Charles University in Prague

Faculty of Social Sciences

Institute of Economic Studies

BACHELOR THESIS

Impact of metro station proximity on apartment value in Prague

Author: **Jan Láznička**

Supervisor: **Mgr. Barbara Pertold-Gebická, M.A., Ph.D.**

Academic Year: **2015/2016**

Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

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Prague, May 10, 2016

Signature

Acknowledgments

I would like to thank especially to Mgr. Barbara Pertold-Gebická, M.A., Ph.D. for her valuable advices and helpful comments. Furthermore, I would like to thank to Petr Hána from Deloitte Advisory s.r.o., to Martin Zima and Marek Střelec for the help during the data collection and finally to the management of the real estate server Sreality.cz.

Abstract

This Bachelor's thesis analyzes the relationship between the apartment prices and proximity of the metro stations in Prague. Using the apartment offer prices and apartment characteristics from the real estate agencies, empirical analysis is conducted to examine the metro closeness effect in the case of whole Prague and also different parts of the city. Moreover, the real transaction data are used to study the possible difference between the impacts on the real transaction prices and the offer prices. The results show a statistically significant positive impact of metro closeness on apartment value in the case of a Prague as a whole with 14 967 CZK apartment price decrease when moving additional 100 meters away from the station. In another approach we compare the price differences of apartments located in 250 meters wide zones from their closest metro station. The results show a value premium of 563 851 CZK and 500 691 CZK for the apartments located in the 250-500m and 500-750m zones respectively compared to the ones located more than 1 kilometer away. In the case of different parts of Prague, many different results are obtained. However, majority of them show a positive price impact of metro closeness in Prague.

Keywords apartment prices, public transportation, metro distance, offer prices, transaction prices, Prague

Author's e-mail laznicjan@gmail.com

Supervisor's e-mail gebicka@fsv.cuni.cz

Abstrakt

Tato bakalářská práce analyzuje dopad vzdálenosti od metra na ceny bytů v Praze. Autor využívá nabídkových cen a fyzických charakteristik bytů k provedení empirické analýzy zkoumající cenový efekt blízkosti metra, a to nejprve v celé Praze a posléze i detailněji v jednotlivých městských částech. Za pomoci dat z realizovaných transakcí se autor také zabývá rozdílem mezi dopady na reálné transakční a nabídkové ceny. Co se týče Prahy jako celku, výsledky prokazují cenový pokles 14 967 Kč za každých dalších 100 metrů od nejbližší stanice metra. Další možností je rozdělení bytů do několika 250 metrů širokých vzdálenostních zón od jejich nejbližších stanic. Následná analýza dokazuje největší zhodnocení v případě prstenců vzdálených 250-500m a 500-750m od

stanic metra, a to 563 851 Kč a 500 691 Kč oproti bytům dále než 1km od jejich nejbližších stanic. I přes relativně různorodé výsledky v jednotlivých pražských částech můžeme tvrdit, že většina potvrzuje pozitivní dopad vzdálenosti od metra na ceny bytů v Praze.

Klíčová slova	ceny bytů, veřejná doprava, vzdálenost od metra, nabídkové ceny, transakční ceny, Praha

E-mail autora	`laznicjan@gmail.com`
E-mail vedoucího práce	`gebicka@fsv.cuni.cz`

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Bachelor Thesis Proposal

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Topic characteristics The main purpose of this study is to examine the relationship between the real estate prices and proximity of underground stations in Prague. It appears to be logical that the distance of underground is a major factor affecting the prices of real estate. In my thesis I would like to prove this correlation in the case of Prague and then investigate the effect in the particular city districts. I will divide the analysis into various segments according to type, location, property area, etc. and I would like to explore the divergence among them. In the further analysis, I will compare the studied impact with the impact of other factors affecting real estate value (distance of tram station, number of rooms, floor number). In order to test the hypotheses, I will collect both publicly available data from real estate agencies and data from real transactions and use online maps to determine the closeness of the particular properties to the underground stations. After creating a proper dataset, theoretical econometric model will be used to examine the significance and the actual impact of underground proximity as well as the effect of the other factors.

Some of the thesis research objectives are:

- Is there a correlation between metro station proximity and apartment prices in Prague?
- Is the effect statistically significant?
- What are the main factors affecting real estate value in Prague?

- Does the underground station proximity have considerably greater effect on housing prices than the railway station proximity?
- Is there a difference between the underground proximity impact on transaction and offer prices?

Chapter 1

Introduction

Housing and transport have always been interconnected. From time immemorial people settled around crossroads of trade routes and in the vicinity of transport hubs in order to benefit from the possibilities that these places offer. Nowadays, living close to the transportation routes gives the opportunity to save time, that is currently so valuable. The benefit is even more visible in the case of big cities, where living close to the public transportation offers the possibility of getting to the desired destination quickly and comfortably. When talking about Prague, the fastest way of transportation is undoubtedly metro. It provides fast and direct transport with regular operation and minimum of delays. Therefore, when investing into housing and in our case particularly in apartments, the closeness of metro station should have a positive impact on apartment prices. Several researches have been carried out concerning this topic, however to our knowledge, none of them focusing on Prague metro system.

The objective of this thesis is to analyze the impact of the metro station proximity on the apartment value in Prague. Is there a statistically significant impact in the case of Prague as a whole? Do the results differ in the case of different parts of Prague and various metro lines? Is there a difference between the effect on the real transaction prices and the offer prices? These are the main research questions that are covered on the following pages.

The thesis is divided into following parts: Chapter 2 gives an overview of the previous studies focusing on this topic in other cities around the world. Chapter 3 covers the development of both transportation in Prague and Prague

apartment market. Chapter 4 includes the theoretical framework for our analysis followed by Chapter 5 dealing with the problematic of data and its collection. Finally Chapter 6 presents the results of the analysis and their interpretation and is followed by the Chapter 7 summarizing our findings.

Chapter 2

Literature review

It is generally true, that in the case of major cities, centers are the accumulations of business, free-time and shopping activities and the basic logic is, that the closeness to the city center is considered as a certain quality characteristic. Taking this into account, the closer the property is to the city center, the higher its value should be. Currently, in the age of fast public transportation, the impact of the city center proximity on real estate value can be to a certain extent lowered by the opportunity of living further from the center, however still with short transportation time. This possibility of fast transportation should be logically somehow correlated with the real estate prices and together with other property characteristics should affect its value.

The introduction of hedonic price model (Rosen 1974) simplified the way of testing the impacts of different characteristics on the property values (Debrezion *et al.* 2007). Several relevant studies examining the impact of public transport proximity on real estate value in cities around the world were carried out since that. Not all of them proved the basic idea that the decreasing distance from the public transport station should increase the real estate value. The predicted capitalization of the station vicinity into property prices was demonstrated for instance in the paper of Debrezion *et al.* (2007) regarding the rail stations and Agostini & Palmucci (2008),Grass (1992) or Damm *et al.* (1980) showed the capitalization in the case of metro stations. However Gatzlaff & Smith (1993) or Lee (1973) recorded insignificant effects in their studies. On the other hand Landis *et al.* (1995) and Bowes & Ihlanfeldt (2001) showed negative correlation in the case of train stations which is contrary to the general assumption. However the negative impact was shown only in same parts of the studies.When talking about inconsistencies, we should look in more de-

tail at the studies with different outcomes and at the way they were carried out.

In the first place, when talking about train lines and their effect on property prices, Debrezion *et al.* (2007) tries to explain the capitalization in the case of train stations by a meta-analysis of studies focused on a common research question and that is the impact of train stations proximity on property value. For this purpose a meta-regression model was applied and the meta-analysis equation based on Florax *et al.* (2002) was used. The used hedonic model is represented by this equation:

$$Y = \alpha_0 + \beta_1 P + \beta_2 S + \beta_3 M + \beta_4 ACCESS + \beta_5 DM + \beta_6 T + \epsilon \tag{2.1}$$

This analysis tries to explain the variations in the findings of train based property prices studies by the difference in study characteristics and other variables concerning for example geographical or time effects. The dependent variable Y is the size of impact of railway station proximity on property value in percent. The explanatory variables are the dummy distinguishing between commercial and residential properties, vector of dummies concerning the type of railway, indicator of model type (semi log, double log, etc.), set of binary variables indicating the models with inclusion of other means of transport, dummy for the presence of demographic aspects and finally the time trend dummy. The results of this analysis based on 57 observations through-out the USA indicate, that the closeness of railway station has a higher positive impact on commercial properties than on the residential ones. Moreover, the presence of commuter railway station in the neighborhood has a significantly higher effect than the closeness to the other types of railway stations. And finally, the positive effect of railway station proximity is much higher in the cases, where closeness to other transport lines and highways is omitted, especially in the case of highways, where the inclusion of the highway proximity diminishes the effect of railway. Following the explanation of Debrezion *et al.* (2007), the omitted variable bias was found.

Secondly, interesting paper of Bowes & Ihlanfeldt (2001) focusing on the MARTA (Metropolitan Atlanta Rapid Transit Authority) system in the Atlanta metropolitan area needs to be discussed. The first thing to mention is that the MARTA system consists of elevated, ground-level, and underground tracks. The second

is the fact, that this study also involves criminal aspect of the station proximity. When talking about the methodology, the estimation in this analysis consists of three models: firstly a complete hedonic price model to study the direct impact of improved accessibility by MARTA system and the negative externalities produced by the stations, secondly an auxiliary equation to study the indirect effects of the criminal activities and finally a model to study only the impact of retail development attracted by the stations. Combining these three models, Bowes & Ihlanfeldt (2001) show the effect of individual components on the final property price. The data set is based on sales of single-family homes in the Atlanta region from 1991 to 1994. This analysis is also specific by a large number of location, neighborhood and parcel characteristics included in the regressions.

The results are following. Firstly, the direct proximity effects are generally larger than the individual effects of retail development and crime rise. Moreover when distinguishing between the crime and retail effects, the retail improvement outcome is more substantial than the crime disadvantage, except for the immediate vicinity of the stations located close to the Atlanta downtown. Furthermore, the total effect varies with neighborhood income level, distance to downtown, and distance from the station. Secondly, the largest positive effect of MARTA stations proximity can be found in the middle distance properties (one half to one mile) approximately 12 miles from the central business district of Atlanta. On the other hand the largest negative effect was found in the case of downtown stations especially in the case of stations with a parking lot.

Moving on to metro system more similar to the Prague metro with majority of the stations underground, interesting paper investigating the capitalization of station closeness into housing prices done by Agostini & Palmucci (2008) should be mentioned. The object of this study is the impact of Santiago metro system extension on the housing prices in the capital city of Chile, Santiago. The analysis is specific by the focus on the anticipated capitalization at the moment construction of new Line 4 was announced and at the moment the information about location of future stations was revealed. As an instrument to study the effect of new metro line, the following house price equation was estimated:

$$logP_{it} = \alpha + \beta X_{it} + L_{it} + \delta D_{it} + \eta_i + \mu_t + \epsilon_{it} \tag{2.2}$$

Where the dependent variable $logP_{it}$ is the house i selling price at time t in the logarithmic form and the independent variables are the vector of property physical characteristics, vector related to the neighborhood and location features, variable concerning the access characteristics, location fixed effect, time fixed effect and finally the error capturing unobserved determinants of house price. As stated Agostini & Palmucci (2008), estimation of this equation is equivalent to the Rosen (1974) hedonic price regression. The problem with determining the increase of property prices is the need of comparing the prices after the announcement of construction (or the revelation of stations location) with the prices that would have been in place, if the announcement did not occur. Agostini & Palmucci (2008) offers two possible solutions of this problem. First is the comparison of prices after the announcement with prices before for approximately equivalent group of properties with the usage of before-after estimator and second option is the natural experiment based on Blundell & Macurdy (1999), which consists of comparing before-after estimates of two different housing samples, from which one is affected by the construction of metro and the second not. The logic behind the second approach is that the houses further than 1 kilometer from the station are not affected and the change in prices is the same as if the metro would not have been built. In the second case a difference-in-difference estimator is used.

The final results recorded rise of average apartment prices between 4.2 per cent and 7.9 per cent after the construction announcement and between 3.1 per cent and 5.5 per cent after the engineering project revelation, depending on the distance to the nearest metro station. Additionally, indirect effect of capitalization was observed and that is the increase of tax collection. In this case the rise of taxes collected due to the properties valorization can mount up to 11-17% of investment into the line 4, which is a substantial part of the new metro line price.

When we look at the studies from broader point of view, we can see that the inconsistency of the results can be due to the different characteristics of the transportation lines, for instance the possible side effects of the stations above the ground such as noise, vibrations and unsightliness, or the accumulation of crime around the stations in some cities. Furthermore, it can be caused by the divergence in methodology or the different data quality. Although taking the inconsistencies into account, we are able to conclude, that in most of the cases, the access benefit is reflected positively in the value of residential

properties. This statement is supported by the paper of Parsons Brinckerhoff (2001), summarizing findings of relevant studies concerning this topic. The impacts demonstrated in the studies vary in magnitude and form of the result. Lewis-Workman & Brod (1997) found average home price increase of $1,578 for every 100 feet closer to the BART (Bay Area Rapid Transit) transit system stations in San Francisco and increase of $2,300 in the case of New York city transit stations. Secondly, study of Benjamin & Sirmans (1996) which looked at more than 250 rental observations discovered rent decrease by 2.4 per cent to 2.6 per cent for each 0.1 mile distance increase in the case of Washington D.C. metro system. Last but not least, Voith (1993) found a premium for single family houses close to the Philadelphia rail stations of 7.5 per cent to 8.0 per cent over the average home value.

Chapter 3

Prague analysis

3.1 Transportation in Prague

Prague public transportation dates back to the year 1873, when first concession for public street railway track was granted. Two years later, first ride of the horse-drawn tram initiated public transport in Prague. By the year 1885 the development of transportation enhanced the living standards in the area around almost 20 kilometers of public tram (DPP 2015). After horse-drawn lines electrification in the beginning of the 20th century, substantial boom of the tram transportation took place and started the expansion of public tram lines into suburbs.

In the year 1908 Electrical utilities, the operator of Prague tram lines, introduced first bus line in Prague. However, due to a series of accidents and first World War, Prague's citizens had to wait for a regular bus line until 1925. Firstly considered as supplementary way of transportation, bus lines experienced sizable growth in postwar Prague. Furthermore, in the year 1936, trolley buses were introduced as another possible way of public transportation (DPP 2015).

Year 1938 can be considered as a big milestone in the history of public transport in Prague, due to the decision of Electrical utilities to construct underground tram line (DPP 2015). As a result of World War II., a large part of lines was damaged and the construction of underground tram was postponed. The change of political regime led to series of nationalization and establishment of the Prague Public Transport Utilities. Finally, at the beginning of 1966, work on the underground tram line had begun. A substantial change was made during construction as the planned tram line was replaced by metro. In

1974, line C, the first line of the Prague metro system was put into operation (DPP 2015).

Currently the Prague metro system consists of three separate lines with 61 stations (3 transfer) and forms a core of the Prague public transportation. Using the three metro lines, A,B,C and analysis based on apartment transaction price map (Cenovamapa 2015) we can divide Prague into individual sectors. Firstly, line A, which runs from east to the west and contains 17 stations. Locations in the vicinity of most of the line A stations can be considered as lucrative or even luxurious, because the average prices of apartments close to the stations (less than 500 meters far) are very high. When looking at the individual stations, the most expensive surroundings can be found close to the stations Staroměstská, Malostranská and Můstek, which are also the 3 most expensive station surroundings overall (Cenovamapa 2015). Another reason for considering line A as luxurious is the fact, that only 3 stations have surroundings with average prices of apartments less than 50 000 CZK/m^2. The second metro line, B, running from northeast to the southwest, is the longest one and contains 24 stations. In contrast with line A, more of the line B stations are located in the further suburbs and therefore, 9 stations have surroundings with average prices of apartments less than 50 000 CZK/m^2. Finally, the most stations with such characteristic are located on line C, exactly 14 of current 20 line C stations. This oldest line, operating in a south-north direction, interconnects also the southeast with northeast, thus cheaper housing locations. Latest extension of metro system happened in 2015, when 4 new line A stations were opened in the western part of Prague.

Another parts of the city are connected by 510 kilometers of tram lines consisting of 22 day lines and 9 night lines (TSK 2015). These tramways create dense network in the city center and connect it with the suburbs as well. Further parts of the city and the nearest villages surrounding Prague are accessible by 1678 kilometers of bus lines. Metro, tram and bus lines together with 9 mutually connected train railways, which run from the city center to the outskirts of Prague and further into the whole county, create Prague integrated transport system (PID), which provides most of the public transportation in Prague.

3.2 Prague apartment market

Prague is the largest city of the Czech Republic and has a significant position in the Central European real estate market. In June 2015, Prague had a population of 1 262 612 and its inhabitants occupied more than 550 000 apartments and 90 000 houses (CZSO 2015b). In this part of the thesis, we will have a look at the characteristics of Prague real estate market and analyze the long-term market development through indices such as transaction price index or amount of new construction. The analysis will cover only the object of our study, which are the apartment units.

3.2.1 Historical development of apartment prices

The timeline of apartment prices development can be divided into three parts. Firstly the decade of optimism and significant price increase, secondly downturn as a result of the financial crisis and finally recovery and stabilization. In the late 90s, Czech republic was one of countries with the fastest real estate price growth. According to Šaroch (2004), Czech real estate market at the beginning of new millennium shared most of the general features of post-communist markets identified in the study of OECD (2002):

- Relatively high number of apartments per 1000 inhabitants compared with the numbers in developed countries
- Poor quality of apartments caused by their neglecting during the communist regime
- Dramatic decrease of new development after the change of political regime
- The fourth feature, and also the only exception for Czech real estate market, was the owner-occupied housing ratio, which was only around 36%, this rate can be explained by the long-standing privatization of housing stock (Palacin & Shelburne 2005)

Several years after stabilization of new political regime, the supply of housing, lowered by decrease of new development, did not meet the demand and prices started to rise with the epicenter in the Prague apartment market. Between years 1999 and 2008, the apartment prices more than doubled. This era was accompanied by two substantial price increases. In the beginning, apartment prices in Prague rose due to excess demand by more than 10% a year,

in the year 2001 the increase amounted to 18%. The increase in the case of Prague was more than 6% higher than in the other parts of Czech republic. In the following year, the growth rate exceeded 20% and reached peaked (CZSO 2008).

In the year 2003, the growth stopped and prices of apartments experienced slight decrease followed by stagnation. The cause can be found in the entry of Czech republic to EU (Hlaváček & Komárek 2008). Before the expected integration of Czech republic into Eurozone, speculators started buying real estate expecting prices to rise after the entry and this speculation led to the creation of real estate bubble. In the subsequent two years, Prague market of apartments, instead of expected settlement of prices to the level of major European cities, experienced small price decrease. Prices settled at 60% higher value compared to year 2000. Interesting fact for period of early 2000's was the real estate price level of Prague, which was almost 4 times higher than the unweighted mean of the rest of the country (Palacin & Shelburne 2005).

Approximately in the middle of the year 2005, stagnation had been replaced by a minor price increase. From the second half of the year 2006, substantial boom occured on the Prague apartment market. The optimism caused by favorable circumstances and increasing purchasing power of households rocketed both offer and transaction prices of apartments. Nominal wage growth reached 8% and mortgage market was affected by the mortgage product of Česká Spořitelna, which forced other banks to push interest rates down (CZSO 2014). The rapid price increase started the overpricing process of real estate in Czech republic. However according to Zemčík (2011), the rate of overpricing was rather small and according to Hlaváček & Komárek (2008), the real estate bubble in the years 2007 and 2008 was roughly two times less intensive than the one in beginning of year 2003, moreover from the statistical point of view, it was not very significant.

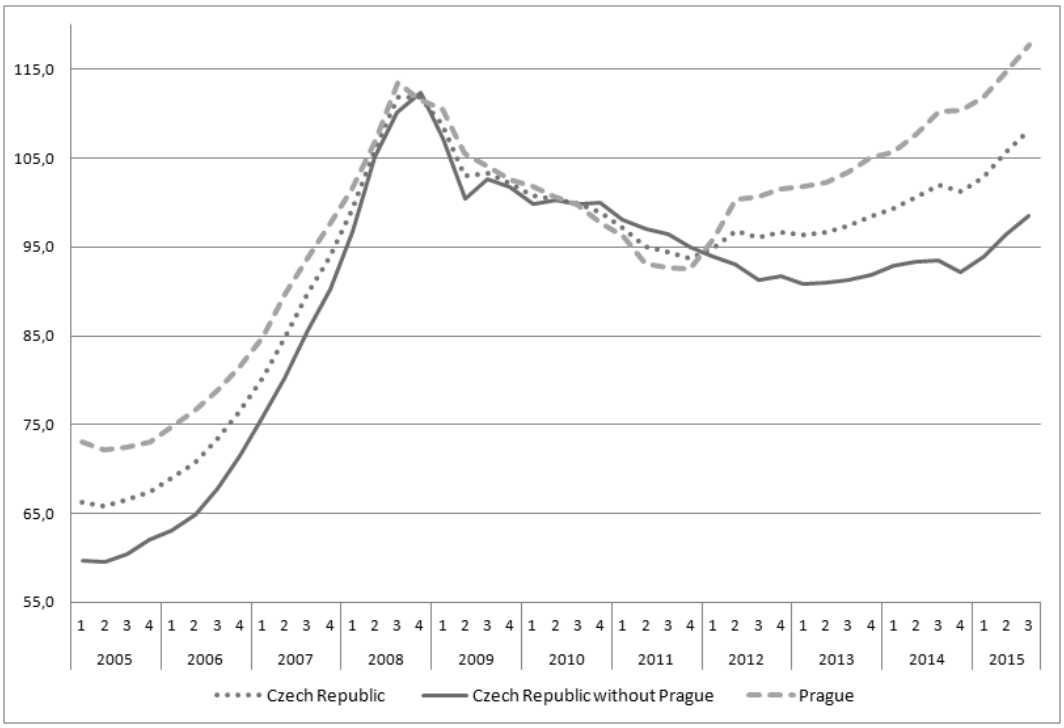
The rapid increase of prices was interrupted by the effects of global financial crisis. The transaction prices reaction was faster than the reaction of offer prices (more on this topic in the next section). However in the end, both prices were affected and the apartment price level experienced downturn. The main factor causing this change was the decrease of demand and according to Deloitte (2009) also the housing saturation of baby boomers. The effects of global crisis can be seen in the outflow of speculative investors and in the expected reduction of households income as well (Deloitte 2009). In the third and fourth quarter of the year 2009, prices stabilized, however the ongoing

downturn of demand caused the minor price decrease in the years 2010 and 2011. Hand in hand with the current recovery of the the domestic economy goes the recovery of real estate market. The recovery in the case of Prague apartment market came at the end of the year 2012 followed with an optimistic year 2013, which ended the years of downturns and fluctuations, returning a noticeable increase of both offer and transaction apartment prices. Current demand for apartments is driven by historically cheapest mortgage loans and the sales of apartments are significantly increasing. The amount of flats sold in the year 2014 in Prague reached 5950 sales, which is an increase of 18% compared to 2013 (Pácal & Soural 2015).

3.2.2 Offer prices

When talking about real estate prices, we must distinguish between the offer prices, advertised by real estate brokers and the actual transaction prices, because the difference between these two prices might be considerable. Firstly we will have a look at the offer prices development in Prague apartment market. The statistics of real estate offer prices are based on the offers of real estate agencies and should be higher than the actual transaction prices, since not all of the properties are sold for the prices proposed by the seller, but significantly cheaper. Indubitable advantage of offer prices is the accessibility, because information are publicly available online. The data used to analyze offer price development in this thesis come from the Czech Statistical Office (CZSO) time series. Fundamental element used is the apartment offer price index based on the quarterly estimates of apartment prices.

Figure 3.1: Apartment offer prices indices, average of 2010=100



Source: Author based on CZSO

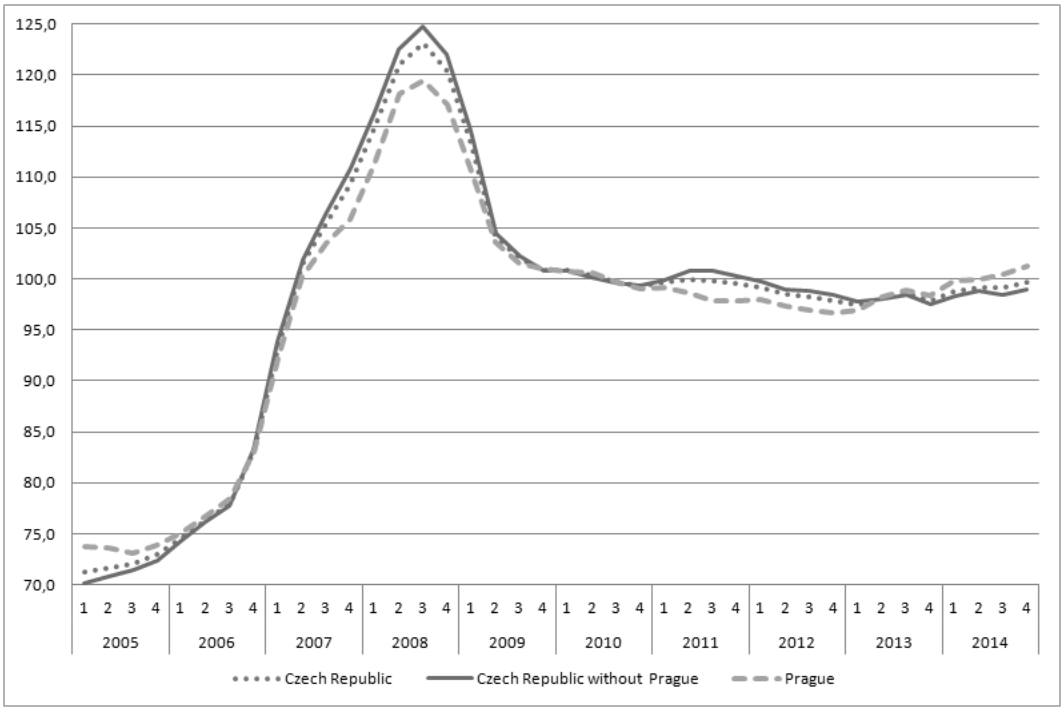
From the figure 3.1 we are able to detect, that the current apartment market, as viewed from the offer side, is experiencing substantial increase. The recovery of apartment offer prices in Czech Republic is driven by the situation in Prague. Moreover, at the beginning of the year 2015, local apartment market overcame the pre-crisis peak price and the prices in the third quarter of 2015 were more than 5% higher compared to third quarter of 2008, thus the pre-crisis maximum. As well the dominant position of Prague as a market leader is evident, because the apartment prices in other parts of the Czech Republic are still well beneath their maximums and it is too soon to talk about long-term increase.

3.2.3 Transaction prices

When talking about aggregated data on apartment transaction prices in Prague during the past decade, we are limited by the time series published by CZSO. They calculate their indices according to official data about the purchase price from real-estate transfer tax, administered by the fiscal authorities. Therefore the calculations do not take into account the prices of apartments sold by developers. Consequently, when looking at the transaction price index, we must have in mind, that not all of the actual transactions are included. Another

complication is the fact, that transaction prices are published with delay. The real-estate transfer tax return is made in March of the year following the one, in which the real-estate transfer was made.

Figure 3.2: Apartment transaction prices indices, average of 2010=100

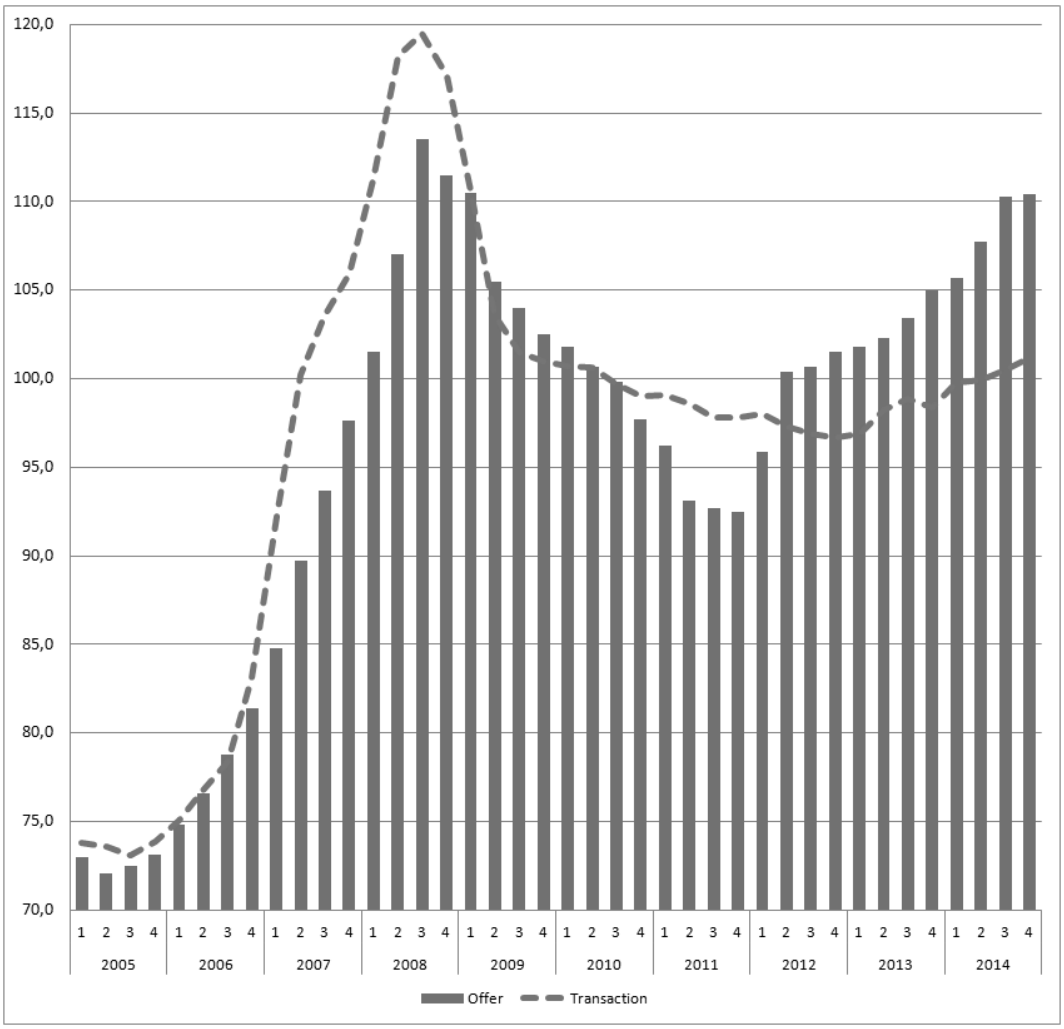


Source: Author based on CZSO

When looking at the figure 3.2, the difference from offer price case is noticeable. Although the data for 2015 are missing, any substantial improvement is not visible in the case of whole Czech Republic nor in the case of Prague. The prices are still moving around the post-crisis minimum and about 20% lower values than in 2008. Although we have to wait for the current data, we can conclude that even when the apartment sales are higher than in the year 2007 (Pácal & Soural 2015), the real transaction prices are well below. Next possibility is to separate transaction prices of new and older apartments. When doing so using data from CZSO (2015a), the difference is obvious. In the case of new apartments, the prices are getting closer to the peak ones, on the other hand prices of older flats have still a long way to go.

The difference between transaction and offer prices can be sizable, according to Deloitte (2012) even more than 10%, and their developments might be distinct. Situation on the Prague apartment market in the past decade proves this statement well. Couple of years before crisis were accompanied by increase

Figure 3.3: Apartment prices in Prague, average of 2010=100



Source: Author based on CZSO

of both prices, with slightly steeper development of transaction prices. This faster increase of transaction prices can be explained by speculative demand and betting on future even higher increase of prices. The second phase, downturn, was accompanied by faster decrease of transaction than offer prices. The reason for this divergence can be found in worsening of households economic situation and outflow of demand on one side and investors willing to sell apartments with at least minor profit on the other side, therefore the offer prices decreased more slowly. The sales of apartments in Prague hit the bottom in the year 2009 with less than 2000 apartments sold (Pácal & Soural 2015). Following year, even when the sales started to grow, the offer prices continued to fall and this time faster than transaction prices, which followed first post-crisis economic recovery and whose downturn was replaced by stagnation. However

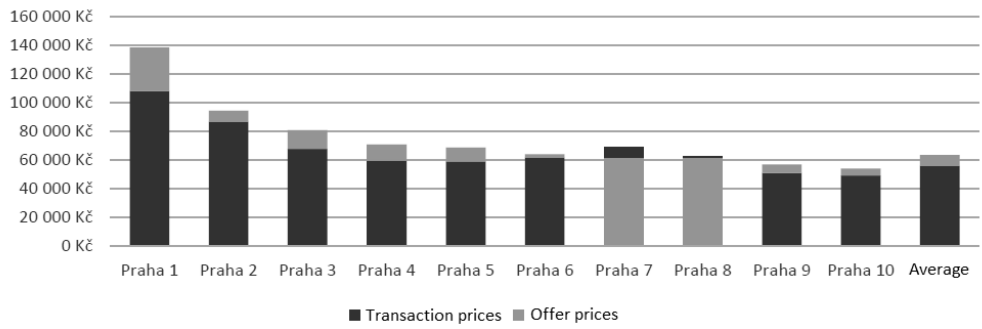
in the year 2012, when looking at the figure 3.3, we can see sizable increase of offer prices, which was not accompanied by increase in the transaction sector. Sellers increased their prices significantly, but the demand side did not adapt. In the last two years transaction prices have finally caught their breath and are experiencing almost parallel increase with the offer ones.

3.2.4 New development

Finally, we will talk about new development in Prague. After the change of regime in 1989, new development in Prague experienced three main phases, slow increase, boom and massive downturn. The transformation into democracy and change of political goals and priorities led to immense drop of apartment construction. Capitalism has put residential development into the hands of private firms and market needed time to adapt to this, for many socialistic decades, unknown system. In the year 1993, only 1143 apartments started being built in Prague. In the following years, amount of new development began to increase and reached 5153 in the year 2000 (CZSO 2015c). The introduction of new financial products on the market and the transition of Czech crown from fixed exchange rate to floating enabled further increase of Prague apartment construction in the beginning of new millennium. The growth rate of new apartments construction in the early 2000s was very rapid and the massive increase of new development could not last forever. The amount of apartments started being constructed reached peak in 2005, followed by two consecutive years of almost the same substantial new apartment construction in Prague (CZSO 2015c). These years were affected by the planned change of value added tax and the motivation of people to buy a new apartment before the expected change takes place, moreover, developers were eager to start as many projects as possible, ahead of the planned increase of value added tax (Mazáček 2015). In the year 2008, first major downfall took place in the new development sector. The causes can be found in the saturation of demand as well as in the first signs of global crisis hitting the Czech apartment market. The decrease of new construction continued in the subsequent years, whereas the number of completed apartments remained high due to the boom in the pre-crisis years. Year 2011 is retrospectively seen as the bottom of new apartment construction, with the number of realized projects more than twice lower, compared to the year 2007 (CZSO 2015c). During recession, situation on the market had changed and instead of luxury and sizable apartments, new devel-

opment in the year 2011 focused on smaller units and apartments with lower standard. Direct impact of crisis was obvious in the structure of offered flats. Some of the projects, that were designed in the years of new development boom and would have been salable in those years without a problem, were left unsold for more than a year and constituted a large part of total new apartments offer (Mazáček 2015). Slight recovery of new development sector in the year 2012 was followed by visible increase of new apartment construction in the subsequent year. Prices of unsold units from the crisis era felt down extensively and this price drop stimulated demand. When looking at the current situation, we are able to state, that the new development sector hit the ground and is experiencing stable increase, however still well below the numbers from years in the first decade of new millennium.

Figure 3.4: Comparison of apartment prices in new development sector according to Prague district



Source: www.cenovamapa.org

In the graph resulting from the analysis based on transaction prices data of apartments in new development apartment houses (Cenovamapa 2014) we can see, that the average transaction price of new apartment in Prague in 2014 was 55 600 CZK/m^2, whereas the average offer price was 63 200 CZK/m^2. The difference was almost 12%. Secondly, the highest price and also the highest divergence between offer and transaction prices was in the city center, district Praha 1. The offer prices climbed to almost 140 000 CZK/m^2 and with the real transaction value around 108 000 CZK/m^2, it resulted into 22% gap. Interesting situation can be seen in districts Praha 7 and Praha 8, where the average offer price exceeded the transaction price.

Chapter 4

Theoretical Framework

Firstly, we can have a look on the problem of metro proximity impact from the view of consumer and his/her utility maximization. In order to do this, we will follow the Simple Capitalization model of Agostini & Palmucci (2008) based on ALONSO (1964). This model targets the problem of each consumer in the housing sector and that is to maximize the utility based on the size and location of the real estate and all other goods, that the individual consumes subject to his/her budget constraint. Based on Agostini & Palmucci (2008), lets consider that the maximization looks as follows:

$$\max_{s,d,o} U(s, d, o) \tag{4.1}$$

with a budget constraint:

$$Y = o + P(d)s + T(d) \tag{4.2}$$

With s being the size of the property in square meters, d equal to distance of the housing from closest metro station, o as a compound good made of other consumer's goods. Moreover, Y is the consumer's income, $P(d)$ is the price per square meter of the property depending on the distance from the closest station and $T(d)$ is a cost function of transport. The reason for adding the distance into consumer's utility function is that the usage implements the unpleasant necessity of reaching the closest station and therefore moves the ideal housing location.

Lets assume that our utility function U satisfies the following conditions: U is continuous, smooth with continuous derivatives of second order and strictly quasi-concave. Furthermore, U is increasing in s and o and decreasing in d,

because increase in distance leads to increase of travel time. Lets also assume $\delta P(d)/\delta d < 0$,$\delta T(d)/\delta d > 0$. As a result the consumer choice determined by the Lagrange method follows these conditions:

$$U_s - \lambda P(d) = 0 \tag{4.3}$$

$$U_d - \lambda\left(\left(\frac{\delta P(d)}{\delta d}\right)s + \left(\frac{\delta T(d)}{\delta d}\right)\right) = 0 \tag{4.4}$$

$$U_o - \lambda = 0 \tag{4.5}$$

$$Y - o - P(d)s - T(d) = 0 \tag{4.6}$$

Combining equations (5.2) with (5.3) and (5.1) with (5.3) gives us the following outcomes.

$$\frac{\delta P(d)}{\delta d}s = -\left(\frac{\delta T(d)}{\delta(d)} - \frac{U_d}{U_o}\right) \tag{4.7}$$

and

$$\frac{U_s}{U_o} = \frac{P(d)}{1} \tag{4.8}$$

From the first one we are able to conclude, that the increasing distance from metro station, taking into account the decreasing utility when moving further from the station and also the increasing transport costs, leads to decreasing willingness to pay for the same sized property. Moreover, when looking at the first equation we can see, that the increasing distance leads to decrease of the utility from increase of property size and the ratio of substitution between another housing squared meter and another unit of other goods decreases. In conclusion, as the distance from metro station increases, the price of property should decrease.

This simple model developed by Agostini & Palmucci (2008) gives us the basic idea, what the impact of metro station on property value should be, however the model used in our analysis is the hedonic pricing model, introduced by Rosen (1974) and since then widely used in studies regarding real estate valu-

ation (e.g. Bowes & Ihlanfeldt (2001), Bae *et al.* (2003), etc.). The reason is, that this particular model takes into account also other possible influencing elements of the property price. Therefore along with the distance from the closest metro station there is the possibility to consider the other price determinants like physical or neighborhood characteristics as well.

The hedonic pricing model used in our estimation takes into account two sets of variables, structure and accessibility. The structure set is focused on the physical characteristics of the particular apartment, for instance size or number of bedrooms, and the accessibility set contains variables regarding distance features of the property, for example the underlying distance from the closest metro station or the distance from the city center. When looking at other studies focusing on similar topic, we can see, that some of them (Bae *et al.* 2003) use another set of variables namely neighborhood set. The decision not to use the neighborhood characteristic variables is based on fact, that some of them are not easily accessible. In the case of Prague as a whole we rely on the sufficiency of a center distance variable, which together with the metro distance gives us the picture of the concrete apartment location. In the further analysis, the fact that we are working with particular stations is satisfactory. Therefore the apartment price is a function of two sets:

$$P = f(X_s, X_a) \tag{4.9}$$

Where X_s is a set of structure variables and X_a is a set of accessible ones. And broadly taken, the hedonic pricing equation used to estimate the impact of metro proximity is as follows:

$$P = \beta_0 + \sum_k \beta_k x_k + \epsilon \tag{4.10}$$

where k is the number of characteristics.

For each of the research questions a specific combination of apartment characteristics variables is used and the particular equations are estimated using the ordinary least squares method of estimation and the data analysis and statistical software STATA.

Chapter 5

Description of the data

The analysis of metro station proximity impact on apartment prices in Prague is based on two datasets, because of the necessity of using both offer and transaction prices in order to distinguish between the effects on real estate agencies offer prices and real transaction ones. In the case of the prices offered by sellers, all the necessary information including the underlying prices are accessible online on the web pages of real estate agencies. On the other hand, the availability of real transaction prices in the Czech Republic is problematic. The reason is, that although the data are publicly accessible from the databases of cadastral offices, the price of obtaining usable amount of information is high.

Firstly, the data on offer prices are obtained from the real estate server Sreality.cz, which contains real estate offers from the direct sellers. The database is one of the biggest in the Czech Republic and provides daily updated real estate offers which are deprived of dualisms. Based on the filtering mechanism available on the website, the process of obtaining data was automated using automatic web scraping program, Web Scraper. Although the database is logically sectioned and contains information about the real estate locations, it is not possible to export the addresses directly and therefore this problem has been overcome by extracting the real estate coordinates from the map provided by Mapy.cz maps portal. The final extraction contains 5185 apartment offers in Prague with the date of 6.1.2016. However some of the apartment advertisements posted online are not detailed enough, with the location specification only to the quarter or street level. These offers are not suitable for the analysis, because the obtained coordinates are actually the centers of the particular city quarters or streets and therefore biased. After the necessary

removal of apartments with imprecise location coordinates, 2908 apartments are used in the analysis. The data had to be adjusted due to the irrelevance of some apartment characteristics and the divergence of labeling methods on the Sreality website. The final set comprises of 2908 observations on these variables:

- *Price* - the object of our interest, used as a dependent variable in the analysis and representing apartment offer price, based on the pricing of apartments on 6.1.2015. The price is given in Czech crowns.
- *Size* - represents apartment floor area in square meters.
- *MetroDist* - walking distance from apartment to the nearest metro station. The information about the nearest metro station obtained from the real estate server were found frequently misleading, moreover, the distance provided by the sellers are only linear. In order to obtain real undistorted distance, the true walking distance was collected by conversion of both stations and apartments coordinates to their addresses using the reverse geocoding program (Batch reverse geocoding) and secondly calculating the distance between them using Microsoft Excel and Visual Basic, with the usage of Google Maps APIs (Application Programming Interface). The distance is provided in meters.
- *D1000* - also binary variable distinguishing the addresses in vicinity of the metro stations (less than 1000 meters) from the distant ones.
- *M250*,*M500*, *M750*, *M1000*, *MFar* - set of dummy variables indicating the apartment belonging to different distance zones from the metro stations. As an ideal zone width applicable to our case was chosen 250m, because it is wide enough to contain sufficient amount of apartments. The decision to set the distance of 1000 meters as a border between close and distant locations is made based on the nature of Prague transport system, when a better option of transportation is often available in the case of more distant apartments. Starting in the apartment distance of 250 meters and less from the metro station in the case of *M250*, each of the variables equals 1 if the particular apartment is located in the respective 250m zone (thus 0-250m,250-500m,etc.) and the last variable *MFar* equals 1 if the distance of apartment taken into account is more than 1km.

- *Floor* - variable indicating floor of the apartment with 0 as the ground floor.
- *NumBDR* - count variable indicating number of bedrooms.
- *CBDdist* - linear distance from the central business district. As a CBD were used coordinates corresponding to the intersection of streets "Na Příkopě" and "Václavské náměstí". This particular location can be seen as a center of Prague, because of its proximity to the most important Prague addresses. The distance is calculated using Microsoft Excel functions and provided in meters.
- *New* - dummy variable attaining 1 if the apartment is newly constructed, under construction or recently reconstructed and 0 otherwise.
- *Center*,*Middle*,*Suburb* - dummy variables dividing the city into 3 sectors, center (not further than 1750 meters from CBD), middle sector (between 1750 and 4500 meters) and suburb sector (further than 4500 meters). The distances were chosen as they are, because of the accessibility of CBD in 10,30 and more than 30 minutes respectively.
- *Prefab*,*Brick*,*Skeleton*,*Mixed* - set of building characteristics dummies. *Prefab* stands for a prefab construction of the apartment house, *Brick* and *Skeleton* similarly and *Mixed* stands for a combination of used materials.

When looking at the summary statistics of the data in the Table 5.1, it is worth mentioning that the average apartment in the data-set is worth almost 6 million CZK, with 86 square meters of floor area. Moreover,the mean distance from a metro station is more than 1500 meters, with 46% of apartments located in the 1000 meters radius circle around the stations. Interesting fact is the mean distance from the city center, which is more than 5000 meters and we can also state, that there are more newly constructed or renovated apartment buildings than the old ones in our sample.

Secondly, the data on transaction prices, due to the impossibility of obtaining suitable sample from the cadastral offices, come from Deloitte and especially from the Transaction Price Map, which is an application sourcing exclusively data from the Czech Office for Surveying, Mapping and Cadaster and from cadastral offices respective to each location. The information about prices

Table 5.1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.
Price	5931943	4631366	690000	55000000
Size	85.99106	48.95449	20	818
Floor	3.562242	2.020342	-1	9
NumBDR	2.69945	1.041505	1	6
New	.5876891	.4923352	0	1
CBDdist	5125.693	2882.326	75	13630
Center	.1179505	.322605	0	1
Middle	.3425034	.4746286	0	1
Suburb	.5395461	.4985194	0	1
MetroDist	1527.999	1213.499	42	5770
M250	.0357634	.1857317	0	1
M500	.142022	.3491327	0	1
M750	.1825997	.3864045	0	1
M1000	.1004127	.3006011	0	1
Mfar	.5392022	.4985465	0	1
D1000	1527.999	1213.499	0	1
Prefab	.139271	.3462886	0	1
Brick	.6114168	.4875121	0	1
Mixed	.1488996	.3560507	0	1
Skeleton	.1004127	.3006011	0	1
N		2908		

and housing characteristics in the Transaction Price Map database are based on purchased set of completed sale transactions. The access to the application is charged, however for the purpose of the analysis has been given to us a dataset containing information on completed transactions in two parts of Prague, namely surroundings of metro station Jiřího z Poděbrad, located in the wider center of Prague and secondly the prices of apartments around stations Chodov, Opatov and Háje located in the southern outskirts of Prague. Due to the nature of data, the extent of apartment characteristics is not as large as in the case of offer prices. However, the most important variables are included in the final set of 319 apartment units in the case of Jiřího z Poděbrad station and 635 units in the case of three outskirt metro stations vicinities. Consequently, the data set comprises of 954 observations from the years 2013 to 2015 on these variables:

- *Price* - real transaction prices of apartments based on purchase contracts registered by cadastral offices. Price is given in Czech crowns.

- *New* - dummy variable attaining 1 if the apartment is a part of new development project and 0 otherwise.
- *Y2013* - dummy variable distinguishing apartments with purchased contracts signed in the year 2013.
- *Y2014* - The same case as the previous variable but with the signing date in the year 2014.
- *Size* - represents apartment floor area in square meters.
- *MetroDist* - walking distance from an apartment to the nearest metro station. The apartment locations in the original data given by Deloitte include district, street and the house number. Based on these characteristics, precise coordinates were obtained and similarly as in the case of offer prices dataset the closest metro station was found and the walking distance in meters was calculated.

Chapter 6

Empirical Framework

The analysis is divided into 3 parts. We will examine the effect of metro station proximity on apartment values in different ways, firstly in the case of Prague as a whole with the usage of offer prices in the regression, secondly in specific parts of the city and finally we will analyze the difference between metro proximity impact on offer and transaction prices.

6.1 Prague offer prices analysis

In the first part of the empirical analysis, the underlying objective is to examine the effect of metro station proximity on the apartment value in the case of whole city of Prague and with the usage of offer prices data.

In the estimation, we proceed by adding variables into the model and diagnosing the effects of additional explanatory variables.

Firstly, we run the OLS regression only with the basic set of independent variables including *Size*,*MetroDist*,*Floor*,*NumBDR* and *New*. And according to the Table 6.1, the obtained coefficients are statistically significant with the expected signs. In this case, holding other factors fixed, an additional meter from the metro station leads to 572 CZK apartment price decrease, which implies a decrease of 57 200 CZK for another 100 meters. However this model lacks the destination characteristic and therefore suffers from omitted variable bias.

When the *CBDdist* center distance variable is included in order to solve the problem, the *MetroDist* looses its significance. However the high statistical significance of *CBDdist* and its nonnegligible impact indicate, that the distance

Table 6.1: Regression with offer prices

	Model 1 (1)	**Model 2** (2)	**Model 3** (3)	**Model 4** (4)
MetroDist	-572.288***	-7.045	-157.846***	-149.674***
	(45.92)	(48.39)	(43.65)	(44.20)
Size	62832.782***	55097.059***	55565.016***	54866.796***
	(1635.06)	(1533.01)	(1482.14)	(1500.03)
Floor	111685.482***	67963.317**	61203.631*	81888.164***
	(27419.49)	(25182.83)	(24476.52)	(24739.88)
NumBDR	377966.496***	589728.738***	523978.842***	533145.985***
	(76446.16)	(70591.89)	(68382.73)	(68424.47)
New	684686.109***	964831.162***	858336.763***	589246.199***
	(111287.81)	(102620.93)	(99188.93)	(10851.58)
CBDdist	-	-496.110***	-	-
		(21.00)		
Center	-	-	4659261.285***	4651496.157***
			(169845.43)	(177613.40)
Middle	-	-	1531612.770***	1428970.761***
			(111650.88)	(116532.04)
Brick	-	-	-	533423.884**
				(163012.41)
Mixed	-	-	-	1063135.066***
				(201433.77)
Skeleton	-	-	-	1044897.781***
				(217168.25)
Constant	-417193.347*	1346694.880***	-1816018.718***	-2262048.069***
	(200348.75)	(198117.17)	(188880.57)	(219393.56)
R^2	0.600	0.664	0.684	0.688
N	2908	2908	2908	2908

**** p<0.001%, ** p<0.01%, * p<0.05%*
Standard errors in parentheses.

variable should not be left out of the regression. The problem might lie in the high collinearity between *MetroDist* and *CBDdist*, because it is certainly true, that when the distance from metro station is more than lets say 2km it also means, that the particular apartment is not located in the main city center, because if it was, the closest metro station would be definitely closer than 2km. The solution of this problem could be a replacement of direct center distance variable by a set of dummy variables distinguishing between three location zones, center, middle distance and suburb. When including these variables and leaving *Suburb* as a base and looking at the Model 3 in the Table 6.1, we can conclude, that it was a successful step, because the *MetroDist* variable regained significance and the location dummy variables are strongly significant as well. In conclusion, additional meter from the metro station leads to 158 CZK apartment price decrease, which indicates, that the coefficient in Model 1 was overstated.

The final extension of our model lies in the addition of construction characteristics *Brick*,*Mixed*,*Skeleton* and finally leaving *Prefab* as a base. When looking at the results of model 4 in the Table 6.1, we can see, that all of the variables are statistically significant with expected signs and the following effects:

- The answer on the underlying question and that is the impact of Metro station proximity of apartment value is that an additional meter away from the metro station leads to approximately 150 CZK decrease in the property price, which in the longer distance perspective equals to 15 000 CZK per 100m.

- Holding other factors fixed, the effect of additional squared meter of the apartment size results into approximately 54 867 CZK price increase and hand in hand with this result, we can conclude, that the advantage of another bedroom must be paid by more than 533 145 CZK.

- Other verified assumptions are the price premium of more than 589 246 CZK for a new or newly reconstructed building, higher apartment price level in the case of city center and the middle distance zone which mounts up to more than a 4.5 million CZK in the center and almost 1.5 million CZK in the middle distance zone on the contrary to the city suburbs.

- And finally the regression confirmed the idea, that apartments located in prefab constructed buildings should be the cheapest ones. In our case the price difference between brick and prefab units is more than a 530 000 CZK. Additionally, the owners of apartments located in a skeleton units and in a apartment buildings with mixed construction are rewarded by more than 1 000 000 CZK price premium against the owners of apartments in prefab units.

6.1.1 Alternative model with distance zones

A different way of looking at the problem is to replace the direct metro distance variable by a set of dummy variables indicating the apartment belonging to different distance zones from the metro stations: *M250*,*M500*, *M750*, *M1000*, *MFar*. In this alternative model we include all the variables as in the previous approach.

After running the first regression, we can see that the metro distance dummies are not very significant, with only *M750* statistically significant at the 5% level. In order to get a more convincing results, the center distance dummies are replaced by the direct distance variable *CBDdist*, because now when the usage of direct metro distance variable *MetroDist* has been replaced by metro distance dummies, the high collinearity problem disappeared.

Table 6.2: Model with distance zones

	Model 1	**Model 2**
	(1)	(2)
M250	119824.552	36032.703
	(265999.57)	(274311.26)
M500	271140.321	563851.710***
	(156414.02)	(158498.45)
M750	293014.672*	500691.508***
	(138792.86)	(140484.45)
M1000	229228.117	74928.495
	(167449.86)	(172254.38)
Size	54997.075***	54290.444***
	(1503.97)	(1548.99)
Floor	84442.391***	77755.897**
	(24799.74)	(25424.24)
NumBDR	528093.303***	592833.313***
	(68547.20)	(70476.33)
New	596708.822***	733465.946***
	(108685.92)	(112132.12)
Brick	536780.013**	503858.738**
	(163565.08)	(167310.45)
Mixed	1069705.363***	867020.175***
	(204179.31)	(205978.70)
Skeleton	1004260.424***	944858.029***
	(217610.63)	(222020.35)
Center	4692960.094***	-
	(182312.35)	
Middle	1493561.516***	-
	(114661.83)	
CBDdist	-	-461.728***
		(20.81)
Constant	-2631208.093***	609404.856*
	(202252.49)	(265332.30)
R^2	0.687	0.670
N	2908	2908

**** p<0.001%, ** p<0.01%, * p<0.05%*
Standard errors in parentheses.

When looking at the second model in the Table 6.2, it is possible to make more conclusive statements. Firstly the coefficients on *Size*,*Floor*,*NumBDR* are comparable to the ones in the final model of previous approach and are very statistically significant, moreover the construction characteristics have just a little smaller impact on the final price of apartment, the biggest decrease can be seen in the case of Mixed construction, where the price premium compared to Prefab construction is 867 020 CZK. When it comes to strong impact, we have to mention the premium of 733 466 CZK in the case of new or newly reconstructed apartments, which is a greater number than in the previous approach. Additionally, the center distance has a really strong impact, with more than 461 CZK decrease associated with 1 meter distance increase from the city center. Finally, when it comes to the underlying object of our study, the metro distance impact, following outcomes can be concluded:

- Not all of the distance zones variables are statistically significant, namely

M250 and *M1000* are strongly insignificant, on the other hand *M500* and *M750* are strongly significant.

- In the case of *M1000*, the insignificance can be due to the fact, that the station is already too distant from the apartment and other ways of public transport are used instead of the metro and therefore, the metro impact is too diminished to be captured. Even though the variable is statistically insignificant, we can assume, that if there was some small correlation, than it would be positive, however it is not possible to make any numerical judgment based on the coefficient.

- In the case of *M250*, the reason of insignificance is not so obvious. The explanation may lie in the divergent aspects and surroundings of different metro stations. Having an apartment in the immediate vicinity of the metro station can have positive impacts thanks to the low transportation costs, but these benefits might be overweight by the negative aspects of some particular stations, for instance the potential accumulation of criminal activities, possibly greater amount of trash on the ground or higher risk of graffiti on the building. These are just speculations and it is probable, that this description is not applicable to all the stations, however it might definitely be the cause of the insignificance.

- Finally, the biggest and also the statistically most significant impact of metro station closeness on the apartment value was found in the case of 250-500m and 500-750m zones. The price premium compared to the apartments located further than 1000m from the station is more than 563 851 CZK in the case of 250-500m zone and more than 500 691 CZK in the case of 500-750m zone. These impacts are really strong and according to them, we can conclude, that the most demanded area for apartments in the case of metro proximity is the zone between 250-500m far from the station.

6.2 Different parts of the city

In this second section of the empirical analysis, we will have a closer look at different parts of Prague and examine the effect of different metro lines in various city districts. From each metro line three stations in different sections were chosen in order to illustrate the metro effect in different proximities to

the city center. The decision to include exactly these particular stations was made based on the data suitability around these stations, meaning a usable spread of apartments in various distance zones from the particular stations. We use the underlying apartment characteristics variables and use *MetroDist* as a measure of the metro proximity impact. However this time the usage of building characteristics dummies is different and we distinguish only between the prefab and nonprefab buildings. The reason to do so is the smaller sample in the case of some stations and therefore the insufficient number of some kinds of building types in the sample. Therefore the distinction between apartment buildings made of prefab and on the other hand the nonprefab constructed ones is seen as suitable.

Table 6.3: Regressions for individual metro stations- line A

	Skalka	**Jiřího z.P.**	**Staroměstská**
	(1)	(2)	(3)
MetroDist	-315.929*	-1912.890***	-439.632
	(141.55)	(449.25)	(5764.29)
Size	32827.856***	48771.957***	145051.239***
	(5360.54)	(7243.28)	(35703.30)
Floor	-43496.894	202293.273*	304623.113
	(54489.76)	(90190.36)	(572580.20)
NumBDR	490611.204*	817131.347*	2008154.911
	(186187.76)	(365775.13)	(1797641.75)
New	-282515.247	1334742.835***	-3457514.568
	(257836.31)	(372051.21)	(1791787.16)
Prefab	-774187.847*	-	-
	(293927.59)		
Constant	1417957.944*	357889.907	-3666182.411
	(566850.72)	(799058.07)	(4018486.54)
R^2	0.780	0.780	0.760
N	78	97	44

**** p<0.001%, ** p<0.01%, * p<0.05%*
Standard errors in parentheses.

To begin with, the metro line A running from the eastern to the western part of Prague can be in our analysis described by three stations, Skalka as a metro station located in a suburb area of Prague, Jiřího z Poděbrad representing stations located relatively close to the CBD, but still not in the true city center with the distance from CBD around 2 kilometers and finally Staroměstská, station located directly in the Prague downtown. In the case of true center arises a problem of stations closeness, but not only in the case of stations located on one particular line but also when looking at the stations from lines B and C, because each of the three lines runs through the city center and therefore it results into the lack of sufficient data on apartments further from

the stations. However after analyzing the data spread, Staroměstská station was chosen as a representative of the stations located in the center of Prague.

- In the case of Skalka station, our estimation is based on sample of 78 observations and shows us a good picture of the impact with relatively statistically significant variables. When looking at the Table 6.3, we can see that *Floor* and *New* are statistically insignificant, however all other variables are statistically significant at the 5% level, with *Size* strongly significant. The metro distance impact is relatively strong with almost 316 CZK apartment price decrease for each meter further from the Skalka metro station, which implies a 31 600 CZK decrease for 100 meters.

- When it comes to Jiřího z Poděbrad, the first thing to mention is that there are no prefab buildings in the sample which consists of 97 apartments, therefore the *Prefab* is omitted. The reason of the lack of apartments located in prefab buildings in our sample is that we are coping with station in relatively luxury and old area with most of the buildings constructed of bricks. All other variables are statistically significant at the 5% level with the expected signs and the distance from the metro station is reflected in apartment prices by more than 1912 CZK decrease for each meter away from the station which implies a strong impact of 191 200 CZK for each 100 meters.

- Finally, Staroměstská station is located in the most luxurious and oldest part of the city, surrounded by important historical monuments and tourist attractions. The result of the regression as seen in the Table 6.3 is not surprising. The strong statistical insignificance of *MetroDist* can be explained by the fact, that the most valuable apartments are located as close as possible to the so called "high streets", in other words best shopping streets, and also close to the main tourist routes and therefore it is understandable, that the positive impact on the apartments located close to the metro station is somehow diminished or even negligible.

Moving on to the line B, we have a problem of slightly inadequate samples. In the case of some of the station, the sample consists of usable number of apartments, however when looking at the data in detail, it is obvious, that the result would be biased because substantial part of the apartments is often located in one big development project. When using the data in the analysis of whole Prague it does not pose a problem, however when focusing just on a

Table 6.4: Regressions for individual metro stations- line B

	Lužiny	**Anděl**	**Křižíkova**
	(1)	(2)	(3)
MetroDist	-19.475	-195.266	-1145.641
	(323.29)	(372.86)	(973.52)
Size	25415.230***	58963.030***	106155.396***
	(4989.15)	(5400.25)	(19294.37)
Floor	76898.117	30959.245	379103.546*
	(57476.08)	(135510.03)	(173576.40)
NumBDR	806491.500**	796718.841*	-533546.415
	(284177.35)	(307092.49)	(666286.21)
New	-105747.143	896303.165	2495087.830***
	(320645.43)	(466091.08)	(695181.95)
Prefab	-1815787.745***	-	-
	(375003.65)		
Constant	545749.767	-610480.800	-3248904.577*
	(722795.61)	(985946.11)	(1450829.11)
R^2	0.914	0.705	0.716
N	38	143	51

**** p<0.001%, ** p<0.01%, * p<0.05%*
Standard errors in parentheses.

specific station, the bias would be serious. Therefore, two of the stations chosen for the analysis in the case of line B, Lužiny and Křižíkova, are not extensive in size, however are not dealing with this problem. In the case of Anděl, we are not facing this particular problem nor a problem of small sample at all. Firstly, line B runs from the northeastern to the southwestern part of Prague and when looking at the stations chosen, Lužiny is a station located in the Prague's western suburbs, on the other hand Anděl and Křižíkova are stations located around 2 kilometers from the CBD, southwestwards and northeastwards respectively.

- In the case of Lužiny, the impact of metro station as seen in the Table 6.4 is surprisingly insignificant, the reason might be the small sample of only 38 observations and the small amount of apartments located in real vicinity of the station, however there is no visible correlation between the apartment price and the metro distance in the regression.

- Speaking about the station Anděl, our sample consists of 143 apartments, however the *MetroDist* is still very insignificant. Nonetheless the explanation here is more obvious. The whole area surrounding this metro station is accompanied by a lot of tramway lines, therefore substitutes to the metro transport. Transportation by these tram lines is not faster than metro when traveling to the true CBD, however lot of places are reachable by direct trams. In addition, lot of nice residential areas are

located further from the station and away from the lively area around the metro station itself. On the other hand there are also some very expensive apartments located in the vicinity of the station. Altogether the disparity of the area might be the reason of the statistical insignificance.

- Finally, Křižíkova station with 51 apartments in our sample is a third example of insignificant *MetroDist* variable. The insignificance is not that strong as in the two previous cases, nevertheless it is still not possible to conclude a positive impact of metro closeness. The reason here might be following: metro line B in this part of Prague is accompanied by a tram line, which runs into the city center as well and when moving closer to the center, it might be more comfortable to use a tram with a minimum of walking instead of taking a walk to the metro station. Moreover when moving away from the metro line but not closer to the city center, it might also show that the fastest way to reach the desired destination is often to take a tram or a bus.

Table 6.5: Regressions for individual metro stations- line C

	Vltavská	**Kobylisy**	**Háje**
	(1)	(2)	(3)
MetroDist	2381.302***	-525.439*	-311.169**
	(452.29)	(255.32)	(104.33)
Size	34951.788***	15274.413***	27363.610***
	(8308.93)	(3185.40)	(3719.90)
Floor	71301.100	232738.441*	-83322.796*
	(78377.12)	(108594.21)	(32460.71)
NumBDR	1093618.971**	1595595.908***	272369.565*
	(322843.85)	(242251.00)	(117936.49)
New	663505.594*	279203.604	-284399.922
	(316422.87)	(469665.72)	(198599.64)
Prefab	-1845037.099	-1008695.378	-1417007.189***
	(1291975.29)	(552066.27)	(309827.58)
Constant	-2820065.565***	-517601.169	2603463.691***
	(749449.20)	(948775.32)	(506902.73)
R^2	0.789	0.776	0.937
N	72	84	39

**** p<0.001%, ** p<0.01%, * p<0.05%*
Standard errors in parentheses.

Finally, line C connects city center with the northern, northeastern, southern and southeastern parts of Prague. The stations representing this line in our analysis are Vltavská, just two stops away from the true city center, Kobylisy station located around 5 kilometers in a straight line from the CBD and Háje, which is a terminal station in the southeastern Prague suburbs.

- In the first place, we have a really interesting result in the case of Vltavská station, because the coefficient on *MetroDist* is positive and statistically

very significant, meaning an increase of apartment value when moving away from the station. Expressed in numbers based on the Table 6.5, each meter away from the station results into more than 2381 CZK increase of apartment price which implies a 238 100 CZK increase in the case of 100 meters. However, when looking at the situation from the Prague inhabitants point of view, moving away from the Vltavská station could also mean getting closer to the beautiful park Stromovka and the nice residential area of Letná. Additionally, the surroundings of the station and station itself are not particularly nice and frequently occupied by homeless people. Having these facts in mind, the positive sign of *MetroDist* seems to be reasonable.

- Moving to Kobylisy, the positive sign of the *MetroDist* coefficient is as expected and the impact of more than 525 CZK loss in apartment value for each meter away from the Kobylisy station seems to be reasonable, because of metro transport being the fastest way of reaching the city center in this part of Prague. Multiplying this number by 100 we get the 52 500 CZK price decrease associated with 100 meters increase in distance.

- In the case of almost 10 kilometers distant station as viewed from the CBD, Háje, despite only 39 apartments in the sample, we have a credible results implying a negative correlation between the metro station distance and the apartment value. Transformed into numbers, the impact equals more than 311 CZK decrease in apartment value for each meter away from the Háje station resulting into 31 100 CZK for each 100 meters. The result seems to be trustworthy because of the high R-Squared and also thanks to the fact, that transportation by metro is by far the fastest way to reach the city center in this part of Prague.

6.3 Transaction vs. offer prices

In this section we will cover the question, whether there is a difference between the impacts of metro proximity on offer and transaction prices. As was previously mentioned, the difference between these two types of prices according to Deloitte (2012) might be even more than 10%. To analyze this issue, we will use both offer and transaction prices datasets. The arising obstacle is the different nature of those sets. When talking about the offer prices, we have a data from

one particular day in January 2016, however in the case of transaction prices, the data come from the years 2013, 2014 and 2015, additionally they are more narrow than the offer ones. The way out of this problem lies in the narrowing of offer prices dataset to the level of the transaction one and also changing the form of variables *Price*, *MetroDist* and *Size* to logarithmic in order to be able to compare the impact between these two distinct samples. In the case of transaction prices, year indicating dummy variables *Y2013* and *Y2014* are included, leaving apartments from 2015 as a base. Because the transaction data are not easily accessible in a large amount and we are restricted only to stations Jiřího z Poděbrad as a representative of center stations and Chodov, Opatov and Háje in the case of suburbs, moreover with only basic set of variables, we need to be cautious when interpreting the results.

Firstly, we will have a look at the station Jiřího z Poděbrad. When looking at the average offer and transaction price for square meter in the first quarter of 2015, using our transaction prices data and offer prices data adjusted for the passage of time using the offer price index for Prague, we have a result of 57 601 CZK in the case of real transactions and 67 871 CZK in the offer sector. This means, that the difference was almost 18%. Having that in mind, we can have a look at the Table 6.6.

Table 6.6: Comparison- Jiřího z Poděbrad

	Transaction	**Offer**
	(1)	(2)
logMetroDist	-0.113**	-0.223***
	(0.04)	(0.04)
logSize	0.940***	0.867***
	(0.05)	(0.06)
New	0.399***	0.248***
	(0.05)	(0.05)
Y2013	-0.150	-
	(0.08)	
Y2014	-0.098*	-
	(0.04)	
Constant	11.924***	13.143***
	(0.35)	(0.42)
R^2	0.637	0.793
N	319	99

**** p<0.001%, ** p<0.01%, * p<0.05%*
Standard errors in parentheses.

The first thing to mention is, that the sample sizes are distinct. We have 319 observations in the case of transaction prices sample and 97 in the case

of the offer one. It is also probable, that not all of the variables affecting the apartment prices are included. Despite this fact it is possible to make several conclusions:

- In the case of transaction prices, holding other factors fixed, 10% increase in the metro distance leads to 1.13% decrease in the apartment value.
- In the case of offer prices, 10% increase in the metro distance leads to 2.23% decrease in the apartment value.

This is a strong imbalance between the two results. However, the reason might lie in the difference we stated earlier and that is the 18% gap between average offer and transaction prices. This divergent valuation of property might imply that the premium of having a metro station close to the apartment might be overstated from the seller side and in reality, the capitalization of metro closeness into apartment value is lower. The actual difference between the impacts could be lowered when adding other explanatory variables into the model, however it is obvious, that the divergence is substantial.

Table 6.7: Comparison- Chodov, Opatov, Háje

	Transaction	**Offer**
	(1)	(2)
logMetroDist	-0.021	-0.007
	(0.03)	(0.03)
logSize	0.938***	0.749***
	(0.03)	(0.04)
New	0.418***	0.085**
	(0.02)	(0.03)
Y2013	-0.129***	-
	(0.03)	
Y2014	-0.062**	-
	(0.02)	
stHAJE	0.018	0.003
	(0.03)	(0.04)
stOPATOV	0.015	-0.027
	(0.03)	(0.04)
Constant	10.978***	11.833***
	(0.20)	(0.25)
R^2	0.798	0.804
N	635	91

**** p<0.001%, ** p<0.01%, * p<0.05%*
Standard errors in parentheses.

Secondly, the comparison in the case of southern part of the line C, particularly stations Chodov, Opatov and Háje, is not easy. In the previous case we were dealing with a station in old and luxury part of Prague with no prefab

buildings in the offer sample (and probably in the transaction sample as well) and therefore the problem of not including the building characteristic variables did not posses such a big problem. However here the problem of omitted variable bias is very probable, because as was discovered in the section 6.2, the *Prefab* dummy variable was strongly statistically significant in the case of suburb station Háje. Unfortunately our data in the case of transaction prices are not as wide and we are not able to include the building characteristics into our model. When looking at the Table 6.7, the results are not as expected, the not inclusion of building characteristics dummies probably leads here to bias of both models. *logMetroDist* is not statistically significant even on low significant levels and therefore the difference between impacts can not be reliably interpreted.

Chapter 7

Conclusion

When analyzing the impact of metro proximity on apartment prices in Prague, the main obstacle is the collection of data. Real estate offer prices are publicly available, however the real transaction ones are hard to reach. Therefore the main research questions were examined based on the data on apartment offer prices with more apartment characteristics. In particular, the two underlying questions were to analyze if there is a statistically significant impact on apartment prices in the case of Prague as a whole and if the results differ in the case of different parts of Prague and various metro lines. Additionally, it was examined, if there is a significant difference between the impacts on offer and transaction prices.

Regarding Prague as a whole, two different approaches were applied. Firstly, single variable was used to indicate the distance of apartments from their closest stations in meters. In this case the impact reached 14 967 CZK for each additional 100 meters away from the station. The second approach was based on the distance zone variables, each indicating a certain 250 meters wide distance ring from the station closest to the particular apartment. The results showed strong statistical insignificance of impacts in the 0-250m and 750-1000m zones, probably due to the different aspects and surroundings of various metro stations in the first case and possibility of better option of transport in the case of quite far 750-1000m zone. On the other hand, it was proven, that the apartment location in 250-500m and 500-750m zones has a positive price impact of 563 851 CZK and 500 691 CZK respectively, compared to the apartments located further than 1000 meters from the station.

The extensive problem of different impacts in various parts of Prague was simplified to three representative stations on each of the three Prague metro lines. The strongest negative correlation was found in the case of line A station Jiřího z Poděbrad with 191 200 CZK apartment price decrease for each 100 meters away from the station, on the other hand, surprising really strong positive correlation was found close to the station Vltavská with 238 100 CZK apartment price increase for each 100 meters away from the station. Altogether, despite the statistical insignificance in the line B regressions, the positive impact of metro closeness prevailed in most of the examined suburb stations, the ones located in the midway to the center showed diverse effects on apartment prices and finally, the only true center station examined, Staroměstská, confirmed the assumption of diminishing benefit of having apartment close to the metro station in the case of the city center.

What concerns the different impact on offer and transaction prices, our analysis showed overvaluation of metro closeness in the case of offer prices. Speaking about line A station Jiřího z Poděbrad, holding other factors fixed, 10% increase in metro distance leads to 2.23% decrease in apartment value and that is 1.13% more than in the case of transaction prices. However, the other estimation in the southern suburbs of Prague showed us, that the transaction prices dataset is too narrow to make clear conclusions on this topic.

The models presented in out paper can be further extended by adding additional explanatory variables as another location or building characteristics. This extension might lead to slightly different and more robust results, however the access to certain data was not possible in the time of writing this thesis. Nevertheless, the results have demonstrably shown, that there is a provable impact of metro proximity on apartment prices in Prague.

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