RENTAL HOUSING PRICE DIFFERENTIALS AND THE COST OF COMMUTING. EVIDENCE FROM KYIV

by

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Abstract

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This study provides estimation of the commuting cost on the basis of spatial rental housing price differentials throughout Kyiv. A framework for the analysis is developed within which the cost of commuting is approximated with the function of time of commuting travel and both the monocentric and the polycentric models are estimated, examined and interpreted. The results of this study show that the monocentric model is not appropriate for the analysis of the commuting cost because it gives downward biased estimates of the latter. The findings also comprise the fact that for the inhabitants of Kyiv commuting indeed matters and the possibility to commute less costs relatively much money, and, finally, that the "real" economic centre of Kyiv is not the "geographical" centre of the city at Majdan Nezalezhnosti as it was assumed before, but Pechersk.

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With thanks to Dr. Tom Coupé

Chapter 1

INTRODUCTION

Commuting is an important part of contemporary urban life. I have interviewed 124 inhabitants of Kyiv about how much time did it take for them to get from their residences to their job locations, and the average answer was 36.2 minutes per journey. This practically means that on average the inhabitants of Kyiv spend more than an hour per day for commuting, and that is 11 days a year. Thus, the natural question of how people do assess these 11 days or the commuting cost arises.

The commuting cost is nothing else than the cost of travel plus the cost of commuting time plus the value of the change in utility associated with travel. So, in order to assess the commuting cost one should estimate its three components. The cost of travel is exogenous, therefore only the two latter are to be estimated.

It is widely agreed (Morgan, 1967; So et. al., 1998; O'Sullivan, 2000; Chan and Tse, 2001) that in the process of choice of the place of residence one of the major key points is the cost of commuting. Also *Gibbons* and *Machin* (2003) suggest that efficient housing market "reflects *all* benefits and cost to commuters". Within this research we shall try to assess the commuting cost on the basis of the housing price spatial differentials throughout Kyiv. Although the cost of commuting can also be estimated in other ways, for instance, as a component of the labour cost of production (i.e., one might divide the labour cost into the cost of labour effort and the cost of labour time, which is time at work plus the commuting time) – such methodology could give the estimates of the commuting cost from the 'other side'.

In order to estimate the commuting cost one might also be interested in the commuting pattern, that is, where people generally commute from and to. The theory suggests three possible models: the city where employment is concentrated within one district (monocentricity), the city where employment is concentrated within several districts (polycentricity) which was described by *O'Sullivan* (2000) and the dispersed employment city (Morgan, 1967), and basically all the models suggest that the residences are dispersed throughout the city. In this research we shall check the monocentric and the polycentric models, within which we shall approximate the commuting cost with the cost of travel to the centre of Kyiv and also to seven other sub-centres.

There are also two approaches of approximating the commuting cost: one is to do it with the commuting distance and the other – with the commuting time. We believe that the 'time' approach should be better for the 'distance' approach needs very strong assumptions to be satisfied (e.g. all roads must be of equal quality etc.) and does not tell anything about what would happen if the velocity of transportation increases. The 'distance' approach is however doing well when estimating the model where means of transportation are based upon the pull of muscle (e.g. pedestrians or horse-riders). On the other hand, the 'time' approach does not deal with heterogeneous individual transportation abilities (the time of commuting from A to B is considered to be the same for any individual at time t), but it greatly deals with the existence of the heterogeneity in the velocity of commuting across districts. Within this study we shall use the commuting time approach only and we shall disregard the distance approach because the velocity of transportation is indeed heterogeneous so we shall be able to use the positive aspects of the time approach, and also because the impact of negative aspects of this approach is assumed to be very small because the housing market does not reflect the heterogeneous individual transportation abilities but rather averaged (and thus homogenized) individual abilities of transportation.

The paper comprises five chapters. In the next chapter the literature related to the topic is reviewed. In the third chapter the methodology is introduced. In the fourth chapter the data is described, and the fifth chapter tells us about the estimation process.

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LITERATURE REVIEW

As far as we are estimating the commuting cost via the housing price differentials the literature we must be interested in should be of three groups: one group concerning the commuting patterns, another – the housing prices analysis and the last group analysing the commuting cost via the housing prices.

Among the studies of the commuting patterns the three ideas are the most popular: one based upon the monocentricity assumption (i.e., in the city there is one "central business district" (CBD) where everybody works and there are residences diffused around it); the other one is based upon the polycentricity assumption (i.e., there is a CBD plus there are several sub-centres); and the last one based upon the assumption of diffusion of job locations (i.e., both the jobs and the residences are dispersed throughout the entire city).

Among the monocentric models one of the most famous is that based upon the housing-price function which negatively relates the rental price to the distance from the city centre in a monocentric city (O'Sullivan, 2000). This relationship was empirically confirmed by *Jerry Jackson* (1979) on the basis of the data for City of Milwaukee. In his work Jackson regressed the rental housing price on the distance to the centre, but he used not the linear geographic distance as a regressor, but the railway distance and the 'expressway' distance instead. He found the railway distance to be insignificant, but the 'expressway' distance to be significant at 5% level in determining the rental housing prices.

Morgan (1967) however empirically demonstrated that commuting does not necessarily imply travelling into or even through the city centre on the basis of the New York – New Jersey consolidated area data. In his paper he introduced the time of commuting series for those who live within the "five boroughs", or those who live within 25 miles from the centre, and for those who live further than 25 miles from the centre of New York. The median of commuting time was the highest for those living in the centre (67 minutes) and declined with the distance from the city centre. Morgan suggested that:

- The jobs are dispersed, and people work mostly in the area they reside.
- The speed of commuting increases with the distance from the city centre due to less traffic.

Hamilton and *Roell* (1982) used the monocentric model to estimate the commuting and found that its predictions were almost eight times lower than the actual commuting values. Hamilton and Roell used the geographical distance approach and decentralised employment around the central business district (CBD) assumption. They also assumed that all the roads are radial contractions to the CBD. The commuting pattern in the situation when job and residence locations are not on the same ray they called the "wasteful commuting". On the basis of the 14 US cities data they found that the "wasteful" commuting took almost 90% of all the commuting distance. Thus Hamilton and Roell concluded about the poor ability of the monocentric model of predicting the commuting pattern. Instead they suggested the "random commuting" concept, where the households randomly choose job and residence locations. They also suggested such explanations of the "wasteful" commuting as:

- The two-worker household
- The demand for the non-commuting travels
- Heterogeneous residences and jobs
- People may change jobs more often than residences

- The wrong variable used in the analysis (i.e., geographical distance instead of time).

White (1988) argued that the percentage of the "wasteful" commuting was not as high as *Hamilton* and *Roell* (1982) found it to be. She suggested that Hamilton and Roell's assumptions were too strong so that any city satisfying them can hardly be found. White suggested the commuting time approach under the polycentricity assumption (i.e., the jobs outside the CBD were not diffused, but rather concentrated in sub-centres). She showed that in case of heterogeneous jobs the employer located not in the CBD might demand more workforce than he can find on the ray expanding from the CBD, therefore he might pay some higher wage, and thus commuting in this case cannot be considered as "wasteful". White's estimate of such "wasteful" commuting was only 11%, therefore she concluded that excess commuting was only a "minor factor in explaining the commuting behaviour", and that *Hamilton* and *Roell* (1982) had gotten upward biased estimates.

Small and *Song* (1992) conducted almost the same research as *White* (1988) on the basis of Los Angeles data, and they showed that indeed *Hamilton* and *Roell* (1982) were upward biased in estimating the "wasteful" commuting due to the strong assumption of monocentricity, but *White's* (1988) estimates were downward biased due to the large size of the neighbourhoods she used in the sample. Small and Song used both large and small neighbourhoods samples and found that the "wasteful" commuting percentage was 33% when using the former and almost 66% when using the latter. They also concluded that the monocentric model is not appropriate to explain commuting.

Wheaton (2002) in his theoretical model suggested that in the modern city job locations are diffused, thus both the monocentric and the polycentric models are inappropriate. Still, he agreed that the residences must be more dispersed than the jobs because the residences require more space than jobs.

Next, as this analysis concerns the housing prices, it would be naturally for us to focus on the studies of their determinants. The most popular housing prices analyses are those based upon the hedonic indices estimation. This method basically means that the researcher should divide the price of the housing unit (which are usually heterogeneous) into the prices of its components (which are assumed to be homogeneous, i.e., area, conditions, location etc), and thus find the estimates of these components' prices in order to find the price of a unit of housing.

On that issue there are several papers worth mentioning. *Kain* and *Qiugley* (1967) provided a hedonic analysis of rental housing pricing in St. Louis. As the regressors they used the dwelling unit conditions such as the quality of walls, floor, ceiling, lighting etc; the neighbourhood quality such as the conditions of streets and pavements, the percentage of poor quality housing within the neighbourhood etc; the structure of a dwelling unit (e.g., central heating, the area etc.). They have concluded that the quality conditions and the volume of services provided with the housing are strongly correlated with the price of a housing unit. Into their model they also included the variable of the geographical distance from the central business district of the city, which appeared to negatively influence the rental price. Also *Margo* (1996) presented such analysis for the rental housing market of New York in 1830-1860. He used the advertisements data for the housing prices and conditions variables, and he also divided New York into nine neighbourhoods. The model he presented was the panel data estimation of the rental price per unit of housing. His conclusions were that the rental price was lower in the neighbourhoods located in the non-metropolitan area, the quality of the housing service positively affected the rental price, and also that the rent was negatively related to the duration of the rental contract.

In Ukraine *Antonina Mavrodiy* (2005) provided a real estate sales price factor analysis based upon Kyiv data from 1996 to 2004 on a macro- and from 2004 to 2005 on a micro level (as far as we know this has been the only scientific research of the Ukrainian housing market so far). Using OLS in differences and FE estimation she had found that GDP, interest rate, wage rate and the population significantly positively influence the housing prices. On a micro level, using the data from "Aviso" newspaper for April 2004 and April 2005, the hedonic approach and the "official" division of Kyiv into ten districts, she had found that the number of rooms, the metrage, the height of ceiling and the availability of furniture indices are both statistically and economically significant in estimating the housing sales price. She had also found that location near the underground positively influences the housing price, the left-bank of Dnepr and the far-from-the-centre districts were cheaper than the other in the sense of housing services price, and also that the "economic distance" to the centre was less important in 2005 than in 2004. The latter statement was also supported by *Tkachuk* (Ткачук, 2005), who empirically discovered that recently in Kyiv the households tended to choose residences farther from the city centre and even outside the city boundary. Considering that the demand for the far-from-the-centre locations was very low in 2000 the major reason of its increase can only be the huge increase of the housing prices since then. Thus the housing price ratios[1] seem to increase with the increase of the housing prices.

Finally, the commuting cost analyses via the housing prices involve both the housing price hedonic indices estimation and the commuting pattern analysis.

Chan and Tse (2001) in their model of Hong Kong rental prices and commuting cost suggested that the geographical distance is a bad proxy for commuting cost and suggested the "economic distance", which was nothing else than the

[1] The ratio of the housing price at some location to the housing price in the city centre.

commuting time (basically, travel time to the CBD) plus the cost of travel, instead. They used the advertisements data from the first half of 2000 (406 obs.), and regressed (OLS) the sales price of housing unit on the cost of travel, commuting time, the latter squared and the age of the building. They also used two dummies – for location in Kowloon and in the New Territories. As a result, they concluded that the "economic distance" parameters were statistically significant, although the commuting time coefficient was found to be economically insignificant.

Gibbons and Machin (2003) related housing prices to the "rail access", which they defined by the distance to the nearest train station and by the frequency of service at that station. They used the London 1997-2001 data for the two railway systems: the London Underground/Docklands Light Railway (LU/DLR) and the Network Rail (NR); and for the characteristics of the housing service (they used hedonic approach to evaluate the housing price differentials). Applying cross-section OLS and FE they found out that the "rail access" has been very significant in the determination of the housing price. Moreover, the distance to the LU/DLR seemed to have higher impact on rent than the distance to the NR, but the frequency of the NR service mattered more than the frequency of the LU/DLR service. Applying this result to Kyiv intuitively it may be said that the frequency of the overland transportation service should matter more than that of underground, but the access to the underground is to matter more than the distance to the overland transit due to relatively wider access to the latter and almost equally high service frequency of the former throughout Kyiv.

Almost all the researchers assume that the choice of job is prior to the choice of residence. A different point of view was presented by *So, Orazem and Otto* (1998) who conducted the analysis of the commuting cost, housing cost and wage effects on the choice of residence and job locations under the assumption that agents choose job and residence jointly. In their model they allowed the agents to have four choices: to live and to work in the metropolitan area, to live in the metropolitan area and to commute to non-metropolitan area, to live and to work in the non-metropolitan area, finally to live in the non-metropolitan area and to commute to metropolitan area. Constructing a system of the four indirect utility equations and applying the multinomial logit estimation led them to the conclusion that the probability of commuting is greatly elastic to the commuting time (the elasticity coefficient was about from -1.6 to -1.75). They calculated that for their data the probability of commuting goes to zero if the commuting time reaches 1 hour. They have also concluded that commuters had higher wages, they were younger, and they had lower non-labour income. Also children appeared not to influence the probability of commuting.

The general idea coming from the literature related to the topic is that when estimating commuting cost via the housing prices one should use not the distance but the commuting time to approximate the commuting cost (White, 1988; Small and Song, 1992; Chan and Tse, 2001), or if using distance one should modify the data in a way such that this distance would reflect commuting time as much as possible (e.g., the underground rail way distance + the overland transportation distance instead of direct geographical distance)(Jackson, 1979). It is suggested by Small and Song (1992) to use neighbourhoods as small as possible in order to get unbiased estimates of commuting parameters, and also use polycentric model because the monocentric has been found to be incorrect and the diffused employment model is argued not to be significantly better than the polycentric while being much less parsimonious (White, 1988; Small and Song, 1992). Then the commuting cost approximation function should be included into the housing price model as one of the hedonic components of the housing services. It has been shown that this hedonic component appears to be statistically significant for many cities (i.e., one is indeed able to "dig" the commuting cost from the spatial housing price differentials) (Kain and Quigley, 1967; Chan and Tse, 2001). Finally, estimating the impact of commuting parameters on the housing prices one may find how much the commuting costs and what the travel patterns are.

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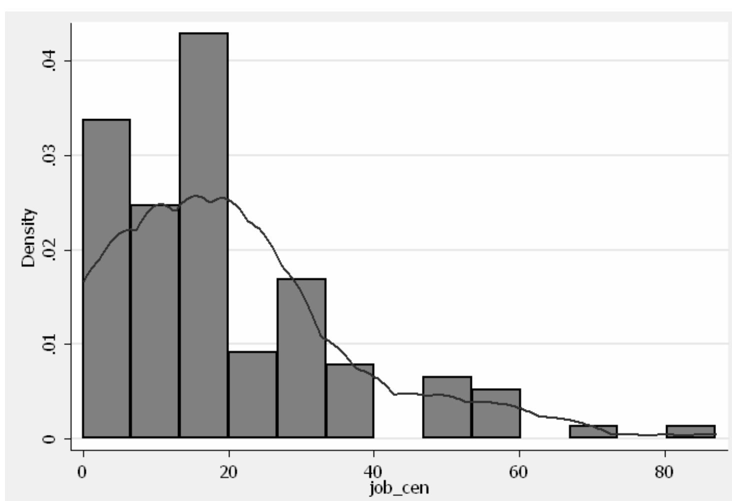
METHODOLOGY

A. THE MONOCENTRIC MODEL

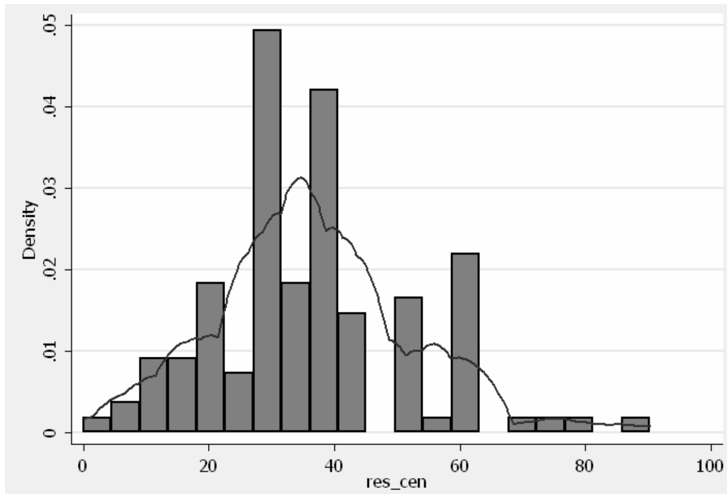
First of all we shall try to estimate the commuting cost using the monocentric model of commuting pattern. Although many researchers (e.g., White, 1988) argue that modern cities are polycentric we can still assume monocentricity for Kyiv due to:

a) The jobs indeed are distributed closer to the city centre than the residences, which can be seen on the histograms #1 and #2 – this supports the assumption of inward commuting

Histogram 1. The histogram and KDE (Gaussian kernel) of the travel time (in minutes) from job location to the city centre (survey data)



Histogram 2. The histogram and KDE (Gaussian kernel) of the travel time (in minutes) from residence location to the city centre (survey data)



b) The Kyiv transportation system is built in such a way that it has three almost straight underground lines which intersect in the centre of the city and more spread overland public transportation, but the main goal of the latter is to carry people to the underground stations → if somebody travels from his location to any other location which is not on his overland transportation route or on his underground line then he will almost certainly travel through the city centre.

c) 72% of interviewees when answering the question "what did you choose first: residence or job?" said that the choice of residence was prior. Of course, this does not mean that people when choosing a place of residence do not take into account their job location, but this means that when choosing a residence these 72% people chose their residence locations on the basis of expectation of their future job location which is the city centre.

d) The mean, median and std. error for the job-residence travel time are 36.24; 35; 20.03 minutes respectively, and for the centre-residence travel time are 36.44; 35; 15.89 respectively (the correlation is 0.36). This means that in Kyiv the "real" commuting time, which is hardly measurable, does not significantly differ from its proxy – the travel time from residence location to a city centre.

The commuting pattern we shall assume to be the following:

a) Inward travelling to the city centre by the underground lines;
b) Travelling to the nearest (in terms of time) underground station by the overland transportation.

And the model is as following:

$$\mathbf{R_t^0 - R_t^i = f(cost\ of\ commuting)}$$

Where:
$\mathbf{R_t^0}$ – the average price for rental housing in the centre of Kyiv with certain characteristics which are widely spread throughout Kyiv at time t;
$\mathbf{R_t^i}$ – rental price for the i-th apartment at time t;

Here we relate the rental housing price differentials to the commuting cost, and we expect positive relationship between them. We assume the cost of commuting to be the function of commuting time

$$\textbf{Cost of commuting} = T_t^i * (\alpha 1 + \alpha 2 * T_t^i)$$

Where:
T_t^i – time needed to get from i-th apartment to the city centre at time t;

Basically, here we assume that the cost of a minute of commuting also depends on commuting time, thus allowing for concavity of commuting cost.

Finally, we should add the hedonic indices to the model in order to homogenize rental housing units:

$$R_t^0 - R_t^i = T_t^i * (\alpha 1 + \alpha 2 * T_t^i) + q_{it} * \beta + \omega_{it}$$

Where:
R_t^0 – the average price for rental housing in the centre of Kyiv with certain characteristics at time t;
R_t^i – rental price for the i-th apartment at time t;
T_t^i – time needed to get from i-th apartment to the city centre at time t;
q_{it} – characteristics of the i-th apartment at time t;
ω_{it} – error term;
α – commuting cost parameters;
β – other hedonic indices;

Nevertheless, even if the above arguments are true and the monocentric model can give us relatively nice estimates of the commuting time cost, it still cannot be considered as reasonable assumption that people work only in the centre of Kyiv – thus we shall not be able to describe the commuting behaviour with this model. The theory suggests that we should use the polycentric model for this purpose

B. THE POLYCENTRIC MODEL

Within this approach we shall estimate the model where individuals have not just one commuting option (to the city-centre), but rather several reasonable options for commuting.

The framework we introduce includes the following:

a) there is some number of centres **g** which is less than the number of districts of city (Here 8 sub-centres and 88 districts);

b) the inhabitants of Kyiv have the possibility to work only either in the centre or in any of the sub-centres.

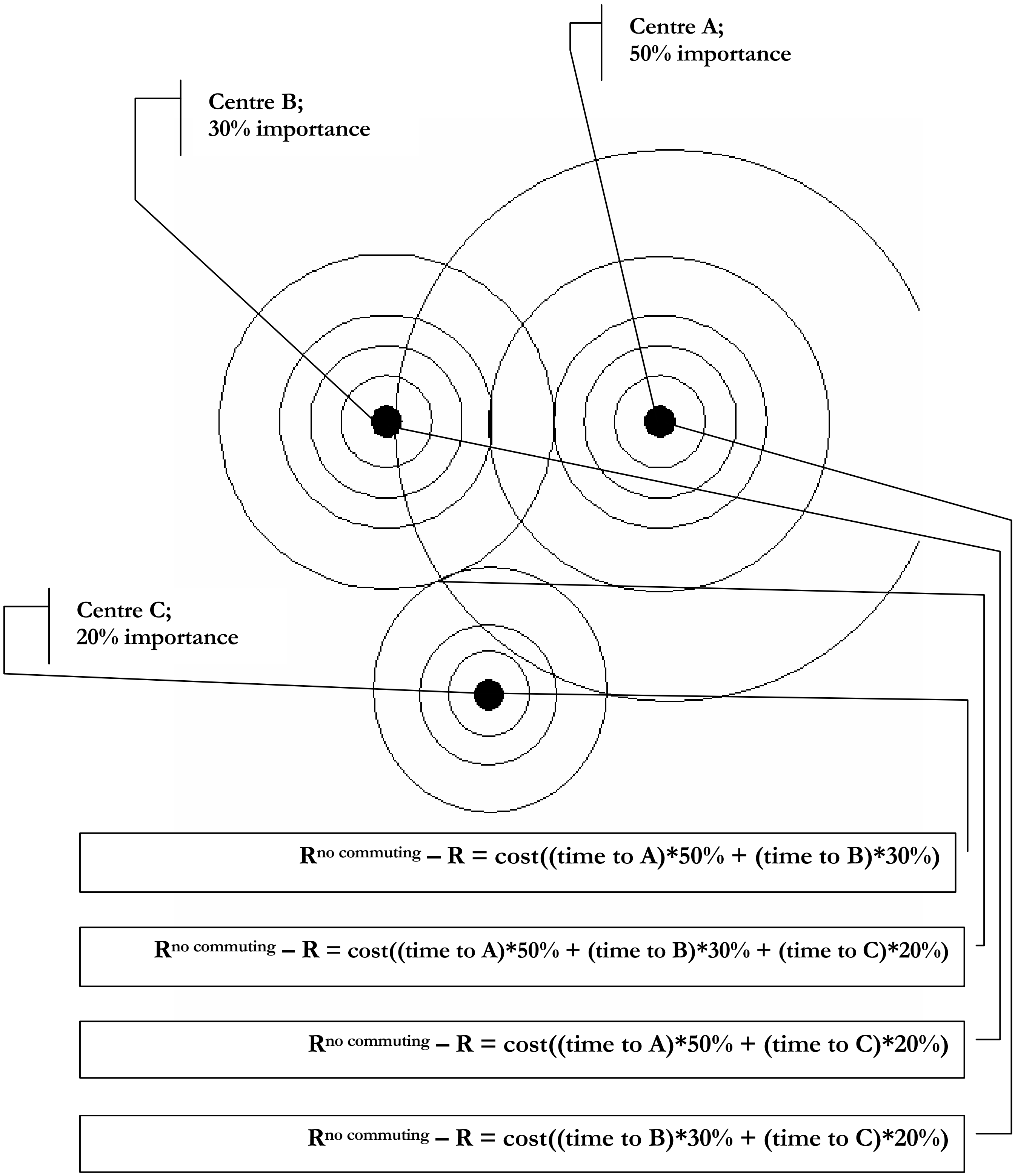
Thus, the following equation will be considered as true:

$$\mathrm{R}^{\text{no commuting}} - \mathrm{R}_{\mathrm{t}}^{\mathrm{i}} = \mathrm{f}(\sum_{k=0}^{g} \rho^{k} * (\text{cost of travel from i to (sub-)centre k})$$

Where $\mathbf{R}^{\textbf{no commuting}}$ stands for the housing price at the location where there is no commuting from. The parameter ϱ^{k} measures the "importance" of the option to commute to k^{th} sub-centre. If we normalize $\Sigma\varrho^{k} = 1$, which is quite logical we shall get the percentages of that "importance" for each (sub-)centre.

As an example, consider that we have a city with 3 centres (see picture 1). Let's assume that centre A is 50% important, centre B – 30%, and centre C is 20% important. Within this framework we have no such "ideal" location where people do not commute from, but we assume that the rental housing price for such location exists and we call it $\mathbf{R}^{\textbf{no commuting}}$. At any location within that city the rental price would be lower than $\mathbf{R}^{\textbf{no commuting}}$ because of positive commuting cost. That is, even in the centre A, which has the highest value, people would positively value their commuting cost to centres B and C, so that the rental housing price differential in centre A would equal the cost of travel time to centre B multiplied by 30% plus travel time to centre C multiplied by 20%. In centres B and C, as well as in any other location on that city map, this differential would be equal to the cost of travel time to A multiplied by 50% plus travel time to B multiplied by 30% plus travel time to C multiplied by 20%. Thus the housing prices remain the highest in the centre A, but they behave differently on different rays from this centre: if there is an important sub-centre on a ray expanding from A, then the housing prices along this ray decline flatter than on the ray going through no sub-centres or less important one.

Picture 1. The scheme of the polycentric city with a centre and 2 sub-centres



Chapter 4

DATA DESCRIPTION

First, I conducted a survey from Oct.22, 2005 to Nov.26, 2005 in the form of interviewing people on the topic of my interest. The questionnaire I used comprised questions about people's job and residence locations, time of travel between them, time of travel to the city centre both from job and from residence place, usual means of transportations; their dwelling characteristics including price (value) and conditions; neighbourhood characteristics; personal information including age, sex, income, education, number of children etc. Totally I have interviewed 124 inhabitants of Kyiv. The method I used was to choose a point somewhere close to the city centre, stand there for three-four hours and interview each 10^{th} passer-by. If refuses – try to interview the next one and so on. However, even although we are able to draw some relationships and conclusions from this dataset, it will not be the best solution to use only these data because of: first, the small size of the set, which basically means that we cannot rely on the asymptotic theory when doing inference; and second, there is always a big difference between what people do and what people say – in that sense these data can be considered as biased.

So, in our analysis we shall mainly use the pooled monthly data for the rental housing prices, dwelling and district characteristics and travel times for years 2002-2005. 12665 observations total.

For the rental housing prices and characteristics we shall use the advertisements data from "Aviso" newspaper[2]. The advertisements there usually contain

[2] Popular advertisements newspaper in Kyiv. Issued 2-4 times a week.

information about dwelling location, its rental price and such characteristics as number of rooms, metrage, telephone connection availability, condition, furniture availability etc. We shall take the data for 1-room rental dwellings available for long-term rent only (because they are widely dispersed throughout Kyiv, so we shall have enough observations for each location and more or less homogeneous sample) although this paper now becomes restricted to the analysis of commuting behaviour of those who rent single-room apartments. When collecting the data we shall assume that whenever some characteristic's availability is advertised it is available, and we shall assume some characteristics to be unavailable if they are not advertised or their unavailability is announced. We shall also use only the advertisements which indicate the housing location explicitly and precisely.

One of the major problems connected with such way of data acquisition is that the advertisements do not strictly correspond to "real" rented-out apartments. First of all, if some service is not announced it does not necessarily mean that it is unavailable. Every apartment rented out comprises many different services, and for conciseness the landlords advertise only those which they consider to be the major (e.g., the availability of a refrigerator usually is not announced in cases of elite and very expensive housing letting out). All the other services are announced implicitly within the rental price (basically, the higher the price the higher quality apartment is advertised, as it is expected by the general public). There can also be cases where landlords announce availability of a service which then appears to be unavailable – just to attract attention of potential lodgers. This problem may particularly result in bias in the estimates due to errors in variables, but no better methodology of data acquisition is applicable for this research. Thus we only have to assume (still, quite reasonably) that only a small portion of rental housing advertisements is erroneous, so that the overall impact of errors in variables is very low.

Another problem related to the advertisements data is that they are standardized to a large extent (i.e., in most cases only the "standard" hedonic components of housing are reported). Landlords usually advertise availability of telephone, fridge, furniture, television, area of the apartment etc., but they rarely report water supply conditions, thickness of walls, personalities of neighbours and landlord himself etc. They also do not announce in advertisements whether they allow smoking, drinking and loud behaviour in their apartments or not. Still, all these things *a priori* should influence the rent, but they are omitted in dataset constructed from advertisements. This problem should particularly result in the omitted variable bias, however if we assume (again, quite reasonably) that the probability of having significant correlation between location and these "omitted variables" of housing quality is low, then we can still use the methodology of assessing the commuting cost via the spatial rental price differentials.

As long as the neighbourhoods of Kyiv are also quite heterogeneous we need to assign certain characteristics to them and use these characteristics in the analysis in order to avoid spatial autocorrelation. There are, basically, no already collected and approved data on that issue, so I assigned the characteristics for the neighbourhoods myself. These variables are therefore subject to subjectivity although I tried to be objective as possible. I assigned the values 0, 1 and 2 to the variable of "greens" if there were little or no trees in neighbourhood, if there were "enough trees for the urban area" and if the neighbourhood was located in park or forest area respectively. The values of 0, 1 and 2 were assigned to the variable of "river" if neighbourhood was located very close to some water-place, within 20 minutes foot walk and farther respectively. The variable "roadwidth" was assigned the value 1 if the width of roads in the district was generally large and 0 otherwise. If the neighbourhood was considered to be elite the variable "elite" was assigned the value 1, if there was a market located within the neighbourhood the variable "marketplace" was assigned the value 1, if the neighbourhood was surrounded by industrial plants the variable of "industrial zone" was considered to equal 1, if the neighbourhood was generally considered to be noisy, the variable "noise" was assigned the value 1; "transport" was considered to equal 0, 1, 2 or 3 if there was no close by public transit available, one route, two routes, three and more or underground respectively. The variables of "sixtiesseventies" and "old" correspond to the time of construction of the neighbourhoods (basically, if they were built in mid-soviet times or before the World War II, the newly built districts are omitted due to multicollinearity). The same, the variables of "smallbuildings" and "more_nine" correspond to the general "height" of neighbourhoods (i.e., if there are generally small buildings in the neighbourhood or considerably large – more than nine floor high). Despite certain degree of subjectivity these characteristics do help homogenizing the neighbourhoods, thus helping to estimate the commuting cost parameters in a very precise way.

In order to introduce the travel times into model we shall use the data from the schedules of the underground and overland (i.e., bus, trolleybus and tram) public transportation in Kyiv provided by "Kyivsky Metropoliten" and "Kyivpastrans" respectively. The whole travel time then consists of the time of travel by underground plus the time of travel by overland plus the time needed to get to the nearest bus stop(s) and/or time needed to get to the underground station platform(s).

The whole dataset can then be divided into 5 major groups: housing prices, travel time, housing characteristics, neighbourhood characteristics and the periods of time (month dummies):

Housing prices:
rent – the rental price per flat, $;
logrent – the natural logarithm of rent.

Travel time:
centretravel – time of travel to the city centre from a certain location, minutes;
pechtravel – time of travel to Pechersk from a certain location, minutes;
kontrtravel – time of travel to Kontraktova square from a certain location, minutes;
kpitravel – time of travel to KPI from a certain location, minutes;
petrtravel – time of travel to Petrivka from a certain location, minutes;
terminaltravel – time of travel to the railway terminal from a certain location, minutes;
luktravel – time of travel to Lukjanivka from a certain location, minutes;
livtravel – time of travel to Livoberezhna station from a certain location, minutes;
~**travelsq** – time of travel squared.

Housing characteristics:
telephone – the dummy for the telephone connection (1 if available, 0 – if not);
TV – the dummy for television set (1 if available, 0 – if not);
technics – the dummy for other home technics provision (1 if available, 0 – if not);
door – the dummy for having extra-protective door (1 if available, 0 – if not);
fridge – the dummy for fridge (1 if available, 0 – if not);
height – the dummy for more-than-average height of the flat (1 if height is more than average, 0 – if not);
furniture – the dummy for furniture (1 if available, 0 – if not);
brick – the dummy for the material the building was constructed from (1 if from brick, 0 – if not)
glass – the dummy for the glassed balcony (1 if available, 0 – if not)
renovated – the dummy for if the flat had been renovated recently (1 – if had been, 0 - otherwise);
euroremont – the dummy for "euroremont" – a renovation of the flat under the highest standards (1 if available, 0 – if not);
studio – the dummy for specially designed "euroremont" (1 if available, 0 – if not);
area – the area of the whole flat, m^2;
euroarea – "euro" multiplied by "area";
renarea – "renovated" multiplied by "area";

Neighbourhood characteristics:
greens – the characteristic of being a green neighbourhood (2-park or forest area; 1-"enough trees for urban area"; 0-little or no trees)
river – the characteristic of being close to some water-place (2-very close; 1-can be reached on foot; 0-far);

roadwidth – the dummy for roads being narrow in that district (0-narrow, 1-wide);
smallbuildings – the dummy for buildings being generally small in that district (1-small, 0 - not);
more_nine – the dummy for buildings being generally high in that district (1-high, 0 – not);
noise – the dummy for noisy neighbourhood (1 – if the neighbourhood is noisy, 0 - otherwise);
industrial zone – the dummy for neighbourhood located in the industrial zone (1 – if yes, 0 - otherwise);
transport – the characteristic of the transportation facilities in the neighbourhood
elite – the dummy for elite neighbourhood (1 – if the neighbourhood is elite, 0 - otherwise);
sixtiesseventies – the dummy for neighbourhood being built in 1956-1970;
old – the dummy for the neighbourhood being built before the World War II;

Time period:
t1 – t48 – month dummies (years 2002-2005).

Chapter 5

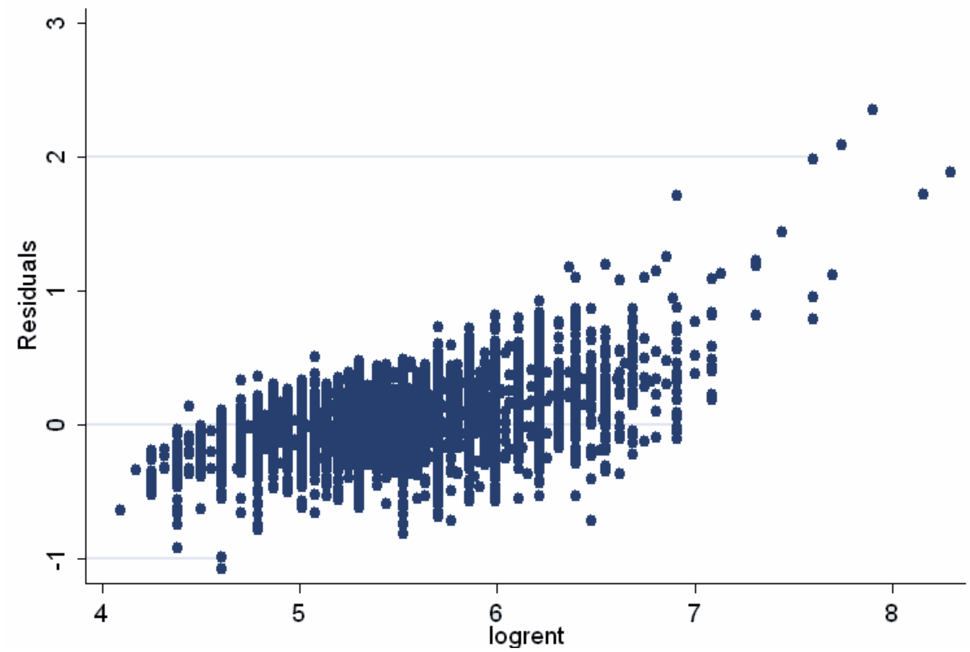
ESTIMATION

A. THE MONOCENTRIC MODEL

As long as in our theoretical model R_t^0 is fixed at time **t** we shall place it into a constant term, thus regressing R_t^i on the variables of commuting time, neighbourhood and housing condition characteristics. To be sure whether we should do it in the linear or in the log-linear form we check if the coefficient of the parameter $(\log(\hat{R}_t^i)) - \log(\hat{R}_t^i)$ is significant if introduced into the linear form equation. On the basis of this test (the t-statistics for $(\log(\hat{R}_t^i)) - \log(\hat{R}_t^i)$ parameter equals 22.03) we accept the log-linear model and reject the linear one.

Then we search for the functional form: that is, if we should include commuting time squared into regression or just introduce it in levels only. On the basis of the likelihood-ratio test (LR $\chi^2 = 237.50$) we reject the hypothesis that the commuting time squared has no effect on rental housing prices, therefore it should be included into regression. However the RESET test (proposed by J.B. Ramsey (Johnston and DiNardo, 1997)) suggests that both models are significantly misspecified: for the model excluding the commuting time squared RESET F(3, 9715) = 35.77, and for the model including it RESET F(3, 9714) = 64.13, which basically means that some important variable(s) is excluded from the model. To find out why it is so we should take a look at the residuals:

Scatter 1. Actual values of $\log(R_t^i)$ versus residuals from the monocentric model

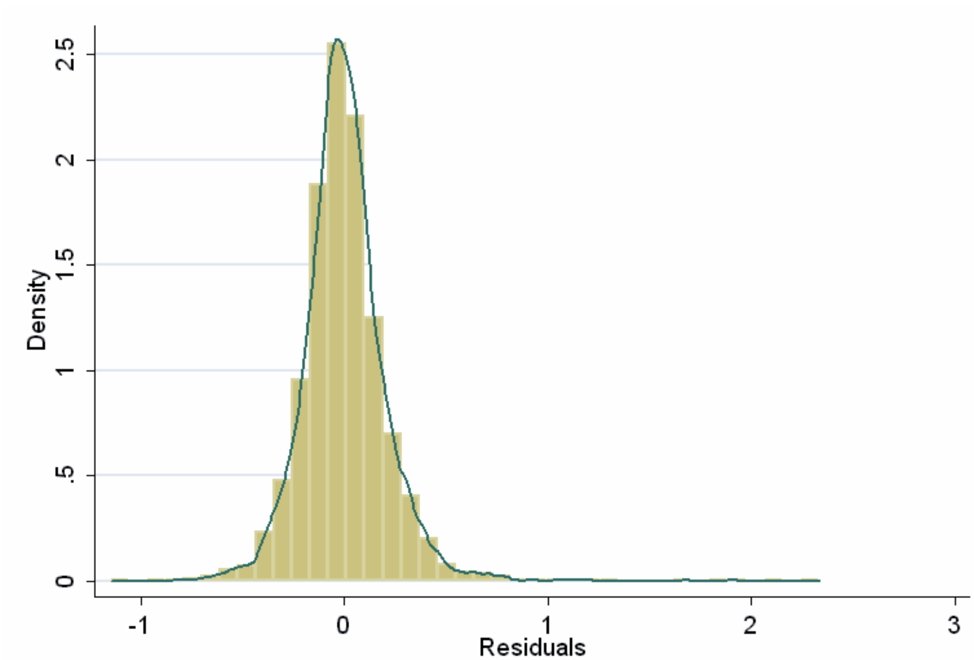


From the graph above we can see that the values of $\log(R_t^i)$ are generally overestimated for small values of R_t^i, and they are underestimated for large R_t^i, even though all available data is included into the model. This happens due of general belief that a more expensive service should be of better quality than the cheaper one, so the providers of the high quality housing services do not need to advertise all hedonic components of their housing, instead they charge the price very high. On the other hand, the providers of low quality housing simply charge a low price instead of advertising the poor quality of service. Still the data and the statistical methods do not account for these implicit housing quality characteristics; therefore there is a specification bias in the model (and also autocorrelation if ordered with respect to rent). However, we are interested not in predicting the rental price, but in assessing the value of the commuting time; and the data for commuting time are explicitly available for **all** housing in the sample;

therefore if we assume that commuting time does not correlate with those implicit characteristics we can still use our model in spite of the existing specification bias.

Then we check the residuals of the monocentric regression for normality.

Histogram 3. The histogram and KDE (Gaussian kernel) of the residuals from the monocentric model



The Skewness/Kurtosis test $\chi^2(2)$-statistics for residuals is 2505.32, which means that we can reject the hypothesis of normal distribution of the residuals on a very high confidence level. Still, due to the fact that we have a very large sample (9796 observations included into regression – the loss of more than two thousand observations is due to omitted data for the variables of "area" and "transport" in these observations) we can rely upon the central limit theorem, which tells us that if the error terms are *iid*$\sim(0,\sigma^2)$ then the OLS estimators are $\sim^{asy}N(\beta, (se(\beta))^2)$ (Gujarati, 1995); thus the common hypothesis testing asymptotically remains valid.

When checking for homoscedasticity (i.e., if the variance of the residuals is constant), the Breusch-Pagan/Cook-Weisberg test suggests that heteroscedasticity is present in the residuals (the $\chi^2(1)$-statistics equals 1306.08, which allows us to reject the null-hypothesis of constant error term variance at a very high level of confidence); so we should use robust (with White-corrected estimates) regression instead of OLS.

Table 1. Monocentric model. Robust regression estimates (dependent variable logrent)

travel time	**-.02595776*** **	**marketplace**	-.01186781**
travel time squared	**.00022626*** **	**telephone**	.01034207*
if greens = 1	.015314	**TV**	.0497018***
if greens = 2	-.02060007*	**technics**	.15756883***
if river = 1	-.03389399***	**door**	.01693787***
if river = 2	-.02855717***	**fridge**	-.03183103***
if transport = 1	.14853284*	**height**	.03899398**
if transport = 2	.124181	**furniture**	.007735
if transport = 3	.092612	**studio**	.20467805***
roadwidth	-.04739192***	**euroremont**	.34129346***
smallbuildings	.054884***	**renovated**	.16332899***
more_nine	.01869021**	**brick**	-.00216
industrial zone	-.01422511**	**glass**	.006359
noise	.008643	**area**	.01384015***
sixtiesseventies	.009118	**euroarea**	-.00078
old	.0580754***	**renarea**	-.00236242***
elite	.12001338***	**month dummies**	included (+)***
		constant	4.7554276***
F	**663.2553**		
N	**9796**		

From the monocentric model we can say that commuting time is significant both statistically and economically. Basically:

% change in $\mathbf{R \approx - \Delta T*(0.026 - 0.000226*\Delta T)}$, where **T** is the commuting time in minutes per journey and **R** – rental housing price in USD per month. This means that, for instance, for the one who rents a dwelling for $241.25 (average in the "aviso" sample) per month and who's one-way commuting time equals 36.24 minutes (average in the survey sample) 1 extra minute of one-way commuting would cost approximately $4.297/month.

Rental housing prices are also influenced by the neighbourhood characteristics. They are significantly negatively elastic to the closeness to water-places. Rent is also significantly larger if the streets in the neighbourhood are narrow (an indicator of an old and historical district). In the districts with low buildings housing price is also significantly larger than in other districts, but very high buildings are also valued more. Rent is positively related to the old age of the neighbourhood and also to the fact of the neighbourhood being elite. Location in the industrial zone and near markets significantly decreases the housing prices.

The housing conditions characteristics also appear to impact the rent. Basically, the more facilities provided the higher the price, except for fridge: the availability of fridge announced significantly decreases the rent. This may be due to the fact that fridge is usually announced when housing services satisfy only basic needs (i.e., usually cheap housing) so it may be an indicator of poor service quality. Housing prices are the most affected by "euroremont" and area. They are also highly affected by having a studio-design and just simple renovation, though each square metre of renovated apartment costs less than usually. Among the movables the home technical equipment other than usual telephone, TV and fridge seem to affect the housing price the most.

B. THE POLYCENTRIC MODEL

When estimating the polycentric model we are already aware of the problems which occurred in the process of monocentric model estimation, therefore we run a robust regression of $\log(R_t^i)$ over our explanatory variables adding the other commuting options, namely to Pechersk, to KPI, to Kontraktova square, to railway terminal, to Petrivka, to Lukjanivka and to Livoberezhna station.

First, we run a regression keeping travel time in levels only, so we could draw some inference about the importance of different commuting options (we can't do this when introducing the quadratic form of travel time into equation because of possible heterogeneity of commuting – 1 minute of travel time might be assessed differently when travelling to different locations due to different and hardly measurable quality of transportation services on different routes).

Table 2. Polycentric model. Robust regression with travel time in levels only (dependent variable logrent)

pechtravel	**-.01151184*** **	**sixtiesseventies**	.06031382***
kpitravel	**-.00149513** **	**old**	.17450427***
kontrtravel	**.01376078*** **	**elite**	.12730981***
petrtravel	**-.00728125*** **	**marketplace**	.06681728***
centretravel	**-.00288285** **	**telephone**	.0094565*
terminaltravel	**-.00185926** **	**tv**	.04963279***
livtravel	**-.00023175**	**technics**	.14632524***
luktravel	**.00134421*** **	**door**	.01370337***
if greens = 1	.0644718***	**fridge**	-.02976724***
if greens = 2	.08205445***	**height**	.02800212
if river = 1	-.06819128***	**furniture**	.005811
if river = 2	-.00495639	**studio**	.18505139***
if transport = 1	.02370152	**euroremont**	.29423779***
if transport = 2	-.03568287	**renovated**	.15901112***
if transport = 3	-.08566399	**brick**	-.00573905
roadwidth	-.06207707***	**glass**	.01300075**
smallbuildings	.22948576***	**area**	.01460813***
more_nine	.08033425***	**euroarea**	.00032571
industrial zone	-.04654373***	**renarea**	-.00242858***
noise	-.00349012	**month dummies**	included (+)***
		constant	4.5855614***

F **657.21389**

From the polycentric model we can see that among the suggested centres the most important is not the actual centre of Kyiv, but Pechersk. Even Petrivka appears to be more important than the city centre. More, closeness to such locations as Kontraktova square and Lukjanivka significantly decreases the housing prices. One of the possible explanations of such results is multicollinearity. Indeed, if we look at the correlation matrix of the travel times we can see that these variables do highly correlate with each other.

Table 3. Matrix of correlation between travel times to (sub)-centres

	pechtravel	kpitravel	kontrtravel	petrtravel	centretravel	terminaltravel	livtravel	luktravel
pechtravel	1							
kpitravel	.5813	1						
kontrtravel	.7719	.5307	1					
petrtravel	.5401	.2762	.9062	1				
centretravel	.8951	.7066	.9087	.6901	1			
terminaltravel	.6455	.9403	.6366	.403	.7914	1		
livtravel	.4279	.24	.5425	.4048	.5735	.3659	1	
luktravel	.8389	.6582	.8072	.5968	.8968	.7129	.4615	1

But the existing multicollinearity is not perfect, and therefore our results still have the properties of BLUE. The reason why Kontraktova square and Lukjanivka have appeared to be negatively important can as well be the omitted variable bias. That is, in our analysis we have omitted some sub-centre(s) which are significantly more important than Kontraktova square and Lukjanivka and is (are) located somewhere on the opposite to these locations rays (in terms of travel time – not in geographical terms) expanding from the centre of highest importance (which now seems to be Pechersk).

Still, even having omitted important sub-centres we should use the polycentric model to draw inference about the cost of commuting. The matter is that the included (sub-)centres collect information about commuting cost as much as they can. In case of monocentric model we assumed that the rental prices for homogenized housing were behaving in the same way on each commuting time ray expanding from the city centre. Within the polycentric model we introduce more options of how the housing prices may behave on different rays from the centre of the highest importance. If we have included those omitted sub-centres we should conclude from our analysis that the housing prices decline flatter on their respective rays from the most important centre than on the rays where Kontraktova square and Lukjanivka are situated, but even within the "incorrect" model we have obtained the same result. We have, however, lost the possibility to draw precise inference about the level of importance of different sub-centres, and also our estimates of commuting cost could be biased because the omitted sub-centres could be situated not on the rays exactly opposite to the Kontraktova square and Lukjanivka commuting time rays thus the information of the latter is biased, still this bias is much less than the bias of the monocentric model because in the polycentric we take into account much more information.

In order to derive the commuting cost from the polycentric model we should run a regression including a quadratic form of travel time also because in the previous sub-chapter we have found that such specification is correct.

Table 4. Polycentric model. Robust regression (dependent variable logrent)

pechtravel	**-.01620689*** **	**more_nine**	.04864504***
kpitravel	**-.00869322*** **	**industrial zone**	-.04305788***
kontrtravel	**-.00966723*** **	**noise**	-.01193248
petrtravel	**.00041523**	**sixtiesseventies**	.03655002***
centretravel	**-.00375804***	**old**	.107724***
terminaltravel	**-.0023117**	**elite**	.09246767***
livtravel	**.00115578**	**marketplace**	.03669071***
luktravel	**.00030343**	**telephone**	.01189905*
pechtravelsq	**.00013304*** **	**tv**	.04697886***
kpitravelsq	**.00011665*** **	**technics**	.14240482***
kontrtravelsq	**.00035537*** **	**door**	.01420423***
petrtravelsq	**-.00009819** **	**fridge**	-.02859233***
centretravelsq	**-.00015987** **	**height**	.02513768
terminaltravelsq	**-.000002179**	**furniture**	.00701272
livtravelsq	**-.000001349**	**studio**	.1968189***
luktravelsq	**-.000001022**	**euroremont**	.27270243***
if greens = 1	.04600565***	**renovated**	.14175156***
if greens = 2	.05042031***	**brick**	-.00825345*
if river = 1	-.04349254***	**glass**	.01212422**
if river = 2	.00508389	**area**	.01412248***
if transport = 1	.09152835	**euroarea**	.00085209
if transport = 2	.03464133	**renarea**	-.001977***
if transport = 3	-.00992755	**month dummies**	included (+)***
roadwidth	-.05160276***	**constant**	5.0800574***
smallbuildings	.13758533***		

F	**631.01305**
N	**9796**

Adding the coefficients of travel times we obtain the following commuting cost equation:

$$\text{\% change in } \mathbf{R} \approx -\Delta T^*(0.0388 - 0.000342^*\Delta T),$$

where **T** is the commuting time in minutes per journey and **R** – rental housing price in USD per month. If we again compute the value of 1 minute extra one-way commuting for the one who rents a dwelling for $241.25 per month and who's one-way commuting time equals 36.24 minutes (as we did using the monocentric model) it would be equal to approximately $6.358/month which is larger than the value estimated with the monocentric model (basically for all values of commuting time and rent in the sample the polycentric estimates of commuting cost are larger than monocentric). Thus, as long as the polycentric model is "more correct" than the monocentric we can conclude that the latter underestimates the cost of commuting. This may be also due to the fact that within the monocentric framework there was such a district where commuting from was impossible – the city centre, and there were no such districts within the polycentric one, thus even in the city centre the cost of commuting was positive.

Rental housing prices within the polycentric framework are again highly influenced by the neighbourhood conditions. Trees significantly positively influence the utility of living in a neighbourhood thus increasing the housing prices there. Rents are also significantly negatively influenced by locating somewhat close to water-places (location very close or very far seems to be much better). Rental housing is again more expensive if the streets in the neighbourhood are narrow, but location near the markets now significantly increases the rents, unlike in the monocentric model. The estimates of the other neighbourhood conditions as well as the dwelling characteristics coefficients are well consistent with those from the monocentric model, and therefore their interpretation remains the same.

Within our polycentric framework we are unable to draw precise inference about the importance of the commuting options due to problems discussed above. Probably, the only solution to that would be to run a separate regression for each commuting option.

Table 5. Polycentric model. Separate robust regressions (dependent variable logrent). Commuting cost parameters and F-statistics

(sub)-centre	travel time coefficient	travel time squared coefficient	F-statistics
Pechersk	**-.02133936*** **	**.00015229*** **	**709.56**
city centre	**-.02595776*** **	**.00022626*** **	**663.26**
Kontraktova square	**-.02593476*** **	**.00023241*** **	**645.74**
Livoberezhna station	**.025003*** **	**-.0003535*** **	**618.92**
railway terminal	**-.01424144*** **	**.00009821*** **	**609.69**
Lukjanivka	**-.00825627*** **	**.00003656*** **	**603.86**
KPI	**-.02133936*** **	**.00015229*** **	**592.15**
Petrivka	**-.01020951*** **	**.00007366*** **	**589.16**

When running separate regressions we basically have eight monocentric models each assuming that the respective sub-centre is the one and only centre of Kyiv. Although the travel time coefficients are statistically significant in each of them we shouldn't really care of them because they are biased due to omitted other sub-centres (if we also look at these coefficients from the model with the centre at Livoberezhna station we may notice that the value of commuting cost has the wrong sign for any value of travel time in the sample – but this is only an indicator of that the "real" centre is somewhere opposite to Livoberezhna station, thus the model with the centre at Livoberezhna station is incorrect and should not be taken into account). The only thing we are interested in now is to see assigning what centre explains the rental differentials the best.

From the table above we can see that indeed the model with Pechersk in the centre performs the best in terms of fitting to data. F-statistics for Pechersk regression (709.56) is much higher than that for the city centre (663.26) –

Pechersk's the closest pursuer. Therefore we conclude that the actual city centre in Kyiv is not the geographical city centre, but Pechersk.

Kontraktova square also seems to be an important commuting option. After it go railway terminal, Lukjanivka and KPI. Petrivka brings up the rear among the other suggested commuting options.

From the full output tables of separate regressions (table 6) we can see that the estimates of the housing conditions characteristics are quite robust, that is, in any regression they are consistent with those from the other regressions and also with the estimates from the polycentric model, and since they are consistent with the previously obtained estimates their interpretation remains almost the same. Small differences indeed occur, and they are due to a bit different sample correlations between times to travel to different sub-centres and respective housing characteristics. The neighbourhood characteristics coefficients are not as robust as those of the dwelling characteristics (the differences in coefficients obtained from different regressions are a bit larger) due to possibly higher differences in correlations with the travel times, but they all still have consistent signs and consistent values thus holding certain degree of robustness, and therefore allowing us to be confident about the correct estimation of our models.

Table 6. Polycentric model. Separate regressions
Robust regression estimates, dependent variable logrent

	city centre	Pechersk	KPI	railway terminal
travel time	**-.02595776*** **	**-.02133936*** **	**-.02133936*** **	**-.01424144*** **
travel time squared	**.00022626*** **	**.00015229*** **	**.00015229*** **	**.00009821*** **
if greens = 1	.01531359	.05621417***	.01822567*	.03070154***
if greens = 2	-.02060007*	.04542533***	.0310375**	.02795168**
if river = 1	-.03389399***	-.06875333***	.01345746	.0225336**
if river = 2	-.02855717***	.00190706	.03109881***	.02671907***
if transport = 1	.14853284*	.16844298*	.11076349	.08133343
if transport = 2	.12418119	.13850185*	.1059962	.05835619
if transport = 3	.0926119	.10616783	.09565218	.05320267
roadwidth	-.04739192***	-.05768169***	-.05216329***	-.03584603***
smallbuildings	.054884***	.25402996***	.14338314***	.13627867***
more_nine	.01869021**	.03739886***	-.00721311	.00692024
industrial zone	-.01422511**	-.0350911***	-.02432592***	-.00755901
noise	.00864264	.0298468***	.00595939	-.0297361***
sixtiesseventies	.00911838	.05256694***	-.04221247***	-.03761563***
old	.0580754***	.17076512***	.06586244***	.03598859**
elite	.12001338***	.04453721***	.25707912***	.26562633***
marketplace	-.01186781**	.04093696***	.00487858	-.00719688
telephone	.01034207*	.01096777*	.00608079	.00635258
TV	.0497018***	.0498734***	.05417145***	.05210261***
technics	.15756883***	.14531235***	.16470026***	.16054885***
door	.01693787***	.01582479***	.0171377***	.0150187***
fridge	-.03183103***	-.03045628***	-.03982891***	-.03753077***
height	.03899398**	.023171	.04141742**	.04925578**
furniture	.00773505	.00717634	.00822147	.00808417
studio	.20467805***	.1858565***	.20211394***	.20874342***
euroremont	.34129346***	.29956397***	.3630781***	.33059563***
renovated	.16332899***	.15028897***	.19322403***	.18003692***
brick	-.00215805	-.0035568	-.00162254	-.00353505
glass	.00635887	.01118562**	.00704972	.00678133
area	.01384015***	.01424762***	.0158792***	.01521968***
euroarea	-.00078188	.00029325	-.0008462	-.00001498
renarea	-.00236242***	-.00216651***	-.00309595***	-.0027412***
month dummies	included (+)***	included (+)***	included (+)***	included (+)***
constant	4.7554276***	4.6220659***	4.333299***	4.5254376***
F	**663.25525**	**709.56111**	**592.15217**	**609.69234**
N	**9796**	**9796**	**9796**	**9796**

Table 6 continued. Polycentric model. Separate regressions
Robust regression estimates, dependent variable logrent

	Kontraktova square	Petrivka	Lukjanivka
travel time	**-.02593476*** **	**-.01020951*** **	**-.00825627*** **
travel time squared	**.00023241*** **	**.00007366*** **	**.00003656*** **
if greens = 1	-.01529628	.0126871	.03974196***
if greens = 2	-.03902404***	.0012298	-.00005499
if river = 1	-.04582075***	-.0357858***	.00380219
if river = 2	-.06529771***	-.04175004***	.01701714*
if transport = 1	.33625349***	.22058285**	.23252807**
if transport = 2	.28691441***	.17548765*	.24010412**
if transport = 3	.28160029***	.20741369**	.23475274**
roadwidth	-.07293644***	-.08643713***	-.07235925***
smallbuildings	.13851606***	.18696356***	.13915268***
more_nine	-.00640758	-.0067007	.00541604
industrial zone	-.00833823	.00076625	-.02420867***
noise	.04256869***	.05942727***	.02749212***
sixtiesseventies	-.00100106	-.00880533	-.01832776*
old	.07114939***	.07566132***	.12421714***
elite	.16271639***	.21775978***	.16754273***
marketplace	-.05726909***	-.05502699***	-.02930974***
telephone	.0120759*	.01170212*	.00761508
TV	.05340658***	.0557104***	.05203437***
technics	.15886826***	.16178959***	.16047729***
door	.018754***	.01944149***	.01795351***
fridge	-.03218944***	-.03674198***	-.03591635***
height	.01806702	.02359433	.03168293*
furniture	.00958147	.00898929	.01025651
studio	.19907545***	.19751762***	.20666362***
euroremont	.30749491***	.35237577***	.35566055***
renovated	.1818289***	.19628941***	.19936405***
brick	-.00250216	-.00183324	-.00466391
glass	.00384914	.00261133	.00643224
area	.01396514***	.01525245***	.01547097***
euroarea	.00053817	-.00050003	-.00076485
renarea	-.00284629***	-.00316834***	-.00333522***
month dummies	included (+)***	included (+)***	included (+)***
constant	4.6426743***	4.3234059***	4.2554355***
F	645.74282	589.15701	603.86241
N	9796	9796	9796

CONCLUSION

Commuting travels are the things the inhabitants of a large city each day need to spend an hour or even more on. The need to commute generally gives people disutility, and it is vitally important for any city development policy to measure this disutility in order to set up the right priorities and to make sound decisions upon the city-building issues and the development of the transportation system in particular. A number of studies concerning assessment of the cost of commuting were done and described in literature. The general idea of many of them was to relate the commuting cost to the housing price spatial differentials because commuting is generally determined by location, and location is one of the services provided by housing, thus the value of housing comprises the utility from consuming its services and, among other, the disutility from commuting. This paper is the first one that delivers a framework for assessing the commuting cost on the basis of housing price differentials for the City of Kyiv. Within this study both monocentric city and polycentric city models were investigated and it was found that the polycentric model performed better in estimating the commuting cost parameters for the monocentric one significantly underestimated the value of commuting.

Among the other findings of this work the most important are, first of all, the fact that for the inhabitants of Kyiv commuting indeed matters and the possibility to commute less costs relatively much money. Second, the “real” economic centre of Kyiv is not the “geographical” centre of the city at Majdan Nezalezhnosti, but Pechersk – at least for those people who rent single-room apartments. This result implies the need of restructuring the city transportation system – now it is performing in such a way that facilitates travels to the "geographical" centre the most and it would be more beneficial to switch to facilitating travels to Pechersk.

Housing prices were also found to be significantly determined by the attributes of dwelling and also by the characteristics of the neighbourhood. The presented in the paper assessment of the impact of each such neighbourhood characteristic upon the housing prices may be particularly useful to those city development policy-makers who want to maximize the overall wealth and utility of the citizens of Kyiv.

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APPENDIX

Table A1. Descriptive statistics of variables

Variable	Obs	Mean	Std. Dev.	Min	Max
rent	12665	241.2517	152.6717	55	4000
logrent	12665	5.364454	0.461784	4.007333	8.294049
pechtravel	12665	38.58381	13.80345	5	70
pechtravelsq	12665	1681.212	1069.257	25	4900
kpitravel	12665	38.88472	12.95361	10	73
kpitravelsq	12665	1680.997	1098.569	100	5329
kontrtravel	12665	34.57315	11.52948	5	61
kontrtravelsq	12665	1330.054	837.1977	25	3721
petrtravel	12665	36.49412	12.18088	13	68
petrtravelsq	12665	1482.262	952.0402	169	4624
centretravel	12665	31.85938	12.66044	5	61
centretravelsq	12665	1176.881	828.2633	25	3721
terminaltravel	12665	36.38042	11.35104	7	64
terminaltravelsq	12665	1453.711	873.0599	49	4096
livtravel	12665	36.53415	11.64057	10	66
livtravelsq	12665	1472.217	868.2746	100	4356
luktravel	12665	39.57758	14.14953	10	72
luktravelsq	12665	1768.46	1182.65	100	5184
telephone	12665	0.803711	0.397205	0	1
tv	12665	0.445875	0.497081	0	1
technics	12665	0.127122	0.333123	0	1
door	12665	0.308804	0.462018	0	1
fridge	12665	0.657876	0.47444	0	1
height	12665	0.013344	0.114747	0	1
furniture	12665	0.828267	0.377163	0	1
studio	12665	0.025267	0.15694	0	1
euroremont	12665	0.070825	0.256543	0	1

renovated	12665	0.259218	0.438223	0	1
brick	12665	0.211291	0.40824	0	1
glass	12665	0.306988	0.461263	0	1
area	9937	34.09208	7.136105	11	195
euroarea	9937	2.70484	10.36393	0	100
renarea	9937	9.343363	15.92418	0	150
greens	12665	0.974023	0.590677	0	2
river	12665	0.378129	0.706333	0	2
roadwidth	12665	0.610975	0.487548	0	1
smallbuildings	12665	0.082195	0.274673	0	1
more_nine	12665	0.366206	0.481786	0	1
transport	12494	2.548183	0.559334	0	3
industrial_zone	12665	0.242163	0.42841	0	1
noise	12665	0.187051	0.389968	0	1
sixtiesseventies	12665	0.659613	0.473858	0	1
old	12665	0.100118	0.30017	0	1
elite	12665	0.252902	0.434692	0	1
marketplace	12665	0.42653	0.494592	0	1
t2	12665	0.007106	0.084002	0	1
t3	12665	0.005922	0.076728	0	1
t4	12665	0.009475	0.096881	0	1
t5	12665	0.010975	0.10419	0	1
t6	12665	0.00379	0.061448	0	1
t7	12665	0.008606	0.092374	0	1
t8	12665	0.010107	0.100026	0	1
t9	12665	0.007422	0.085834	0	1
t10	12665	0.013186	0.114075	0	1
t11	12665	0.011844	0.108187	0	1
t12	12665	0.013028	0.113399	0	1
t13	12665	0.014844	0.120933	0	1
t14	12665	0.014133	0.118046	0	1
t15	12665	0.018397	0.134388	0	1
t16	12665	0.011133	0.104928	0	1
t17	12665	0.032531	0.177412	0	1

t18	12665	0.029767	0.169951	0	1
t19	12665	0.011291	0.105662	0	1
t20	12665	0.018792	0.135795	0	1
t21	12665	0.02953	0.169294	0	1
t22	12665	0.025819	0.158602	0	1
t23	12665	0.018792	0.135795	0	1
t24	12665	0.026609	0.160943	0	1
t25	12665	0.033794	0.180706	0	1
t26	12665	0.02195	0.146527	0	1
t27	12665	0.02653	0.160711	0	1
t28	12665	0.016581	0.127701	0	1
t29	12665	0.027477	0.163476	0	1
t30	12665	0.023924	0.152819	0	1
t31	12665	0.012396	0.110651	0	1
t32	12665	0.028425	0.16619	0	1
t33	12665	0.009396	0.09648	0	1
t34	12665	0.02124	0.144188	0	1
t35	12665	0.016265	0.126499	0	1
t36	12665	0.01666	0.127999	0	1
t37	12665	0.031583	0.174894	0	1
t38	12665	0.012791	0.112377	0	1
t39	12665	0.044374	0.205933	0	1
t40	12665	0.029925	0.170387	0	1
t41	12665	0.027398	0.163248	0	1
t42	12665	0.043901	0.204882	0	1
t43	12665	0.046585	0.210757	0	1
t44	12665	0.017134	0.129775	0	1
t45	12665	0.030241	0.171256	0	1
t46	12665	0.024556	0.154773	0	1
t47	12665	0.024872	0.15574	0	1
t48	12665	0.04998	0.217913	0	1