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FACULTY OF SOCIAL SCIENCES
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Working in Prague but living in Central Bohemian Region, is it financially worth it ?

Bachelor thesis

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Declaration of Authorship

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Prague, July 31, 2020

Lukas Biro

Abstract

The thesis analyses the costs of rental offers in Prague vs. four districts in CBR (Central Bohemian Region): Kladno, Příbram, Kolín, and Mladá Boleslav. We use data from the real estate agency to calculate the net present value of the costs of each apartment and compare it between the capital city and the districts in CBR. To do that, couples of the apartments (one from Prague and one from CBR district) are created based on matching characteristics. We assume individuals commute to Prague every workday and estimate their transportation and time costs. We evaluate 6 different scenarios and perform a sensitivity analysis of five different variables to see their effect on the probability that Prague is more expensive than one of the four districts mentioned above. The results suggest that Mladá Boleslav is unprofitable while the other three areas are comparably expensive to Prague in case an individual uses transit commuting, earns a low salary, or commutes by a car while keeping the cost of 1 km of around 2 CZK. Similarly, the annual growth rate of rental prices between 6 and 8 percent in all districts would result in comparable profitability of Kladno, Příbram, and Kolín to Prague.

JEL Classification:	R11, R21, R31, R41
Keywords:	housing market, Prague, rental offers, net present value, transportation, cost estimation, Central Bohemian region

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Abstrakt

Práce analyzuje náklady na pronájem v Praze vs. čtyři okresy v Středočeském kraji (SK): Kladno, Příbram, Kolín a Mladá Boleslav. Údaje z realitní kanceláře používáme pro výpočet čisté současné hodnoty nákladů na každý byt a jejich porovnání mezi hlavním městem a okresy v Středočeském kraji. Za tímto účelem se vytvářejí páry bytů (jeden z Prahy a jeden z okresů SK) na základě odpovídajících charakteristik. Předpokládáme, že jednotlivci dojíždějí do Prahy každý pracovní den a odhadujeme náklady na dopravu a čas. Vyhodnocujeme 6 různých scénářů a provádíme analýzu citlivosti pěti různých

proměnných, abychom viděli jejich vliv na pravděpodobnost, že Praha je dražší než jeden ze čtyř výše uvedených okresů. Výsledky naznačují, že Mladá Boleslav je nerentabilní, zatímco ostatní tři oblasti jsou pro Prahu srovnatelně drahé, pokud jednotlivec používá tranzitní dojíždění, vydělává nízký plat nebo dojíždí autem při zachování nákladů 2 Kč na 1 km. Podobně by roční růst cen nájemného mezi 6 a 8 procenty ve všech okresech vedl ke srovnatelné ziskovosti Kladna, Příbrami a Kolína i Prahy.

Klasifikace JEL:	R11, R21, R31, R41
Klíèová slova:	trh s nemovitostmi, Praha, nabídky pronájmu, čistá současná hodnota, doprava, odhad nákladů, Středočeský kraj
Název práce	Pracovat v Praze, ale žít ve Středočeském kraji. Vyplatí se to finančně?
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Bibliographic Record

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Acronyms

CZK Czech Crowns

VOT Value Of Time

NPV Net Present Value

CZSO Czech Statistical Office

CSV Comma Separated Value

CBR Central Bohemian Region

CBRD Central Bohemian Region District - one of the four districts (Kladno, Příbram, Kolín, Mladá Boleslav)

CBRDs Four Central Bohemian Region Districts (Kladno, Příbram, Kolín, Mladá Boleslav)

Bachelor's Thesis Proposal

Author	Lukáš Bíro
Supervisor	Mgr. Vít Macháček
Proposed topic	Working in Prague but living in Central Bohemian Region, is it financially worth it ?

Research question and motivation The main objective of the thesis is to do a cost analysis of renting flats in Prague vs. renting flats in 4 districts in Central Bohemian Region, namely, Kladno, Kolín, Příbram, and Mladá Boleslav. The underlying assumption for the analysis is that the person renting the apartment is commuting every day to Prague's city center for work. The important part of the analysis is to financially evaluate time spent traveling to work by different transport modes and use this as a factor in cost analysis. In this manner, there is no research done at all. The most similar works compare the profitability of renting to house ownership. The main motivation to conduct the analysis is growing rental prices in Prague and above-average salaries in the capital. The trend of increasing prices for renting is clear, forcing people towards finding alternatives to living in Prague. Furthermore, there is a study that many people live in the Bohemian region and travel to Prague because of work daily (CZSO, 2013). According to this study, many people commute long distances to work outside their home region. This was a primary source of our motivation together with many friends considering living far outside the city.

Expected contribution The topic has not been studied from this perspective for the local area. The literature regarding the comparison between investing in renting in Prague versus renting in nearby districts in the Central Bohemian Region is lacking. However, a bachelor thesis done by Tláskalová (2018) analyzed the costs and benefits of renting vs. house ownership in Prague in detail. In her thesis, she examined all the benefits and costs of renting vs. buying apartments and evaluated it using net present value formula in different investment strategies. All this served as a source of inspiration, and our analysis is similar in data extraction, creation of

datasets, and methodology of calculating NPV. However, apart from the completely different research question, this work varies in multiple ways as it compares four different districts in the Central Bohemian Region with Prague and will take daily commuting to work into account with direct transportation cost and the cost of lost time. This is a completely new methodology, as no work attempted to use the value of time with housing choice preference. In this manner, this work is aimed at individuals who cannot afford to buy an apartment or do not want to do it for personal reasons. In order to do the analysis correctly despite simplifying assumptions that are going to affect the results, we will model multiple parameters to account for the problem. Hopefully, by analyzing recent data, this work can serve as a guide and useful overview of alternative housing choices for someone working in Prague.

Methodology The data about rental offers for all districts will be obtained from website sreality.cz using programming language Python. Next, we will use coordinates of the apartments to calculate distances and travel times to the center of Prague using Google Maps API. Similarly, as did Tláskalová (2018), after data preprocessing, we will use these formulas for net present value to calculate the profitability of rental offers:

MR = R + MRI

AR = 12*MR

PVR = (AR/(r - g))*(1-((1+g)/(1+r)))

where MR = monthly rent, AR = annual rent, MRI = monthly renter's insurance, PVR = present value of rent

Transportation cost is accounted for based on the mode of transport. Financial estimation of commuting will heavily depend on the income of an individual. The value of car transportation time will be calculated as:

PVTC = DS/1000*2*WD*KMC*t

where PVTC = transportation cost, DS = distance in meters, WD = workdays in one year, KMC = cost of 1 km in Czech crowns, t = time period in years.

The value of transit transportation time will be calculated as:

PVTC = ATP * t

where PVTC = transportation cost, ATP – annual transport pass, t = time period

in years.

In order to see the effect of the value of time on the profitability, we will model all possible cases it can obtain and analyze results. We will calculate it for all five districts to be able to compare four districts in the Central Bohemian Region with the alternative of living in Prague.

Outline

1. Introduction to the topic.
2. Literature Overview
3. Data
4. Methodology
5. Results
6. Conclusion

Core bibliography

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Author Supervisor

Chapter 1

Introduction

In recent years, living in Prague has become a massively discussed public topic. Prague is the financial center of the Czech Republic with the highest average salary but also the highest cost of apartments by quite a substantial margin (CZSO 2019a). The growing prices of both renting and buying force people to explore a wide range of options with regards to living. Simultaneously, the banking sector is strongly regulated after the financial crisis with the criteria one needs to fulfill for a loan being consistently stricter. These facts lead to struggles connected with ownership of an apartment, which is, according to a recent bachelor thesis by Tláskalová (2018), from a purely financial perspective less profitable than renting in most of the cases. Multiple other sources supported the fact that renting may be an advisable solution. According to the article by Shutterstock (2019), 32% of people lease the apartment in Prague, while numbers in other metropolises are much higher: e.g. London – 49%, Amsterdam – 70%, Hamburg – 76%, Vienna – 78%, and Berlin – 84%. Furthermore, the prices of new apartments increased by 80% from 2014 to 2018. At the same time, the rental prices increased by 42%, but the average gross wage only by 22%. It is expected that Prague's numbers will rise in future years. The article concluded that the number of people not able to afford to rent in Prague is going to increase in the subsequent years and with the solution of moving into the CBR to rent.

The trend of moving from Prague to CBR was supported by CZSO in their press release published in March (CZSO 2020b). It was stated that the biggest migration of people within the Czech Republic was from Prague to CBR, with 14.8 thousand people moving there in 2019. Only 7.4 thousand moved in the opposite direction (from CBR to Prague).

The aforementioned reasons motivated us to analyze and compare the cost of renting in Prague versus renting in 4 districts in CBR, namely, Kladno, Příbram, Kolín, and Mladá Boleslav while commuting to Prague daily during the workweek. The original idea behind the thesis was to compare renting in Prague vs. the 4 most populated cities in CBR only. However, the whole districts in CBR are analyzed due to a small number of offers in the cities. The 4 districts were also chosen because they surround Prague from every cardinal direction. We recognize there are 2 districts of Prague-East and Prague-West that belong to CBR and are a popular place to move to due to their proximity to the capital. However, they are not considered in our analysis as they do not contain populated cities and their closeness to Prague means our crucial concepts in the thesis, i.e. the effect of commuting and Value of Time, may not be as apparent. Finally, we are more interested in seeing whether it would still be reasonable to live in more distant locations and do long-commute to Prague daily.

To perform the cost analysis, rental offers from the 4 districts are matched to rental offers in Prague, while keeping the characteristics of the apartments the same. We subsequently identify 3 types of costs – apartment costs, transportation costs, and opportunity costs of commuting. Their net present value is calculated, summed, and compared between the apartments. Many other factors affect individual renting decisions; however, as they are often based on preferences and utility, they are not included as costs in the thesis.

The research questions we would like to answer are: Is renting outside Prague financially more profitable than renting in the capital when commuting to Prague daily? What role do different transportation modes play in the decision process? How sensitive are the results to the variables such as rental growth rates of individual districts, km cost of car travel, and net wage?

The thesis is structured as follows. Chapter 2 provides an overview of the bibliography for the thesis and presents the results. Chapter 3 describes the process of extraction, preprocessing, and matching of the data in detail, as well as the description of the variables and the datasets. The subsequent Chapter 4 presents the methodology with models, formulas, model's inputs with their specifications. Furthermore, the concept of sensitivity analysis derived from default scenarios is also explained. Chapter 5 presents and comments on the results. Finally, we conclude the thesis and discuss the implications of the results in Chapter 6.

Chapter 2

Literature Overview

Literature regarding the comparison of the profitability of rental housing in different locations is lacking. Furthermore, no research tries to explore this phenomenon by including commuting cost and time as a central aspect of the analysis. Most of the existing literature focuses on similar topics such as the comparison of profitability of renting vs. house ownership, household and long-distance commuting, motivation to choose a particular type of commuting, or an estimation of the Value of Time. Since these are the most important concepts to our thesis, they are summarized here.

2.1 The profitability of renting vs. house ownership

In the thesis of Tláskalová (2018), she used cost-benefit analysis to compare the profitability of renting vs. apartment ownership in Prague. She obtained the data from sreality.cz at the beginning of March 2018 for both rental and buy offers. A method of creating offer pairs by matching apartments based on their mutual characteristics such as total living area, number of rooms, floor number, construction material, and property status was proposed. By using previously available information about the Czech economy, Tláskalová assumed values of rental growth, interest rate, etc. Subsequently, different investment strategies were compared, namely: renting - renting a bigger apartment, buying an apartment - selling it - buying a bigger one, buying an apartment-renting it-buying another one with a strategy of lifelong renting (30 years). For each of the 3 strategies, she observed 4 different groups of apartments. The net present value of costs and benefits was calculated and compared for each apartment in each

observed group. The matching pairs enabled her to compare the apartments and decide which one is more profitable. In this manner, the work concluded that ownership was more profitable than renting only in 1 out of 12 observed groups in the city of Prague, subject to the aforementioned assumed values.

Tabner (2008) compared renting vs. house ownership in the United Kingdom by using the Gordon Growth model. This model is generally used in finance to determine the intrinsic value of future dividends with a constant growth rate. For his analysis, he observed 6 potential groups of purchasers, which differed in terms of funding and different marginal tax rate. The results of the analysis should allow different groups of purchasers to estimate the present value of rental income more precisely, thus allowing them to more rationally decide whether to rent or buy a property. Tabner (2008, p.12) concludes that:

> If the UK property market continues to be attractive as a place for wealthy foreign investors to park their money, as suggested by some property investment management firms, disciplined risk reward analysis will make renting relatively more attractive than buying, for less wealthy unfunded housing consumers. However, studies of household finance such as Campbell (2006) indicate that poorer families tend to make less sophisticated financial decisions that result in a transfer of wealth from less wealthy to more wealthy households.

This result confirms the trend that rental housing may become more attractive than buying for poor households.

2.2 Households and long-distance commuting

Long-distance commuting is a well-researched phenomenon with a plethora of literature discussing the issue. Most of the research focuses on assessing variables that explain it well from the econometric perspective. Our focus is put on papers that look at housing, household income, or household size as their primary objective in explaining long-distance commuting. Papers about long-distance commuting focusing on other variables are neglected.

To start with, literature in Europe is not clear about the definition of long-distance commuting, with Sandow & Westin (2010) indicating 30km, whereas

Holz-Rau *et al.* (2014) prefer 100km. For our purposes, 30km seems more fitting, as that is approximately the radius of Prague's district. In other words, commuting from outside Prague's district will be considered long-distance commuting.

In the aforementioned paper, Sandow & Westin (2010) analyze data between 1995 and 2005 and cover all long-distance commuters in Sweden. Surprisingly, their results indicate that a higher income generally results in a continuation of long-distance commuting for more years. Also, importantly, it is a strategic choice, more so than a solution only for a few years. Slightly different results were drawn in the USA, where Marion & Horner (2008) analyzed a relationship between income and extreme commuting (exceeding 90 minutes), concluding with the fact that the probability of this type of traveling increases as household income decreases.

Staying in the same region, more specifically in the area of California, Mitra & Saphores (2019) try to examine the determinants of long-distance commuting and how apartment costs around employment centers affect them. The proposed hypothesis of a strong relationship between long-distance commuting and median housing costs was confirmed. The job-housing ratio also proved to be very significant, which is consistent with a study by Zhao *et al.* (2011). The lack of housing affects mostly low-wage workers, as they travel long distances to make up for lower wages.

Plaut (2006) used data from the American Housing Survey from 2001 to analyze commuting decisions of spouses in dual-income households. However, only dual-career married couples commuting to work by car were used as a sample. Therefore, the results are not applicable to other modes of transport. The study concluded that the value of housing is positively correlated with commute time, meaning that couples often travel longer to enjoy more luxurious accommodation. Additionally, income sensitivity to travel time is approximately the same between genders, with women being slightly more sensitive. This result indicates that due to almost equal income sensitivity to travel time, we do not have to make assumptions on the gender of the potential tenant. Plaut (2006) also states that couples do not trade commuting time one for each other. Both time and distance appear to be strongly complementary, meaning that decisions affect both in the same direction in either shorter or longer commuting. This fact is, however, in contrast with previous research done by Davis (1993). The paper concludes that commuting decisions are made jointly rather than separately. To conclude, studies have found conflicting information about

whether greater income results in commuting longer distances. As Dargay & Van Ommeren (2005) conclude, the conflicting impacts of increasing income on commuting time - the positive effect of the demand for higher quality dwelling and the negative effect of an increasing value of time demand – just about cancel each other out.

2.3 Value of Time

As defined by Brůhová-Foltýnová (2010, para.2): "Value of time is the subjective value of travel time. It is the amount the individual is willing to pay in order to reduce his/her travel time by one unit."

The textbook Economics of urban transportation, Small *et al.* (2007), suggests using a share of the hourly wage as a way to express an approximation of the Value of Time.

Brůhová-Foltýnová (2010) used the comparison of logit, multinomial probit, and mixed logit models on 763 observations that were collected during working days in Pilsen in 2005. The study concluded with multiple claims. The VOT was reported to be between 35% and 42% of the average hourly wage. The results are quite robust to various models that were used. Other purposes seem to imply lower values than travel to work. Furthermore, public transport displays higher values of time than traveling in a car.

According to Van Ommeren *et al.* (2000), VOT is sensitive to the distance of commuting. Furthermore, it was found that it is around 33% of the hourly wage for commutes of less than an hour round trip with the value being doubled for longer commutes. Also, VOT increases with income, although less than proportionally. Waiting time and walking are valued from 2 to 2.5 times higher than in-vehicle time or 1.6 to 2 times higher than in-vehicle time in case of waiting or walking for transit. The paper concludes that VOT is usually between 20% and 90% of the gross wage rate for personal journeys, with an average of approximately 50%.

Literature concerned with comparing renting and buying focused on the commuting context was not found.

Chapter 3

Data

In this chapter, the process of obtaining, preprocessing, and matching the data is presented.

3.1 Extraction

To perform the cost analysis of renting, we need to obtain a dataset containing rental offers from 5 different districts: Prague, Kladno, Příbram, Kolín, and Mladá Boleslav. The data was scraped from sreality.cz, real estate server with housing offers. It is chosen because of its multiple advantages. Firstly, it is the largest database of apartments for the analyzed region. Secondly, it is frequently updated and does not contain duplicate offers. Lastly, data for rental offers are adequately structured and highly detailed. The data was requested using Python. It was used to pull the data from the public API of sreality.cz using *requests* library. The process to obtain all the offers for 1 district involved calling 2 different types of requests. The first type looks like this:

https://www.sreality.cz/api/cs/v2/estates?category_main_cb={}&category_type_cb={}&locality_district_id={}&locality_region_id={}&per_page={}&page={}

Sreality.cz was fed with parameters specified in Figure 3.1:

The request returns a JSON from which it is possible to extract an ID of each offer corresponding to the specified search.

Each ID was subsequently supplied to another API search:

https://www.sreality.cz/api/cs/v2/estates/{ID}

Figure 3.1: Sreality.cz API parameters

- category_main_cb - specifies the type of housing
  1. **Apartments**
  2. Houses
- category_type_cb - specifies the type of the contract
  1. Selling
  2. **Renting**
- locality_region_id - specifies the country's region
  10. Prague Region
  11. Central Bohemian Region
- locality_district_id - specifies the district within the specified region
  50. Kladno
  51. Kolín
  53. Mladá Boleslav
  58. Příbram
- per_page - specifies the number of offers per page, default is 20 offers, but 40 or 60 can be chosen
- page - specifies the number of the offer page

Source: Own construction about public API of sreality.cz

where the ID is in the last part of request

The request returns detailed information (Subsection 3.3.1) about the offer in JSON format. This information was downloaded for each offer. Subseqently, information about all the offers for one particular district was stored in CSV. The whole process of extraction was repeated for each district, and the CSVs were merged together to create a single dataset. The data of all rental offers was requested on February 25th, 2020.

3.2 Preprocessing and cleaning the data

The first step of preprocessing was accounting for missing values, inconvenient naming, or getting rid of irrelevant characteristics. Next, 78 offers with no price tag were removed, out of which 76 were in Prague, 1 in Kladno, and 1 in Mladá Boleslav.

The other issue was that prices in the Prague city center are much higher than on the periphery. This can distort the whole profitability as the expensive apartments in the city center can outweigh the effect of affordable flats in the suburbs. Moreover, it is assumed that people considering leasing in districts outside of Prague will do so because of financial reasons. They will not be interested in renting in the expensive city center but in the cheaper periphery. Therefore, offers in the city center are excluded from the analysis.

To find the reasonable boundary between the city center and periphery, the following set of steps is performed:

1. The boundary is set at a 100 meters of air distance from Venceslas Square splitting the Prague's dataset on the city center and the suburbs

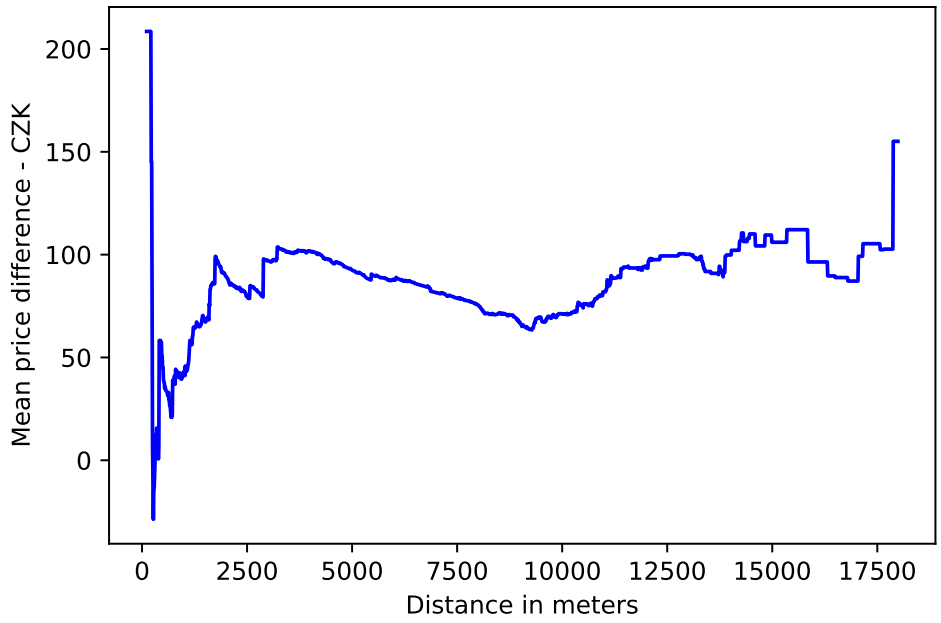
2. The mean price for 1 m^2 is calculated for both the city center and the suburbs

3. The mean price of the suburbs is subtracted from the mean price of the city center resulting in the mean price difference

4. Steps 1 – 3 are repeated, always adding 10 meters to the boundary until it reaches 17990 meters. Once the value is reached, the algorithm stops.

The resulting graph displays the distribution of the difference between the mean value for $1m^2$ in the city center and the rest of the city (Figure 3.2). It can be observed that in order to maximize the difference in mean prices,

Figure 3.2: Mean price difference between the center and the suburbs



Source: Own construction based on data from sreality.cz

the city center would have to be a 100m of air distance surrounding Venceslas Square. Setting this value for the city center range would not be practical as very few apartments fall into such a small range. Observing the figure, it was decided that the optimum size of the city center would be between 2500 and 5000 meters. The local maximum in this range is at 3230 meters. Therefore, offers are considered to be on the 'periphery' if their air distance is greater than 3.23 km from the Venceslas Square and in the 'city center' if the air distance is lower or equal to 3.23 km from the Venceslas Square. As a result, 3012 observations in the city center are dropped.

After the initial preprocessing, the number of observations for the individual districts is summarized in Table 3.1.

Table 3.1: Number of observations in each district

district	Number of observations
Prague	2457
Kladno	98
Příbram	30
Kolín	37
Mladá Boleslav	59

Source: Own construction based on data from sreality.cz

3.3 Description

3.3.1 Description of variables

These are the variables present in all datasets that are necessary for further analysis:

Price

The variable represents the cost of the monthly rent. The reported price may be distorted as sometimes it represents the final cost, and sometimes it may be further elevated by various fees, such as utilities, garage and real estate agency fee. Table 3.2 describes the distribution of price with comments specifying whether fees are involved or not. All districts have a similar ratio of the final price to price with fees. The effect of the distortion should be approximately the same in all districts, therefore, it is further neglected. The cost of the monthly rent used in the analysis will be represented by the reported price. The units of the variable are Czech crowns.

Size

The size of the apartment is presented in square meters and includes only the living area. It does not include a balcony, a terrace, a garage, and a cellar.

Number of rooms

This variable represents the number of habitable rooms without counting hallways, bathrooms, toilets, and storage rooms. The standard notation marks the location of the kitchen – kk means that one of the rooms contains a kitchenette,

Table 3.2: Distribution of price comments

	Empty	Without fees	With further fees	Unspecified
Prague	25.8%	7.7%	53.3%	13.2%
Kladno	19.4%	12.3%	46.9%	21.4%
Příbram	33.3%	3.3%	36.7%	26.7%
Kolín	24.3%	8.1%	46.0%	21.6%
Mladá Boleslav	22.0%	16.9%	45.8%	15.3%

Note:
Empty – no entry in price comments
Without fees – matching strings: 'bez poplatků', 'včetně'
With further fees – matching strings: 'Poplatky', '+', 'plus', 'Plus', 'polatky', 'poplatky', 'zálohy'
Unspecified – not matching strings: 'bez poplatků', 'včetně', 'Poplatky', '+', 'plus', 'Plus', 'polatky', 'poplatky', 'zálohy'

Source: Own construction based on data from sreality.cz

while +1 means that the kitchen is in the separated room. Therefore, for example, 2+kk = 2 and 2+1 = 3. In this manner, the room with a kitchenette is not considered to be equal to a room without it. The number of rooms ranges from 1 to 6.

Floor

This variable is turned into a dummy because full detail is not needed. In general, living on the first floor is seen as disadvantageous and is demanded by fewer people. Therefore, the variable takes a value of 0 if the apartment is on the lowest or the first floor, otherwise, it takes a value of 1.

Construction type - Brick dummy

There are originally 7 different types of construction: Brick, Panel, Mixed, Skeleton, Wooden, Stone, and Prefabricated. Brick dummy is created having a value of 1 if the apartment is made from brick, otherwise it has a value of 0.

Property status – Newly built dummy

There are originally six different types of property status: Newly built, Very good condition, Good condition, Bad condition, After reconstruction, and Be-

fore reconstruction. A newly built dummy is created, having a value of 1 if the apartment is newly built. Otherwise, it has a value of 0.

Coordinates

GPS location of each offer.

Distance and duration variables calculated from Prague's city center

There are four more variables based on the distance between the apartments and the city center of Prague:

- the car commuting duration between the apartments and Prague's city center
- the car commuting distance between the apartments and Prague's city center
- the transit commuting duration between the apartments and Prague's city center
- the air distance between the apartments and Prague's city center

The connection between the variables lies within the 2-step process used to obtain the values. The first step is to choose a place to represent the city center of Prague. Venceslas square was chosen since its location and character fulfill the conditions the best. It is the central place of action and is geographically located in the middle of the city. Furthermore, it is one of the main shopping and tourist places of the capital. Thus, it seems the most suitable place to represent the city center of Prague. The second step involves feeding the specific algorithm with coordinates of the apartments and the coordinates of the Venceslas Square (50.081295, 14.428038). However, the algorithm differs for all 4 variables and is described separately for each of them.

The car commuting distance and duration from Prague's city center

The variables were obtained using Google Distance Matrix API. The request looks like this:

https://maps.googleapis.com/maps/api/distancematrix/json?origins=50.081295,14.428038&destinations=50.0056202822706,14.4290776869966&mode=driving&key={}

The parameters *origins* and *destinations* require the coordinates to be in the form of latitude, longitude. The origins and destinations were supplied with coordinates of Venceslas Square and the coordinates of the individual apartments, respectively. The parameter *mode* specifies the travel mode which is set to driving. The last parameter *key* serves as a unique code for Google to bill the customer as it is a paid service.

The response of the request is the duration of the car commuting from the origin to the destination in seconds and the distance in meters. Google states that the returned duration should be the best estimate of travel time, incorporating information about historical traffic conditions and live traffic. Live traffic becomes more relevant as the departure time get closer to now.[1] The algorithm was run during the peak time of a working day to mimic the real-time when people commute to work.

The transit commuting duration from Prague's city center

Similarly to car commuting, the transit commuting duration was obtained using Google Distance Matrix API. The request is the same as in the case of car commuting with only one exception. The parameter *mode* takes the value of transit.

The response is the duration of the travel from the origin to the destination using urban transport while accounting for additional walking time. This means traveling by a combination of bus, metro, train, or tram. There is no preference for any one mode of transport over the other. Again, to ensure the data are relevant, the algorithm was run during the peak time of a working day.

The air distance between the apartments and the Prague's city center

The air distance from Prague's center is geodesic distance calculated by geopy library.

3.3.2 Description of datasets

3.3.2.1 Numerical variables

The summary statistics of the numerical variables in the five datasets are presented in Table 3.3 – Table 3.7.

[1] (Google 2020)

Table 3.3: Prague's numerical variables statistics

	count	mean	std	min	50%	max
Price	2457	19854	12407	3000	16500	180000
Price per m squared	2457	311	82	100	298	1233
Number of rooms	2398	2	1	0	2	6
Size	2457	66	39	10	58	440
Road distance	2457	9526	3690	3829	9054	25856
Road duration	2457	1038	256	534	1003	1834
Transit duration	2457	1843	450	705	1815	3972
Air distance	2457	6297	2501	3231	5638	18047

Table 3.4: Kladno's numerical variables statistics

	count	mean	std	min	50%	max
Price	98	11346	2929	5000	11000	23500
Price per m squared	98	238	61	100	228	422
Number of rooms	98	2	1	1	2	6
Size	98	51	22	18	49	150
Road distance	98	34046	4966	22410	31989	46432
Road duration	98	2423	206	1896	2408	2869
Transit duration	98	3824	939	2179	3803	7687

Table 3.5: Příbram's numerical variables statistics

	count	mean	std	min	50%	max
Price	30	10286	2703	5000	10250	16000
Price per m squared	30	198	52	101	198	302
Number of rooms	30	2	0	1	2	4
Size	30	54	16	31	52	99
Road distance	30	60140	11140	36319	62808	75874
Road duration	30	3031	464	2130	3113	3899
Transit duration	30	5798	1419	3434	5981	8251

The first thing to notice is the massive variation in the number of observations for each district. While Prague has almost 2500 observations, all of the districts in CBR have less than 100. Therefore, there are not many offers to choose from outside of the capital. The next variable which differs significantly is the price. However, part of the variation may be captured by a different size of the apartments. It can be observed that Prague and Mladá Boleslav offer bigger-sized apartments than the rest of the districts despite the fact that the number of rooms seems to be the same everywhere, which is a result of

Table 3.6: Kolín's numerical variables statistics

	count	mean	std	min	50%	max
Price	37	10316	2529	6000	10000	18500
Price per m squared	37	206	59	134	187	379
Number of rooms	37	2	0	1	2	5
Size	37	53	18	28	47	104
Road distance	37	67109	12966	36846	73769	79240
Road duration	37	3207	380	2424	3387	3626
Transit duration	37	3924	646	2908	3750	6025

Table 3.7: Mladá Boleslav's numerical variables statistics

	count	mean	std	min	50%	max
Price	59	15319	4570	8000	15000	28000
Price per m squared	59	276	151	102	250	1190
Number of rooms	59	2	1	1	2	6
Size	59	65	33	18	58	230
Road distance	59	63000	8132	40472	63813	86207
Road duration	59	2824	301	2004	2850	3600
Transit duration	59	5762	1318	2532	5698	10633

Source:

The Table 3.3 to Table 3.7 are all author's construction based on data from sreality.cz

rounding numbers.

To compare rent between districts accounting for the size, price/m^2 was calculated. Observing the values, Prague leads with the median of 298 crowns per meter, followed by Mladá Boleslav with 250, Kladno with 228 and both Příbram and Kolín with under 200 crowns. Still, substantial differences are observed. This is an important fact because it means that without taking transportation and time cost into account, Prague would be the most expensive district. This is entirely in accordance with our expectations.

The next variables to look at are the various distances and durations of travel from Prague's city center. As was expected, car transport is almost twice as fast as transit transport, saving a substantial amount of time daily. However, in Prague, the car distance is longer than the transit distance. In our opinion, it is the effect of two phenomena - the subway and walking. Both are more straightforward than driving a car. It could be seen that offers in CBRDs are spanning over huge areas, because the difference between min and max car distance is around 40km, except the district of Kladno, where it is only about

24km. This means that Kladno's district will not be as impacted by transport and time cost as the other three districts.

3.3.2.2 Dummy variables

The statistics of dummy variables floor, brick type of construction, and newly built property status are described in Table 3.8 - Table 3.10. The dummy variables are important because they form the matching criteria, which are explained in the next section. It can be observed that the majority of the apartments are above the first or ground level. The ratio of the ground floor to other floors is relatively stable except Kolín, where more than 40% of offers are on the ground floor, which may be either coincidence or the buildings in Kolín do not have many levels.

Table 3.8: Floor dummy distribution

Floor		1	0
Prague	observations	1958	499
	percent	79.7%	20.3%
Kladno	observations	70	28
	percent	71.4%	28.6%
Příbram	observations	24	6
	percent	80.0%	20.0%
Kolín	observations	21	16
	percent	56.8%	43.2%
Mladá Boleslav	observations	44	15
	percent	74.6%	25.4%

With regards to the brick dummy variable, approximately two-thirds of the offers in each district are of brick type construction. The only exception is Kladno, where approximately only half of the offers is that way.

The property status of newly built dwelling is tilted towards Prague with a 30% share, while other districts only have around 10% of this type of apartments. This fact is crucial because it can, to some extent, explain why Prague's apartments are more costly - newly built apartments are valued more than the ones already built.

Table 3.9: Brick dummy distribution

Brick		1	0
Prague	observations	1638	819
	percent	66.7%	33.3%
Kladno	observations	51	47
	percent	52.0%	48.0%
Příbram	observations	20	10
	percent	66.7%	33.3%
Kolín	observations	26	11
	percent	70.3%	29.7%
Mladá Boleslav	observations	40	19
	percent	67.8%	32.2%

Table 3.10: Newly built dummy distribution

Newly built		1	0
Prague	observations	746	1711
	percent	30.4%	69.6%
Kladno	observations	12	86
	percent	12.2%	87.8%
Příbram	observations	2	28
	percent	6.7%	93.3%
Kolín	observations	5	32
	percent	13.5%	86.5%
Mladá Boleslav	observations	6	53
	percent	10.2%	89.8%

Source: Table 3.8 - Table 3.10 are author's construction.

3.4 Matching

Cost comparison of Central Bohemian Region districts with Prague is done by coupling apartments in the individual districts with those in Prague. One apartment is always from Prague, and the other one is from CBR. The process of matching works as follows:

1. The dataset is split into five smaller ones where each dataset contains offers from only one district

2. The matching criteria are identified

3. A loop is created in a way that every flat in Prague's dataset is compared

to every flat in one of the CBRDs. If the matching criteria are the same for both apartments, a couple is created and stored together.[2]

4. The newly created couples are stored in a new dataset. This process is repeated for each district (Kladno, Příbram, Kolín, and Mladá Boleslav), resulting in 4 separate datasets with couples of apartments having the same characteristics.

The final analysis is performed on the dataset with couples of apartments from Prague and apartments from the CBRD.

The following characteristics are chosen to serve as the matching criteria:

- Criterion 1: Area of the apartment (tolerance +- $1m^2$)
- Criterion 2: Number of rooms in the apartment
- Criterion 3: The floor dummy
- Criterion 4: Brick house
- Criterion 5: Newly built house

The offers are matched if the values of the criteria variables are the same. For example, a newly built house criterion means that newly built apartments will be matched with other newly built apartments, and all the other types of property statuses will be matched together. This fact takes care of the price premium put on newly built apartments in comparison to the rest. In this manner, all matching criteria were chosen to equalize the character of the dwelling as much as possible. Lastly, the distribution of the final observations in the datasets is presented in Table 3.11.

Table 3.11: Number of observations of the final datasets

district	Number of observations
Prague - Kladno	1907
Prague - Příbram	1003
Prague - Kolín	686
Prague - Mladá Boleslav	1532

Source: Own construction based on data from sreality.cz

[2]Note that for one apartment in Prague, there may be 0, 1 or more matched apartments from the other district.

Chapter 4

Methodology

In this section, the model with formulas is explained first, followed by presenting the model inputs with their definitions and default scenarios with sensitivity analysis. Let us start with the general model description.

4.1 The model and formulas

4.1.1 The general model

The model is built around the assumption that renting the apartment has only costs and no financial returns in renting the apartment.[1] Then, 3 different categories of costs are defined: apartment costs, transportation costs, and time costs. For each apartment in the datasets, all three costs are calculated using the NPV formula and are summed together. The NPV calculation is done for 2 different timeframes: 5 years and 15 years. The calculation is described by the following formula:

$$NPV = PV_t^{AC} + PV_t^{TC} + PV_t^{COT} \tag{4.1}$$

where PV = present value, AC = apartment cost, TC = transportation cost, COT = the cost of time, t = timeframe

The resulting NPV represents the total living cost in the apartment and commuting to work for either 5 or 15 years. It is calculated for each offer. The final datasets contain pairs of apartments created by the matching procedure (Section 3.4). Then, NPV is compared for every couple in the dataset, and a cheaper district of the two, either Prague or the alternative, is identified.

[1] No financial benefits are meant only from the tenant's perspective

Afterward, the number of times Prague has been more expensive than the CBRD from the whole dataset is obtained and divided by the length of the dataset. In this manner, a probability of Prague being more expensive than CBRD is obtained.

4.1.2 Breakdown of the NPV calculation

The Equation 4.1 represent the calculation of the NPV for a single apartment. The NPV is obtained by summing the PV of apartment cost, transportation cost, and cost opportunity of time. These 3 categories of costs, together with the PV formulas, are described in detail here:

4.1.2.1 Apartment cost

Renting involves numerous expenses for the tenant. They are divided into one-time and recurring costs. We refer to two possible one-time costs: the security deposit to the owner and the fee to the real estate agency in case its services are used, and the owner does not pay for it.

One-time costs

The security deposit shows commitment and serious interest in the apartment from the tenant´s side, but also serves as an insurance for the owner in case the tenant withdraws from the contract too early, damages something or simply refuses to pay. In general, the deposit is either paid upfront or deducted from the first payments of the monthly rent. However, it is a refundable cost and after the renting is finished, it is repaid.

With regards to the fee to the real estate agency, it may or may not be involved, and either way, it does not represent a significant amount in comparison to the other costs. In the Czech Republic, it is still uncommon to search for rental housing with a real estate agent. For these reasons, no one-time fees are accounted for in the analysis.

Recurring costs

Recurring costs are the monthly rent and the insurance cost for the tenant. Monthly rent is a classic payment of the tenants to the owner to let them live in the apartment for one month. The other cost is the flat contents insurance.

Landlords' insurance generally protects their items and does not include tenants' personal belongings such as laptops, TV, or other valuable possessions. Even though it is not compulsory, it is advisable to be insured against adverse situations such as floods, theft, fire, thunder, etc. The insurance is an annual payment. Both recurring costs enter the analysis.

The calculation of apartment costs

Similarly, as did Tláskalová (2018), the following three equations are used to calculate the present value of apartment costs. The cost of monthly rent is computed as the sum of the rent payment and payment of annual insurance divided by 12 to obtain monthly value.

$$MR = R + \frac{I}{12} \tag{4.2}$$

where MR = cost of monthly rent, R = rent payment, I = annual insurance cost.

To transform this equation into an annual cost, we multiply it by 12.

$$AR = 12 \cdot R + I \tag{4.3}$$

where AR = annual cost of rent.

Finally, the PV of growing annuity formula is used to account for payments over t years.

$$PV_t^{AC} = \frac{AR}{r-g} \cdot \left[1 - \left(\frac{1+g}{1+r}\right)^t\right] \tag{4.4}$$

where PV_t^{AC} = present value of apartment cost, r = discount rate, g = annual growth of rental rate, and t = time period in years.

4.1.2.2 Transportation costs

Transportation costs are an essential part of the analysis as they represent the money spent on commuting from home to work. These costs differ based on the mode of transport. In the thesis, three different ways of transportation are considered: commuting by car, commuting by transit (urban transport), and mix commuting. These three combinations should cover all modes of commuting that individuals consider when deciding whether to live in Prague or outside the district. Car commuting and transit commuting are presented separately.

Mix commuting is defined as a combination of the car commuting in CBRDs and transit commuting in Prague.

Commuting by car

The critical assumption is that people travel by car from their dwelling to work and vice versa. Cases where it would be preferable for a car journey to include a change to urban transport, are neglected.

The calculation of car transport cost

The following formula is used to determine the NPV of car transportation cost for t years:

$$PV_t^{TC} = \frac{DS}{1000} \cdot 2 \cdot WD \cdot KMC \cdot t \tag{4.5}$$

where PV_t^{TC} = transportation cost, DS = distance in meters, WD = workdays in one year, KMC = cost of 1 km in CZK, t = time period in years.

Distance in meters is divided by 1 thousand to change the units to kilometers. It is further multiplied by 2 to include return way from work. Also, note that the PV of the growing annuity formula is not used because the discount rate and the growth rate are assumed to have the same value. Therefore, the PV of a series of future payments over multiple years can be calculated by multiplying the cost by the respective number of years.

Commuting by urban transport

It is assumed that in Prague and the CBRD cities people will buy an annual ticket for urban transport. This fact enables them to use a mode of transport of their choice. Google API calculated the duration of urban commuting, but the information about the route and mode of transportation was not available.

The calculation of urban transport cost

To compute urban transport cost in the district cities over the period of t years, the following equation is used:

$$PV_t^{TC} = ATP \cdot t \tag{4.6}$$

where ATP = annual transport pass.

Again, it is assumed that the relative cost of the annual pass remains constant over the years. Therefore, multiplying the urban transport cost by the number of years to obtain PV is sufficient.

The valuation of lost time

The uniqueness of this work rests on the fact that the valuation of lost time spent by commuting is included in the analysis. It is estimated by a concept called the value of time that was presented in the literature part of the thesis. It is the only non-monetary and subjective cost that enters the analysis. We believe it should play an important role in deciding where to live because frequently people commute long distances without taking lost time into account. Despite the fact, people subconsciously merit their time, and that is why we think it should not be excluded from the calculations.

The calculation of cost of time

To determine the cost of time over t years, the number of hours spent commuting over the whole period is multiplied by the value of time expressed as a percentage of the hourly wage.

$$PV_t^{COT} = \frac{CDR}{3600} \cdot 2 \cdot WD \cdot NWR \cdot VOT \cdot t \tag{4.7}$$

where PV_t^{COT} = present value of cost of time, CDR = commuting duration in seconds, WD = workdays in one year, NWR = net wage rate, VOT = value of time

The commuting duration can be either by car or transit.

4.2 Model inputs

In this section, all the necessary input variables that were not obtained by scraping are described together with their assigned default value.

Timeframe

The critical parameter of the present value formulas is the timeframe. We decided to scrutinize 2 periods - 5 and 15 years. In general, less than 5 years could be unstable due to possible frequent changes in the apartments. Moreover, the economy, together with the housing market, is dependent on business cycles,

and short periods are inconvenient. Long term period of 15 years was chosen to compare the outcomes of the short and long-term period. In addition, the period extended for more than 15 years seems unreasonable, and the difference of 10 years should be sufficient to observe possibly interesting deviations in the results.

Workdays

Number of workdays represent the number of days an individual commutes to work in Prague in a single year. The value is set at 250.

Growth of rental prices

Growth of rental prices represents a rate by which prices change over a specified period. In our case, the period is set at 1 year. Prague will be observed first, with CBRDs following directly afterward. In previous years there was a trend of increasing prices in Prague, which has recently shifted due to the effect of coronavirus. In the last 12 months, the average annual rental growth rate in Prague decreased by 7.6%.[2] However, if we look further into the past, the annual growth of rental prices in Prague between the years 2014 and 2018 was 7.3%.[3] Older data taken over longer periods are lacking. Fortunately, the data for selling prices are more available, and it is assumed there is a possible arbitrage if the growth of selling prices is different from the growth of renting. Exploiting the difference would profit the owner, and that is why the growth of selling prices becomes relevant for renting. After calculating the average growth rate of the dwelling selling prices in Prague during the last 15 years, from 2005 to 2020, it was approximately 6.25%.[4] Taking into consideration the historical prices of renting together with selling prices, we decided to set the default value for the rental growth rate in Prague at 6.5%. We expect that the decrease in the last 12 months is only temporary and will not last for long. Moreover, our analysis is done for 5 and 15 years. Hence, temporary effects should not have such a significant effect on the long-term average.

For the CBRDs, the rental data are not available. Therefore, we derived the growth rate from the average selling prices per $1m^2$. The Czech Statistical Office publishes the data between 2015 and 2017 for each district in CBR (CZSO 2019b). The 4 districts of our interest experienced the following growth

[2](Mix 2020)
[3](Johnston 2019)
[4](CZSO 2020a)

over the period of 3 years: Kladno - 20.3%, Příbram - 27.5%, Kolín - 17.1%, Mladá Boleslav - 26.2%. Similarly to Prague, the prices may be affected by business cycles, and data for more years are lacking. Therefore, it is difficult to estimate the default growth rate correctly. We assume the long term average will be very similar to Prague. Finally, the growth rate of 7% for all the remaining districts was chosen as the default value.

Discount Rate

This variable represents the opportunity cost of renting. In other words, it represents a rate at which money could be multiplied if people put them into a bank instead of investing them elsewhere. That means the higher the discount rate, the greater the yield one could get if money was stored in a bank savings account, and the lower is the net present value of the future cash flow. It is a safe option and represents high liquidity and almost no risk. We realize there are multiple other options of investing capital with greater rewards and higher risk. However, the point of the thesis is not to judge people for their love of risk taking. Rates of current and savings accounts in the Czech Republic are just above 0, and therefore, people tend to look for other investments. Tláskalová (2018) used a value of 3.61% as she assumed the same value as a mortgage interest rate. Tabner (2008) used a value of 6%. Regarding Average Deposit Rates, in March 2020, the average annual deposit interest rate, in the czech crowns, of new contracts with a fixed term up to 1 year between credit institutions and retail customers (households) was 1.38%. Also, the highest return of time deposit accounts in the European Union for the moment is offered by J&T Bank at 1.4%.[5] This number is reflecting the current coronavirus pandemic. All things considered, we decided to use a value of 2%. The value will be used for both short term and long term perspectives.

Insurance

The insurance cost is obtained from the website, which provides costs of insurance by comparing five different insurance companies; namely, AXA, ČPP, ČSOB, Slavia, and Maxima.[6] The final value rounded to the nearest hundred is 1,300 CZK yearly. It is the arithmetic mean of the offers from the five

[5](TheBanks.eu 2020)
[6](Srovnávač.cz 2020)

aforementioned companies. It represents medium level insurance for up to 300 thousand crowns.

Cost per km

The cost of 1 km of car travel represents the expenses related to the vehicle over a period of time divided by the corresponding amount of mileage to and from work over the same period. The expenses related to the vehicle include acquisition, operation, maintenance, and other payments related to car travel, such as parking fees or highway tolls. This variable can take on various values depending on the car purchase price, car fuel consumption, a number of kilometers in and outside the city, driving style, and car-sharing.

To derive a reasonable value of km cost, the following calculation is used. Assuming a timeframe of 5 years and buying a new car for 400 thousand CZK, the depreciation calculator[7] says the remaining value of the car after 5 years of average depreciation is 156 thousand CZK. Similarly, if we assume the fuel consumption is about 7 liters per 100 km and the price for 1 liter is 30 crowns, then fuel consumption costs 210 CZK per 100 km. If the average traveled distance is 25 thousand kilometers per year, then the km cost is calculated in the following manner:

$$\frac{400000 - 156000 + \frac{25000}{100} \cdot 210 \cdot 5}{5 * 25000} = 4.052 \tag{4.8}$$

Assuming a 15 years period and using the same initial value of the car as before, the main difference is the depreciation. It is assumed that the remaining value of the car after 15 years is only 28 thousand CZK. The computation is as follows:

$$\frac{400000 - 28000 + \frac{25000}{100} \cdot 210 \cdot 15}{15 * 25000} = 3.092 \tag{4.9}$$

We can see that the cost of 1 km of a car ride is lower when we use the same car for a period of 15 years because the depreciation is the greatest in the first years. However, this does not have to be true because, after the first years, repairs of the car are much more frequent and can drive up the cost substantially. For that reason, we decided to assume the same value of 5 CZK for both periods.

[7]Source: https://goodcalculators.com/car-depreciation-calculator/

Urban transport cost

The total cost of urban transport in Prague is covered by an adult annual transport ticket for 3650 CZK. It enables an individual to use all the transport modes within the city. We realize some apartments are outside the valid zone covered by the ticket, and commuting would get more costly. This fact is, however, neglected.

For the CBRDs, the default total values of commuting costs are calculated as follows:

Kladno: 3650 + 7128 + 4*1120 = 15258
Příbram: 3650 + 16632 + 12*300 = 23882
Kolín: 3650 + 14256 + 4*830 = 21226
Mladá Boleslav: 3650 + 16632 + 4*1173 = 24974

It is assumed that people commuting from the districts will buy the annual transport ticket in Prague for 3650 CZK. Moreover, transport between the district cities and Prague is covered by an annual region ticket with the cost depending on the tariff zones.[8] The zones and costs of the districts are as follows:

Kladno – zone 3 – 7128 CZK
Příbram – zone 7 - 16632 CZK
Kolín – zone 6 – 14256 CZK
Mladá Boleslav – zone 7 – 16632 CZK

These tickets enable an individual to travel to Prague by any mode of transport. The last cost in the calculation is the annual expense for traveling in the CBRD city. It is the equivalent of the Prague's annual ticket, but for the respective district cities. This assumption was made because we assume people will commute to Prague from the station in the district city. None of the cities have an annual ticket, therefore, either a quarterly ticket was multiplied by 4, or a monthly ticket by 12 to obtain yearly cost.[9]

All calculated costs for CBRDs are only an estimation and may not represent real-life expense of urban commuting. That is why a sensitivity analysis will be performed to see the effect of a possible variation in the values.

[8](PID 2020)
[9]Sources: (ARRIVA 2020b) (ARRIVA 2020a) (OAD 2020) (MHD 2020)

Net wage rate

The net wage is the amount of net salary paid to a worker per month. We assume all the people work in Prague. Hence, to obtain its value, let us look at the development of the average gross wage there. In recent years, the mean gross salary has been steadily increasing. It grew from 30,430 CZK in the first quarter of 2010, to 44,237 CZK in the last quarter of 2019 (CZSO 2020c). That is an overall increase of around 45.37% during the period of ten years. However, because of the outbreak of coronavirus, the average gross wage decreased in 2020 to 42,760 CZK. Due to the unpredictability of the economy, we will only work with the actual gross salary. Net wages will be calculated as 70% of the gross salary. After calculation, the default value is set at 30 thousand CZK. The average annual increase in gross wage will not be taken into account. Instead, sensitivity analysis will be performed to account for the variation. In order to obtain the net wage rate in the calculation, the general net wage is divided by 172 hours, representing the average number of working hours per month.

Value of Time

The value of time is a subjective measure. For the sake of the analysis, we are going to refer to the research of Brůhová-Foltýnová (2010). Her research was done for the local area; therefore, it is the most relevant. The study concluded with two important facts. Firstly, VOT in the Czech Republic is somewhere between 35-42%, and secondly, urban transport is generally valued higher than car travel. Hence, we will refer to her research and assume 40% VOT for car travel in the Czech Republic. Small *et al.* (2007) concludes that, for in-vehicle time, the VOT can be around 50%, while for out-of-vehicle time, it can easily exceed 100%. Combining these 2 facts, the value of urban transport is set at 50% because it should be higher than car travel, and it may also involve a few minutes of out of-vehicle time when changing modes or walking.

4.3 Default scenarios and sensitivity analysis

After presenting the general model with formulas and calculations, the way of displaying the outcomes is described. To evaluate the results in a well-arranged manner, we create 6 scenarios as a combination of 3 different types of commuting: car commuting, transit commuting, and mixed commuting (transit commuting in Prague's district and car commuting from CBRD) and 2 different

timeframes: 5 and 15 years. Each of these scenarios takes the default values of the input variables assigned in the model inputs section. After assessing the scenarios with default values, sensitivity analysis of five different numerical variables (rental growth rate of Prague, a rental growth rate of CBRDs, km cost, net wage, and total annual transit cost - CBRDs) is done to allow for variations in the values. Their effect on the probability that Prague is more expensive than CBRD is scrutinized, holding the rest of the dependent variables constant. This is a vital part of the analysis because the default values may not always represent relevant numbers for many individuals. We believe that sensitivity analysis can uncover much valuable information about the overall problem. The sensitivity analysis findings are presented by the x-y function charts. To do that, the lower and upper bound of the variables must be established. The intervals are presented in the Table 4.1:

Table 4.1: The specification of the intervals

Dependent variable	Interval
Rental growth rate of Prague	5 - 8%
Rental growth rate of CBRDs	5 - 9%
Km cost	2 - 20 CZK
Net wage	20 000 - 100 000 CZK
Transit transport cost	10 000 - 30 000 CZK

Source: Own construction

The specification of the intervals was picked to represent all possible values that can occur in the real world. Moreover, the values are averages for either 5 or 15 years, giving us even more confidence to believe they will fall into the ranges. The variables are not normalized to allow for a more straightforward interpretation of the outcomes.

Chapter 5

Results

In this chapter, the results of the thesis are presented. It starts with the examination of 6 default scenarios and the respective probabilities. Afterward, the sensitivity analysis of the dependent variables is performed and commented on.

5.1 The default scenarios

The default scenarios with the probability of Prague being a cheaper district than the alternative are summarized in Table 5.1.

Table 5.1: Probability that Prague is more expensive than the corresponding district for the default scenarios

	5 years			15 years		
district	car	transit	mix	car	transit	mix
Kladno	0.20	0.56	0.16	0.27	0.60	0.22
Příbram	0.06	0.39	0.03	0.11	0.50	0.10
Kolín	0.06	0.77	0.05	0.09	0.79	0.08
Mladá Boleslav	0.03	0.17	0.02	0.05	0.20	0.04

Source: Own construction based on data from sreality.cz

The data in the Table 5.1 show that Prague is a cheaper district in all the scenarios where individuals travel from CBRDs by car. Once the individual drives from CBRDs, the commuting mode in Prague is not important, as the difference between car and mix is negligible. This implies that traveling by car is too expensive and outweighs the effect of cheaper apartments outside

Prague. It drove the total expense of CBRDs up and made them much more expensive regardless of the timeframe.

In the case of transit commuting, the results differ for each district. Kladno and Kolín are cheaper than Prague due to fast commuting by train. In comparison, Mladá Boleslav and Příbram are more expensive or comparable to Prague, because of the preferred commuting by bus, which is slower. This fact is also reflected by longer transit duration in these two districts presented in the Data chapter.

Overall, a more extended period made Prague cheaper in all scenarios, even though the difference between the timeframes was minimal. The only reason is the half-percent difference in the default growth rate between the districts.

All in all, these results are heavily dependent on the default values that were chosen in the model inputs section. Therefore, in order to see the effect of variation in the values of the dependent variables on the probability, we are going to present the findings of sensitivity analysis by x-y graphs of each of the five variables for each scenario for all districts.

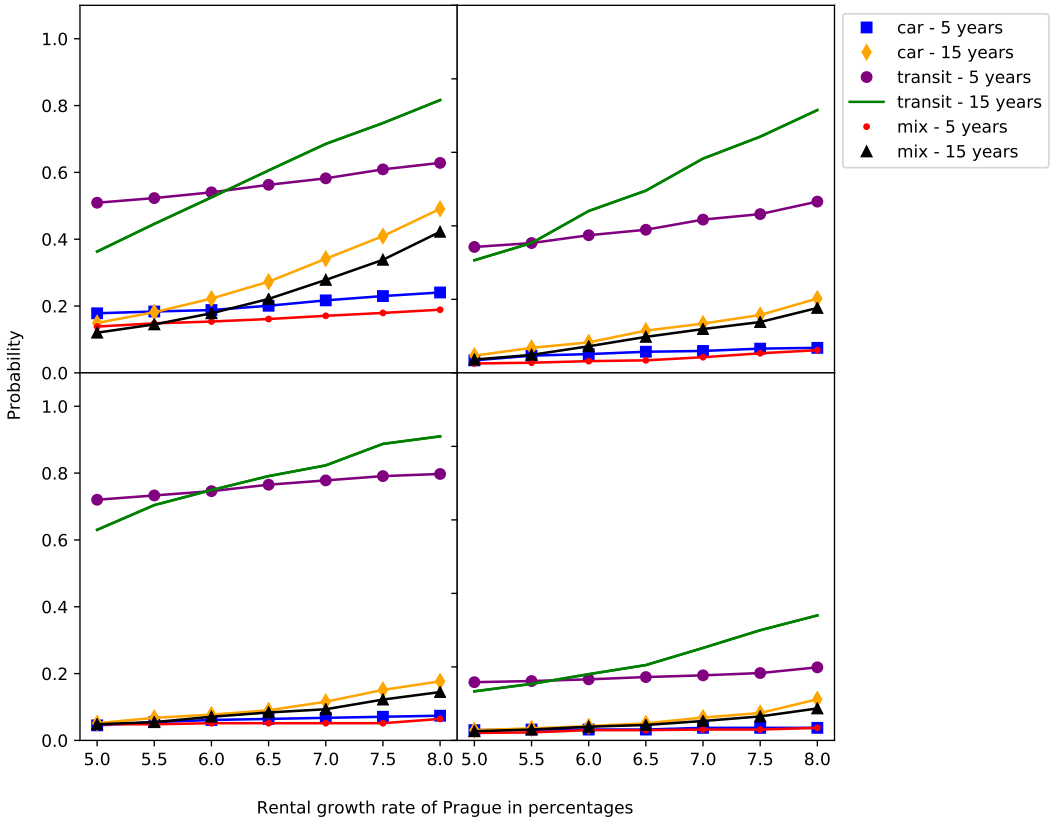
5.2 Sensitivity analysis

In this section, the findings of sensitivity analysis are presented separately for each variable and each district. The general manner of commenting on the results will be first to describe the trends common to all areas and, subsequently, to point out the differences among them. Also, the figures presented in the following section show results for all four districts with Kladno being upper left corner, Příbram upper right corner, Kolín bottom left corner and Mladá Boleslav bottom right corner. This order is consistent for all five variables.

5.2.1 The rental growth rate of Prague

Firstly it is important to mention that the variable is not in the hands of the individual and is driven by economic forces. The sensitivity analysis reveals a positive relationship between the rental growth rate of Prague and the probability of it being cheaper. However, this fact is only applicable for the long-term period because the short-term effect is negligible. Overall, car and mix transportation favor Prague as the probability never goes above 0.2, meaning Prague is a cheaper option in 80% of the offers. The only exception is Kladno, where, because of its proximity to the capital, the car or mix transfer can be attractive

Figure 5.1: Probability of Prague being more expensive than CBRDs - Rental growth rate of Prague



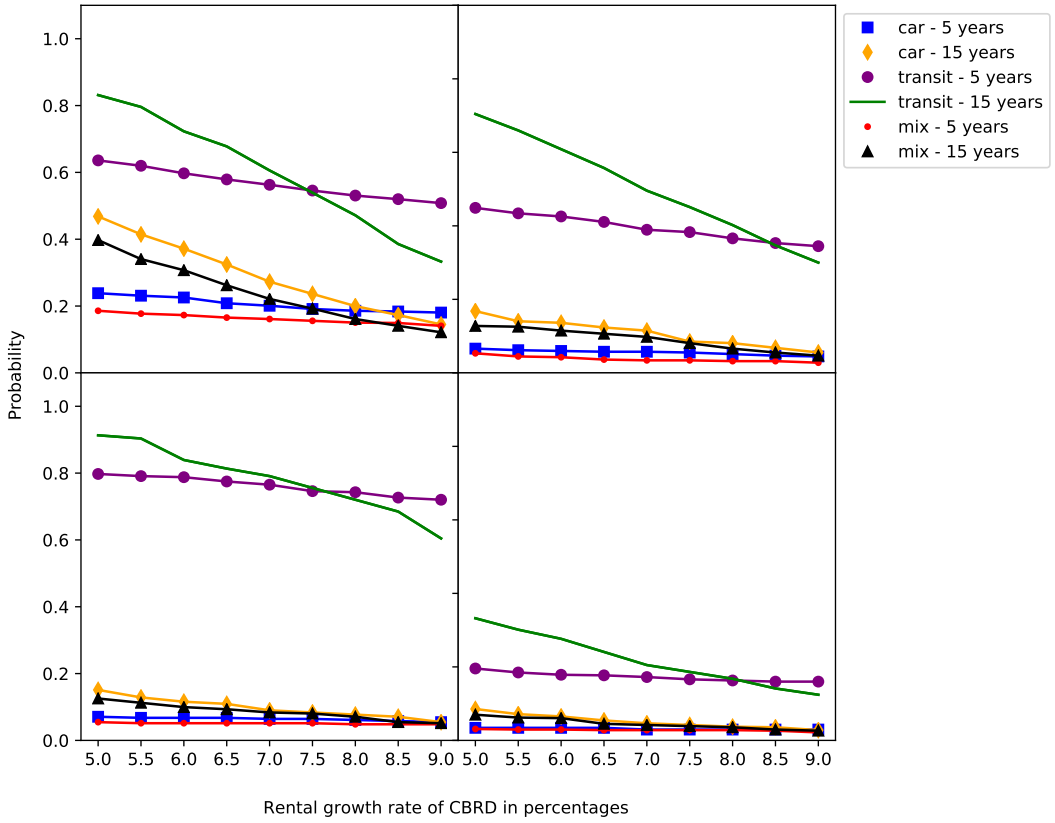
in case of a high average price increase. Otherwise, the total cost of these two types of commutes is too high.

The effect of the rental growth rate is essential in transit travels. Considering the 15 years timeframe, Kladno and Příbram will be cheaper if the growth rate exceeds 6 and 6.5%, respectively. Kolín will be a better option regardless of the price growth. On the other hand, Mladá Boleslav will always be more costly. Generally, an increase of 1% in price growth results in a probability increase of 5 to 10%. Since we do not expect substantial variations in the average growth rate, all in all, transit commuting is the only rational option for all CBRDs except Mladá Boleslav.

5.2.2 The rental growth rate of CBRDs

The effect of the rental growth rate of CBRDs on the probability is reversed to the growth rate of Prague. The impacts are of a similar magnitude but in

Figure 5.2: Probability of Prague being more expensive than CBRDs - Rental growth rate of CBRDs

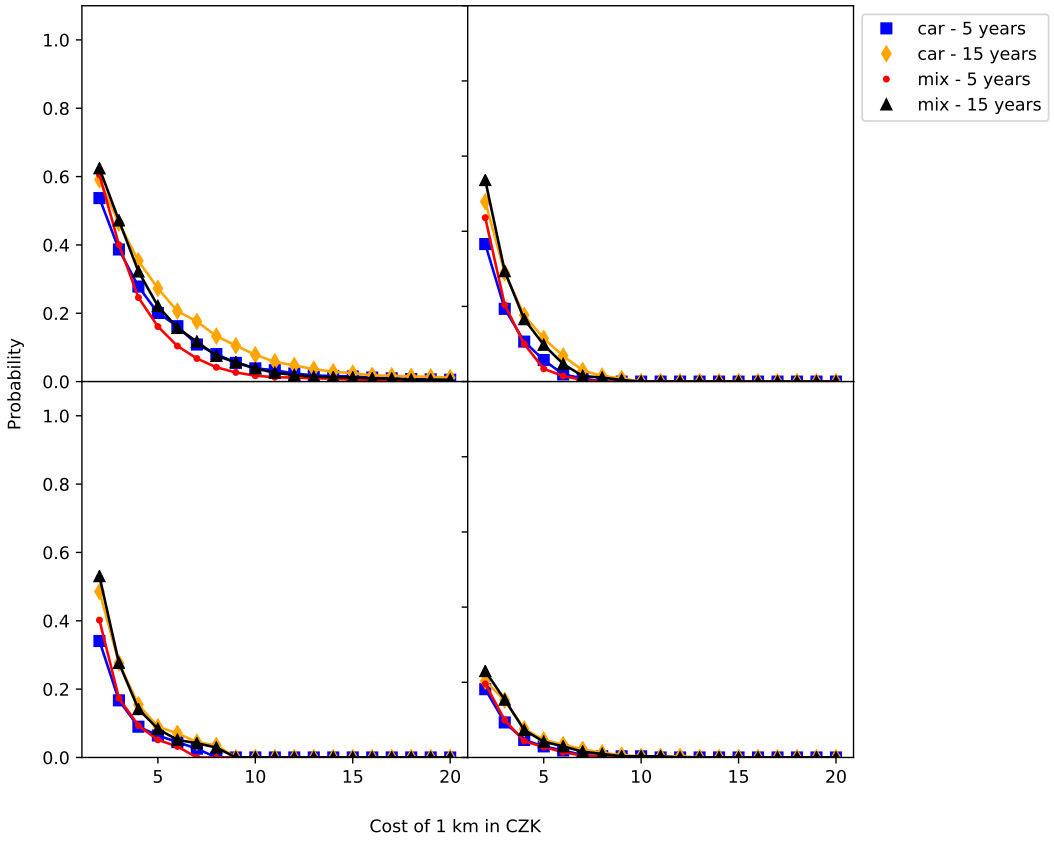


the opposite direction. Still, most of the conclusions hold such as transit being the only mode of transport that makes financial sense outside Prague. Also, the short-term stance is not affected by different growth rates almost at all. As before, in case of transit, Mladá Boleslav is not a financially sound option, followed by Příbram where the growth rate plays an important role

5.2.3 Km cost

The km cost is the first variable where sensitivity analysis uncovered a negative quadratic relationship to probability. The range of km cost is pretty broad because it is based purely on the individual and not based on the economic forces as the previous two variables. Observing the Figure 5.3, the probability varies from 0.6 to 0. The cost under 2 CZK results in CBRDs being cheaper or comparable to Prague. The exception is Mladá Boleslav, which is always more costly. As the value increases, the non-linear effect is penalizing long

Figure 5.3: Probability of Prague being more expensive than CBRDs - Km cost

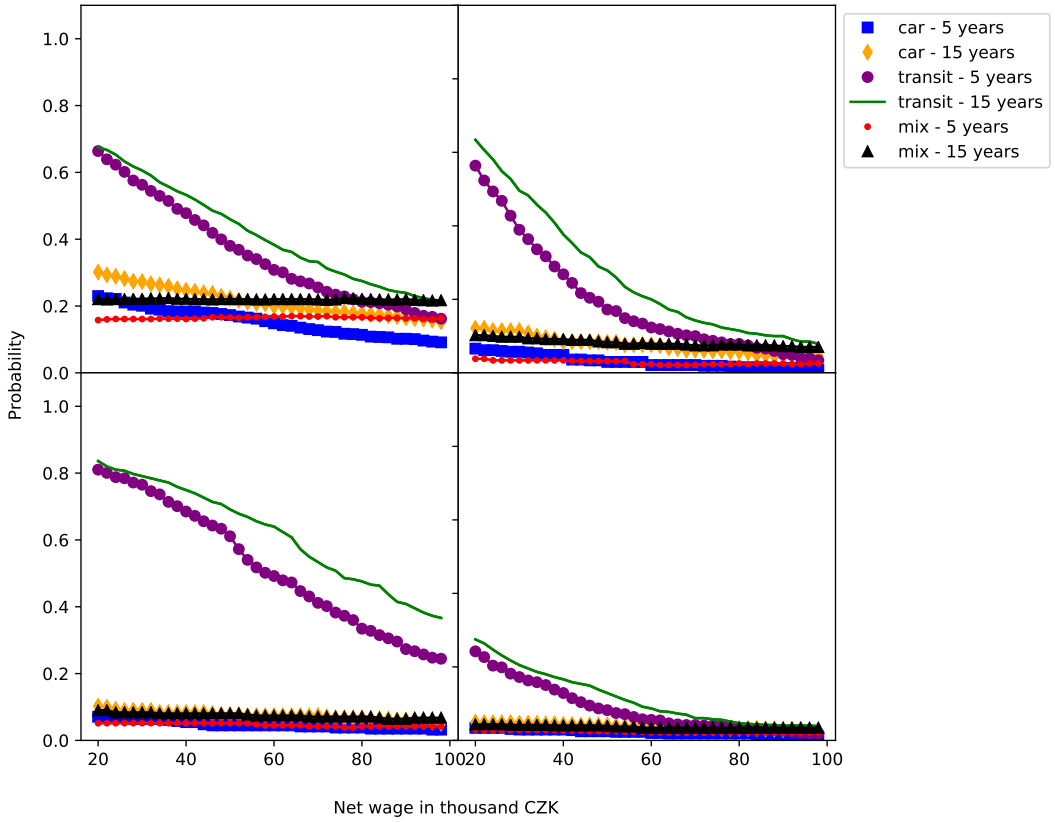


commuters, and Prague becomes a more favorable choice. For each district, the car cost above 10 CZK translates into a probability of almost 0. This means that keeping the car commuting expenses low is of crucial importance in case one wishes to cut down costs and make the travel worth it. Still, the cost of around 2 CZK is meager and would almost certainly be accomplished only by sharing a ride with multiple other people on a regular basis. The transit traveling was omitted due to km cost not affecting it.

5.2.4 Net wage

The sensitivity analysis of wage revealed a negative relationship to the probability. This complies with expectations because higher wage translates into a greater opportunity cost of time, disadvantaging longer traveling. Again, the impact can only be seen for transit commuting because the expenses of two

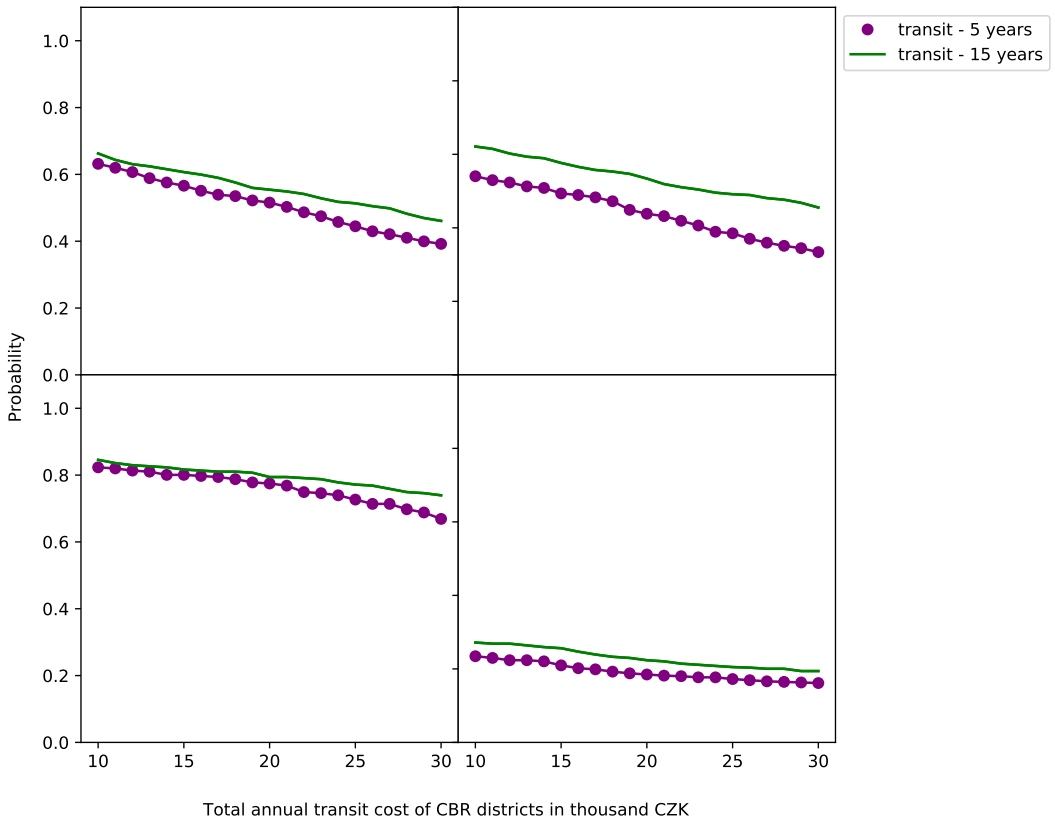
Figure 5.4: Probability of Prague being more expensive than CBRDs - Net Wage



other modes brought the probability to almost 0. Timeframes did not create variation in the outcomes.

Looking at transit commuting, Kladno, Příbram, and Kolín are particularly sensitive to changes in wages. A 10 thousand increase in wage translates into approximately 0.1 decrease in probability for Příbram and around 0.05 for Kladno and Kolín. The breakeven point where Prague would be comparable to other districts also differs substantially. In Kladno it is around 40 thousand, in Příbram it is somewhere between 20 and 30 thousand, and for Kolín it is between 60 and 70 thousand. Therefore, in case someone earns more than 80 thousand, Prague is undoubtedly a cheaper option. The distance of Mladá Boleslav from Prague, together with expensive apartments, made it a more costly option regardless of the net wage.

Figure 5.5: Probability of Prague being more expensive than CBRDs - Total annual transit cost of CBRDs



5.2.5 Total annual transport cost - CBRDs

Surprisingly, the variation in total annual transit cost has a negligible impact on the comparison between Prague and other districts. The reason is that transit cost is much smaller than car cost; hence, all the drawn conclusions from Table 5.1 hold in this case as well. Other scenarios are not displayed since the transport cost does not affect them.

Chapter 6

Conclusion

The objective of this thesis is to present the cost analysis of renting in Prague and four other districts in the Central Bohemian Region: Kladno, Příbram, Kolín and Mladá Boleslav with the assumption of commuting to Prague daily. The cost analysis was performed by calculating Net Present Value of three types of costs, apartment, transportation, and cost opportunity of time for every rental offer in each district. The apartments in Prague and CBRDs were matched based on their characteristics, to keep the nature of the dwellings equal. The NPV of the individual offers was compared, and the probability that Prague is more expensive than the other district was derived. The whole calculation was done for six different scenarios, a combination of three different types of commuting: car commuting, transit commuting, and mixed commuting (transit commuting in Prague's district and car commuting from CBRD) and two different timeframes (5 and 15 years). For each scenario, a sensitivity analysis was performed on five variables: the growth of rental prices in Prague and CBR districts, cost of 1 km of driving a car, net wage, and total annual transport cost for CBRDs. These variables were chosen because of the difficulty of estimating them accurately and their possibly substantial impact on the outcome.

Based on our data, the results suggest that Mladá Boleslav is an expensive district, and regardless of the situation, most offers in Prague will be cheaper. For the other three districts, the situation differs based on circumstances. In general, transit commuting is cheap and makes the CBR districts advisable while driving to work is expensive and favors Prague. The growth rate of prices in Prague and CBR districts did not affect the short-term period, only the long-term, and their impact is contrary. Kolín proved to be more profitable

regardless of the growths, while Kladno and Příbram are comparable to Prague in the range of 6 to 8 percent, for both variables. We discovered that in case the cost of 1 km is kept below 2 CZK, commuting by car can be comparably profitable for Prague and the other districts. Otherwise, as was previously mentioned, Prague should be preferred. The net wage affects the cost analysis in a significant manner. The higher the wage, the more inclined an individual should be to living in the capital. Overall, the breakeven points of the salary are approximately: Kladno - 40 thousand, Příbram – 30 thousand, and Kolín - 60 thousand CZK. The total annual transit cost for CBR districts discovered no impact on the comparison of the areas.

To conclude, we can see that the general notion of Prague being a much more expensive city does not have to be true if we account for travel costs and the opportunity cost of lost time. The problem is that most of the people do not consider valuing time when making decisions. The purpose of this thesis was to show the other perspective and inspire individuals to think about time as a valuable asset.

Most of the existing literature analyses profitability of renting vs. ownership accounting for apartment costs only (Tabner 2008), (Tláskalová 2018). However, we believe the combination of apartment costs, commuting costs and time costs is what makes this work unique and hopefully, inspires further research in this manner. Even though this paper considers renting, the model can be applied to the analysis of ownership as well. In addition, there are ways in which the research topic can be extended further, such as by scrutinizing other districts or obtaining more actual and vast data from multiple real estate agencies. It would undoubtedly bring more insights and relevant implications for the whole research problem.

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