PUBLIC TRANSPORTATION AND FLAT PRICES: THE IMPACT OF ACCESSIBILITY BY METRO IN BUDAPEST

By

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Submitted to

Central European University

Department of Economics

In partial fulfilment of the requirements for the degree of Master of Arts in Economics

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Budapest, Hungary

2020

ABSTRACT

This thesis considers the effect of that metro stations have on the value of nearby dwellings in Budapest in order to answer the question: is the value increase caused by the metro station is large enough to consider the introduction of value capture policies to fund future public transportation projects? The analysis has two main steps: first the thesis shows that the proximity to the central business district (CBD) of Budapest and to the nearest metro station has no significant relationship with the quality of the flats using a smaller dataset from a real estate advertisement website. In the second step using another, larger dataset containing real transaction values the thesis uses OLS regression to show the effect of nearby metro stations and the effect of on the value of panel dwellings. The results show that an extra minute distance from the nearest metro station has about 0.37% effect on the per square meter price of the flat and an extra minute distance from the CBD has an about 0.94%, and that these effects are large enough to think of the introduction of value capture policies.

ACKNOWLEDGEMENTS

I would like to thank Professor Békés for his guidance and great ideas whenever it was required. I also would like to thank Balázs Munkácsy for his suggestions, ideas and support.

TABLE OF CONTENTS

LIST OF FIGURES

List of Tables

Introduction

Metro lines are the backbone of every large city's public transportation network, and it is no different in Budapest. According to the operator BKV Zrt., the 4 metro lines of Budapest carried over a million passenger a day in 2014 (BKV, 2014). To put this in context, the metro line M3 carries more passengers per day, than the entire Hungarian State Railways (500 000 person versus 380 000) (BKV, 2014; Hungarian Central Statistical Office, 2015). Metro lines can provide very reliable, high capacity and fact connections within the city. Their downside is, that they are extremely expensive to build. It is very hard to compare the cost of different metro lines, but usually it costs at least about 100 million euros to build one kilometer of underground railway (Joób and Gyulai, 2014; Lepeska, 2011). Many benefits from a metro line, not just the ones who use it: those who still use cars can travel faster due to smaller traffic jams, air quality can improve for everyone, etc. In my thesis, I would like to focus on another externality of metro lines: the higher value of nearby real estate. If we could internalize this externality trough a well-designed property tax, we could potentially decrease the cost of subway construction for cities, resulting in more metro lines, and all in all increasing social welfare.

In my analysis, I will estimate the effect of closeness of metro station on block flat prices in Budapest. My analysis has two steps, with two different datasets. The first dataset contains information on many attributes of the dwellings, however, contains only about 3500 flats, while the second one contains only the average price and the average floorspace aggregated in a relatively small area, called census tract, and accessibility information to nearby metro stations and to the central business district (CBD) of Budapest. So, in the first step I'm going to show that the quality of flats is not related to either their proximity to the CBD nor to the nearest metro station. After that, I can use the second dataset to estimate how much an extra minute travel from the nearest metro station and from the city center decreases the price of the real estate. My analysis shows, that one additional minute from the nearest metro station has about -0.37% on the per square meter price on the house. If we take this number and use it to calculate the overall effect the metro line can have on real estate value, we get a number large enough to consider the introduction of value capture policies to help the funding of future metro building projects.

The rest of this thesis is structured in the following way: in the first chapter I write about some of the earlier works on the relationship between public transportation and real estate value. In the second one I introduce the two datasets that I'm going to use in my analysis. The third chapter contains the results of my calculations, followed by the concluding remarks.

Chapter 1 - Background

1.1 Real estate price and public transportation accessibility

Since the work of William Alonso, a basic theory of land use has been developed (Alonso, 1964). The basic thought behind the bid-rent model is that people are willing to pay a certain amount of money depending on the location of the land. This rent will be smaller and smaller as distance grows from the center in the case of cities. If people live further away from the CBD, they will pay less for commuting, but they will pay more for transportation by money and by their time.

The relationship between real estate value and accessibility to public transportation has been studied empirically in many cities in recent decades. One of the earliest analysis of this relationship come from Laakso. He used a classical hedonic regression model to determine the effects of various factors on the prices of properties in Helsinki. He included structural variables regarding the dwellings; location variables which included distance from the nearest metro station to the nearest suburban center, to the city center by car and public transportation etc.; and neighborhood variables. He found that the distance to the city center is the most important price influencing factor in the case of Helsinki dwellings: a one percent increase in time from the center can cause a 0.2% drop in price. He also finds that houses located within walking distance from a metro or commuter railway station are 7.5% higher, than properties located elsewhere, however in the close proximity to the station he registers negative effects of the station (Laakso, 1992).

Debrezion and his coauthors tried to summarize the large set of papers that deals with the impact of railway stations. They conduct a meta-study of 57 estimation results from various papers by using the effect sizes as dependent variables and using the variables and function forms in the equations as dependent variables. Their main goal was to identify the source of contradictions in the conclusions of the papers in this filed. They find that overall the effects of heavy and commuter railway stations are greater, than light rail transit, heavy railway having about 0.9% higher impact on property price, and commuter railway having about 14% higher impact, than light rail stations on residential property. Their analysis also finds, that with every 250 meters closer to the station house prices increase with about 2.4% (Debrezion et al., 2007).

Another meta-analysis was conducted by Mohammad and his coauthors. in 2013. They have a broader set of estimates in their meta-analysis, than Debrezion et al. with 102 observations, and they also introduce additional contextual and methodological factors to their analysis. They find that heavy railway investment has lower impact, than light rail, which is in contradictory to what Debresion et al. has found. They suspect that higher negative environmental factors are behind this phenomenon, i.e. higher noise levels. However, they agree with the previous paper that commuter train has the highest impact by far, about 24-25%, since it provides faster connection than light rail. They also find that including property characteristics in the equations have no significant impact on results, which is an important conclusion for my thesis as well (Mohammad et al., 2013).

One of the most recent papers estimating the relationship between public transportation availability and real estate value was conducted by Corder and his coauthors. They use hedonic and spatial hedonic regressions for aggregated data from two cities, Rome and Santander. The main differences are the size of the cities (Rome with about 3.5 million residents, Santander with 250 000 residents) and the structure of the two cities is that Rome is a multicenter city, while Santander is a monocentric city, just like Budapest. In their analysis the authors take into account the number of jobs in an area, and the number of trips generated by a single area. They find that the overall impact of one additional minute of travel is about -1% in Santander, and about -0.6% in the case of Rome. In the case of Santander, only the accessibility of the central business district was significant, the relative accessibility to the urban center the gravity indicator that they use to model importance of travel connections were not, which can be the result of the monocentric nature of the city, according to the authors. (Cordera et al., 2019)

I'm not aware of any previous paper, that dealt with the relationship between public transportation accessibility and real estate prices in Budapest. A paper of Békés and coauthors. examined the relationship between accessibility of towns on public roads and real estate prices in them, however they left out Budapest from their analysis due to its very specific nature and focused on the rest of the country instead. However, they find that better accessibility could be the reason behind higher real estate prices even on the countryside (Békés et al., 2016).

Chapter 2- Data

2.1 Basic properties of Budapest flats

In my analysis I'm going to work with one special type of real estate in Budapest, panel flats. These flats were built in the second half of the 20th century, using mostly pre-fabricated elements, and are mostly made of concrete. These flats are rather similar to each other as I'm going show in this chapter, which is helpful for my later analysis where I will not have much detail about the characteristics of the individual flats.

In order to be able to determine, whether the distance from the CBD and a nearby metro station is in connection with the quality of the flats, I downloaded the more than 3700 panel flat advertisements available for Budapest on one of the largest property advertisement sites in Hungary, ingatlan.com and then cleaned it by dropping outliers (the top and bottom 1% in terms of price and size) and unrealistic values. I used a self-written Python code for that[1], and it collected all available proprieties of the flats, although there was a great variability in the amount of provided information in the advertisements. Despite the fact that this is a non-representative sample of all the flats in the city, I can use the collected data to show that property quality is independent from the distance from metro stations.

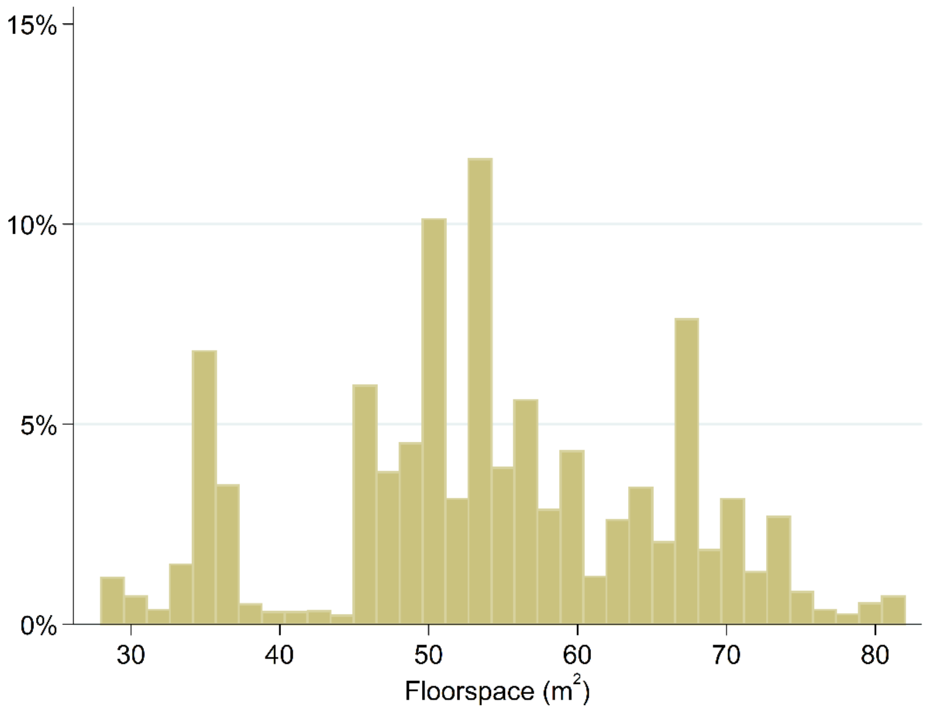
As I mentioned before, these flats are very similar in many respects. There were quite a few attributes that were the same across all the 3700 flats. In almost all apartments the clear high was less than 3 meters, and almost none of them had direct connection to a garden. All of them had heating, toilet, bathroom and kitchen in them, where this information has been provided, so they had all the basic comfort utilities required in a modern home. In about 85% of them heating was provided through district heating, a way of heating, where hot stream is

[1] The code is availibel here: https://bit.ly/2Y6BKSg

generated in a distant plant and then that steam is transported to the residential buildings in pipes. The bathroom and the toilet were in separate rooms in 78% of flats.

In the rest of the attributes, flats differ. They were all built between 1950 and 2000, in our sample half of them before 1980, and half of them after 1980. We cannot see it from this data source, but other sources confirm, that most blocks were built before 1990, so we can speak about a 40 years long period when these flats were constructed (Erdősi et al., 2003). The most important propriety of the homes is the floorspace, which diverges between 30 and 80 m^2 with a mean of about 54 m^2. The distribution of the homes can be seen on figure 1 below. About half of the flats is said to have a balcony. These are usually small ones, the mean size of them is 4 m^2, and 95% of them is said to be smaller than 6.76 m^2. The problem with this variable is, that it it's not stated if a flat has no balcony, so I cannot distinguish between those cases where there isn't a balcony and where they just don't indicate it, so I will not use it in my analysis.

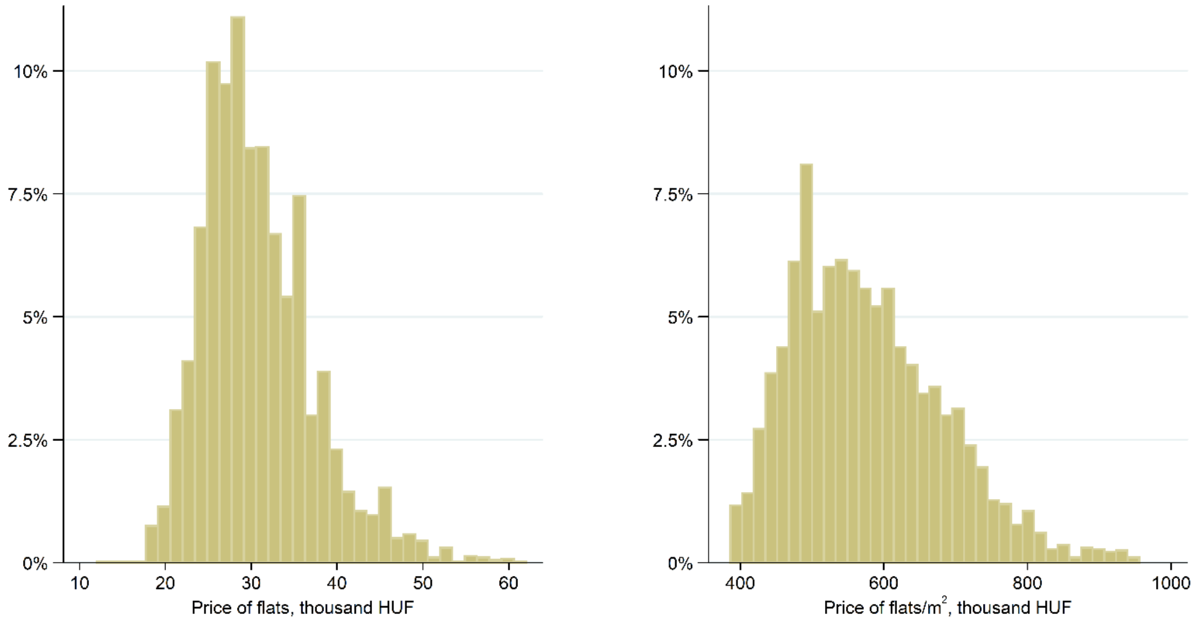
Figure 1 Distribution of floorspace



Almost 70% of the flats are located in a 10-story building, and 14% of them is located in a 4 story building, which is representative of the panel blocks in the city. The rationale behind building a 4 or 10 level high buildings is that the regulation required the construction of an elevator if the building was higher than 4 levels, so these two sizes were the most economical to build: 4 level houses without an elevator, or 10 ones with an elevator, where the higher number of flats compensated for the extra cost of the elevator.

Finally, the price of the flats varied between 12 and 62 million HUF, with a mean of 30.6 million HUF. The per square meter price of the homes varied between 386 000 and 955 000 HUF, with mean of 575 thousand HUF. Histograms of both variables is presented on figure 2 below.

Figure 2 Distribution of flat prices

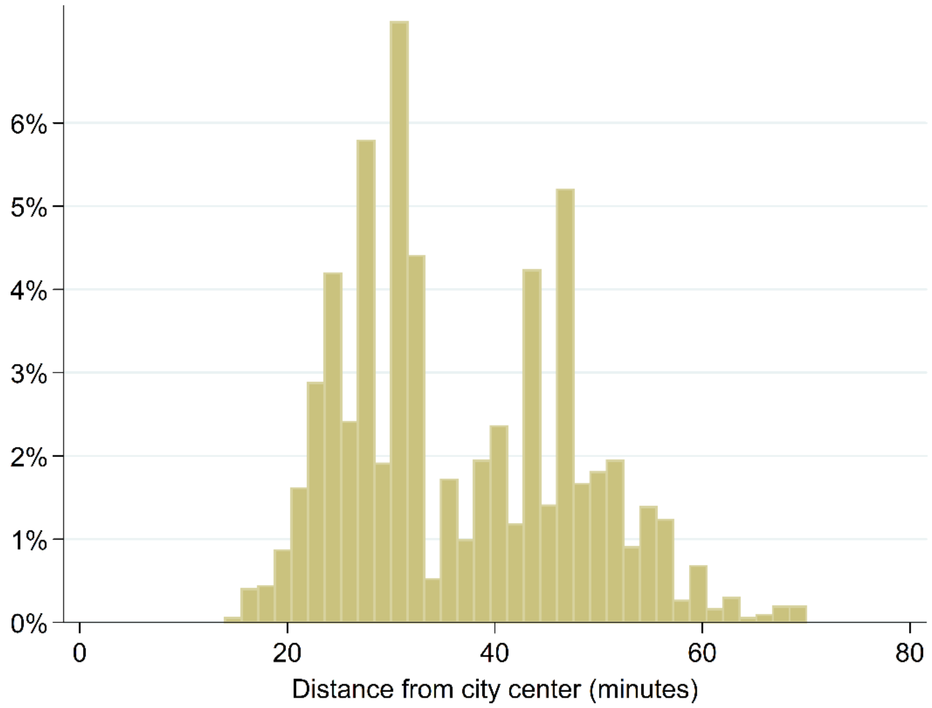


2.2 Distance from the city center and metro stations

The travel times between the flats to the nearest metro station, and between the flats and the city center were calculated by the publicly available API of HERE Maps. It combines all of the public transportation opportunities in Budapest, except the long-distance bus service of Volánbusz, but it is not going to be an issue for my analysis, since the focus of their service is connecting towns around Budapest with the city center, and not within city connections. I asked the API to calculate the fastest route by public transportation between the flat and all the metro stations, and then my algorithm choose the shortest one of them to get the distance of the flat and the nearest metro station. When I calculated the distance to the city center, I asked the API to calculate the traveling time between the flat and Astoria, a central point in downtown Budapest. All travels were planned to begin at 8 AM on a Monday morning. I calculated travel times instead of distance because the former is far more important to residents: they care about how much time they have with travelling, and they aren't really interested in the actual physical distance they cover in a day if they use public transportation to commute.

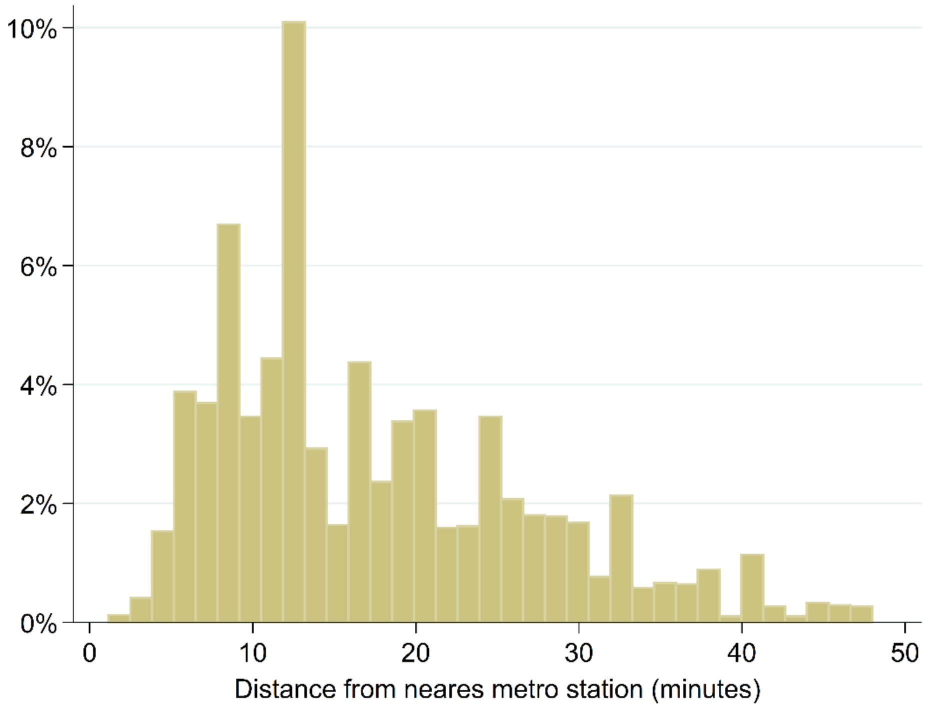
The travel times from the city center were mostly between 20 and 60 minutes, so they are not located directly in the city center, but they appear in inner districts (about 30 minutes away from the center in i.e. district VIII., IX., XIII.) as well as in outer districts. All in all, we can say that they are pretty diverse in this regard, which is great for our analysis.

Figure 3 Distribution of dwellings distance from city center



The flats in general are quite close to a metro station, the majority of them is within a 15-minute public transportation ride away, however in district XVII. or XXI (the Csepel island) the average distance to the nearest metro station is above 25 minutes. We can point it out here as well, that there's a great variety in the distance from the metro stations depending on the locations (see figure 4).

Figure 4 Distribution of dwellings distance from the nearest metro station



2.3 Dataset of the Hungarian Central Statistical Office

The second dataset, that I am going to use in my analysis is the real estate database provided to me by the Hungarian Central Statistical Office (HCSO). They have a dataset of every flat traded in Hungary going back years, which dataset comes from the National Tax and Customs Administration. However, due to privacy regulation, they are allowed to give only aggregated data to researchers, and not the record of individual flats being traded. So, I asked them to aggregate the purchases of flats of 2014 and 2015 in every tract of the Hungarian census, so I can connect this dataset to another one containing travelling times between these tracts. (A census tract in Hungary is relatively small, it contains about 100-150 addresses.) The downside of choosing a two years long period is that real estate prices could change significantly during that period, however it gave me access to more data, since the Statistical office could aggregate at least three purchases. If there had been less than that in that tract, they simply won’t provide the data. So, in the dataset that I recieved I had the average flat size and average price of the flats traded in a census tract, and out of that I could calculate the average price per square meter in that tract in thousand HUFcod.

The other dataset that I connected to this previous one was the so-called GEO dataset of the Institute of Economics of the Centre for Economic and Regional Studies. This dataset contains the travel times on the fastest route between every two census tract in Hungary by car and public transportation on a Wednesday morning in January of 2014, so at the beginning of the period for which I have the data aggregated. This dataset also included the coordinates of the center of the tract. By the ID code of the tracts I was able to connect them easily.

The two explanatory variables, that I will use in this dataset are also the distance from the nearest metro station and the distance from the city center, both measured in minutes. When I calculated the distance from the nearest metro station, first I looked for the closest census tract to every metro station in the city, and later used that tract as an approximation for that metro stop. Usually, I was able to find a metro station within a few hundred meters of the stations. After this, I only had to look for the closest tract acting as a metro station to the tracts containing information on flats to find the distance between them. To calculate the travel times to the city center, I used the same method: I selected the census tract closest to Astoria, and then I used the travel times between this spot and the rest.

The following two graphs, figure 5 and 6 show the distribution of the travel times to the nearest metro station and to the city center. We can find many differences if we compare them to the previous histograms (figure 3 and 4), which I created for the flats from ingatlan.com, but that can be due to the difference in measure unites (on the former the units are flats, here they are census tracts), the difference in time (2014 versus 2020), or the difference in the algorithm used to find the fastest route (I used the HERE Maps API, meanwhile they used a custom algorithm provided by a private firm.) However, there are strong similarities as well. This data also confirms that there are no flats in the city center, and we can see a quite similar doublepeak distribution than before. The data shows that these flats are close to metro station, the mean travelling time is 15 minutes.

Figure 5 Distribution of distance from metro station

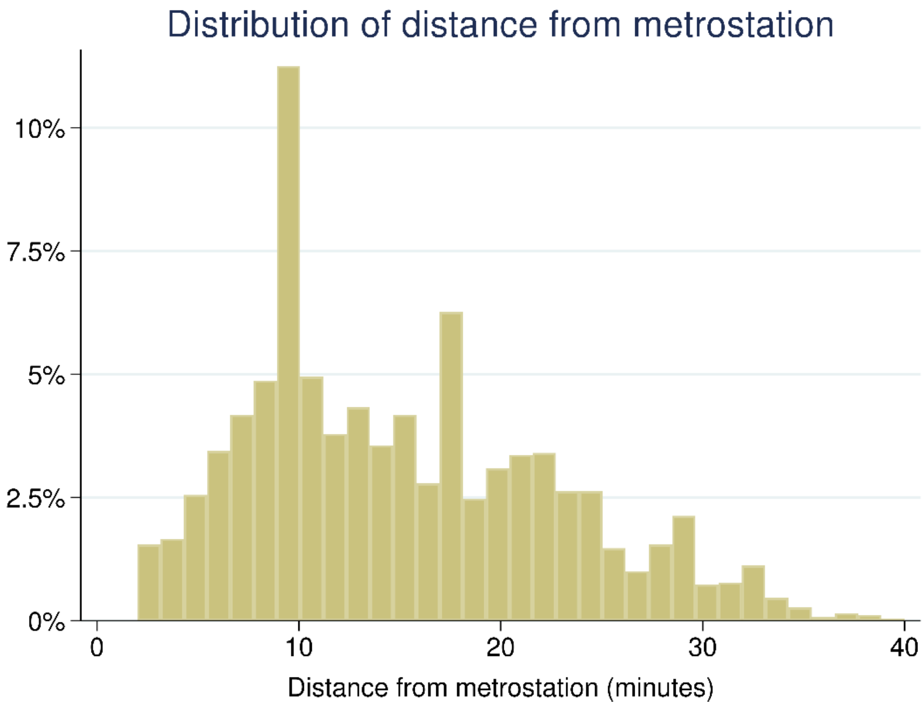
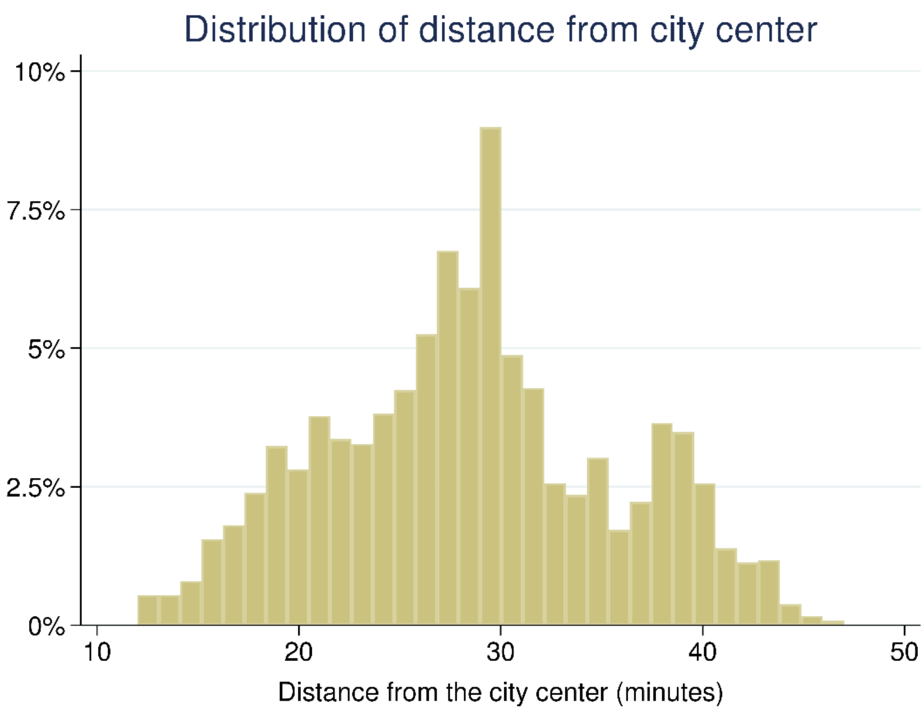


Figure 6 Distribution of distance from city center



Chapter 3- Results

3.1 Relationship between location and properties of the flats

In order to be able to test my hypothesis on the dataset that doesn't contain additional information on the properties, only their location and their average size and average price, I have to examine if there's any relationship between the location of the flats and the quality of the flat. So, in this chapter I look at the connection between the accessibility of the flats and the other proprieties that we know of. On the three graphs below (figure 7, 8, and 9) I plotted three attributes (floorspace, number of rooms if we sum full and half rooms, and the floor on which the flat is located) of the flats against their distance from the metro station, and performed a kernel-weighted local polynomial regression on them. The fitted values are displayed by the red line, and the 95% confidence interval is marked by the gray area. They show basically no relationship between these three proprieties and the distance from the nearest metro station, the slope of the line is very close to zero in each case. This is great news for us, since it means that the effect of the quality of the flats won't be taken up by the distance variable when we use it later in our analysis. Below them I plotted the same attributes against the distance to the city center (figure 10, 11 and 12), but the results are quite similar, namely, there is no clear connection between them and the distance from Astoria. It does not seem worthy to plot the rest of the attributes, since they were either identical for all flats, as described in the previous graph, or they take only a few values, and therefore plotting them would not be highly informative.

Figure 7 Floorspace plotted against distance from metro station

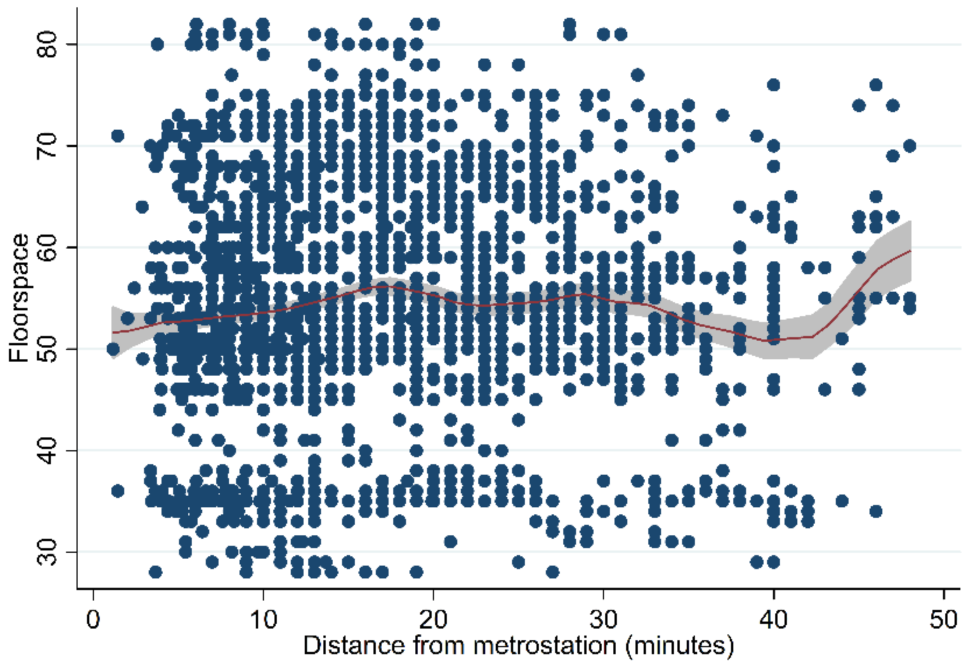


Figure 8 Number of rooms plotted against distance from metro station

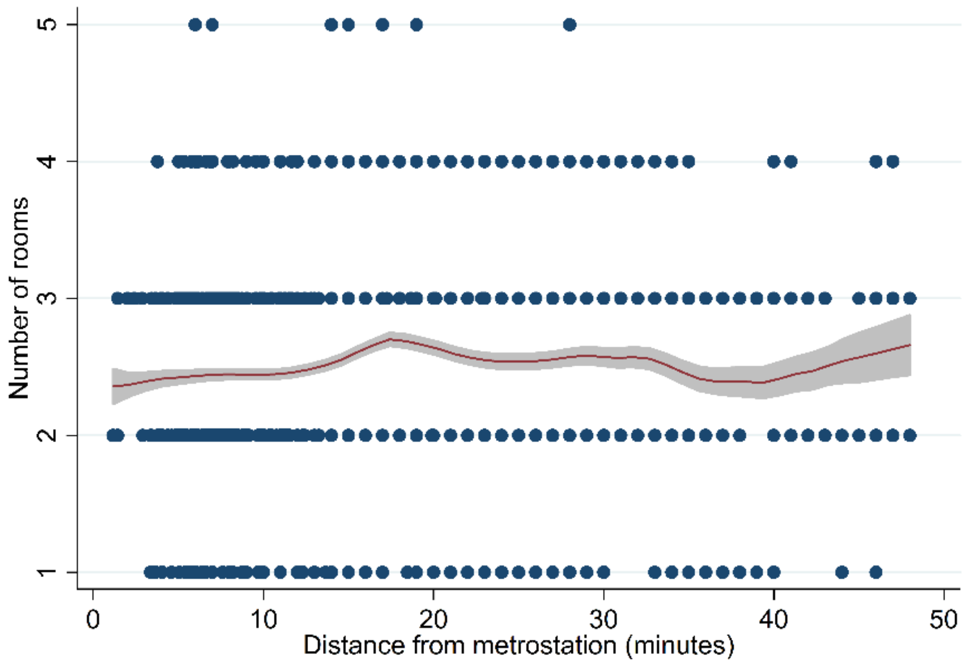


Figure 9 Flat's floor plotted against distance from metro station

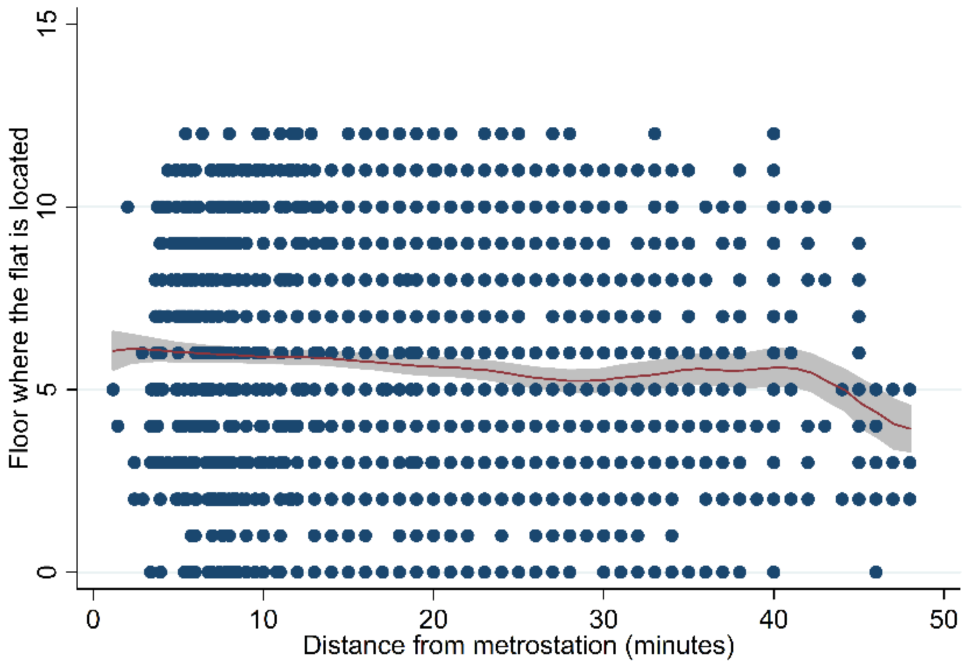


Figure 10 Floorspace plotted against distance from city center

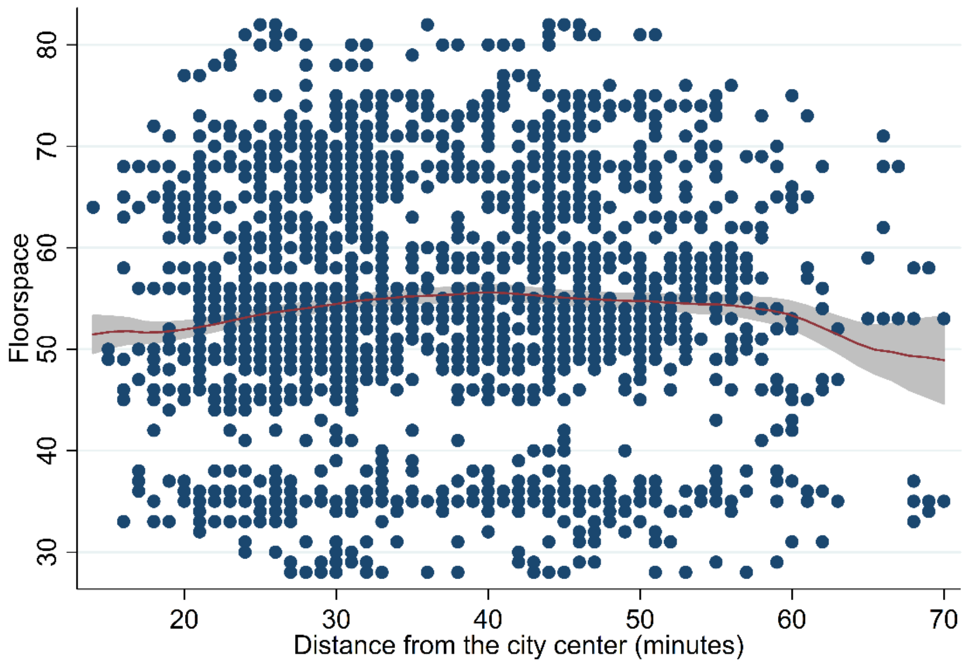


Figure 11 Number of rooms plotted against distance from city center

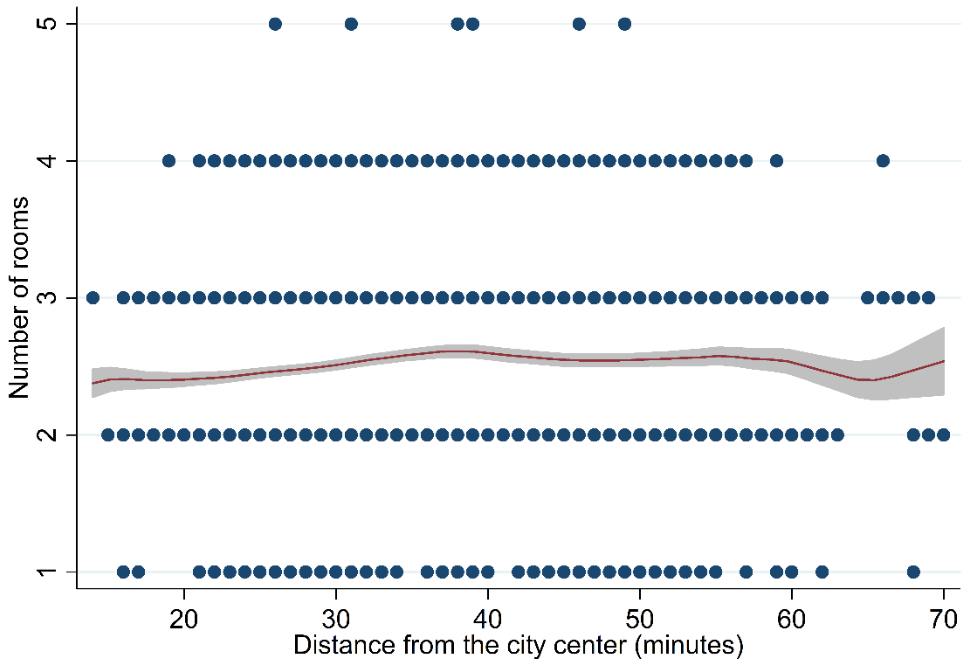
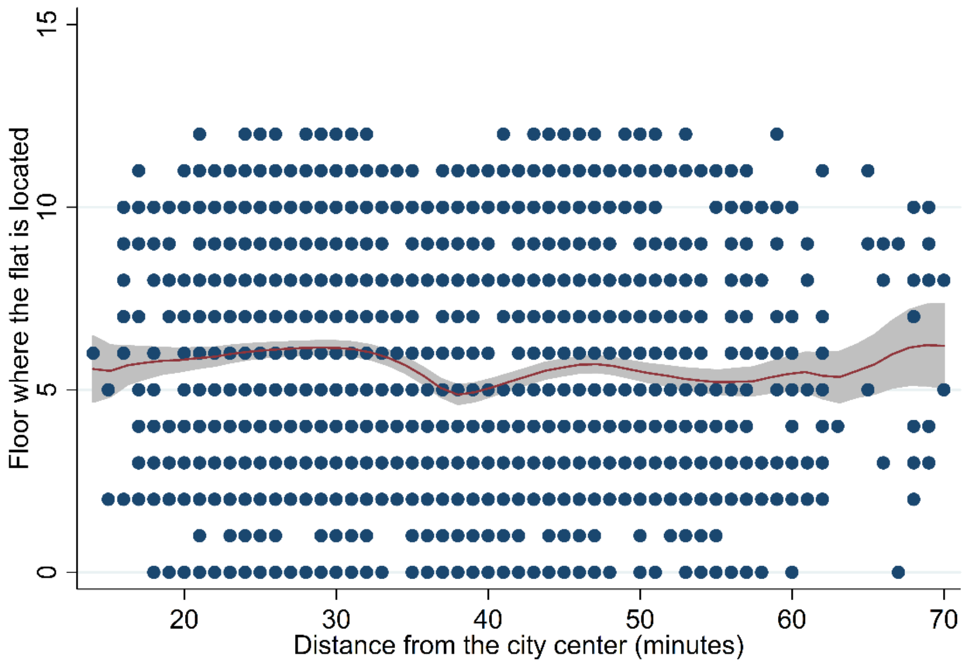


Figure 12 Flat's floor plotted against distance from city center



In order to explore the relationship between these variables in a more exact way, I regressed the distance from the metro station and the distance from the city center on the per m2 prices of the flats in six variations, using different combination of variables. In the first one, I included only these two variables in the regression, imitating the regression that I will be able to run in the second dataset, due to the difference in available information, in the other models I controlled for many attributes of the flats with various specifications to show the robustness of the model, i.e. the number of rooms, floorspace, the existence of an elevator, the level on which the floor is and the quality of the flat as stated by the advertiser. The results can be seen in the table 1 below.

Table 1. Regression results for dwelling attributes on price

	(1)	(2) [1,2]	(3) [2]	(4) [1,2]	(5) [1,2]	(6) [1,2]
	Price / m2	Price / m2	Price / m2	Price / m2	Price / m2	Price / m2
Distance from metro station (minutes)	-2.446***	-2.696***	-2.714***	-2.703***	-2.679***	-2.728***
	(0.221)	(0.189)	(0.202)	(0.234)	(0.204)	(0.250)
Distance from the city center (minutes)	-1.975***	-2.266***	-2.292***	-2.327***	-2.276***	-2.259***
	(0.189)	(0.164)	(0.174)	(0.208)	(0.176)	(0.222)
Number of rooms		12.80***	14.98***	15.92***	13.51***	16.01***
		(3.334)	(3.556)	(4.143)	(3.606)	(4.401)
Floorspace		-5.240***	-5.090***	-5.287***	-4.976***	-4.885***
		(0.205)	(0.252)	(0.259)	(0.257)	(0.318)
Elevator		-53.49***	-53.87***	-53.62***	-54.28***	-54.16***
		(4.317)	(4.220)	(5.348)	(4.692)	(5.700)
Bathroom in separate room			-6.025		-7.060	-11.86*
			(4.725)		(4.811)	(6.035)
Built after 1980				6.527		7.334
				(3.595)		(3.824)
Observations	3607	2819	2470	1826	2400	1609
BIC	43185.4	32302.0	28238.9	21017.9	27508.1	18528.7
RMSE	96.00	72.48	72.31	73.35	72.10	72.92

The coefficients of the two explanatory variables in Model 1 and Model 6 are quite close to each other. I conducted a Wald test in order to check formally whether or not they are the same. The results, that are presented in the table 2 below, show, that we cannot reject the hypothesis that the coefficient of the variable showing the distance from the metro station are the same in the two models. Neither can we reject the same hypothesis regarding the variable on the distance from the city center.

Table 2. Wald test results for metro station and city center distance

Model 1 (Metro station distance) = Model 6 (Metro station distance)	
chi^2 (1)	1.54
Prob > chi^2	0.21
Model 1 (City center distance) = Model 6 (City center distance)	
chi^2 (1)	1.97
Prob > chi^2	0.1606

However, just because we cannot reject the hypothesis, it does not mean that they are the same. How do the coefficients of these two variables change, if we include more control variables? We can see, that regardless of the exact specification of the model, the coefficients of the two explanatory variables are larger (in absolute terms) than in Model 1. If we would use Model 1 to estimate the impact of the proximities of a metro station and the city center, we would underestimate the size of this impact. This means, that we can use the results of the estimation of the dataset provided by the HCSO, we don’t have to fear to overestimate the effects of those variables.

I have shown that the quality of the flats does not depend on the distance from the metro stations. In many attributes the flats that are in my dataset are the same, like having their own kitchen and bathroom, and having the same inner high. The other attributes show very weak or no relationship with the distance from either the city center or the nearest metro station. Finally I have presented, that even if the attributes of the properties are related to the distance, leaving them out from the regression will only underestimate the coefficients, and we don't have to fear of overestimation, when we evaluate the effects of a nearby metro station on the flat price.

3.2 Estimating the effects of the distance of the nearest metro station

After we have seen that the quality of flats in Budapest is not related to the distance to the nearest metro station, we can estimate the effect of it on the price of the flat. For that I have used the dataset from HCSO combined with the GEO dataset, as detailed in the previous chapter. I use a very simple linear equation for that:

$$mean\ price = \beta_0 + \beta_1 * distance\ from\ metro\ station + \beta_2 * distance\ from\ center$$

We can use a linear model, because the relationship between the average price and the two variables are close to being linear, as we can see on the two graphs below (figure 13 and 14), where I have plotted the average price against the distance from the nearest metro station and the distance from the city center, and fitted a non-parametric trend on them. The linearity is more apparent in the case of the former, but it is also present in the latter.

Figure 13 Average flat price plotted against distance from metro station

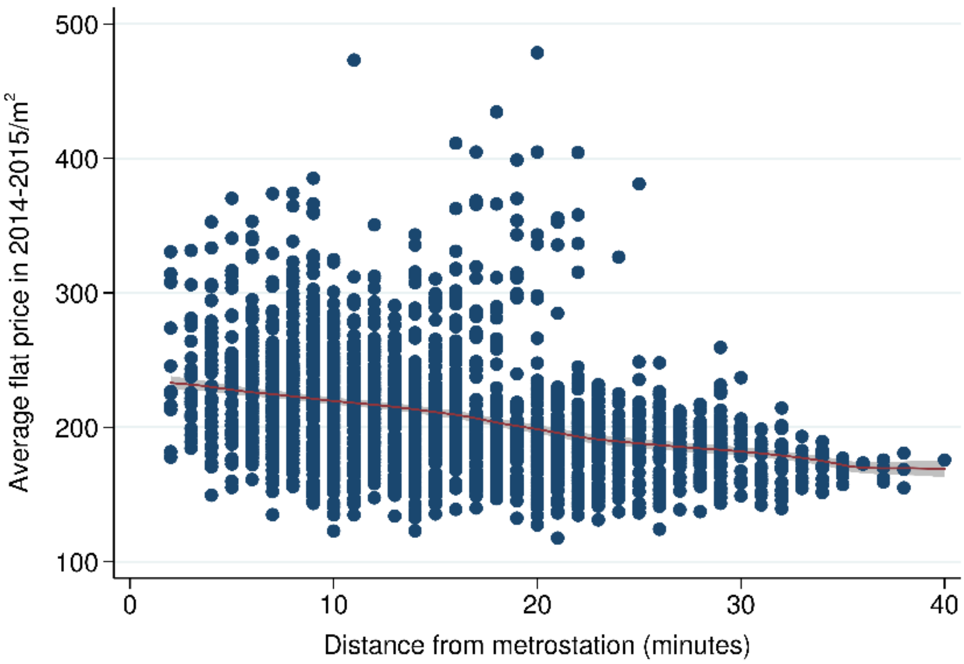
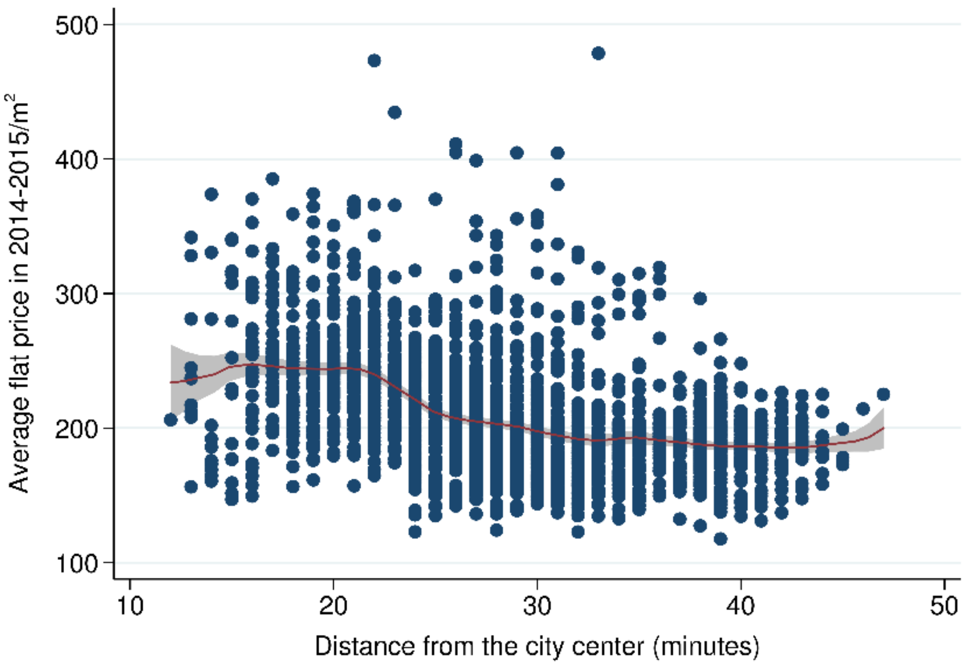


Figure 14 Average flat price plotted against distance from city center



I calculated the model using the mean price and the log of the mean price as dependent variables. The results can be found in table 3 below:

Table 3. Regression results for metro station and city center distance on flat price

	(1) Mean price / m^2	(2) Log (Mean price / m^2)
Distance from metro station (minutes)	-0.567^{**}	-0.00367^{***}
	(0.185)	(0.000822)
Distance from the city center (minutes)	-2.266^{***}	-0.00943^{***}
	(0.199)	(0.000884)
Constant	282.5^{***}	5.646^{***}
	(4.047)	(0.0180)
Observations	2141	2141
Adjusted R^2	0.181	0.191

The results show that the price of a flat is significantly influenced by the proximity of the city center and by the closeness to the metro station as well. On average, the mean price/m^2 in a census tract one minute closer to a metro station is 576 HUF higher, while one minute closer to the CBD of Budapest is 2266 HUF higher. When we look at Model (2), where I use the natural logarithm of the mean price/m^2 we can see that on average the mean price is bigger by 0.37% per every minute closer to a metro station, and the by 0.94% per every minute closer to the CBD.

There are many factors that can influence the price of a dwelling beside these two variables, therefore we have to be careful with causal interpretation. One factor is the quality of the flats, which was addressed in the previous subchapter. Another important factor that has an effect on flat price is the quality of the dwelling's surrounding area. A part of that is the quantity and quality of available services in the neighborhood (shops, doctor, schools, etc.), but in Budapest I believe this doesn't play a big role, since from most dwellings the CBD can be reached quickly, where a wide range of services is available. Another aspect of the quality of the surrounding area is public safety. There is no criminal statistics in Hungary with such geographic precision, but it in recent years there have been a number of reports of drug use near metro stations (Ács et al., 2019; Szilák, 2018), so I believe that we can reject the hypothesis that areas closer to metro stations are safer, which would make us overestimate the real effect of stations on flat prices. An additional problem can be, that we cannot observe the actual price being paid for the flat, only the price that is written in the purchase contract. The tax system incentivizes sellers to write a smaller value on the contract than the actual one. If flats further away from the center and metro stations are being traded in this semi-illegal way, our results are false. However, I don't see any reason why the sellers of flats located in the outer parts of the city would use this tax avoiding scheme more than sellers in the inner parts. We also have to mention that this technique is disadvantageous for buyers in many cases, which puts a limit on the use of this scheme. Overall, I think that we can interpret these results as causal relationship

Looking at the results in another way: an extra 5 minute travel to the nearest metro station can have an 1.8% effect on the price and is with 95% confidence between 1% and 2.6%, which is pretty big if we consider that the average panel flat costed about 10.8 million HUF (about 33 000 euros), and a 1.8% of that price is about 200 000 HUF, only because of a 5 minutes shorter travel. (Using the ends of the confidence interval, we get that this value must be between 108 000 HUF and 280 000 HUF for the average dwelling.) We have to keep in mind, that as we have seen in the previous chapter, our estimations are likely to be underestimated, the real effects of metro station proximity and city center accessibility can actually be even larger.

Concluding remarks

In this thesis I have demonstrated that the proximity of a metro station has a significant effect on the price of panel flats in Budapest, which is estimated to be about -0.37 percent per minutes. I have also shown that the distance from the city center has a statistically significant effect on the price of flats, about -0.94 percent per minute. These results are in line with my expectations. First, I have shown, that the effect of these two variables is not related to other attributes of the properties, and that if we leave the control variables out, we might only underestimate the effect of city center and metro station proximity, and not overestimate it.

Theory of real estate pricing tells us, that one of the most important aspect of real estate is its location. In case of a flat the real question is how fast the resident can get to the city center, where most of the jobs and where cultural recreation opportunities are. Commuting is costly both financially and timewise. So, the faster it is getting to the city center, the less resources are required, and therefore real estate prices will be higher as we get closer to the middle of the city. This theory is confirmed by my analysis, since the further the flats are, the less valuable they are. We also see, that even after controlling for time it takes to get to the city center, we see that flats closer to metro stations are more expensive. Our estimation says, that if we take two flats with the same distance from the city, but one of them is closer to a metro station, then that one is going to be more expensive. The reason for that can be, that it provides a more frequent and reliable connection, than the other modes of public transportation, and therefore offer a more convenient service.

This result can have policy implications as well. As presented above, we can think of the higher real estate price near a metro station as a positive externality that we should internalize in order to reach the socially optimal level of metro lines in Budapest. Using a very vague approximation, I would like to show that this external effect is significant if we compare it to the budget of a metro building project. Let’s look at one of the stops of the newest line in the city, ‘Bikás park’. In my database there, are about 15689 individual addresses in the census tracts to which the closest station is this stop, and since we have these tracts in the dataset, we know, that there have been at least three purchases of panel flats in these tracts. If we multiply the number of flats with the previously estimated 200 000 HUF extra value in real estate, we get over 3.1 billion HUF worth of externality in real estate value only from one single metro station out of ten on the line. I don’t want to argue that this externality comes anywhere close to the 450 billion HUF cost of the entire metro line M4 project, neither do I want to brag about the exact numbers, but I wanted to show that the magnitude of this externality is big enough to be considered by policy makers.

However, I must note the limitations of my analysis. This analysis addresses only one city with a monocentric structure, and it does it only at one timepoint, and therefore more general conclusions cannot be drawn from it. Another constraint is the datasets that have been used in this thesis, which don’t allow more precise estimations. For more general conclusions more research is necessary: the analysis of time series data of real estate prices before and after the construction of a new metro line at multiple new locations would allow for a more general conclusion.

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