 1 indicates that the observation is in close proximity to the center and 0 if not. The center of Moscow was identified through the POLY_ID-number in the dataset.



CORE	OLS_RESIDU	OLS_PREDIC	POP_DEN	TOTPOP
1.0000	716.3524	1154.8794	9.2647	4.8853
0.0000	1324.1820	-129.2446	9.9529	5.0550
1.0000	930.6333	2338.2996	8.6389	4.4331
0.0000	-158.6525	2257.6123	9.7189	4.8165
0.0000	114.1807	2024.1255	8.5219	4.7964
0.0000	49.1449	2363.7803	9.0715	4.7102
0.0000	-186.2971	1398.9939	10.1126	5.2014
0.0000	-304.7060	2478.8587	9.2416	4.9433
0.0000	-12.1045	2469.9182	9.5656	4.8247
0.0000	-433.9575	2143.3703	9.4509	4.9006
0.0000	-249.0345	2000.7637	9.5473	4.7904
0.0000	89.3008	2026.4846	8.9036	4.9670
1.0000	341.8515	1827.7083	9.4639	4.7729
0.0000	-294.2391	1757.1356	9.9881	4.9261
1.0000	228.9573	2137.3831	9.4876	4.7554
0.0000	605.0139	414.1387	10.0065	5.0986
0.0000	73.7745	1763.3470	9.1537	4.8945
0.0000	-95.6776	1773.0377	9.0453	4.8969
0.0000	602.5778	695.9736	9.6224	5.1050
1.0000	-138.3748	2178.6336	9.4794	5.0395
1.0000	-155.5654	2527.8551	9.1790	4.6820

Figure 25. Construction of the spatial variable CORE (Source: GeoDa 1.4.6)

Results of OLS with spatial variable in Table 5 demonstrate that all used independent variables are statistically significant ($p < 0.05$). Notwithstanding, the coefficients for AGE_MEAN, BUDGET_SHARE and DWELLING are still negative indicating the negative relation to income. CORE variable is highly related to mean income; that is why this model better explains spatial income differences than previous. Comparison of the OLS results with the standard OLS regression has shown that results are quite resembling but the less negative Log likelihood, lower Akaike info and Schwarz criteria provide a better fit to the observed data compensating for the added spatial variable. An Adjusted R-Squared value of 0.48 indicates that the explanatory variables explain 48 per cent of the variation in income. The regression diagnostics again expose considerable non-normality (significant test of Jarque-Bera) and heteroskedasticity (significant Breusch-Pagan and Koenker-Bassett tests), as well as a strong spatial autocorrelation of the residuals (Moran's *I*).

Table 5. Results of OLS regression with spatial variable

Variable	Coefficient	Std.Error	Probability
CONSTANT	8897.72	1922.011	0.00001***
POP_DEN	196.3026	55.33775	0.00053***
AGE_MEAN	-160.9491	44.75682	0.00045***
EDUC_SHARE	4277.898	1080.432	0.00012***
BUDGET_SHARE	-11.91095	5.072921	0.02029*
DWELLING	-920.2187	92.33847	0.00000***
CORE	646.5626	318.3776	0.04418*

In parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Source: Author's calculations using 2010-2014 data in GeoDa 1.4.6

Given that both LM-Lag and LM-Error statistics are not significant and neither rejects the null hypothesis (Table 6), it is recommended to stick with the OLS results in this particular case (Anselin 2005). Moran's *I* test statistic is significant ($p < 0.05$), indicating a conflict with the LM test statistics likely due to the Moran's *I* power against other alternatives than spatial autocorrelation, such as heteroskedasticity or non-normality.

Table 6. Diagnostics for spatial dependence (OLS with spatial variable)

TEST	MI/DF	VALUE	PROBABILITY
Moran's I (error)	0.1008	2.2763	0.02283*
Lagrange Multiplier (lag)	1	0.0009	0.97571
Robust LM (lag)	1	5.5639	0.01833*
Lagrange Multiplier (error)	1	3.2492	0.07146
Robust LM (error)	1	8.8122	0.00299**
Lagrange Multiplier (SARMA)	2	8.8131	0.01220*

In parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Source: Author's calculations using 2010-2014 data in GeoDa 1.4.6

Analyses of normality and homoskedasticity (Figures 26 – 27) have shown similar results like before, that the variance of residuals OLS_RESID2 is not randomly distributed, heteroskedasticity is evident. As shown in Figure B.1 (b) (Appendix B), the residuals OLS_RESID2 are still not randomly distributed; the spatial data violated the assumption of no correlation among them. There are statistically significant patterns of spatial autocorrelation and

an indication of systematic over- (negative residuals) in the outlying areas or underprediction (positive residuals) basically in the Northern Administrative Area of Moscow. The Gi* Cluster map of the residuals OLS_RESID2 (Figure B.2 (b), Appendix B) uncovers statistically significant clusters of high and low values similar to the previous results.

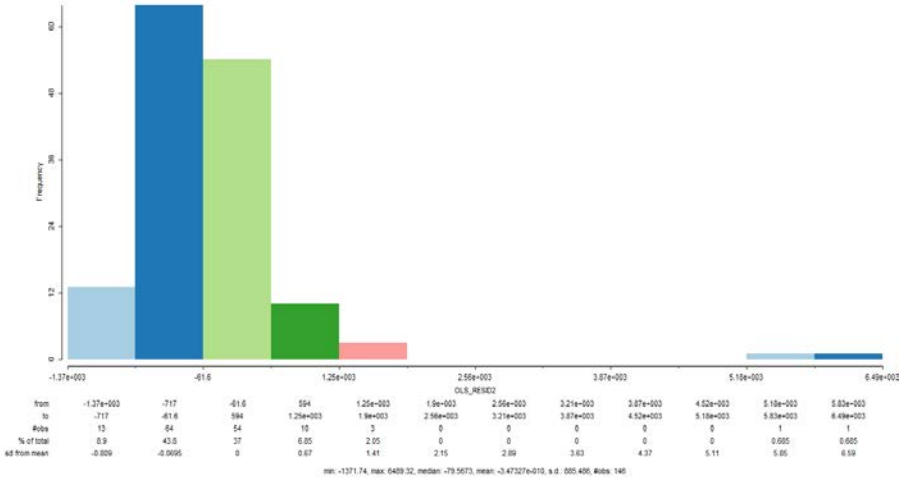


Figure 26. Histogram of Residuals OLS_RESID2 (Source: GeoDa 1.4.6)

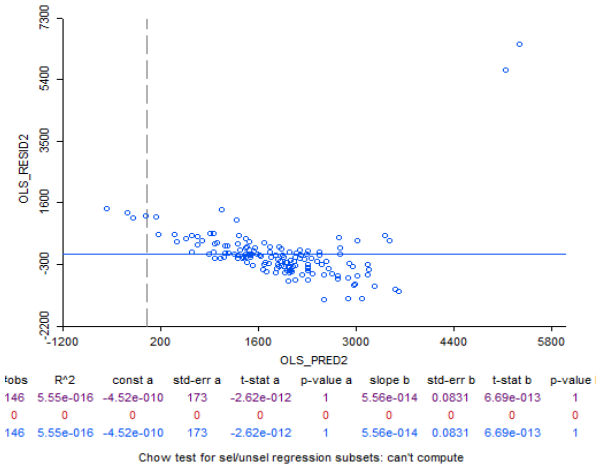


Figure 27. Residuals OLS_RESID2/predicted value plot (Source: GeoDa 1.4.6)

Figure 28 showing distributions of the independent variables versus the residuals OLS_RESID2 exhibits signs of heteroskedasticity of the residuals. Data points of the variable CORE are sliced into two groups according to values of the predictor (core and periphery) with different size.

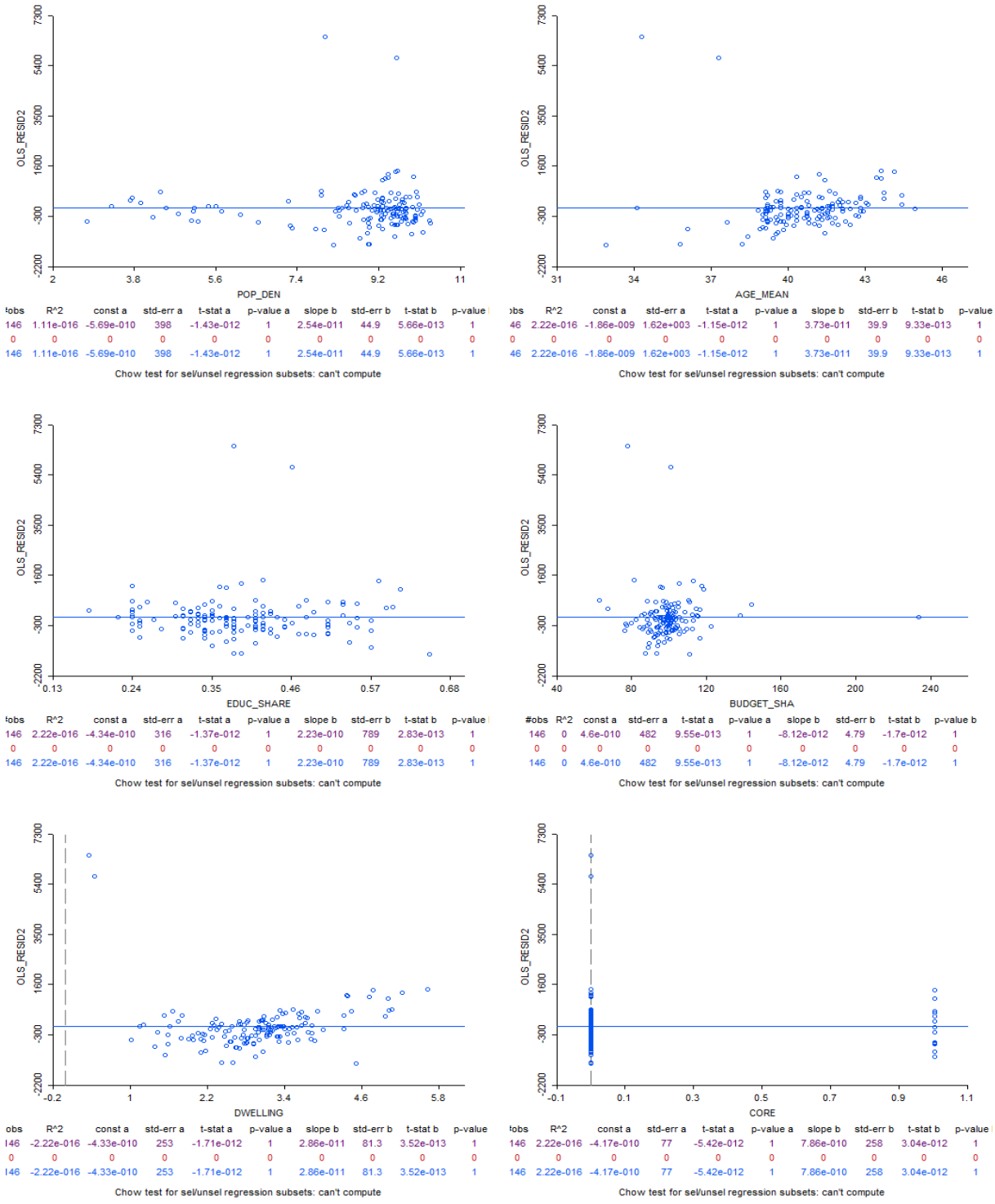


Figure 28. Residuals OLS_RESID2/predictor variables plots (Source: GeoDa 1.4.6)

Moran's *I* for the residuals OLS_RESID2 is greater than 0, exhibiting positive spatial autocorrelation (Figure 29).

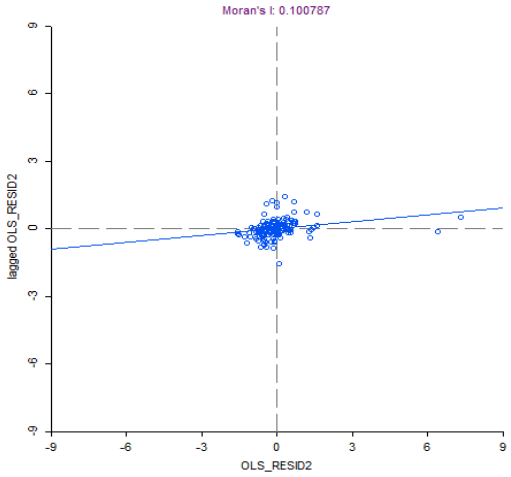


Figure 29. Moran's I scatterplot for residuals OLS_RESID2 (Source: GeoDa 1.4.6)

4.1.3 Spatial Error Model

Addressing the issue of spatial autocorrelation requires running a spatial error regression analysis with the same set of explanatory variables as in the first OLS model (Table 7). Spatial error is indicative of omitted spatially correlated covariates that affect inference. The spatial autoregressive coefficient (Lambda) is estimated as 0.39 and is significant. With the exception of population density (POP_DEN), all other variables are statistically significant and Breusch-Pagan test for heteroskedasticity and a Likelihood Ratio test on the spatial autoregressive coefficient are significant, suggesting remaining specification problems in the model. Hence, it is possible to conclude that although allowing the error terms to be spatially correlated improved the model fit, it did not make the spatial effects disappear. Controlling the expected order W > LR > LM on the spatial autoregressive error coefficient demonstrates compatibility, as the square of the z-value $W = 3.99^2 = 15.92 > LR = 7.79 > LM$ (error) = 5.06 (from the first OLS).

Table 7. Spatial error model estimation results

Variable	Coefficient	Std.Error	z-value	Probability
CONSTANT	8656.412	1838.776	4.707703	0.00000***
POP_DEN	127.3917	67.84297	1.877743	0.06042
AGE_MEAN	-151.4267	41.52055	-3.64703	0.00027***
EDUC_SHARE	5809.585	1026.4	5.660156	0.00000***
BUDGET_SHARE	-10.26402	4.646252	-2.209097	0.02717*
DWELLING	-1000.804	86.90446	-11.51615	0.00000***
LAMBDA	0.3949675	0.09903829	3.988028	0.00007***

In parentheses * p < 0.05, ** p < 0.01, *** p < 0.001

Source: Author's calculations using 2010-2014 data in GeoDa 1.4.6

The R2 value is pseudo-R2 not directly comparable with the measure given for OLS results (Anselin 2005). The proper measures of fit are the Log likelihood, Akaike info and Schwarz criteria. An increase in the Log likelihood, relative to the standard OLS decrease of the Akaike info criterion and Schwarz criterion assume an improvement of fit for the spatial error specification (Table 8).

Table 8. Comparison of the data fit

	Standard OLS Model	Spatial Error Model
Log likelihood	-1199.57	-1195.68
Akaike info criterion	2411.15	2403.36
Schwarz criterion	2429.05	2421.26

Source: Author's calculations using 2010-2014 data in GeoDa 1.4.6

In the spatial error model it is important to distinguish the model residuals ERR_RESIDU used in further diagnostics and the prediction error ERR_PRDERR which is the difference between the observed and predicted values. As Figure 30 shows, the Moran's *I* statistic for ERR_RESIDU is 0.0143891, which points out that including the spatially autoregressive error term in the model has considerably diminished the extent of spatial autocorrelation, as it is supposed to be. By contrast, the Moran's *I* statistic for ERR_PRDERR of 0.175281 is practically similar to the original OLS residuals.

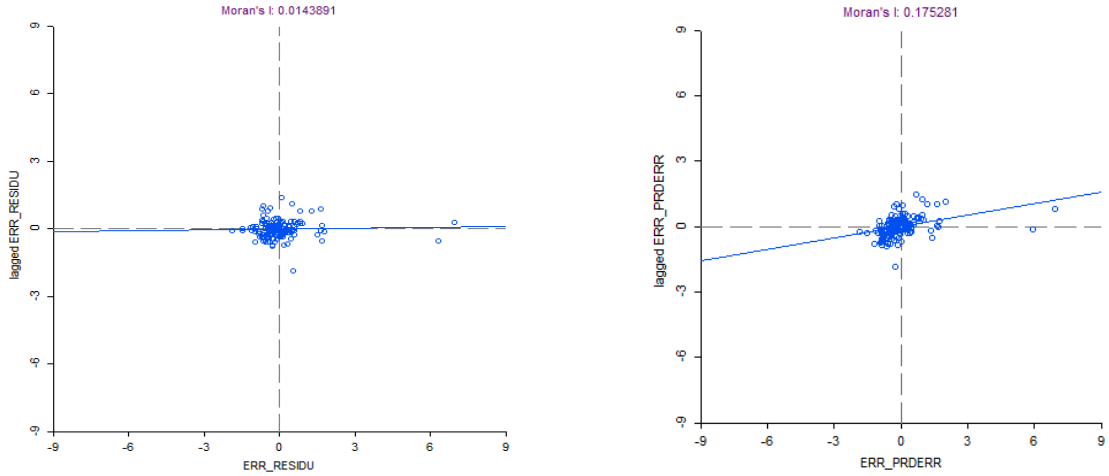


Figure 30. Moran's I for spatial error residuals ERR_RESIDU and spatial error prediction error ERR_PRDERR (Source: GeoDa 1.4.6)

Analyses of normality and homoskedasticity (Figures 31 – 32) have uncovered better results than before. Residuals ERR_RESIDU are still not normally distributed but there are not so large deviations from the normality. As shown in Figure B.1 (c) (Appendix B), the residuals ERR_RESIDU still indicate some signs of spatial autocorrelation. However, the Gi* Cluster map of the residuals ERR_RESIDU (Figure B.2 (c), Appendix B) uncovers more dispersed pattern of neighboring features.

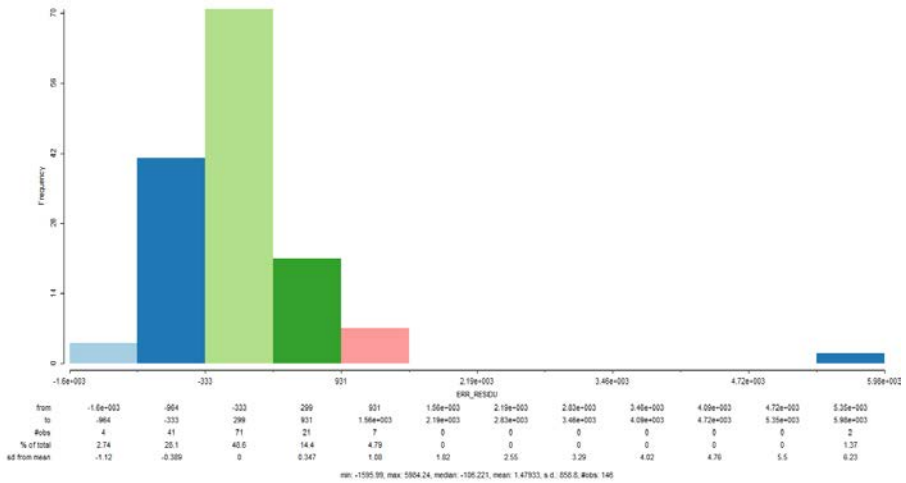


Figure 31. Histogram of Residuals ERR_RESIDU (Source: GeoDa 1.4.6)

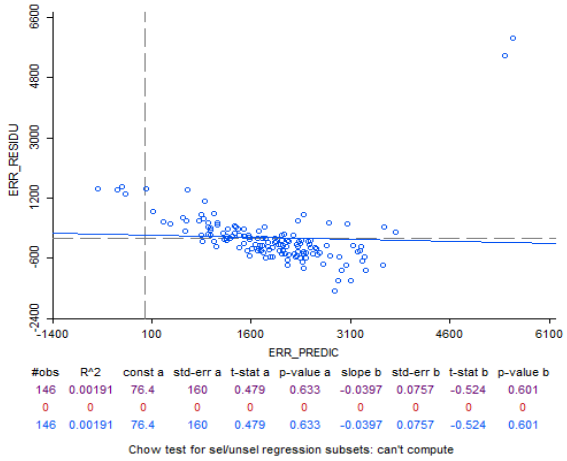


Figure 32. Residuals ERR_RESIDU/predicted value plot (Source: GeoDa 1.4.6)

Scatter plots comparing the correlation between the residuals ERR_RESIDU and the independent variables have been shown in Figure 33. Data points reveal only some signs of heteroskedasticity.

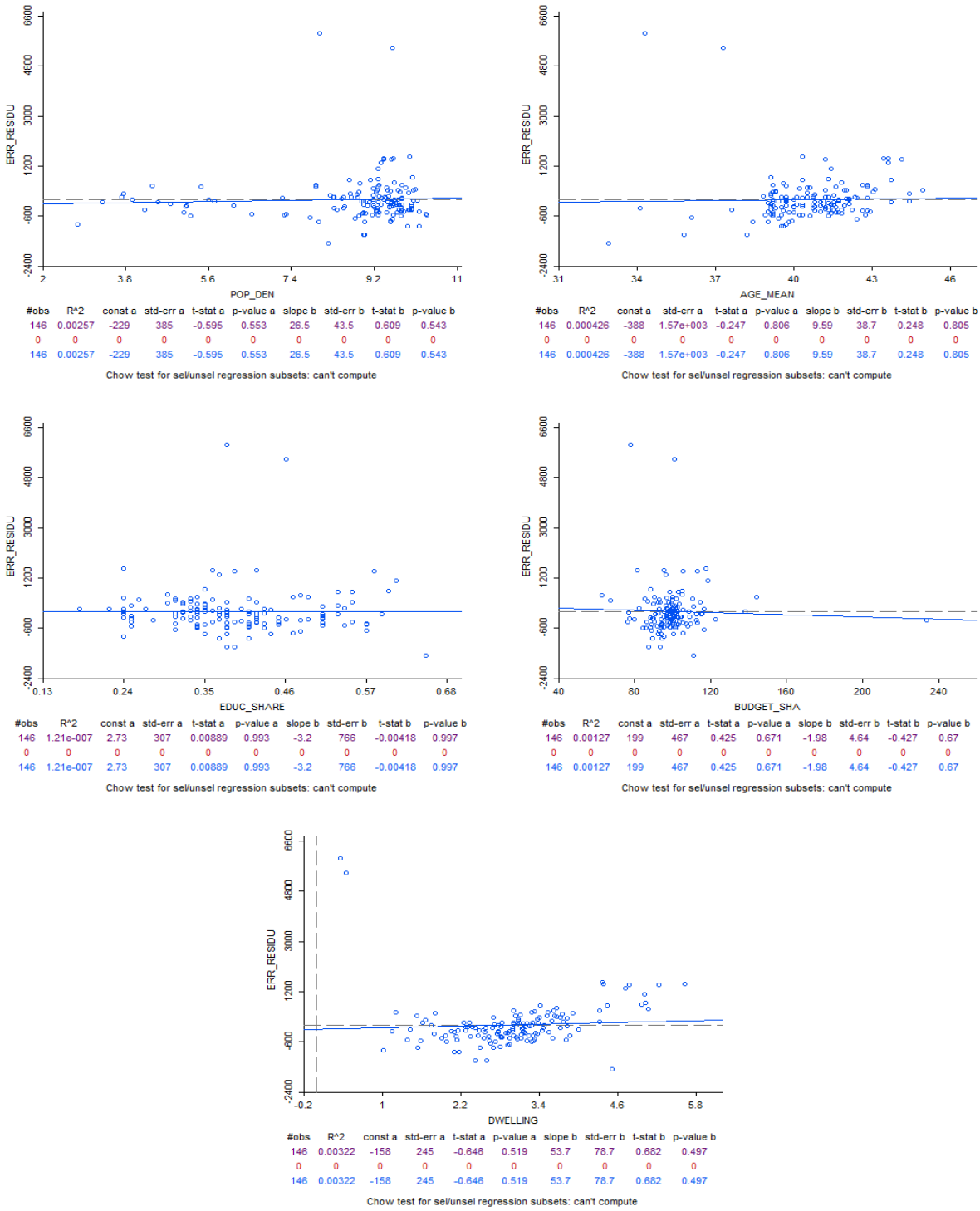


Figure 33. Residuals ERR_RESIDU/predictor variables plots (Source: GeoDa 1.4.6)

4.2 Cluster Analysis of the Shape of Income Segregation

The second research question also requires conducting cluster analysis by means of the hierarchical clustering procedure in order to identify the dominant patterns of income segregation, assess the intensity of income segregation and the extent to which the multiple variables overlap. Moving from the bottom upwards, the coefficients from Agglomeration Schedule providing mean distances for every possible number of clusters from 1 to 145 were rewrited in Table 9 to reveal the changes in the coefficients as the number of clusters increase. A conclusion is to use the optimum number of six clusters sharing similar characteristics more or less independently of their geographical location in the city, as succeeding clustering contributes less to distinguishing between cases. Using ESRI ArcGIS tools, the spatial configurations were displayed on the map (Figure 34).

Table 9. Re-formed Agglomeration Schedule

Number of clusters	Agglomeration last step	Coefficient this step	Change
2	870	652.794	217.206
3	652.794	522.692	130.102
4	522.692	402.902	119.79
5	402.902	320.658	82.244
6	320.658	286.046	34.612
7	286.046	257.608	28.438
8	257.608	232.901	24.707

Source: Author's calculations using 2010-2014 data in IBM SPSS 19

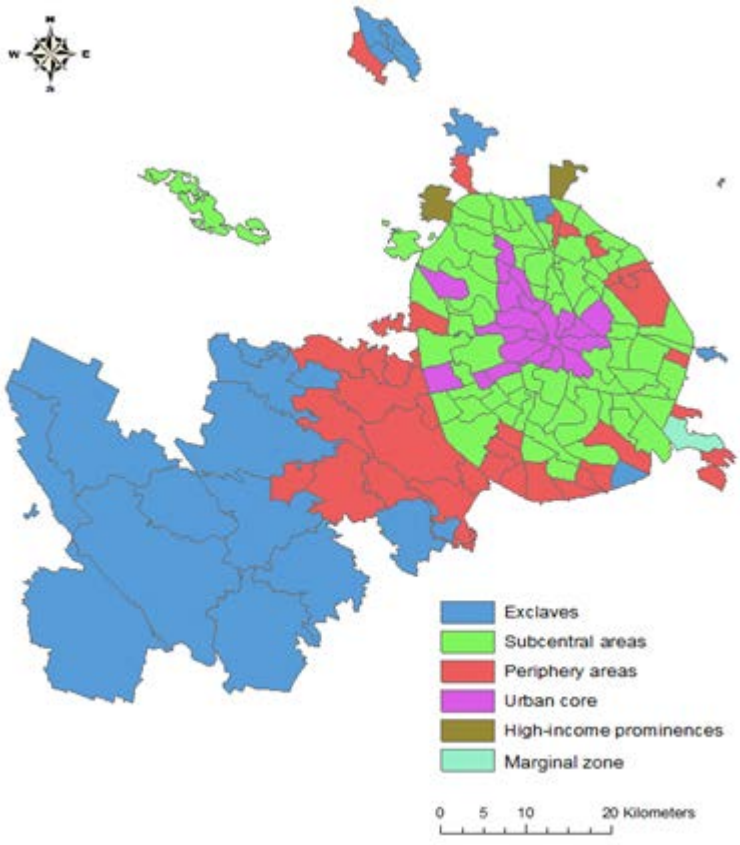


Figure 34. Clusters of Moscow (Source: ArcGIS 10.2.2)

Cluster 1 – Urban core

Neighborhoods belonging to the first cluster are found within the central, western and northern districts of Moscow and are characterized by higher average per capita income levels, the highest educational level among the employed and the highest housing sale prices, and capacity to accumulate financial and administrative capital and attract a larger share of business activity and labor workforce in comparison with other areas. The economically active population comprises a high proportion of managers, financiers, and those working in the public sector. Despite concentration of non-residential functions, population density is relatively high which is the result of gentrification and renovation of urban space. In addition, the urban core is becoming more and more exclusive with ongoing processes of polarization, as new upper class are moving there while the original population and functions are being squeezed out to the periphery. At present, this cluster is characterized by striking contrasts between affluence and poverty, but this situation is regarded as natural and does not evoke protest on the part of the poor deprived of material and cultural wealth.

Cluster 2 – Subcentral areas

The cluster exhibits relatively high population densities, general well-being, and high labor force participation due to the proximity to the urban core. As opposed to industrial or commercial areas, this is mainly a residential transitional zone inhabited by the families of persons engaged in professional and clerical pursuits of young and old ages who have had school if not university education. This zone is further subdivided into two zones: the first zone being more densely built-up and having a high share of good quality housing and the second zone representing the ring of mixed industrial – residential areas that used to belong to the outskirts of the city before the new quarters with a lower end of the housing stock were built there.

Cluster 3 – Periphery areas

This cluster displays peripherally located commuter areas close to the borders of Moscow Ring Road and outside it, in the suburban districts of the city (Novomoskovsky Administrative Area and Kryukovo District in Zelenograd) and is characterized by low population density, relatively younger age structure, lower incomes per capita and relatively low educational level. The housing stock mainly consists of 5-6 storey multi-flat housing. The cluster combines the atmosphere of village residence with access by public transit or by car to the downtown metropolitan center for work, shopping, and entertainment. Areas belonging to the cluster are to a great extent dependent on public transfers.

Cluster 4 – Exclaves

This cluster mainly involves remote low-density territories of Moscow not having common borders with the main part of the city (Zelenograd and Troitsky Administrative Areas) or close to the very margins. The cluster's social fabric is predominantly represented by low social strata with poor education. Historically, the populations in these areas have been occupied in traditional industrial or rural industries, but nowadays the inhabitants are much dependent upon services and employment opportunities provided by the public sector. The housing prices are one of the cheapest in the city and per capita incomes are below the average.

Cluster 5 – High-income prominences

Prominences of Moscow are areas located outside the Ring Road, but having a common border with the main part of the city. The name comes from the specific shape of the boundaries on the map if old Moscow is considered as the «Sun». The highest average incomes in 2013 can be found only in two prominences of Moscow: Mitino and Severny Districts. Mean incomes can

be significantly increased by the presence of numerous very high income recipients. Analysis of incomes of these areas in previous years has shown that the increase in mean incomes has not been gradual and can be explained by inflated annual wage fund of workers engaged in real estate operations, housing rent in Mitino District (US$ 115397) and in utility, social and personal services in Severny District (US$ 92605). Mitino District located in the North-Western Administrative Area was built up in the 1990s and has become one of the most prestigious high-density areas of Moscow owing to a favorable ecological situation and infrastructure development (Moscow City Government 2015). Housing stock includes individual monolithic houses with increased comfort and improved design. Severny District located in the North-Eastern Administrative Area of Moscow is characterized by lower population density and includes multi-storey buildings and gated cottage settlements. Educational level is above the average in both neighborhoods.

Cluster 6 – Marginal zone

Proceeding outwards, the last cluster includes only one marginal neighborhood (Kosino-Ukhtomsky District in the east of Moscow) which experiences the most negative development because of being one of the remotest margins of the city. Income, educational level and relative share of employed population are all substantially below the city average. It is defined by a very low population density, bad ecological situation, high concentration of ethnic migrants and the smallest share of skilled workers.

Box-plot in Figure 35 shows a visual comparison of the level and dispersion in quartiles of the income by all six clusters. In sum, the cluster analysis has revealed the range of alternative spatial forms and the reverse Burgess type Concentric Zone Model (1928) as a dominant form of income segregation in Moscow, represented by Cluster 1 characteristic of higher-order administrative and commercial functions on the one hand and residential functions on the other.

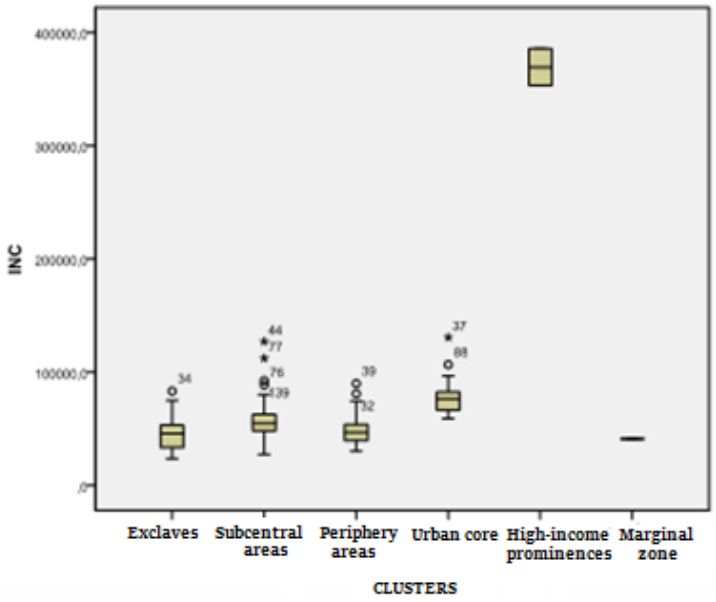


Figure 35. Box-plot of variable INCOME (Source: IBM SPSS 19):

Clusters confirm a significant variation in the spatial form of economic segregation, with the first and the fifth clusters (urban core and high-income prominences) having the highest income, whereas subcentral and periphery areas, exclaves, and marginal zone have experienced a significant decline.

4.3 Trends in Segregation of Affluence and Poverty

For giving an answer to the third research question, all Moscow neighborhoods have been classified into six relative income categories based on ratios of neighborhood average income to average income for the total metropolitan area, following the approach of Bischoff and Reardon (2013). When income data is divided into a larger number of categories, the measure is more precise.

1. **Poor** with the lowest income (neighborhood mean income is 0 to 67 per cent of metropolitan mean income).

2. **Low income** (neighborhood mean income is 67 per cent to 80 per cent of metropolitan mean income).

3. **Low-middle income** (neighborhood mean income is 80 per cent to 100 per cent of metropolitan mean income).

4. **High-middle income** (neighborhood mean income is 100 per cent to 125 per cent of metropolitan mean income).

5. **High income** (neighborhood mean income is 125 per cent to 150 per cent of metropolitan mean income).

6. **Affluent** with the highest income (neighborhood mean income is 151 per cent of metropolitan mean income or greater than that).

As a result of analyzing differences in average income variance across the city of Moscow through the one-way ANOVA procedure (Figure 36) complemented with descriptive statistics, the null hypothesis that there are no differences between income groups is rejected because the probability is less than the significance level, and variation between group means is greater than the variation within columns. The comparison of between-column variations to within-column variations leads to the *F*-statistic > 0.05; therefore it is likely that there is a statistically significant difference between the categories. The small value for Bartlett's statistic confirms that the assumption of the variances being the same across groups is not violated in these data, so the use of ANOVA is justified.

Summary of INCOME

NAME	Mean	Std. Dev.	Freq.
Affluent	5378.2966	3692.0897	8
High income	2499.7064	129.67676	15
High-middle	2069.2656	123.61713	30
Low income	1383.0027	78.345024	26
Low-middle	1667.8442	109.195	41
Poor	1054.6682	154.67038	26
Total	1879.1848	1254.0844	146

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	130717785	5	26143557	37.61	0.0000
Within groups	97327726.5	140	695198.046		
Total	228045512	145	1572727.67		

Bartlett's test for equal variances: chi2(5) = 495.6347 Prob>chi2 = 0.000

Figure 36. One-way ANOVA for variable INCOME (Source: Stata 12.0)

Growing urban segregation in Moscow is marked by higher concentrations of both affluence and poverty (Figure 37).

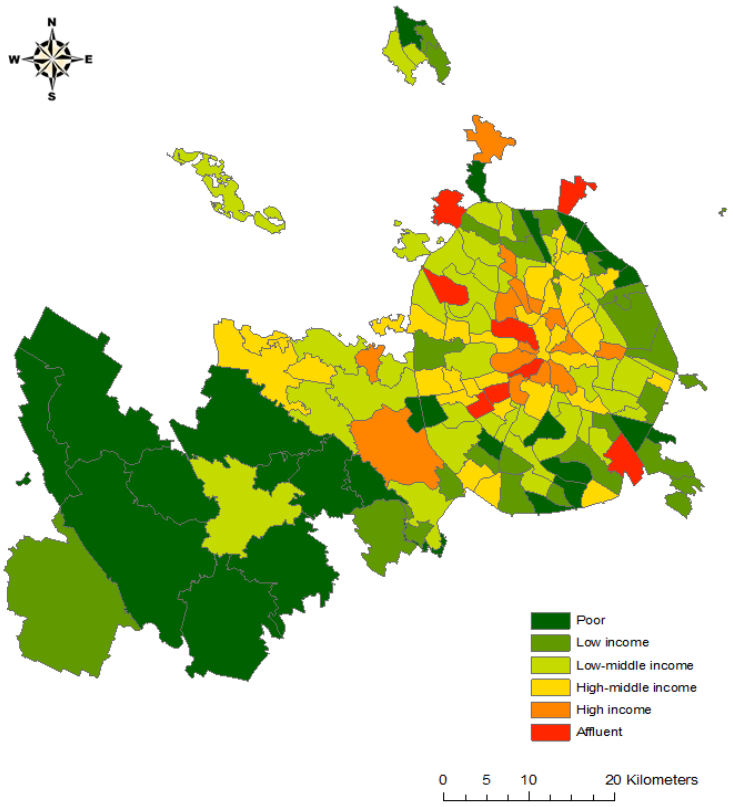


Figure 37. Income categories in 2013 (Source: ArcGIS 10.2.2):

There are 8 truly affluent neighborhoods in Moscow according to the 2013 data: Presnensky and Yakimanka Districts in the central part of the city, Krylatskoye District in the west, Cheryomushki and Akademichesky Districts in the south-west, two prominences Mitino and Severny Districts correspondingly in the north-west and north-east and Vykhino-Zhulebino District in the south-east. 26 peripheral southern, eastern and northern directions (Kurkino in the north-west, Zapadnoye Degunino in the north, Lianozovo, Bibirevo, Severnoye Medvedkovo and Losinoostrovsky Districts in the north-east, Nagatinsky Zaton, Brateyevo, Chertanovo Severnoye and Orekhovo-Borisovo Yuzhnoye in the south, Veshnyaki and Novokosino in the east, Maryino in the south-east, Tyoply Stan in the south-west, Silino in Zelenograd), together with the majority of settlements in Troitsky Administrative Area, have incomes below the poverty line.

Mapping of income differences across Moscow neighborhoods in 2002 and 2010 demonstrates that overall differences between center and periphery, as well as east and west are quite stable (Figure 38).

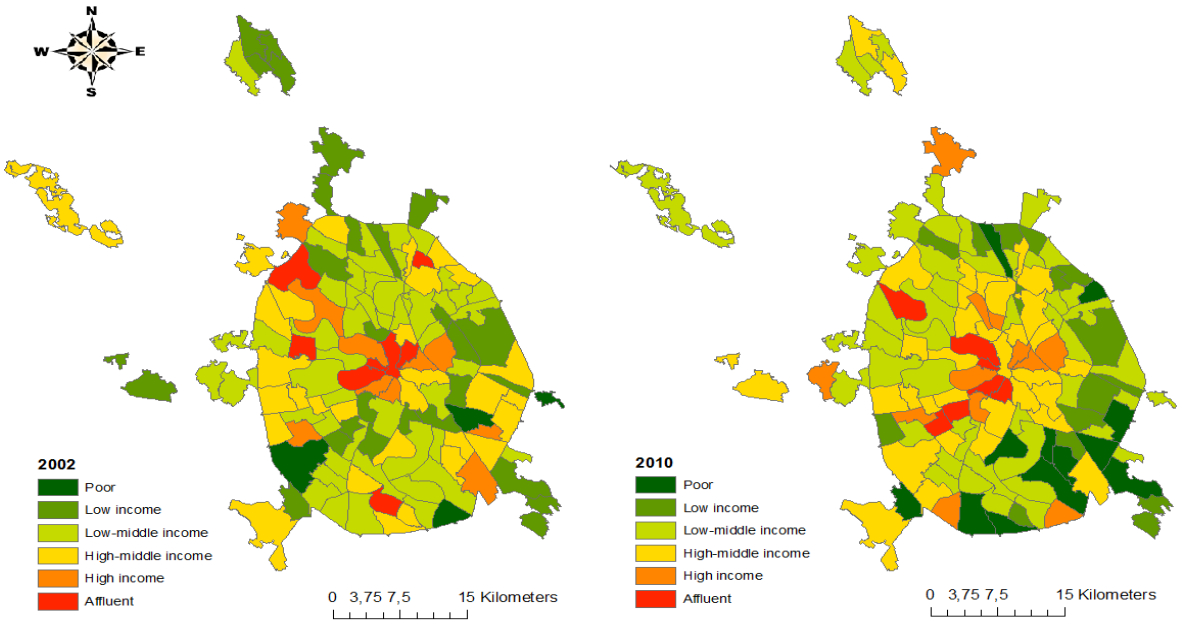


Figure 38. Differences in income 2002 and 2010 (Source: ArcGIS 10.2.2):

Due to the formation of modern geography of prestige and growth of spatial polarization, the prestigious central part and the western districts are becoming more prosperous and most areas of north-east, east and south of the city are more clearly positioned as run-down low-income suburbs with marginalized population. Whilst in 2010, the number of affluent neighborhoods slightly decreased compared to 2002, the proportion of poor neighborhoods almost tripled and the share of middle-income neighborhoods slightly declined.

Table 10 presents the calculated proportion of Moscow population residing in each of these six categories of high-, middle-, and low-income neighborhoods from 2002 to 2013. Middle Income category includes both low-middle and high-middle income neighborhoods; Poor+Affluent category is a self-explanatory income segregation measure. Segregation of neighborhoods by income has grown significantly during the last decade, as there is a gradual but steady decline in the population share living in middle-income neighborhoods, and a corresponding increase in poor and affluent neighborhoods.

Table 10. Proportion of the population by income groups of neighborhoods in Moscow

	2002	2010	2013
Poor	3,37	11,99	15,12
Low income	12,43	11,33	18,06
Low-middle income	39,02	38,11	32,17
High-middle income	29,39	27,47	19,39
High income	9,6	6,56	7,96
Affluent	6,19	4,53	7,30
Middle Income	68,41	65,58	51,56
Poor+Affluent	**9,56**	**16,52**	**22,42**

Source: Author's calculations using 2002-2013 data in Excel 2007

Using the Rank-Order Information Theory index better isolating the unevenness dimension of income segregation and ensuring comparability over time (Appendix C), two additional measures of income segregation based on average income, e.g. the segregation of poverty denoted H10 (the bottom 10 per cent) and the segregation of affluence denoted H90 (the top 10 per cent) have been constructed to provide a more detailed picture of how income segregation varies throughout the Moscow metropolitan area and how it has changed over the last decade (Table 11). For instance, if H10 or H90 is close to 0, it means that the poorest or the wealthiest population is evenly distributed across the city, and if these measures approach 1, population is increasingly clustered. Although the increase in segregation occurred at both extremes of the income distribution, resulting in greater polarization of neighborhoods by income, in all the examined years, excepting the pattern of declining isolation of the poor in 2002, the segregation of poverty is considerably higher than the segregation of affluence and has grown much faster. However, the rate of increase of the segregation of affluence in 2013 was greater than the rate in 2002 and especially in 2010 marked by a decline in income segregation, indicating an accelerating trend towards greater residential polarization of the rich over the last decade as well.

Table 11. The extent of segregation of poverty and segregation of affluence in Moscow, 2002-2013

	2002	2010	2013
Segregation of Poverty (H10)	0,061	0,165	0,188
Segregation of Affluence (H90)	0,100	0,076	0,111

Source: Author's calculations using 2002-2013 data in Excel 2007

4.4 Measuring the Multiple Dimensions of Income Segregation

4.4.1 Traditional Segregation Indices

In order to answer the first part of the last research question, traditional indices of segregation along five separate dimensions of segregation have been computed by means of GeoSegregation Analyzer software developed by Apparicio *et al.* (2013) to assess the global levels of income segregation in Moscow (Table 12). Following Massey and Denton (1988), the evenness and exposure are the most important segregation dimensions for the identification of socially vulnerable income groups. Detailed formulas for the indices used in this paper can be found in Appendix C.

1. Evenness. Because income is measured on a continuous scale and cannot easily borrow the index of dissimilarity from racial/ethnic segregation studies, the measure of income inequality, the Gini index adjusted for tract contiguity, has been used as a measure of evenness. It measures the extent to which the actual income distribution deviates from a hypothetical distribution in which everyone receives an equal proportion of total income. The measure ranges from 0 (perfect equality) to 1 (maximum inequality). Moscow's Gini index equal to 0.4144 has been relatively high and above the warning threshold of 0.4, indicating a large income gap in the city and severe inequality.

2. Exposure. The Isolation index and its standardization (Eta2) measure the extent to which a member of one income group is likely to be in contact with members of the same group by sharing the same residential area. Higher values of isolation indicate higher segregation. At relatively low values of isolation index and its correlation ratio, the neighborhood-level income

groups in the study area experience little exposure and share spatial units with members of other income groups, not being entirely isolated.

3. Concentration. The Absolute concentration index calculates the total area inhabited by the minority income group, comparing this with the minimum and maximum areas that could accommodate a group of that size. A relatively high score of 0.8 points out that minority income groups have achieved high level of spatial concentration in Moscow, occupying a very small share of the total urban physical space.

4. Clustering. The Absolute clustering index expresses the average number of minority income group members in adjacent areal units as a proportion of the total population in those adjacent areal units, where distances between areal units are measured from their centroids (Massey and Denton 1988). The closer to 1 value indicates higher segregation. A value has been close to zero in the study area, assuming low level of clustering and implying that areas are more randomly scattered around the urban environment than adjoined together in a single large enclave.

5. Centralization. Varying between -1 and 1 the Absolute centralization index summarizes a minority's spatial distribution compared to the distribution of land area around the central business district. The closer a group is to the city center, the more segregated it is. Positive value of 0.5 indicates a tendency for minority group members to reside close to the city center.

Table 12. Five dimensions of residential income segregation in Moscow

Dimension	Name	Abbreviation	Value	Interval	Authors
Evenness	Gini index	G	0.4144	[0,1]	Duncan and Duncan (1955)
Exposure	Isolation index	xPx	0.0669	[0,1]	Bell (1954)
	Correlation ratio	Eta2	0.0453	[0,1]	Bell (1954), White (1986)
Concentration	Absolute concentration index	ACO	0.8098	[0,1]	Massey and Denton (1988)
Clustering	Absolute clustering index	ACL	0.0054	[0,1]	Massey and Denton (1988)
Centralization	Absolute centralization index	ACE	0.5252	[-1,1]	Massey and Denton (1988)

Source: Author's calculations using 2013 data in GeoSegregation Analyzer

4.4.2 Factorial Analysis

To answer the second part of the last research question, factorial analysis using dissimilarity indices for ten ethnic groups in Moscow has been conducted because residential income segregation can be increased more within ethnic minorities than within majority population and may sharpen discrimination by the dominant groups (Table 13). The typical approach determines low levels of segregation to be below 0.30, moderate levels between 0.30 and 0.60, and high levels to be 0.60 or higher (Massey 1990, p. 332). Dissimilarity indices for the study area are generally low to moderate, suggesting a relatively high degree of integration of the ethnic groups in the study area. The lowest levels of segregation were generally experienced by the three ethnic groups: Russians comprising the vast majority of Moscow's population, Eastern Slavonic nationalities (Ukrainians and Belarusians) and Mid-Volga ethnicities (Tatars, Chuvash, Mordvinians, Udmurt). The lowest specific was between Russians and Mid-Volga nationalities (0.11), while that between Russians and Slavonic group was 0.12. The position of Ukrainians and Belarusians on the scale of the social hierarchy is compared to Russians, but there are more leaders among assimilated Ukrainians (Vendina 2005). Socio-professional structure of Mid-Volga nationalities traditionally representing the working class of Moscow has markedly polarized, as they formed a highly educated elite as well. The highest mean dissimilarity indices were

experienced by the South-East Asian group (0.31), Siberia (0.29) and Others (0.29) followed by the Middle East and Central Asia groups (both 0.25), assuming a relatively high degree of segregation between the dominant group and poorer ethnic minorities, although at a more moderate scale than in the United States. On the contrary, the lowest mean dissimilarity indices were experienced by the Caucasus group (0.19) and majority Russians (0.20). As emphasized by Vendina (2005), the three Caucasian populations (especially Azerbaijanis, Armenians, and Georgians) are growing rapidly in Moscow, despite the fact that more than two-thirds of Muscovites have been hostile to their presence. Until the 1990s, the Azeri population in Moscow was quite small, and as a consequence, many were mistakenly identified as part of the longer-settled Armenian and Georgian populations in the city. However, trade liberalization in 1991 was followed by a mass influx of Azerbaijanis, who shortly gained control of Moscow's street markets. Comparison of incomes and financial position of different ethnic groups in the city of Moscow shows that Caucasians constitute economically unbalanced group characterized by a strong spread of income (Vendina 2005).

Table 13. Dissimilarity indices for ethnic groups in Moscow

	RUS	SLAV	MID_VOLGA	EUR_AMER	CAUCASUS	S-E ASIA	SIBERIA	MIDDLE EAST	CENTRAL ASIA	OTHERS
RUS	X	X	X	X	X	X	X	X	X	X
SLAV	0.1186	X	X	X	X	X	X	X	X	X
MID_VOLGA	0.1139	0.1265	X	X	X	X	X	X	X	X
EUR_AMER	0.1778	0.1743	0.2003	X	X	X	X	X	X	X
CAUCASUS	0.1367	0.1386	0.1254	0.1557	X	X	X	X	X	X
S-E ASIA	0.3258	0.2926	0.3009	0.2962	0.2633	X	X	X	X	X
SIBERIA	0.2621	0.2811	0.2787	0.2583	0.2335	0.3122	X	X	X	X
MIDDLE EAST	0.2155	0.2271	0.2110	0.2137	0.1810	0.2960	0.2711	X	X	X
CENTRAL ASIA	0.2230	0.1670	0.2119	0.2247	0.1920	0.2989	0.3306	0.2723	X	X
OTHERS	0.2279	0.2371	0.2431	0.2705	0.2480	0.3831	0.3490	0.2912	0.2976	X
Mean	0.20	0.21	0.21	0.22	0.19	0.31	0.29	0.25	0.25	0.29

Source: Author's calculations using 2010 data in GeoSegregation Analyzer

CHAPTER FIVE: CONCLUSION

5.1 Result Discussion

The research presented in the given study was motivated by four main questions. The answer to the first question «What explicit factors affect income and how these income-affecting factors are interrelated?» was given through a multivariate spatial regression analysis. In particular, this study demonstrates that in 2013, income level in the city of Moscow was strongly associated with education share, average age, dwelling-to-income ratio, budget execution share and population density. First of all, higher levels of educational attainment tend to increase income. High returns to education are associated with better socio-economic outcomes and provide strong incentives to invest in job-specific or general human capital in Moscow. As average education levels constantly increase, those without a university degree struggle to find well-paying jobs. Given the correlation between educational attainment and income, neighborhoods with higher levels of educational attainment inequality will experience greater segregation by income. Secondly, income is strongly linked to age, tending to decrease with age across the whole distribution. Younger workers in Moscow started working after the major economic shift occurred, so their incomes are usually higher than those of the older workers. Third, dwelling-to-income ratio exhibited negative relationship with income, assuming that there is a slow recovery in the stability of the housing market as a result of the post-Soviet privatization system which granted property rights free of charge, strengthening potential housing inequalities that could have emerged as a result of the market transition. Overall, housing inequality among Moscow neighborhoods is high due to a large gap between various income groups. Rich and poor Muscovites may live in similarly sized apartments, but their apartments have substantially different conditions. Fourth, higher budget execution share is connected with lower income, confirming that neighborhoods with inequality driven by falling incomes among the poor are heavily subsidized from the state, and districts with income growth for the rich generally experience budget deficit. Finally, higher population density is associated with higher income and hence elevated income segregation. Results of testing the correlation between aforementioned variables confirmed that these explanatory factors are highly related to income. However, the regression analysis revealed no significant effect of industrial (per cent of workers in agriculture and manufacturing) and occupational factors (share of managers, financiers and those employed in the public sector) together with mixed ethnicity percentage variable. This suggests that these predictors have been less determinative of income structure in the study area. Perhaps, the statistical data on industry and occupation are too aggregated to capture the differences in industrial and occupational structure important for income distribution. In addition, in the case of Moscow metropolitan area, spatial error model regarding spatial autoregressive disturbance yielded improvement to the original OLS model and appeared to be more appropriate regression method based on the Lagrange Multiplier statistics reported by GeoDa 1.4.6. The similarity between the results of the standard OLS regression and OLS enhanced with spatial variable alongside with indication of remaining specification problems in the spatial error model assumes a necessity of further refinement of the regression model. Given the fact of statistically significant clustering not owing to random chance in standard OLS and OLS with dummy variable (Moran's *I* greater than zero), initial high degree of non-normality (after examining the residuals in GeoDa 1.4.6 the hypothesis of normality of the error terms was rejected for all regression models) and strong heteroskedasticity, an important question for future research is consideration

of alternative specifications, for instance integrating new key explanatory variables or incorporating various spatial weights to receive more stable results. Despite this, since the units that are analyzed are local subdivisions of space, the study is ecological in character, emphasizing the multidimensional nature of social change in all its facets of finding relationships between population density, age composition, education, dwelling ratio, budget maintenance and income distribution. In general, the main determinants of income have important implications for the reproduction of inequality and spatial form of economic segregation in the study area.

The answer to the second question «Are differences in income segregation related to proximity to the centers of activity, as hypothesized by theory?» is affirmative. Regression analysis with spatial variable CORE producing income sorting according to distance to the central business district has shown that the average income increases depending on the proximity to the center of the urban area. Supplementary analysis of the dwelling-to-income ratio confirmed that houses located closer to the CBD have steadily increased in value in comparison with neighborhoods having high proportions of low-income residents. A location closer to the center has an irreparable advantage of lower commuting costs but higher land prices, that is why, the rich can outbid the poor for favorable central locations, where many old buildings have been either renovated or demolished to create luxury condominiums with all the necessary infrastructure in place. Thus, the findings provide strong evidence of the kind of gentrification squeezing out the poor to the city outskirts, while downtown is being appropriated by the affluent, upper and high-middle classes. Due to the land scarcity in the center, new elite real estate appears also in subcentral areas adjacent to the center, especially in the west and to a lesser extent in the north-west mainly because of environmental quality and easy access to the city. The cluster analysis also provided evidence for the spatial concentration of the exclusive housing and business services in the center of Moscow, reminiscent of the reverse Burgess's Concentric Zone Model (1928) with several unique post-socialist features such as the concentric-radial layout with rings originating from the city center to the peripheral districts with large sleeping quarters disposed in a concentric plan. Despite expansion of the borders in 2012, increasing the territory of Moscow in almost 2.5 times, and aspiration to create a polycentric model of urban development, in reality the city is still very far from a pattern of decentralized reconcentration with most of the employment opportunities and economic activities concentrated in the city center. Substantial contrasts in the quality of the urban environment and infrastructure development within the city will further keep the attractiveness of the Center very high. Meanwhile, the center of Moscow is not uniform with the most prestigious districts constituting enclaves of wealth (i.e. gated communities showing the desire of society to self-isolation) and transition districts with varying specialization. At present, some areas of luxury housing formed so-called Golden Mile within the most expensive quarter Ostozhenka located to the south-west of the Kremlin in the central Khamovniki District. In contrast, a high proportion of lower-class housing can be found in the less prestigious areas of the Center, such as Basmanny, Tagansky and Krasnoselsky Districts. Although the majority of residents of the Central Administrative Area are typically better off financially than other Muscovites, lower strata still living in the center are becoming alienated from extensive infrastructure localized within the Center's boundaries.

Description of the trends in the segregation of poverty and the segregation of affluence in the city of Moscow allows answering the third question: «How is segregation of poor and affluent neighborhoods spatially expressed in the study area and how has it changed over time?». During the examined period 2002-2013, the significant increase in residential segregation by income was

a result of the growing spatial concentration of both poor and affluent neighborhoods and decline of middle-income neighborhoods. On average across Moscow, affluent and high-income neighborhoods are primarily located in the most prestigious and expensive central part, west and south-west, while low-income and poor neighborhoods with the cheapest housing and adverse ecological conditions are mainly concentrated in the eastern, south-eastern and north-eastern outskirts of the city, large part of New Moscow territory and satellite town Zelenograd. In 2013, 7.3 per cent of population lived in neighborhoods classified as affluent (Presnensky, Yakimanka, Krylatskoye, Cheryomushki, Akademichesky, Mitino, Severny, Vykhino-Zhulebino Districts), where mean incomes exceeded 150 per cent of mean income in the total metropolitan area, and 15.12 per cent resided in neighborhoods classified as poor (Kurkino, Zapadnoye Degunino, Lianozovo, Bibirevo, Severnoye Medvedkovo, Losinoostrovsky, Nagatinsky Zaton, Brateyevo, Chertanovo Severnoye, Orekhovo-Borisovo Yuzhnoye, Veshnyaki, Novokosino, Maryino, Tyoply Stan, Silino Districts, together with the majority of settlements in Troitsky Administrative Area), where mean incomes were less than 67 per cent of metropolitan mean income. With the exception of 2002 characterized by relatively low segregation of poverty in Moscow, the isolation of the poor has been consistently greater than the isolation of the rich and has grown rapidly. That is, low-income population is much less likely to live in neighborhoods with middle- and high-income population due to increased residential sorting by income. Spatial concentration of poverty gathering poor people together in space and associated with it unequal pensions and health care provision, different employment opportunities and school education are thus significant issues for the study area. Nevertheless, the segregation of affluence in 2013 was greater than in 2002 and 2010, endorsing a simultaneous trend towards more pronounced form of social isolation of the rich at the neighborhood level. It presupposes that substantial amount of society's resources, services and amenities is concentrated in a smaller proportion of neighborhoods in the city of Moscow leading to the processes of gentrification and the formation of closed enclaves, with long-term adverse consequences for poor and middle-income population deprived of investments in public and private services. Extensive public and green areas, water resources and historical estates are becoming prohibited from common use by means of fenced and well-guarded social infrastructure, closed kindergartens and private schools with higher standards of education, private clinics are reserved only for the most exclusive super-elite. The number of closed condominiums is expected to grow, and Moscow will be gradually transformed to a city for rich people, aggravating problems of social and ethnic inequality. Rising land and estate prices, influx of ethnic migrants, the increasing exclusivity and density of material deprivation definitely assure that the current pattern of increasing segregation based on income and relational capital will continue to be sustained for many years to come.

Finally, by using the segregation indices regarded as global measures, which summarize the degree of residential sorting of the entire city, this study shows that income segregation in Moscow has been structured by multiple dimensions of spatial distance, driven by the last research question « What are the income segregation levels across five classical dimensions of residential segregation and what impact does ethnicity have on socio-economic patterns?». Following Townshend and Walker (2002), if residential segregation is considered as a multidimensional construct, then these dimensions should be clearly apparent in other forms of social segregation in the city, such as income-based segregation. These separate dimensions of income segregation provide a deeper insight into the residential expression of income inequality, which is the main driver of residential income segregation, and more comprehensively describe

the patterns of income characteristics and minority-specific forms of segregation within Moscow metropolitan area. Neighborhood-level minority income groups were relatively high segregated on the evenness, concentration and centralization dimensions, but they had relatively little exposure and lower than average level of clustering. The evenness index revealed that there is a strong income inequality for the highest and the lowest income groups relatively unevenly distributed in metropolitan space. Modern Moscow society is not united and aspires to segregation, as residents prefer to live in a homogeneous environment. The exposure indices pointed out that minority income groups did not have considerably high levels of neighborhood-level within-group contact because of geographical dispersion and relatively large population share residing in more heterogeneous areal units. However, they are closer to achieving the maximum possible spatial concentration by occupying smaller neighborhoods with much higher densities of the city's space, especially in new and peripheral suburban areas of Moscow characterized by a tendency towards contiguous regionalization of low-income groups. In these areas, people are surrounded by others in the same conditions and have less chances of an upward social mobility. Small value along the clustering dimension demonstrates that minority income groups are less likely to be spatially clustered, not occupying the most contiguous set of similar-income neighborhoods. According to the centralization dimension, a large proportion of a minority income group would be also required to change area in order to achieve a uniform distribution around the richer and the most expensive CBD-proximate neighborhoods.

In addition, it was equally important to analyze ethnic segregation predicting levels of metropolitan neighborhood poverty concentration by means of dissimilarity indices. Albeit, there was relative little or moderate segregation between allocated ten ethnic groups based on the 146 districts of Moscow, supporting the overwhelming trend towards integration. Settling of migrants in the study area does not determine the ethnic landscape of the city but their localized places of residence are strongly associated with status differences, socio-occupational characteristics of individuals and the housing market. The lowest levels of segregation were generally experienced by Russians, Eastern Slavonic nationalities, and Mid-Volga ethnicities tending to live near each other due to geographical similarities, related languages and culture. Surprisingly, one of the lowest mean dissimilarity indices were experienced by the Caucasus group which accounts to more than 15 per cent of all working migrants in Moscow. Contrastingly, residents of the South-East Asian group, Siberia group and Others group followed by the Middle East and Central Asian groups experienced the highest levels of segregation, with an average dissimilarity index of 0.29. In this case, the maximum shift in the ethnic composition of the population predominantly occurred in southern, south-eastern and north-eastern parts of the city. Therefore, it is worth coping with socio-economic stratification of the population in Moscow, as income segregation is the main agent of ethnic inequality. A serious problem is not only the lack of intercultural contacts or intolerance, but also the resistance of the Moscow upper and middle classes having aspirations for social isolation. The direct results of this social strategy are spatial poverty and stigmatization of clearly distinguished urban neighborhoods with bad reputation because of increased concentration of ethnic minorities.

Summing up, through a review of relevant literature and a comparative multi-method approach, this paper contributes to addressing the patterns of residential income segregation and forms of spatial division at the neighborhood level in the city of Moscow, indicating clear pockets of poverty on the periphery and affluence in the prestigious central and western parts. A key finding of this study is that increased income segregation has been driven to a larger extent by the

isolation of very poor neighborhoods from middle- and upper-income places. In spite of the fact that the current processes of social segmentation are not extremely sharp, in the future they possibly can lead to negative social consequences, including ghettoization of certain areal units in the city. There is a high probability that the growing exclusivity of the high-income south-western sector and deprivation of low-income outskirts accumulating social disadvantage will substantially increase income-based segregation. I assume that, because of data limitations, further research on the spatial form of income segregation in Moscow will be important. More detailed studies will be needed to better understand specific income and ethnic minority segregation features and consequences of gentrification in displacing the poor to the outskirts of the city. Improving understanding of how poverty and affluence are connected with place is crucially important in the evolving structure of income segregation in Moscow as well. It would be interesting to assess the impact of governmental initiatives on levels of affluent-poor segregation and how segregation structures have been changing over time.

5.2 Planning Policy Recommendations

In my opinion, to primarily address the challenge in connection with the mixing of different income groups it is necessary to apply so-called place-based policies aimed at improving the housing stock or amenities in poor neighborhoods to encourage affluent households to move in there or to disperse affordable housing options allowing poor households to move into affluent neighborhoods. The primary purpose of mixed residential development is spatial association of people with different levels of income in urban complexes with quality housing of various types and providing access to a full range of services and social infrastructure. Overcoming income segregation in Moscow is linked to the shifting populations from high poverty areas to better-off middle-income and affluent areas, as it helps poor people achieve better social integration, improve economic opportunities and get access to higher quality goods. Subsidies and incentives should be also targeted at moderate-and higher-income Muscovites to persuade them to relocate to the low-income and poor neighborhoods, which can reduce stigmatization and enhance area reputation in the study area. Notwithstanding, high-income households may not be prepared to move to more deprived areas until networks of similar households have become established in those areas. For these reasons, it is quite possible for areas of wealth to exist close to areas of deprivation. The government should provide numerous subsidies for the construction of housing developments that contain a mix of market rate and subsidized, rental and private units, which typically creates a mix of households with different demographic composition and income level. The priority should be given to the use of high-density low-rise construction that combines a high level of comfort and reduces the current transport costs. Designing a mixed residential development should focus on the organization of safe environment preventing social tensions between residents of different social and cultural backgrounds, public spaces creating a sense of identity with the place, well-designed green plots and landscaping that enhance the attractiveness of the neighborhood. Quality of building materials and unity of facades should create an integrated urban environment without income level identification signs. However, it is important to bear in mind that sometimes income mixing policies may be unsuccessful in integrating poor, low or low-middle neighborhoods and might even exacerbate inequality, gentrification processes and reinforce poverty instead of reducing it. According to Department of Economic Policy and Development of Moscow (2014), there was a decline in real incomes of Muscovites due to growing political and economic tensions in the country (escalation of the war conflict in Ukraine,

sanctions of Western countries). The economic problems are still persisting, and the level of inflation accounted to more than 107.3 per cent. In the new socio-economic conditions, in which the financial resources of Moscow economy are rather limited, the role of the government is to stimulate the realization of urban planning programs in close collaboration with private investors by developing new legal projects for granting of social support in accordance with actual per capita incomes and cost of living and carrying out measures to improve current redistribution mechanisms to low-income people through donations of money and humanitarian aid, grants for higher education, affordable housing and help in getting a decent employment.

The challenge in relation to the gap between the central business district and periphery in Moscow is suggested to be overcome through an advanced development of a polycentric model by transforming former underutilized industrial zones sufficiently distant from the historic nucleus without further extending the city borders and implementation of so-called indirect approaches aimed at relieving traffic congestion in the city center. The valid solution to reduce trips into the core of Moscow and consequently unload the old city is thus decentralization, or formation of new more specialized centers of activity and office developments outside the Third Transport Ring directly aligned with transport infrastructure. The city should prioritize which locations are to be developed first and promote a consistent strategy for these priority zones. There is much work to do inside of the Ring Road, with plenty of opportunities still existing to develop the inner city. Additional housing opportunities should be provided in the core area to promote walk to work options for avoiding excessive commuter traffic into the city center. Even if there is an observed need, it is suggested to not build too much public housing in the most remote deprived areas as this simply concentrates income segregation further and increases commuter labor migration to the CBD. It is also recommended to extend multi-modal public transit routes into remote neighborhoods to reduce their isolation and consider the relocation of government offices and commercial functions beyond the center’s limits.

In regard to meeting Moscow’s challenges related to housing stock, the recommendation is to apply so-called people-based urban policies aimed at solving problems of polarization and concentration of poverty in specific areas and assisting home buyers or renters to gain access to existing neighborhoods through improved access to mortgage finance, offers of housing vouchers for rent and stronger enforcement of fair housing laws. It is appropriate to include inclusionary zoning policies promoting subsidized affordable housing for low- and moderate-income population in the face of rising housing prices within new housing development and improve the physical environment and amenities of deprived poor neighborhoods, so that higher-income households are less likely to escape. The new strategy for solving the housing problems of Muscovites should be based on entirely new principles – combined mortgage lending system for all citizens with sufficient income to buy property and system of subsidizing the initial payment and grants for the purchase of housing on the waiting list for poor and low-income households in accordance with actual per capita incomes. It is important to ensure that the affluent and high-income segments of the population do not qualify for the free provision of public housing. Introduction of the progressive taxation scale is also an important instrument for the state policy to effectively reduce market income inequality and generate additional revenue in Moscow, which could be spent on social protection and public services, leading to reduction in income-based segregation. Alongside that, Moscow City Hall should offer policies controlling gating (their design, materials, location and extent of walls and fences) and restricting road closures in affluent and high-income neighborhoods to limit closed compounds and improve street and

pedestrian connectivity. In order to decrease the need for separation it is necessary to improve social mobility and make the infrastructure suitable for the requirements of the middle class.

In order to face the migration challenges, the recommendation is to address the labor market by developing policies that can support workers to earn a decent wage, increasing institutional investments in education and health care for migrants, improving anti-discrimination legislation and an inequitable law enforcement system. Tightening the passport registration regime and police control of migration flows will not avoid forming ethnic enclaves in the city, as the main efforts should be directed at fighting with poverty, reconstructing devastated social infrastructure and dilapidated housing that will help maintain the status of peripheral areas and prevent the outflow of the middle class. At the same time, it is important to develop adequate decisions establishing the legal status of migrants in Moscow. In that sense, future policy actions should consist of introducing programs and urban services improving the social and cultural life of migrants, creating the space for their social integration, and carrying out measures to increase the social support to low-income families with children.

In sum, the trends of spatial differentiation processes in the city of Moscow indicate growing income segregation of urban space through the increasing manifestation of inter-sectoral differentiation of the affluent Center – South-West and poor South – South-East. Coping with such segregation and realization of effective measures ensuring balanced socio-economic development of the city and its suburbs will become a fundamental task for urban planning. The general recommendation for policy makers is to focus on smoothing the current and future regional disparities in the social development of the city, preventing the formation of manifestation of income and ethnic segregation, as well as on the regulation of social and demographic development of the Moscow metropolitan area as a whole.

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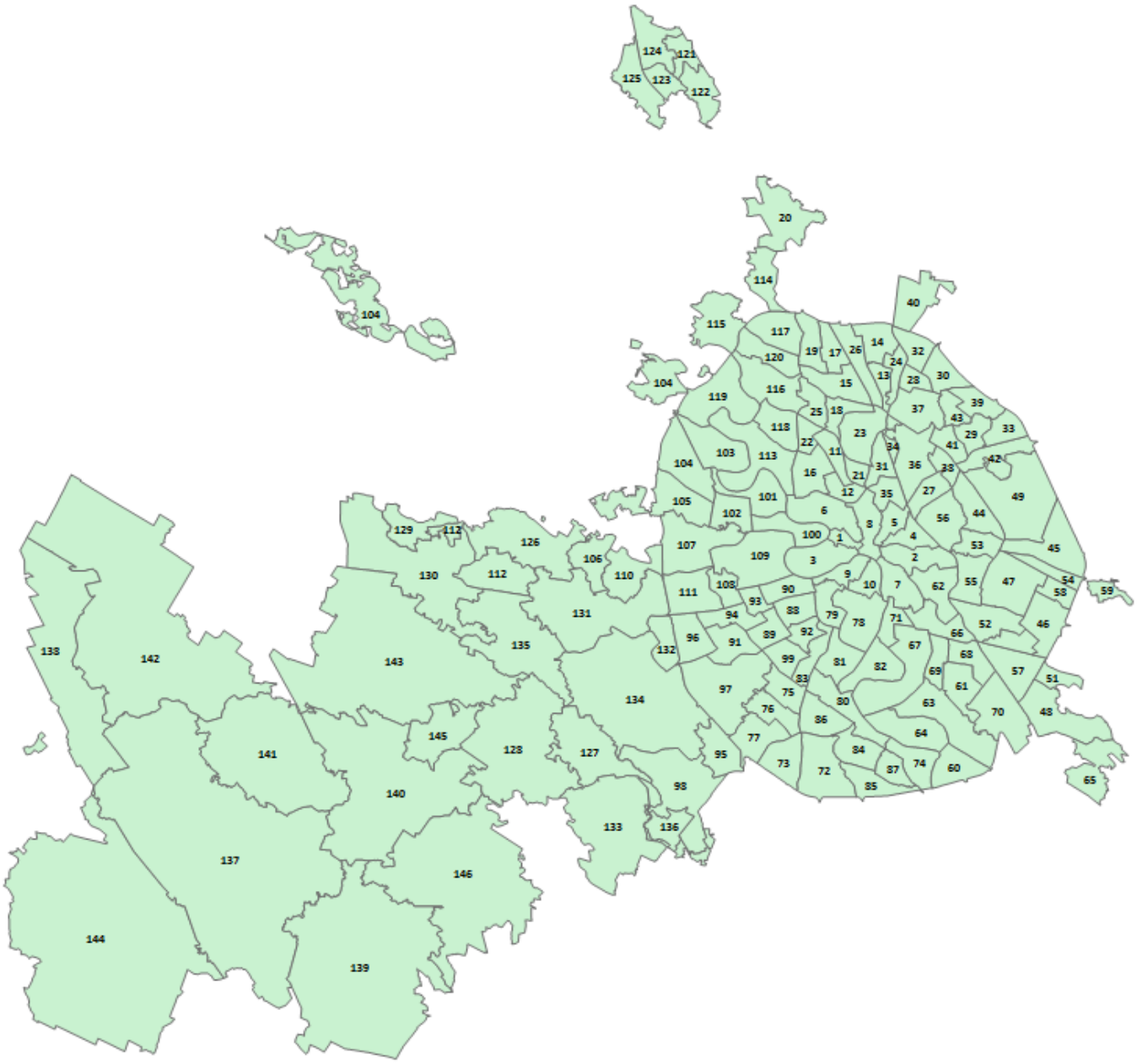

Figure A.1. Map showing location of Moscow neighborhoods (Source: ArcGIS 10.2.2)


Central Administrative Area
1 Arbat
2 Basmanny
3 Khamovniki
4 Krasnoselsky
5 Meshchansky
6 Presnensky
7 Tagansky
8 Tverskoy
9 Yakimanka
10 Zamoskvorechye
Northern Administrative Area
11 Aeroport
12 Begovoy
13 Beskudnikovsky
14 Dmitrovsky
15 Golovinsky
16 Khoroshyovsky
17 Khovrino
18 Koptevo
19 Levoberezhny
20 Molzhaninovsky
21 Savyolovsky
22 Sokol
23 Timiryazevsky
24 Vostochnoye Degunino
25 Voykovsky
26 Zapadnoye Degunino
North-Eastern Administrative Area
27 Alexeyevsky
28 Altufyevsky
29 Babushkinsky
30 Bibirevo
31 Butyrsky
32 Lianozovo
33 Losinoostrovsky
34 Marfino
35 Maryina roshcha
36 Ostankinsky
37 Otradnoye
38 Rostokino
39 Severnoye Medvedkovo
40 Severny
41 Sviblovo
42 Yaroslavsky
43 Yuzhnoye Medvedkovo
Eastern Administrative Area
44 Bogorodskoye
45 Golyanovo
46 Ivanovskoye
47 Izmaylovo
48 Kosino-Ukhtomsky
49 Metrogorodok
50 Novogireyevo
51 Novokosino
52 Perovo
53 Preobrazhenskoye
54 Severnoye Izmaylovo
55 Sokolinaya gora
56 Sokolniki
57 Veshnyaki
58 Vostochnoye Izmaylovo
59 Vostochny
South-Eastern Administrative Area
60 Kapotnya
61 Kuzminki
62 Lefortovo
63 Lyublino
64 Maryino
65 Nekrasovka
66 Nizhegorodsky
67 Pechatniki
68 Ryazansky
69 Tekstilshchiki
70 Vykhino-Zhulebino
71 Yuzhnoportovy
Southern Administrative Area
72 Biryulyovo Vostochnoye
73 Biryulyovo Zapadnoye
74 Brateyevo
75 Chertanovo Severnoye
76 Chertanovo Tsentralnoye
77 Chertanovo Yuzhnoye
78 Danilovsky
79 Donskoy
80 Moskvorechye-Saburovo
81 Nagatino-Sadovniki
82 Nagatinsky zaton
83 Nagorny
84 Orekhovo-Borisovo Severnoye
85 Orekhovo-Borisovo Yuzhnoye
86 Tsaritsyno
87 Zyablikovo


South-Western Administrative Area
88 Akademichesky
89 Cheryomushki
90 Gagarinsky
91 Konkovo
92 Kotlovka
93 Lomonosovsky
94 Obruchevsky
95 Severnoye Butovo
96 Tyoply Stan
97 Yasenevo
98 Yuzhnoye Butovo
99 Zyuzino
Western Administrative Area
100 Dorogomilovo
101 Filyovsky park
102 Fili-Davydkovo
103 Krylatskoye
104 Kuntsevo
105 Mozhaysky
106 Novo-Peredelkino
107 Ochakovo-Matveyevskoye
108 Prospekt Vernadskogo
109 Ramenki
110 Solntsevo
111 Troparyovo-Nikulino
112 Vnukovo
North-Western Administrative Area
113 Khoroshevo-Mnevniki
114 Kurkino
115 Mitino
116 Pokrovskoye-Streshnevo
117 Severnoye Tushino
118 Shchukino
119 Strogino
120 Yuzhnoye Tushino
Zelenograd Administrative Area
121 Matushkino, earlier Number 1
122 Savyolki, earlier Number 2
123 Staroye Kryukovo, earlier Number 3
124 Silino, earlier Number 4
125 Kryukovo
Novomoskovsky Administrative Area
126 Vnukovskoye Settlement
127 Voskresenskoye Settlement
128 Desyonovskoye Settlement
129 Kokoshkino Settlement
130 Marushkinskoye Settlement
131 Moskovsky Settlement
132 Mosrentgen Settlement
133 Ryazanovskoye Settlement
134 Sosenskoye Settlement
135 Filimonkovskoye Settlement
136 Shcherbinka Town District
Troitsky Administrative Area
137 Voronovskoye Settlement
138 Kiyevsky Settlement
139 Klenovskoye Settlement
140 Krasnopakhorskoye Settlement
141 Mikhaylovo-Yartsevskoye Settlement
142 Novofyodorovskoye Settlement
143 Pervomayskoye Settlement
144 Rogovskoye Settlement
145 Troitsk Town District
146 Shchapovskoye Settlement

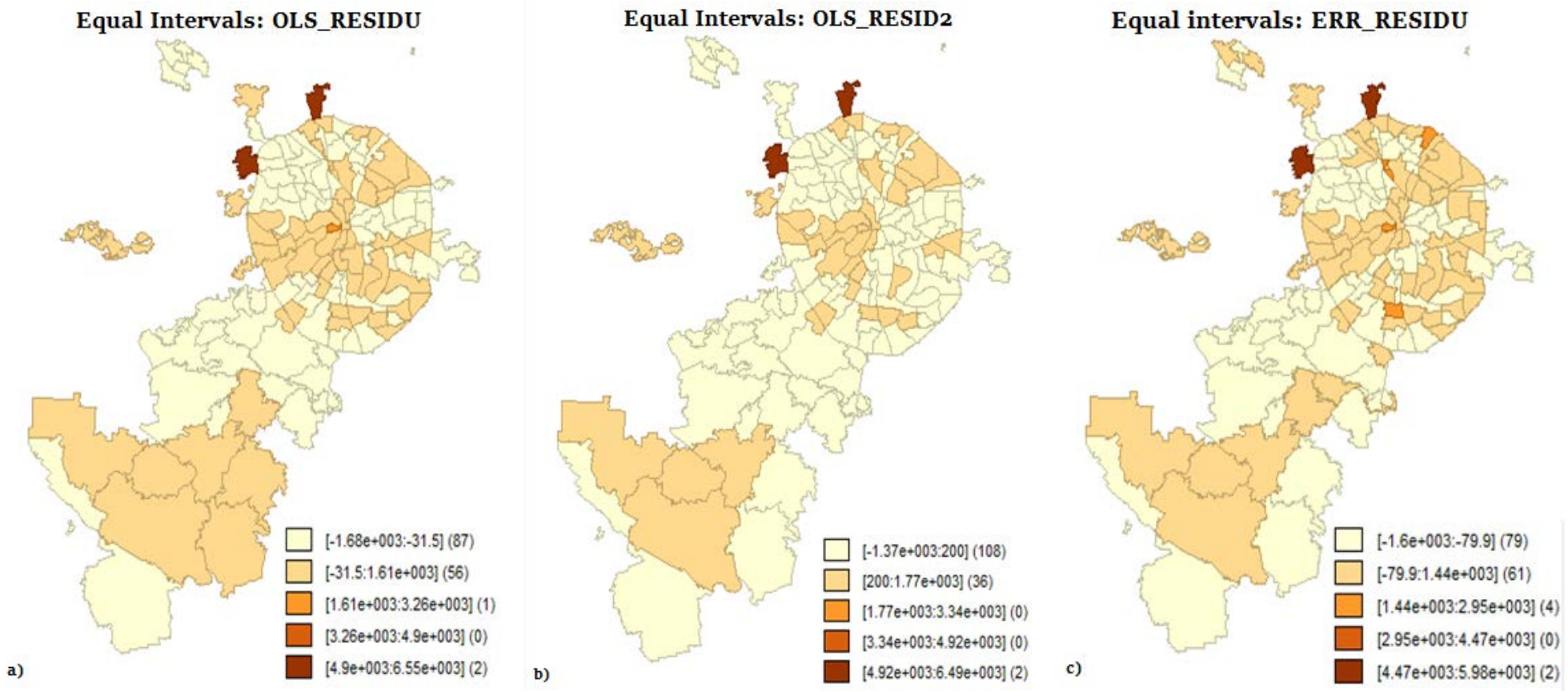

Figure B.1. Mapped distributions of residuals OLS_RESIDU, OLS_RESID2 and ERR_RESIDU (Source: GeoDa 1.4.6)

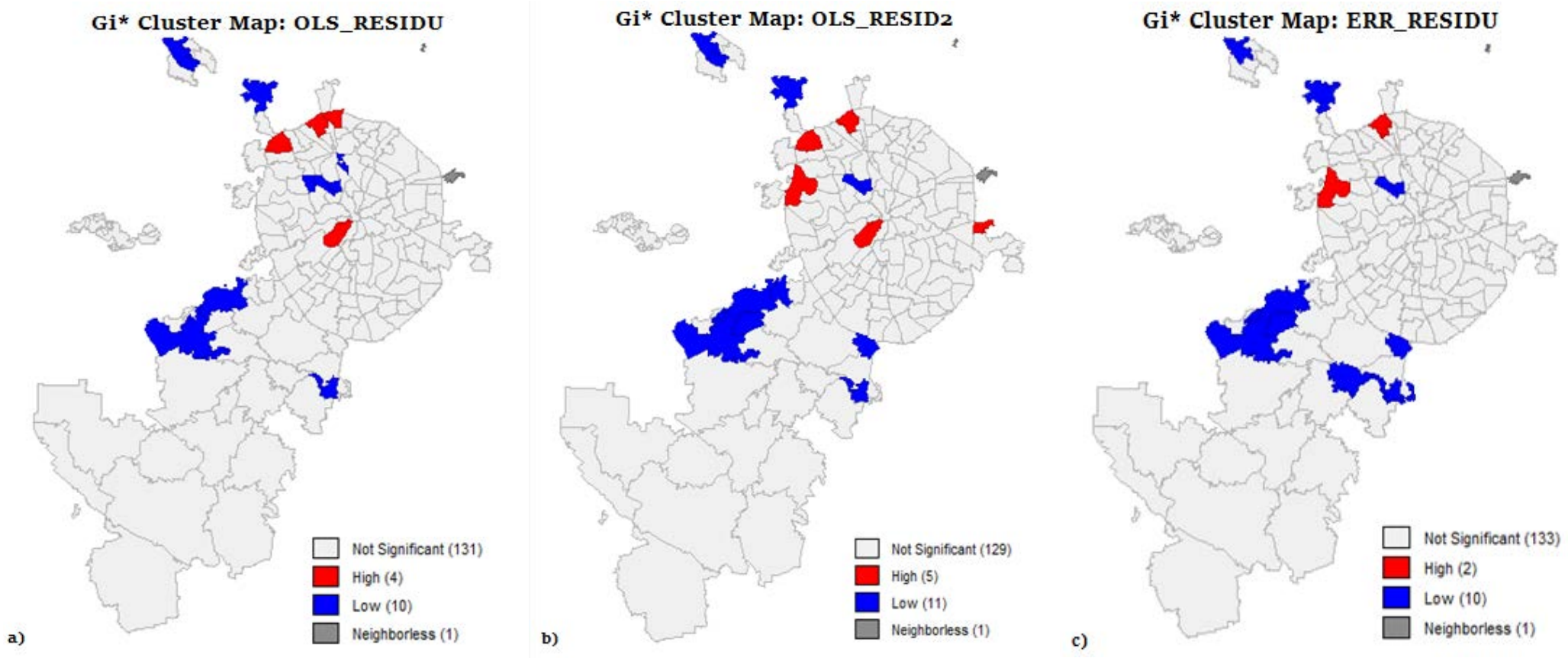

Figure B.2. Gi* Cluster maps for residuals OLS_RESIDU, OLS_RESID2 and ERR_RESIDU (Source: GeoDa 1.4.6)

Mathematical Formulas of Segregation Indices

I. Rank-Order Information Theory Index

1. Entropy index of the population (Theil 1972):

$$\mathrm{E}(p) = p \log_2 \frac{1}{p} + (1 - p) \log_2 \frac{1}{1-p}$$

2. Traditional Information Theory index of segregation computed between two groups:

$$\mathrm{H}(p) = 1 - \sum_j \frac{tjEj\ (p)}{TE(p)}$$

3. The Rank-Order Information Theory Index as a weighted average of the binary income segregation at each point in the income distribution:

$$H^R = 2 \ln(2) \int_0^1 E(p)H(p)dp$$

where

p – income percentile ranks in a given income distribution, scaled to range from zero to one;

tj – population j of neighborhood j;

T – population of the overall metropolitan area.

II. Five Dimensions of Segregation

1. Evenness (Gini index):

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left[t_i t_j \left|p_i - p_j\right|\right]}{2T^2 P(1-P)}$$

2. Exposure (Isolation index and Correlation ratio):

$${}_xP_x = \sum_{i=1}^{n}\left[\left(\frac{x_i}{X}\right)\left(\frac{x_i}{t_i}\right)\right]$$

$$Eta^2 = \frac{{}_xP_x - P}{1-P}$$

3. Concentration (Absolute concentration index):

$$ACO = 1 - \left\{\frac{\left[\sum_{i=1}^{n}\left(\frac{x_i A_i}{X}\right) - \sum_{i=1}^{n_1}\left(\frac{t_i A_i}{T_1}\right)\right]}{\left[\sum_{i=n_2}^{n}\left(\frac{t_i A_i}{T_2}\right) - \sum_{i=1}^{n_1}\left(\frac{t_i A_i}{T_1}\right)\right]}\right\}$$

Spatial units are sorted by land area in ascending order.

4. Clustering (Absolute clustering index):

$$ACL = \frac{\left\{\left[\sum_{i=1}^{n}\left(\frac{x_i}{X}\right)\sum_{j=1}^{n}(c_{ij}x_j)\right]-\left[\frac{X}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}c_{ij}\right]\right\}}{\left\{\left[\sum_{i=1}^{n}\left(\frac{x_i}{X}\right)\sum_{j=1}^{n}(c_{ij}t_j)\right]-\left[\frac{X}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}c_{ij}\right]\right\}}$$

5. Centralization (Absolute centralization index):

$$ACE = (\sum_{i=1}^{n} X_{i-1}S_i) - (\sum_{i=1}^{n} X_i S_{i-1})$$

Spatial units are sorted by distance from the city center in ascending order.

where

A_i – area of spatial unit i;

A_j – area of spatial unit j;

c_{ij} – cell value of the binary contiguity matrix;

n – number of spatial units in the metropolitan area;

n_1 – rank of spatial unit where the sum of all t_i equals X (from 1 to n_1);

n_2 – rank of spatial unit where the sum of all t_i equals X (from n to n_2).

P – proportion of group in the metropolitan area, X/T;

p_i – proportion of group in the spatial unit i, i.e. x_i/t_i;

p_j – proportion of group in the spatial unit j, i.e. x_j/t_j;

S_i – cumulative proportion of area of spatial unit i (from 1 to i);

T – total population in the metropolitan area;

T_1 – sum of all t_i in spatial unit 1 to spatial unit n_1;

T_2 – sum of all t_i in spatial unit n_2 to spatial unit n;

t_i – total population in spatial unit i;

t_j – total population in spatial unit j;

X – total population of group X in metropolitan area;

x_i – total population of group X in spatial unit i;

x_j – total population of group X in spatial unit j;

X_{i-1} – cumulative proportion of group X in spatial unit i (from 1 to i).

III. Index of Dissimilarity

$$ID = \frac{1}{2}\sum_{i=1}^{n}\left|\frac{x_i}{X} - \frac{y_i}{Y}\right|$$

where

n – number of spatial units in the metropolitan area;

x_i – total population of group X in spatial unit i;

X – total population of group X in the metropolitan area;

y_i – total population of group Y in spatial unit i;

Y – total population of group Y in the metropolitan area.