KAIRI SÜLLA

# The Influence of Public Transport Accessibility on Apartments' Attractiveness in the City of Tallinn, Estonia

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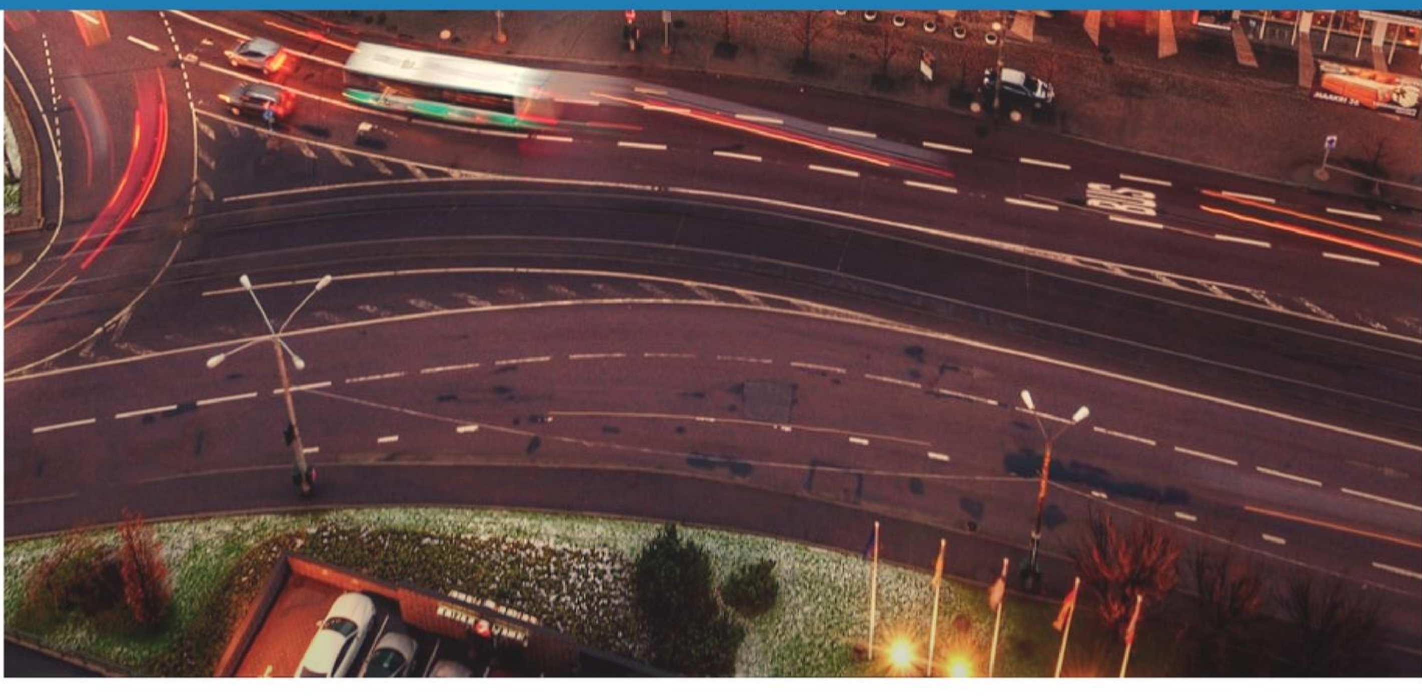

**COLOPHON**

Title: The Influence of Public Transport Accessibility on Apartments' Attractiveness in the City of Tallinn, Estonia
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**Author**
Name: K. (Kairi) Sülla
Student number: 0871772
Email: kairi.sulla@gmail.com
Telephone number: +372 53 482 342

**Graduation committee**
*Chairman:*
Prof. Dr. Ir. B. (Bauke) de Vries (TU/e)
*First supervisor:*
Dr. Ing. P.J.H.J. (Peter) van der Waerden (TU/e)
*Second supervisor:*
Dr. Q. (Qi) Han (TU/e)
*External supervisor:*
Prof. Dr. K. (Katrin) Paadam
Tallinn University of Technology

TU/e Technische Universiteit Eindhoven University of Technology

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# SUMMARY

This study identified the market demand for apartment characteristics in Tallinn, Estonia with special focus on the connection between public transportation service levels and apartment attractiveness. Following, the answers to the main research question:

*What is the influence of service levels of public transportation stops on apartments' attractiveness in Tallinn, Estonia?*

and sub-questions:

*What are important factors affecting apartment attractiveness (represented by price) and how large is their role?*
*How does public transportation service level affect apartment attractiveness?*
*What is the current situation of apartment market and public transportation in Tallinn, Estonia?*
*What are important factors of apartments' attractiveness in Tallinn? Are people willing to pay for a high public transportation service level in the vicinity of apartments?*

will be discussed.

Literature study revealed that housing attractiveness (represented by price) is affected by a variety of factors which has interested researchers for decades and is continuing to be a discussed topic. Housing is a unique "product" due to its immobility and heterogeneity, thus price and attribute effect comparisons between apartments in different countries and even cities in one country are complex. There are several reoccurring basic characteristics affecting housing price, e.g. structural characteristics like size of the dwelling, number of rooms and building age and locational characteristics like distance from the central business district, but their exact effect and importance depends highly on specific market and location. The Appraisal Institute (Kinnisvara hindamine, 2008) - a global professional association of real estate appraisers - even considers the real estate prices and market to be affected by 4 different kind of forces: societal, economical, institutional and environmental.

The connection between accessibility and property values is considered to be fundamental to land markets and urban structure (Alonso, 1964; Hess and Almeida, 2007). The exact relationship between property price and public transportation service levels has been studied across the world with results showing positive, negative and no interaction between the two elements. This can be contributed to the complexity of urban processes, research methods used and the heterogeneity of different housing markets. Most commonly accepted agreement is that heavy rail creates highest access premiums, followed by light rail, whereas proximity of bus stop increases the property value the least, if at all.

For the city of Tallinn, the connection between apartment attractiveness and public transportation service levels has not been researched before, although distance to PT stop has been included in literature about apartment characteristics affecting its price and a report of valued living space in Tallinn (Paadam, Siilak, & Ojamäe, 2014) displays that new housing areas often lack the necessary access to PT. Overall, very little information is available about factors affecting housing price. One study contributing to this field is of

Võhandu (2015) who investigated the apartment characteristics influencing the rental prices in Tallinn and concluded these to be following: apartment's floor area, number of rooms, floor that the apartment is located on, construction year of the apartment building, distance from the city center, distance from the closest public transportation stop and condition of the apartment.

Although, there are differences between rental and buying market, main factors affecting price can be considered the same. Other Estonian authors, e.g. Berg (1998) and Kuhlbach (2002), consider the apartment location (including proximity to PT stop, schools, stores) the most important factor in its price and other characteristics like area of the kitchen and its layout, building material, parking place, view and furniture left in by the previous owners etc. to also have an effect on price.

Based on literature study, 10 most important attributes affecting apartment's attractiveness were chosen and used in the survey to collect data for the thesis. Public transportation service level was specified with 3 different attributes: distance to PT stop, PT type and PT frequency. Full list of attributes and their levels is seen in Table 1 below.

**Table 1. Attributes and attribute levels used in the thesis**

| Attribute | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| **Price** | 60,000 € | 80,000 € | 100,000 € | |
| **City district** | center | surrounding | edge | |
| **Building year** | ... - 1940 | 1941 - 1990 | 1991 - ... | |
| **Heating** | central or gas | electric | wood | |
| **Floor** | first | middle | last | |
| **Free parking** | yes | no | | |
| **Distance to the supermarket** | < 7 min walking | 7 - 14 min walking | > 14 min walking | |
| **Distance to public transportation stop** | < 5 min walking | 5 to 10 min walking | > 10 min walking | |
| **Public transportation type** | bus | tram | trolley | mixed |
| **Public transportation frequency** | at least every 10 minutes | every 10 to 20 minutes | less than every 20 minutes | |

As a research method, discrete choice modeling was used. The data was collected using stated choice experiment, presenting all respondents with two apartment alternatives (described by different attribute levels) and asking the respondent to indicate their preference. Stated choice experiment allows to create hypothetical apartments, making it possible to study not existing solutions, whereas the respondents' decision-making process resembles the real life. To analyze the data, multinomial logit modelling was used.

The study revealed that the heating type has the highest impact on apartment attractiveness with central heating being highly preferred and electric heating immensely disliked. Unforeseen substantial importance of the heating type – preceding even the apartment location – could be attributed to raising energy prices and importance of heating in Estonian climate, demonstrating Tallinn's residents concern with utility costs when buying an new apartment and suggesting to housing developers that more energy efficient buildings could be sold faster and with higher profit margins.

Regarding public transportation, the results indicate that PT frequency has significant effect on apartment attractiveness in Tallinn. This demonstrates: firstly, the overall importance of PT service levels in residents apartment buying decisions; and secondly, the potential for the City of Tallinn to implement more transit-oriented development in order to create sustainable urban environment for its residents. The importance of PT frequency was nearly equal for both frequent and infrequent PT users, suggesting the willingness to use PT in both groups, however indicating certain factors currently hindering the PT use of the infrequent users. The author suggest analyzing the Tallinn's PT system as a whole (with special focus to be given to new housing areas) and setting a public transportation development strategy to achieve greater urban sustainability.

Further qualitative research and additional quantitative research is needed to fully interpret and confirm the quantitative results of this thesis. This thesis is scientifically relevant, contributing to the research of apartment attractiveness as well as land-use and transportation connection. Societally, the work can path the way towards better urban sustainability policies and practically provides developers and public authorities information about market needs in terms of housing and transportation. Practically, the thesis gives insight to real estate developers on housing characteristics that could increase their profits on new housing development and to public authorities to understand the need for developing the PT system further and to achieve greater sustainability in Tallinn.

# ABSTRACT

This study identified the market demand for apartment characteristics in Tallinn, Estonia with special focus on the connection between public transportation service levels and apartment attractiveness. As a research method, discrete choice modeling was used. The data was collected using stated choice experiment. The study revealed that the heating type has the highest impact on apartment attractiveness with central heating being highly preferred and electric heating immensely disliked. Unforeseen substantial importance of the heating type – preceding even the apartment location – could be attributed to raising energy prices and importance of heating in Estonian climate, demonstrating Tallinn's residents concern with utility costs when buying an new apartment and suggesting to housing developers that more energy efficient buildings could be sold faster and with higher profit margins.

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# List of abbreviations

CBD – central business district
DCM – discrete choice modeling
MNL – multinomial logit
PT – public transportation
RP – revealed preference
SP – stated preference
WTP – willingness to pay

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# 1. INTRODUCTION

## 1.1. PROBLEM DEFINITION

Currently 54% of the world's population is urban (i.e. 3.9 billion people). Nearly half of these people live in cities with a population less than 500,000 inhabitants and one eight in mega-cities of more than 10 million people. World's largest city Tokyo has 38 million inhabitants. Fastest growing cities are located in Asia and Africa, whereas in developed countries the growth rate is lower and some cities are even witnessing population decline due to overall population stagnation or declination (United Nations, Department of Economic and Social Affairs, Population Division, 2015).

Undoubtedly, cities are the centerpiece of the world, having both positive and negative impact on humankind. One of the most intriguing example of this is that although accounting for 70% of global carbon dioxide emissions, urban areas also create 80% of global GDP (UN-Habitat, 2016). During the last decades, several authors (Ernst, de Graaf-Van Dinther, Peek, & Loorbach, 2016; Martine, 2005; UNFPA, 2007) have suggested that in spite of posing several global issues, with the right planning cities and urbanization can lead the way towards sustainable development, which is necessary for our planet to last.

With vastly expanding population, the topics of urban housing and transportation become increasingly more important (UNFPA, 2007). Housing is something that every person needs; it accounts for a large share of household's expenditures and affects individual's life quality (Jun, 2013). Thus, the choice of housing, its location, type, etc., is a complex decision for individuals and households. Housing is also important in a broader sense - it takes up a great deal of land, affects wider economy and is of great interest to public authorities on both local and national level. With housing policies and regulations public authorities can determine how and where its residents live and how much is spent and received from it on a governmental level.

Transportation is another topic with a vast impact on urban life. Technological achievements have increased the mobility of people. Average commuting times through the last 100 years have remained the same, but the distances have increased enormously (Rodrigue, 2013). Transportation policies of public authorities can orient cities to cars or public transportation (PT), determine how many of its residents prefer to walk and cycle, and through this shape the overall face of the city. Cities developing public transportation are often considered more sustainable and having a better living environment (Sung & Oh, 2011), whereas car-orientation increases sprawl and the negative effects assigned to it (Kuby, Barranda, & Upchurch, 2004).

Tallinn is a capital city in Northern Europe. With a population of 440 000 people ("CitizMap," n.d.) it is a home for approximately one third of Estonian residents. Its development has been highly affected by foreign rule across centuries. Re-gaining independence in 1991, after 50 years of Soviet regime, Estonia went through drastic changes. Focusing first and foremost on economic development, urban planning fell to the background only receiving more attention in recent years (Leetmaa, Tammaru, & Anniste, 2009). It is often criticized that the planning processes in Estonia are led by private sector and there are several shortcomings in public authorities work, e.g. not involving the stakeholders (especially the residents) in the planning process sufficiently. Tallinn Planning Guide (Viljasaar, Vaher, Ader, & Tõugu, 2012) states: “The tradition of collaboration between the local people, developer and administration is almost non-existent”.

This work will path the way towards better understanding between the above mentioned three stakeholders in the urban processes in Tallinn. As the residents are often neglected in the planning process, the main aim is to capture their needs on two important topics – housing and transportation – allowing the municipality and developers respond better to market demand. Thus, the research problem can be formed to the following question:

*What are residents´ needs in Tallinn when it comes to apartment characteristics and public transportation service levels?*

Furthermore, answering this question could give the municipality feedback on their current public transportation initiatives, input to develop policies and strategies for more sustainable urban development, and on increasing the livability in Tallinn. For developers gained information could help in choosing the location, type and characteristics of their new housing development to shorten the sale periods and increase the profit margins.

Although, there have been studies which include residents’ decision making process when moving to a certain area in Tallinn (Paadam et al., 2014; Põldma, 2012), then no previous studies were found which would help identify the actual market demand for apartment characteristics. For public transportation (PT) a few studies about overall satisfaction with the PT system and service levels were found (Namm, 2015; Tallinn City Government, 2011).

## 1.2. Research question

This problem will be approached by investigating how public transportation service levels affect apartment attractiveness (which is reflected by price) and how this compares to the effect of other important apartment characteristics. The main research question is following:

*What is the influence of service levels of public transportation stops on apartments’ attractiveness in Tallinn, Estonia?*

This will allow analyzing factors that people consider important in an apartment and also residents’ appreciation of public transportation. The sub-questions helping to answer the main research question are the following:

1. What are important factors affecting apartment attractiveness (represented by price) and how large is their role?
2. How does public transportation service level affect apartment attractiveness?
3. What is the current situation of apartment market and public transportation in Tallinn, Estonia?

4. What are important factors of apartments' attractiveness in Tallinn? Are people willing to pay for a high public transportation service level in the vicinity of apartments?

## 1.3. RESEARCH DESIGN

The study starts with a literature review on city development and the stakeholders in the processes (Chapter 2). Specific focus is given to housing and transportation. Factors affecting apartment price will be determined (sub-question 1) and importance of transit oriented development discussed together with transportation decision making and the quality attributes of public transportation service. Finally, the relationship between property value and public transportation accessibility will be analyzed (sub-question 2). Chapter 3 focuses specifically on Tallinn and gives background information of the city's urban development path, followed by the overview of the current situation of apartment market and public transportation service (sub-question 3).

The research is quantitative. To find an answer to the main research question "What is the influence of service levels of public transportation stops on apartments' attractiveness in Tallinn, Estonia?" the apartment preferences of Tallinn residents will be collected using stated choice experiment. This requires the respondents (representative sample of residents) to evaluate simulated apartments formulated from realistic variations of market offerings. The experiment also adopts the concept of willingness to pay (WTP) by including the price into variations. WTP is the amount of money that the consumer is willing to pay for a certain alternative. The data will be analyzed using discrete choice modeling (DCM). DCM uses econometric models based on responses from a representative sample of potential future customers to identify key patterns in the survey responses. It also provides relative weighting for each driver and, if seen necessary, for interactions among drivers (Vasilache, 2013; Verma, Plaschka, Hanlon, Livingston, & Kalcher, 2008). DCM will identify how important public transportation accessibility is to the residents and if a certain mean of transport is preferred over another. The research method in discussed in Chapter 4 and results presented in Chapter 5.

Research design is schematically captured in Figure 1.

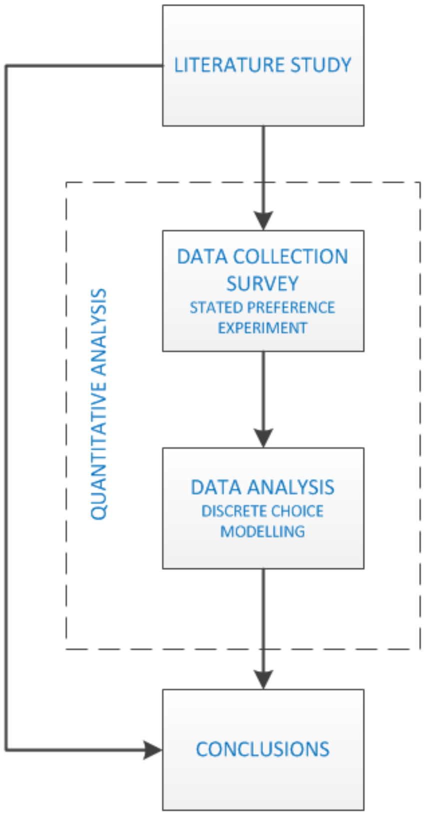



**Figure 1. Research design**

## 1.4. Expected results

The results of the study will give an overview of the impact of public transportation service level on apartment attractiveness through its value in Tallinn, Estonia. The topic will be analyzed from the residents' point of view using quantitative methods. The results will give initial information on whether public transportation characteristics are a considerable factor in apartment price in Tallinn and what is the residents' willingness to pay for a good transportation service level.

The outcome of this work will be an examination of how and to what extent are public transportation service levels affecting apartment attractiveness in Tallinn. This study is highly meaningful scientifically, practically and societally as transportation impact on property values has not been investigated before in Estonia, although this information undoubtedly provides insight to how transportation and land-use planning are connected and thus, gives input for public authorities and housing developers for their work. Acknowledging residents' needs in urban planning processes and in housing development helps developers to create a living environment that fits the market demand. In addition, knowing residents' mind-set, public authorities can better prepare for planned changes (e.g. moving towards more sustainability by increasing the share of public transportation).

# 2. CITY DEVELOPMENT & STAKEHOLDERS

## 2.1. INTRODUCTION

Housing and transportation decisions are some of the most important decisions that individuals make, affecting directly their quality of life, finances, daily schedule and at the same time the urban structure of a city (Jun, 2013). Housing choice consists of several different decisions: which housing type to choose, to rent or to buy and most importantly, where the dwelling is located. Different attributes connected to a certain dwelling affect its price and can roughly be divided into two – structural characteristics and locational characteristics (Kauko, 2002). Properties are unique products, thus the real estate (incl. housing) markets, affected by societal, economic, environmental and institutional forces, are singular, too (*Kinnisvara hindamine*, 2008). Real estate developers are entrepreneurs responsible for the supply side of housing market and are highly responsible for shaping our cities and lives. The interaction of real estate developers with other agents in the development process determines the attributes of new developments and the face of the city (Maruani & Amit-Cohen, 2011).

Transportation development in a city is led by public authorities and affects urban life enormously. Depending on the transportation mode that public authorities focus on, cities can be either transit- or car-oriented, occasionally a mixture of both (Rodrigue, 2013). In the light of urbanization and overall increasing population of the world, issue of sustainability in the transportation sector has risen. It is believed by many experts (Cervero & Kockelman, 1997; Cervero & Murakami, 2008) that transit-oriented development is the most sustainable transportation path for cities, but a strong combination of different forces is needed to make changes towards it. TOD can be achieved through changing the dimensions of built environment (Cervero & Murakami, 2008) – a task for public authorities to lead. To change residents' transportation habits, their transportation mode selection process needs to be understood together with the role that public transportation service levels have in it.

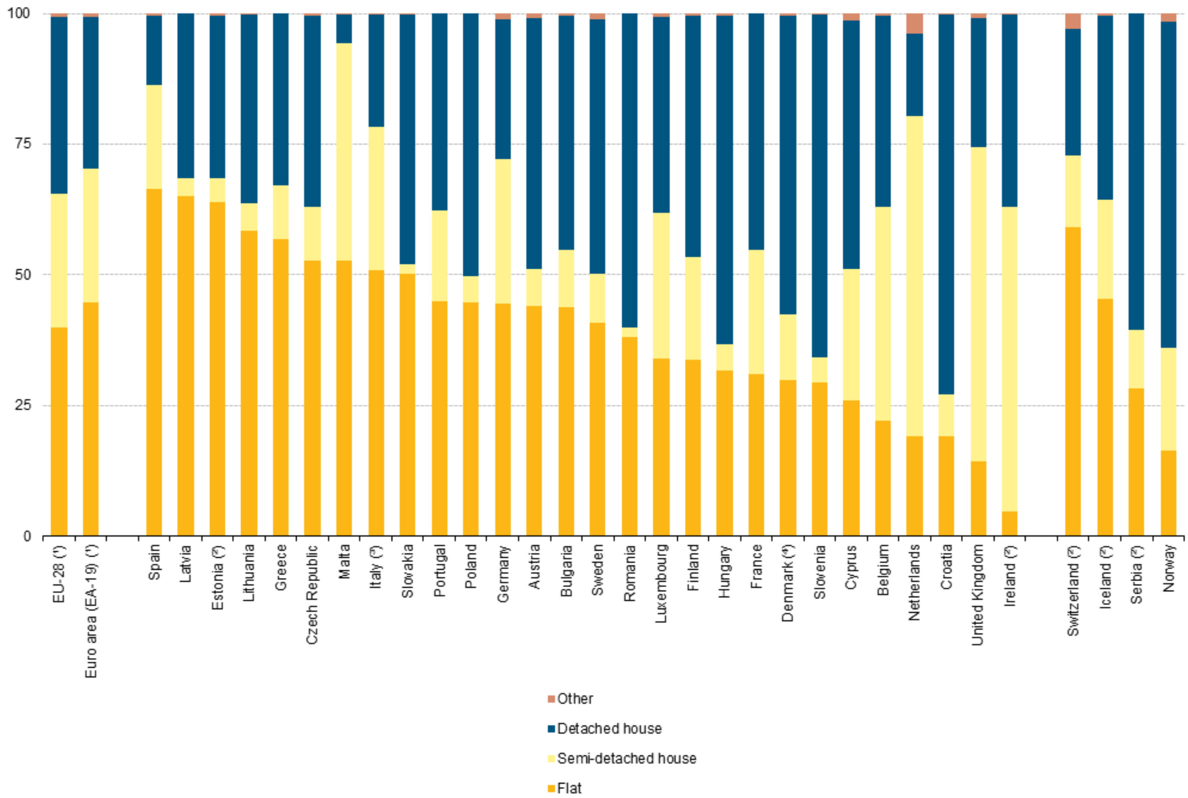
From residents' point of view public transportation creates a connection between home and work, school, stores, services, etc. PT service should thus be one important characteristic affecting dwelling price as it changes the accessibility of other parts of the city. The relationship between public transportation system, PT stops and property value is considered being one of the corner stones of land markets (Hess & Almeida, 2007). The interaction of PT access and property price has fascinated many researchers (Bae, Jun, & Park, 2003; Efthymiou & Antoniou, 2013; Hess & Almeida, 2007) who, in their studies, have demonstrated negative, positive and interestingly even no connection between those actors. Understanding this connection allows real estate developers to build housing with the needed attributes, residents to have housing that matches their demands and public authorities to steer the land-use and transportation processes in the city towards higher sustainability. Following, a literature overview of housing, transportation and their connection is given.

## 2.2. Housing

The largest share of urban land is occupied by housing, accounting for more than 50% of land use in some cities (Balchin, Kieve, & Bull, 1988). A place to live is something that everyone needs and thus housing is a common matter connecting every human being. In addition to its necessity, housing accounts for a great share of household's expenditures. According to Housing Europe (Pittini, Ghekiere, Dijol, & Kiss, 2015) housing costs in 2013 represented on average 22.2 per cent of household's disposable income.

### *2.2.1. Housing types and tenure types*

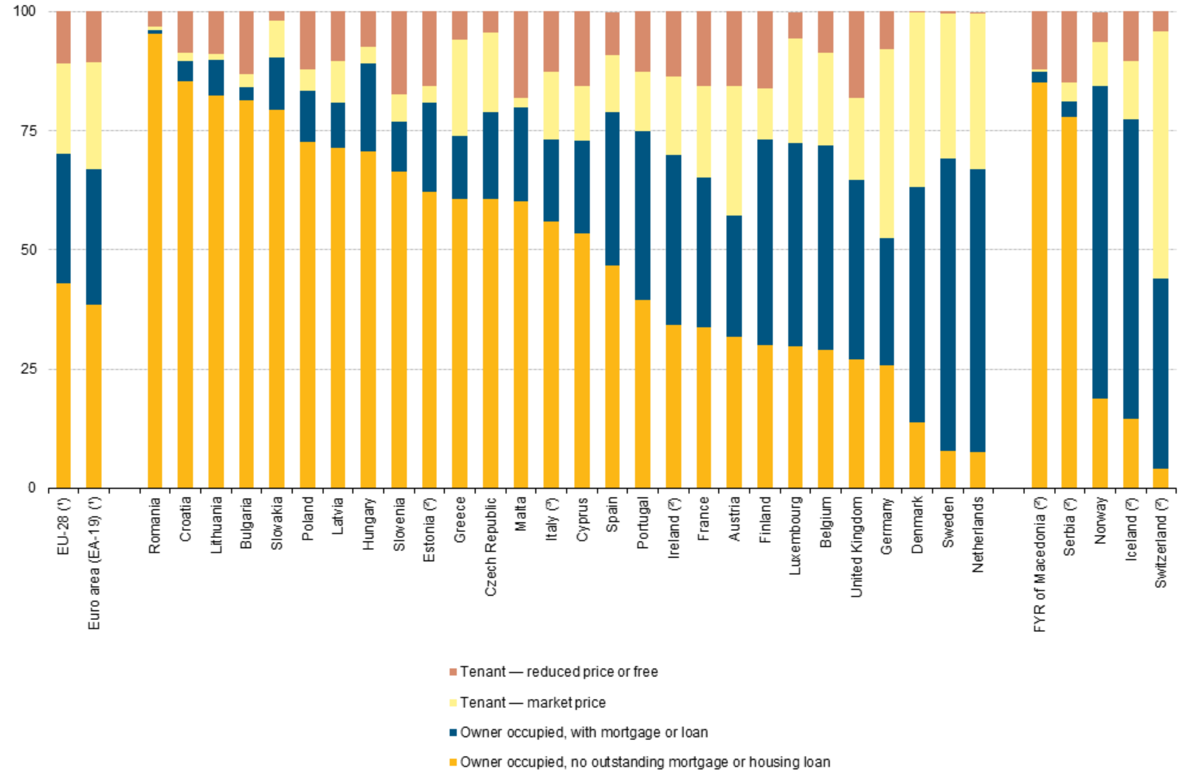
European Union (2014) defines a dwelling as „a room or suite of rooms — including its accessories, lobbies and corridors— in a permanent building or a structurally separated part of a building which, by the way it has been built, rebuilt or converted, is designed for habitation by one private household all year round" and divides dwellings into two main types – houses (detached or semi-detached) and apartments (flats). In 2014 40 % of EU population lived in apartments, 25.6 % in semi-detached houses and 33.7 % in detached houses (see Figure 2). Share of people living in apartments was highest in Spain (66.5%), Latvia (65.1%) and Estonia (63.8%) and lowest in Ireland (4.7%), United Kingdom (14.4%) and Norway (16.4%).




(1) Estimates.
(2) 2013.
(3) Provisional data.
(4) 2012.
*Source:* Eurostat (online data code: ilc_lvho01)

**Figure 2. Distribution of population by dwelling type, 2014 (% of population) (Eurostat, n.d.)**

A decision between owning and renting a dwelling is influenced by several factors – household's financial capability, desired mobility, availability of loans, individual housing preferences, public policy, provision of rental housing etc. (Baker & Lester, 2017; Elsinga & Hoekstra, 2005; European Union, 2014; Montgomery & Curtis, 2006).




(1) Estimates.
(2) 2013.
(3) Provisional data.
*Source:* Eurostat (online data code: ilc_lvho02)

**Figure 3. Distribution of population by tenure status, 2014 (% of population) (Eurostat, n.d.)**

In EU residential housing is mostly owner occupied, with an average of 70.1 % (see Figure 3), although new dynamics have emerged due to unaffordability of owning and people's desire for mobility. Increased share of tenants can be witnessed in EU15 countries (European Union, 2014) and this trend is also seen in rest of the world, e.g. by 2015 the home ownership in the USA had decreased 8 years straight reaching the same level as in 1993 - approximately 64% (Joint Centre for Housing Studies of Harvard University, 2015).

### *2.2.2. Housing choice and location choice*

*"Housing choice is a serious matter for households because it affects family finances as well as quality of life. Buying or renting a house involves not only spending a large proportion of family income, but also choices of neighborhood, location, and environmental characteristics affecting the household's living conditions and quality of life"* (Jun, 2013).

As can be concluded from above housing choice is an important task and has an enormous effect on households' life in several different ways. What differs housing choice from other consumer theories is the fact that, in general, house is an immovable object, thus location has a special meaning (Laakso, 1997). There are two main theories for household location choice - "utility maximization" and "Tiebout" theory (Montgomery & Curtis, 2006), which will be described below.

"Utility maximization theory" states that in order to minimize commuting costs, people seek for dwellings located so that their accessibility to workplace is greater. On the other hand, when they wish for less expensive housing, location further away from employment needs to be accepted together with increased commuting costs. In any case, people's choices are based on wish to maximize household's utility, location being one argument in the consumption set (Alonso, 1964). This theory is also often called transportation and land cost "trade-off" as it suggests that commuting and housing costs are tradable against each other (Krizek, 2003). The theory has several flaws as it assumes simple urban model, where the land price (or rent) is dependent on the distance to the CBD, where all the jobs are located, and on the area of the plot, while the urban area is mono-centric, uniformly dispersed round and flat (Kauko, 2002).

"Tiebout" theory is based on the seminal article of Charles Tiebout (1956) and states that households choose their location based on quality and costs of municipal services (Friedman, 1981). Every household will make residential decisions by weighing the local services against local taxes and show their preferences for those services by moving to a certain place. The services evaluated by households include health services, education, leisure services, law enforcement, etc. (Dowding, John, & Mergoupis, 2002). According to Montgomery and Curtis (2006) the theory assumes housing consumers to have full mobility and full knowledge in their decisions and thus has also been subject to criticism.

### *2.2.3. Attributes affecting housing price*

First of all, it is important to note that - in principle - the terms "value" and "price" have a different meaning in real estate. "Price" refers to market price or exchange value and is a fact. It is a sum of money that the buyer is willing to pay and the seller is willing to receive for a certain transaction. "Value" is an opinion or a hypothetical price, which can be either monetary or non-monetary (Kauko, 2002; *Kinnisvara hindamine*, 2008). Some economic theories consider these terms the same, approximating value as price (Kauko, 2002). In this thesis the terms are also considered synonyms to lower the level of complexity of real estate pricing.

Kauko (2002) states "when income is given, the rational utility and profit maximizing of individuals with respect to optimal location and other property characteristics can be said to form the basis for price formation and (possibly) market segmentation". Hedonic house price studies have been conducted for decades to identify the economic significance of different housing attributes (MacIennan, 2012) and it still continues to be of interest to the researchers. These attributes are generally divided into two: dwelling characteristics and location characteristics (Bowes & Ihlanfeldt, 2001; Hiller, 2014; Kauko, 2002; Laakso, 1992;

Maclennan, 2012). At the same time several authors have considered it important to divide the characteristics into three categories: dwelling, accessibility and neighborhood characteristics (Bae et al., 2003; Forrest, Glen, & Ward, 1996; Hess & Almeida, 2007; Rodríguez & Mojica, 2009), although, as shown by Kauko (2002) neighborhood and accessibility characteristics can be considered as two subcategories to locational attributes (see Figure 4 below).

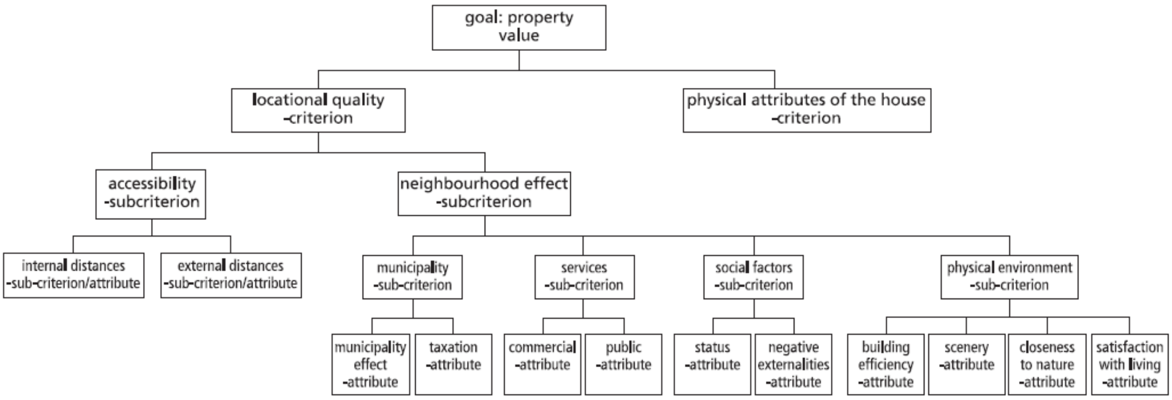



**Figure 4. Factors affecting property value (Kauko, 2002)**

In his study of urban housing prices and the demand for housing characteristics Laakso (1997) gives an overview of 18 empirical studies on the topic since 1979. Essentially in all of these studies price is dependent on structural characteristics of the dwelling and several factors connected to location or neighborhood. Number of variables ranges highly – from three variables used by Lineman (1981(Laakso, 1997) to approximately 30 variables used by Palmquist (1984). Structural characteristics included in every study are the size of the dwelling (number of rooms, floor area or both) and most of the studies also include the size of the plot and building age. Use of locational variables differs deeply, with some studies including none, some only one (distance to central business district) and the study of Li and Brown (1980) including 12. The most common neighborhood variable included in the studies is the income of the households. Other regularly used variables include: quality of schools, crime rate, proportion of rented dwellings, etc.

As an outcome of their extensive literature overview of hedonic price models, Chau and Chin (2003) have identified the most common housing attributes affecting dwelling's price and their expected effect (see Appendix A). Most frequently used structural attributes go in line with Laakso (1997) and include the size of the dwelling, number of rooms and building age. In addition, the effect of the existence of basement, garage or patio, building facilities, building services, floor level and structural quality is often assessed. All the mentioned structural characteristics are expected to have a positive effect on dwelling's price, besides the age of the building. Most commonly used locational attributes are distance from the central business district (CBD), different views or their obstruction and the length of land lease. Again, all of these characteristics have a positive effect on the price, with an exception of view obstruction. Neighborhood characteristics which have an effect on housing price are residents' income, crime rate, noise levels, environmental quality and proximity to different facilities (schools, hospitals, etc.). The crime rate and traffic/airport noise have a negative effect on the price, whereas the effect of proximity of hospitals, shopping centers and forests varies. Rest of the neighborhood attributes has a positive effect on the price.

### *2.2.4. Housing market*

To understand housing markets, real estate market in general needs to be examined. Due to its heterogeneity and immobility real estate itself and real estate market are unique when compared to other products (Lee, Chung, & Kim, 2005; Ling & Archer, 2012). Following, five characteristics of real estate (markets) are explained:

1) **Heterogeneity** – each property has unique features deriving from its age, building design, and most importantly location. In real estate valuation, structural attributes of a home are easily observable (e.g. size and number of rooms), but locational attributes and external effects deriving from location (both positive and negative) are complex to comprehend (Ling & Archer, 2012).
2) **Immobility** – each property is fixed in one location which determines its locational attributes and accessibility (e.g. access to school, work, and shopping). Although it is sometimes possible to physically move a building, it is normally not financially feasible (Ling & Archer, 2012).
3) **Localized markets** – possible alternatives generally lie within a short distance from each other (Ling & Archer, 2012).
4) **Segmented markets** - concrete real estate's market is constrained by the type of property, property's characteristics and market area (can be local, regional, national or international) (*Kinnisvara hindamine*, 2008).
5) **Privately negotiated transactions with high transaction costs** – transactions are mostly privately negotiated between the buyer and the seller and the transaction costs include the lengthy search process for the right property and the final cost of the transaction (Ling & Archer, 2012).

According to Appraisal Institute (*Kinnisvara hindamine*, 2008) the forces that affect real estate market and real estate prices can be divided into four categories: **societal, economical, institutional and environmental**. Societal factors include demographics, people's lifestyle choices and their attitudes towards education and law. Economic factors consist of wages, industrial expansions, economic base of the area and community, price levels, number of new developments that are in the construction or planning phase, etc. From institutional forces, important role is played by availability and level of public services, national, regional and local fiscal politics, property laws and master plans. The environmental forces are clearly dependent on property's location and include local climate (temperature, humidity, etc.), proximity of toxic chemicals, natural obstacles (rivers, mountains, etc.), main transportation systems and the characteristics of the area in close vicinity.

Value (price) of a property (e.g. dwelling) is usually created by four independent economic variables (*Kinnisvara hindamine*, 2008):

1) **Utility** – product's capability to satisfy people needs, wishes or desires;
2) **Scarcity** –product's current or predicted insufficient supply compared to its demand, scarcity increases value;
3) **Desire** – buyer's will to obtain a product which satisfies his/her human needs (e.g. shelter, clothes, food) or individual wishes going beyond essential needs;
4) **Effective purchasing power** – individual's or group's capability to participate in the market, i.e. to buy products or services for money or for its equivalent.

These variables are embedded in the supply and demand theory, where demand for a product is created by its utility and affected by its scarcity. Demand is also affected by desire and will to obtain the product, whereas the effective purchasing power limits the desire. At the same time supply of a product is affected by its utility whereas limited by its scarcity. Scarcity of a product increases the desire for it, but is again limited by effective purchasing power. In the context of real estate this theory states that dwelling's price is directly influenced by demand and indirectly by supply (*Kinnisvara hindamine*, 2008).

### *2.2.5. Residential development*

Housebuilding creates the supply of housing. It involves a variety of activities from land acquisition to marketing and selling the dwellings. The main phases of housebuilding are (Ball, 2012): 1) **project conception and evaluation** – a suitable site will be identified; schemes for layout, roads and other infrastructure designed together with the internal and external architecture; time-line estimations will be made and financial feasibility calculated; 2) **land preparation** – land will be made ready for building, both physically (ground works, connections to utility networks) and in regulatory terms (required permissions will be obtained); 3) **building construction** – the building will be erected; this demands assembling the build team, components and materials, and includes foundation works, service installations, erection of building and completing interior works; 4) **marketing and sales** – erected dwellings need to be sold; this process is supported by branding and marketing activities; additional purchaser requirements will be fulfilled and after sales works conducted. In this process, it is important to ensure customer satisfaction.

As stated in several papers (Coiacetto, 2009; Goldberg, 1974; Robinson & Robinson, 1986), developers are entrepreneurs highly responsible for shaping our cities and thus for the way people live. Coiacetto (2009) even argues that planners and policy makers play a role in urban development processes, but do not build cities – cities are built entirely by private sector interests. At the same time, developer's decisions are based on public (residents') demands. This is also goes in accordance with the supply-demand theory stating that demand with purchasing power will create a new real estate supply (Võhandu, 2015). The relationship between the developers (actors who initiate the plans), planning system (actor who approves the plans) and the public (actor whose demands motivate the plans) is captured in Figure 5. As stated by Maruani and Amit-Cohen (2011): "The outcomes of the interaction between these three agents will eventually determine the attributes of the new development and the spatial pattern of developed areas and open spaces."

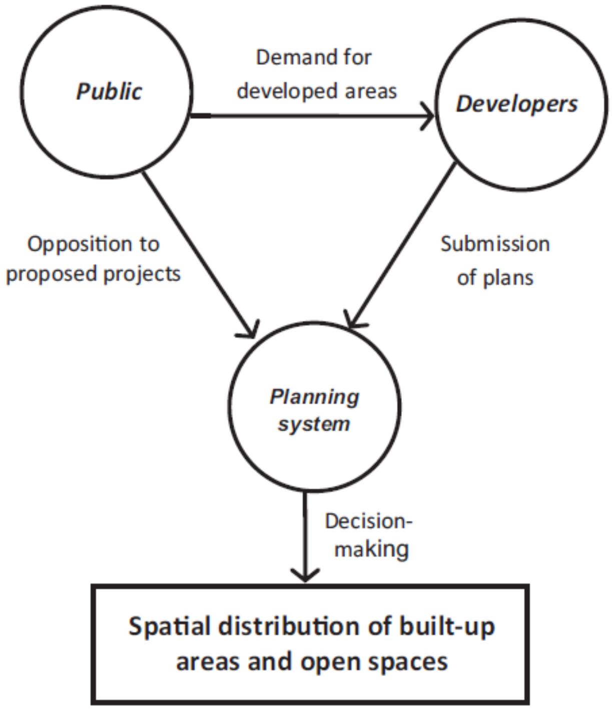



**Figure 5. The development decision model (Maruani & Amit-Cohen, 2011)**

As entrepreneurs, the developers have similar characteristics to entrepreneurs in any other field, i.e. profit seeking, innovativeness and risk taking, but also exhibit several distinctive differences, like the necessity to acquire land before starting the development process and high level of involvement with public institutions (Maruani & Amit-Cohen, 2011). Although, developers' decisions should be based on public (residents') demand, it is the role of public authorities to include all stakeholders in urban planning discussions and steer the urban development through planning regulations.

## 2.3. Transportation

Person's choice of movement depends on personal preferences, availability of different transportation modes, their convenience and varies widely among cities, e.g. in Tokyo 88% of all movements are done by walking, whereas for Los Angeles this figure is only 3% (Rodrigue, 2013). One trip is often made using a combination of different means of transport. The preferences for a certain trip depend on the options a particular person has, e.g. the existence and availability of transportation infrastructure, option to use a car, availability of bus and railway system, the wishes and needs of a household, price of public transportation or gasoline, etc. (Antso, 2010).

### *2.3.1. Transportation development paths*

Rodrigue (2013) has summarized the urban transportation development paths (see Figure 6). The author states that there are 3 different paths starting from pre-industrial city relying on walking and ending with an outcome of either **automobile dependency**, **transit-oriented development (TOD)** or **hybrid cities**. Each of these paths and the steps in between has a different level of urban mobility and ownership of passenger modes. Once following one path, strong economic, political and public will is needed to diverge to another.

(A) **Automobile dependency** - First step on this path is wide distribution of non-motorized transportation, especially the bicycle. Here a divergence (1) can be made towards establishment of PT services. When following the initial path, the next step brings motorization by extensive use of motorcycles, which in turn leads to saturation of motorcycles, cars and buses in the next development phase of the city. As economy develops and the investments to road infrastructure continue, this path results in a car-oriented city, meaning that majority of human movements in the city are made using automobiles.

(B) **Transit-oriented development** - In this development path the motorization is slow and road building moderate. Transit-oriented land use development strategies and large investments in public transportation have led to a city where great proportion of people use public transportation for their movements, i.e. transit city. Transit cities are not very common, yet.

(C) **Hybrid cities** - These cities start with following the same steps as the transit-oriented development, but at a certain point, the pace of road development exceeds the pace of transit development, resulting in the transportation system being saturated with cars and buses. This was a very common situation for cities in developed countries in the end of the 20th century. From here two path divergences can be made: divergence (2) towards more transit oriented forms through restrictions on car use/ownership and promotion of alternative modes of transportation; or divergence (3) leading to automobile dependency through lack of further developments of PT and rapid motorization.

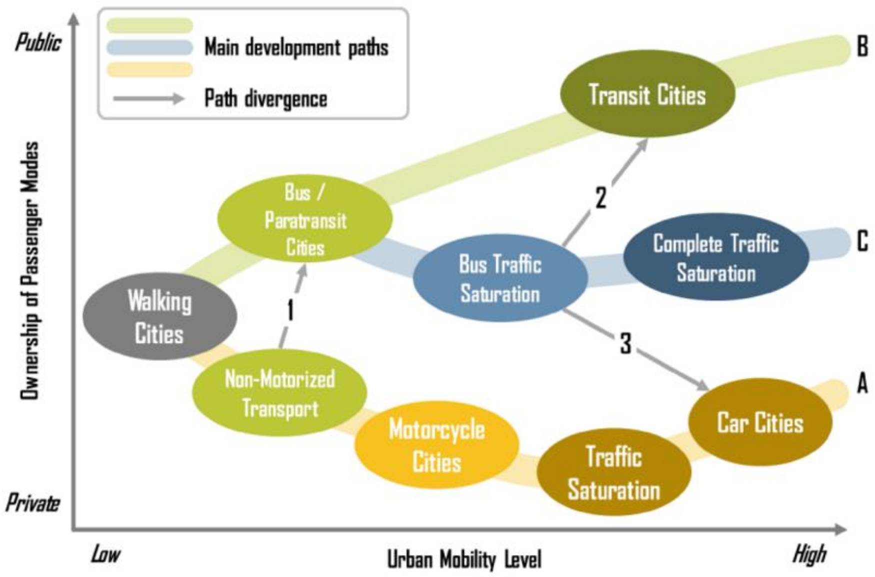



Figure 6. Urban transport development paths (Rodrigue, 2013)

Transportation has significant economic, social, environmental impact and it’s an important factor in sustainability. The negative effects of car dependency and car-oriented development strategies have been captured by many authors: it can lead to urban sprawl and suburbanization (Kuby et al., 2004; Litman & Laube, 2002), it creates decentralization of activities which results in longer travel distances and reduced accessibility (Mavoa, Witten, McCreanor, & O'Sullivan, 2012; Ratner & Goetz, 2013), and it accounts for several environmental issues as air pollution, traffic noise and increased greenhouse gas emissions (Sung & Oh, 2011; Tiwari, Cervero, & Schipper, 2011). Thus, the need to increase the usage of alternative means of transport (especially PT) and combat automobile dependency can be seen (Sung & Oh, 2011; Tallinn City Government, 2011).

### *2.3.2. Transit oriented development*

Transit oriented development (TOD) is one example of contemporary urban design movement, focusing on smart growth of the cities with an distingue characteristic – in the center of focus in TOD is transit station (Cervero & Murakami, 2008). As defined by California Department of Transportation (2005) TOD is:

*"moderate to higher-density development, located within an easy walk of a major transit stop, generally with a mix of residential, employment and shopping opportunities designed for pedestrians without excluding the auto. TOD can be new construction or redevelopment of one or more buildings whose design and orientation facilitate transit use."*

This definition captures all common attributes of different TOD definitions, i.e. TOD usually focuses on an area which is in the walking distance of the station, mixed land-use, increased density, which leads to increased transit ridership and preference towards walking, cycling and other alternative means to car travel (Ratner & Goetz, 2013).

According to Cervero and Kockelman (1997) TOD aims to shape the travel demand and its objectives for transportation are: reducing the number of motorized trips, increasing the share of non-motorized trips and for motorized trips that are still taken, decreasing the distances and increasing the vehicle occupancy levels. These objectives can be achieved through changing the dimensions of built environment, more specifically the 3D's – density, diversity and design. The concept was further developed by Cervero (2008) by adding 2 more dimensions – distance to transit and destination accessibility, changing the concept to 5D's of built environment (Figure 7). High quality environments and sustainability can be achieved by overlapping these 5D's. Following, each of the D's will be explained.

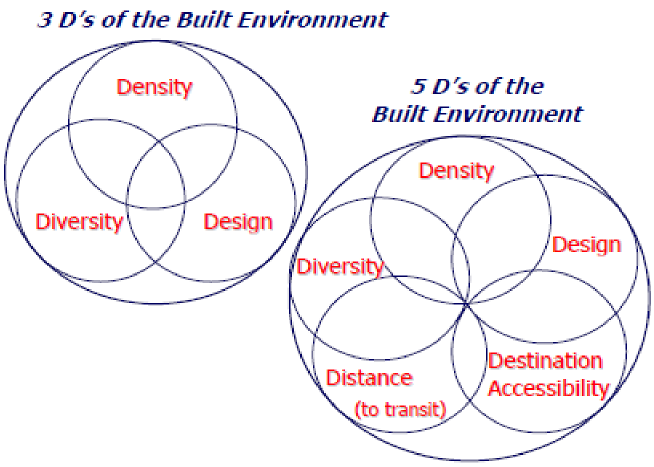



**Figure 7. 3 and 5 D's of built environment (Cervero & Murakami, 2008)**

**Density**

*„Density means having enough residents, workers, and shoppers within a reasonable walking distance of transit stations to generate high ridership* (Cervero & Murakami, 2008)*."*

Density indicates the magnitude of land use developments for housing, employment or other purposes (Cervero, 2002). Higher densities bring activities closer together and thus shorten trips; promote walking and cycling; and encourage transit usage and ride-sharing (Cervero, Ferrell, & Murphy, 2002). Density and diversity are argued to be the most important factors in TOD (Cervero et al., 2002): in low-density areas, transit stations are not able to attract the critical amount of passengers and without mixed land uses, people will not be able to access a variety of destinations with transit and thus are less inclined to use it.

**Diversity**

*„Diversity calls for a mixture of land uses, housing types, building vernaculars, and ways of circulating within neighborhoods* (Cervero & Murakami, 2008)*."*

Diversity of land use creates both supply- and demand-side benefits (Cervero et al., 2002). Former includes the availability of services in the neighborhood (convenience stores close to housing, places to eat close to employment, etc.), reducing the need for off-site travel; and latter includes the reduction of infrastructure loads and bi-directional use of infrastructure (activity centers can be both the origin and the destination of the of the trip).

**Design**

*„Design embodies physical features, site layouts, aesthetics, and amenities that encourage walking, biking, and transit riding as well as social engagement* (Cervero & Murakami, 2008)*."*

In this category, the design of walking environment is considered especially significant as all people who use transit, need to walk some proportion of their trip (Cervero et al., 2002). At the same time the study of Ewing and Cervero (2010) argues that transit-oriented environment is not equal to pedestrian-oriented environment, thus in TOD design it is important not to forget cyclist and car drivers and their experiences with the environment.

**Distance to transit**
Cervero and Landis (1993) argue that people prefer public transportation to private cars when public transportation stop is located close to their home or work. Accordingly, transit ridership has often seen to be exponentially decreasing with distance from a railway station (Cervero et al., 2002; Holtzclaw, Clear, Dittmar, Goldstein, & Haas, 2002). This can frequently also be a product of self-selection, i.e. people who prefer to use public transportation choose their residential location accordingly (they look for housing that has an easy access to transit)(Cervero, 2007).

**Destination accessibility**
*„Destination accessibility pertains to how well a TOD is connected to retail shops, activity centers, and other popular destinations. It thus captures the degree to which public transport efficiently connects a station-area neighborhood to activities spread throughout a region* (Cervero & Murakami, 2008).*"*

The issue of access is addressed in many papers (Gutiérrez, Cardozo, & García-Palomares, 2011; Mavoa et al., 2012; Sung & Oh, 2011; Yang et al., 2013). In their study of destination accessibility via public transportation Mavoa et al. (2012) concluded that in current literature the transit accessibility is determined by: access to transit stop, duration of public transit journey and access to destinations via public transit. First of which is the physical access of the stop, defining the distance that people need to walk to reach the transit stop. Following, the duration of the journey allows understanding where people can reach when travelling by public transit. Finally, access to destinations considers the types of destinations present in reached locations.

### *2.3.3. Transportation mode choice*
People's decision making for routine travel purposes, i.e. shopping or everyday errands is captured by Schneider (2013), who, based on previous research on travel behavior and psychology, has created the theory of routine transportation mode choice decisions (see Figure 8). Firstly, for people to consider a certain transportation mode they need to be aware of it and it needs to be available for them. Next, the set of three elements - basic safety and security; convenience and cost; and enjoyment - form the assessment base of situational tradeoffs between different modes in the choice set. The sequence of analysis of these elements is not determined and they can even be considered simultaneously. Final element in the process is the person's habit which reinforces previous choices. There are also socioeconomic factors affecting the process, which explain the differences in how people respond to each step. Following, the five elements in the routine mode choice and the socioeconomic factors will be described more in depth.

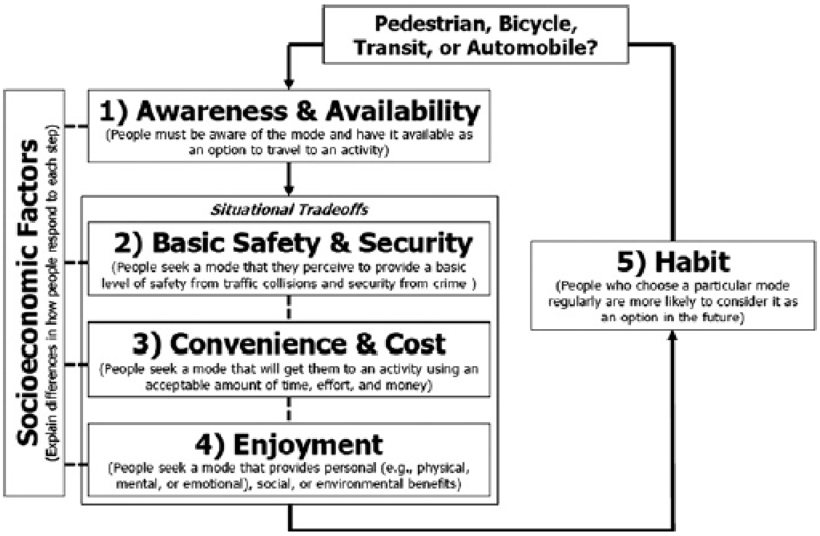



**Figure 8. Proposed theory of routine mode choice (Schneider, 2013)**

**Awareness and availability**

Significance of awareness in travel choice making is proved by, for example, Rose and Marfurt (2007) who showed that a ride to work day encouraged approximately one quarter of people who rode a bike to work for the first time during the event, to still do so 5 months later. The availability of a certain transportation mode is an essential determinant in the probability of choosing it, e.g. owning a car or a bike increases the likelihood of choosing it for transportation (Schneider, 2013). Based on literature study of Sanders (2015) availability of a car increases the probability of using it rather than travelling by public transport for distances up to 2000 km, for short distance travels (up to 10 km) the same is reported for bicycle.

**Basic safety and security**

People seek to travel using a transportation mode which they perceive safe from traffic collision and crime (Clifton & Livi, 2005). The results of Schneider's (2013) research showed that people avoided walking and cycling on roads with high-speed, high-volume automobile traffic and avoided neighborhoods which they considered dangerous in terms of personal security.

**Convenience and cost**

Convenience and costs are often considered the most important factors influencing travel mode choice. Modes that require travelers to gather information are less desirable than modes that involve little preparation. Personal space and personal control over travel movement are also important factors in convenience of travel (Schneider, 2013). People seek to travel by transportation mode which requires less time, effort and money (Cao, Handy, & Mokhtarian, 2006; R. H. Ewing, 2008).

**Enjoyment**

Enjoyment incorporates the emotional, physical and mental benefits that people seek to achieve with using a certain transportation mode. These benefits can occur on an individual (e.g. personal health), social (e.g. showing status) or a global level (e.g. reducing air pollution) (Schneider, 2013). For example, a person can choose cycling over driving to get in better shape, for another person it is important to drive in order to create a certain impression of oneself, whereas someone else is concerned with environment and thus chooses public transit over driving.

**Habit**

Regular choice of one transportation mode has an outcome of using the chosen option more often in the future, too (Gärling, Boe, & Golledge, 2000; Verplanken, Aarts, van Knippenberg, & van Knippenberg, 1994). When people develop routine choices, they tend not to consider as much information about alternative modes of transport (Verplanken et al., 1994). E.g. when people have the habit of driving, they are more likely to drive on shorter-distance trips when compared to people who do not drive that often (Gärling et al., 2000). In the theory of routine transportation mode choice, effect of habit is the final step in the loop and it either increases or decreases future awareness of using a certain mode (Schneider, 2013).

**Socioeconomic factors**

As stated by Ewing and Cervero (2010) socioeconomic factors have a significant effect on transportation mode choice. The factors connected with mode choice include age, gender, household size, income, car ownership, etc. According to Schneider (2013) these factors do not have a direct influence on the choice, but influence each part of the above mentioned decision process. For example, if a household does not own a car, then that mode of transportation is excluded from their choice set of modes; or a family with small children can consider travelling by car more convenient than cycling or taking public transportation.

### *2.3.4. Public transportation service*

Redman et al. (2013) conducted a research reviewing the quality attributes of public transportation that most likely attract car users. The topic of public transportation service quality is relatively new, as most of the studies he reviewed were published within last 15 years. The attributes can be roughly divided in two – physical and perceived. Most common of these are noted in Table 2.

**Table 2. Definitions of public transport service quality attributes (Redman et al., 2013)**

| | Attribute | Definition |
|---|---|---|
| Physical | Reliability | How closely the actual service matches the route timetable |
| | Frequency | How often the service operates during a given period |
| | Speed | The time spent travelling between specified points |
| | Accessibility | The degree to which public transport is reasonably available to as many people as possible |
| | Price | The monetary cost of travel |
| | Information provision | How much information is provided about routes and interchanges |
| | Ease of transfers | How simple transport connections are, including time spent waiting |
| | Vehicle condition | The physical and mechanical condition of vehicles, including frequency of breakdowns |
| Perceived | Comfort | How comfortable the journey is regarding access to seat, noise levels, driver handling, air conditioning |
| | Safety | How safe from traffic accidents passengers feel during the journey as well as personal safety |
| | Convenience | How simple the PT service is to use and how well it adds to one's ease of mobility. |
| | Aesthetics | Appeal of vehicles, stations and waiting areas to users' senses |

The literature study of Redman et al. (2013) revealed discrepancies between public transportation quality level evaluated and supplied by PT operators and its perception by PT users. Rietveld claims that the supplier focuses on the average performance and results while individual user bases his/her opinion on a certain experience. For example, the reliability levels on average over the course of a day are acceptable due to delays during peak-hours and smooth running during rest of the day. Customers travelling during peak hours experience poor performance and their opinion of service quality decreases. Furthermore, Parkan (2002) argues that the attribute levels PT operators check are not the attributes considered important by the PT users.

Redman et al. (2013) concluded that in order to attract car drivers to change to public transportation, several points need to be considered. Firstly, before any PT improvements are implemented, the service providers need to understand the quality attributes that the target group considers important. Secondly, literature study showed that the most important characteristics of PT demand and satisfaction level are reliability and frequency, although a basic level of access and competitive cost needs to be provided by PT for car drivers to consider the modal change. Thirdly, care users are most likely attracted to PT by breaking their habits, e.g. through promotional campaigns and events that encourage trying PT initially.

## 2.4. Public transportation and property value interactions

According to Hess and Almeida (2007): "the relationship between a transit system, the location of transit stations and property values are, in theory, fundamental to land markets and urban structure." This is because public transportation is the medium that provides access to CBD, employment, services, educational institutions, etc., increasing the accessibility of the entire area where it reaches.

Alonso's (1964) utility maximization theory is often used for explaining the relationship between accessibility and land values. Transportation investments are expected to create accessibility benefits to certain properties over others. As the number of plots that receive the accessibility advantage is limited, and access is a scarce good, households and companies are expected to be willing to pay more for the properties with better access if all the other factors remain the same (Rodríguez & Mojica, 2009).

There is a variety of studies on land-use and public transportation interactions with outcomes of positive, negative and no effect on property price deriving from public transportation accessibility (Bae et al., 2003; Efthymiou & Antoniou, 2013; Hess & Almeida, 2007). This inconsistency in results could be attributed to complexity of urban development processes and people's changeable travel patterns (Ryan, 1999). Hess and Almeida (2007) add that studies are often unique due to various research methods used, singularity of local transport system and land-use. This results in ungeneralizable and context specific results. General consensus amongst researchers is that heavy rail creates highest access premiums due to faster speeds, greater coverage and frequent trains. Heavy rail is followed by light rail and proximity of a bus route increases the property value the least (if at all) due to very little fixed infrastructure (Hess & Almeida, 2007).

Hess and Almeida (2007) studied how proximity of light rail transit stations affect the residential property values in Buffalo, New York. Overview of their comprehensive literature study of the effect of proximity to rail transit on residential property values can be seen in Appendix B. Most of these studies found a positive connection between access to rail station and residential property values. Garrett (2004) even found that properties close to transit stations can experience premiums up to 32 percent. This was the highest premium found. Decrease in property values close to transit was recorded due to industrial character of the area (Ihlanfeldt & Boehm, 1987) and nuisance effects like noise, safety, etc. (Landis, Guhathakurta, Huang, & Zhang, 1995). Some studies showed no significant impact of rail proximity on property price (Gatzlaff & Smith, 1993). In their own study Hess and Almeida (2007) found that properties within 0.25 miles (approximately 400 meters) of light rail station can be 2-5 percent more expensive than others. It was also seen that the effect of station proximity is positive in high-income areas, negative in low-income areas and that it is greater for straight line distances rather than for actual walking distances along the street network, suggesting a greater importance of the perceived distance from the station. Three variables – number of bathrooms, size of the property and location on the East side of Buffalo proved to be more important than station proximity in property price formation.

Rodríguez and Mojica (2009) investigated how accessibility advantages created by bus rapid transit (BRT) system extensions affected the value of residential dwellings in Bogota, Colombia. BRT is a "surface metro", encompassing the reliability and amenity characteristics of a rail-based transportation system (Wright & Hook, 2007). As a part of the study, Rodriquez and Mojica conducted a literature overview of relationship between transportation investments and land value, which is summarized in Appendix . In the studies reviewed, access premium was recorded in Massachusetts, London, Illinois, Seoul, San Diego and Bogota, whereas the work of Du and Mulley (2007) and Perdomo et al. (Rodríguez & Mojica, 2009) showed no impact of transit extensions on housing price in Sunderland and Bogota. Rodríguez and Mojica (2009) concluded that the results of the studies vary and omitted it to local land and market characteristics, variables used and the specification of access. Variables used by Rodríguez and Mojica (2009) in their own research of capitalization of accessibility attributes included physical attributes of the dwelling (age, type, floor area, no. of rooms, etc.), accessibility characteristics (distance to transit station, major employment centers, etc.) and neighborhood characteristics (population density, land uses, etc.). Full list of characteristics used can be seen in Appendix C. The researchers looked how the prices changed in residential areas which were already served by BRT after the BRT was extended and thus the accessibility enhanced. They witnessed an increase of 13-14% in asking prices of residential properties. In addition, some anticipation effect on the prices even a year before the extension was seen. This increase of prices was the same for properties up to 1 km from BRT.

Wang et al. (2015) has a different approach to examining land use and transportation interactions. They argue that land value taxation could help Cardiff council finance the local bus system. The argument is based on researching the connection of property price and the number of bus stops surrounding it. Number of bus stops was determined within the radius of 300, 400, 500, 750, 1000 and 1500 meters from the property. For all the distances a positive correlation between the number of bus stops and property price was found. Interestingly, high-end properties were seen to benefit more from additional bus stops than low-end properties.

Several other researches were reviewed for this thesis. The results are gathered in Appendix D. Most of the studies focused on light and heavy rail (Bowes & Ihlanfeldt, 2001; Forrest et al., 1996; Hess & Almeida, 2007) and only a few included bus transport (Efthymiou & Antoniou, 2013; Ibeas, Cordera, dell'Olio, Coppola, & Dominguez, 2012; Rodríguez & Mojica, 2009). Results of rail transportation frequently show a negative impact of station proximity to property price when the station is very close, although the distance varies from 0.25 miles (Bowes & Ihlanfeldt, 2001) to 2 km (Forrest et al., 1996). In addition to station proximity, the effect of railway proximity in general has been measured by Debrezion et al. (2007), who argues that in the Netherlands, the dwellings located within 250 meters from railway are 5% cheaper than those of 500 meters or further away. The negative effect of railway and rail station proximity is mostly attributed to negative externalities (e.g. noise). Bowes and Ihlanfeldt (2001) found that properties within 0.25 miles from railway station have a lower value, but in the distance range of 1-3 miles (1.6-3.2 km) the property value is higher than for those which are either closer or further away from the station. An explanation to this could be that a property which is 1-3 miles away from the station is already far enough from the negative externalities of the station, but still provides enough accessibility. At the same time, Hess and Almeida (2007) and Kay et al. (2014) report exactly the opposite to the previously mentioned, showing increased property prices within 0.25 miles (approx. 400 m) and 0.5 miles (approx. 500 m) from the railway station and lower prices further away. Bae et al. (2003) made a fascinating finding in Seoul, where property prices increased when anticipating a new subway line, but did not show any effect after its completion. It was argued to be due to great public transportation coverage of the city where locations do not differ in terms of public transportation accessibility. Every study which included bus transit showed some positive impact on property prices in vicinity. The highest positive effect was recorded for bus rapid transit (Rodríguez & Mojica, 2009).

Overview of physical and locational variables used in the studies can be found in Appendix E. Most commonly included physical variables are dwelling size, age, type and availability of parking or garage. In addition to distance to PT stop or station, distance to CBD was frequently included to the locational attributes of properties.

## 2.5. Discussion

Cities are shaped by transportation and real estate development. The main actors in these processes are the public authorities, residents and developers who all have their own different aims. In order to achieve better understanding between the stakeholders, interaction between property attractiveness and public transportation service levels in urban areas needs to be investigated.

Although having a great impact on the physical world around us, real estate developers are first and foremost entrepreneurs with an aim to make profit. It is argued that physical world around us is built entirely on private sectors interest (Coiacetto, 2009), but as in any other market, the developed product (a dwelling) is created to match the market demand. In addition to developers (who create the supply) and residents (who are responsible for demand), there is a third party in the real estate development process – public authorities, who is responsible for approving the proposed projects. Interaction between these three actors determines the attributes of new developments and the spatial patterns (Maruani & Amit-Cohen, 2011). Although being a subject to market forces, apartment’s attractiveness can be reflected by its price - more attractive a certain apartment with its unique characteristics is, the more are people willing to pay for it. Researching the effect of different variables on apartment price gives direct input to developers on what is in demand in the market. Structural characteristics most commonly included in the reviewed studies of dwelling price formation are the size of the dwelling, size of the plot, building age and floor level. Locational attributes vary widely, but quality of schools, crime rate, proportion of rented dwellings, distance to CBD, environmental quality and proximity to different facilities are often included.

Considering the locational characteristics, transportation accessibility undoubtedly plays an important role in dwelling’s price. Having a good transportation access between home, CBD and other facilities increases person’s accessibility to services and other destinations of everyday activities. Like housing, transportation affects the life quality of people and shapes the cities. Different development paths stemming from a common starting point in history – walking cities – have now separated the cities into transit-oriented, car-oriented and hybrid cities (Rodrigue, 2013). It is generally accepted that TOD is the most sustainable form of transportation development for cities, thus something that every city should aim for. When already following one path, combination of political, economic and public will is needed to steer towards TOD (Rodrigue, 2013). This initiative should come from public authorities who manage the development processes in the city. Again, close collaboration with developers and residents is needed, as TOD requires changes in the built environment and in people’s perceptions.

Review of previous studies on property price and public transportation accessibility revealed that most studies focus on light or heavy rail transport rather than buses, which are believed to create lower premiums that rail transportation due to little fixed infrastructure. Variety of results were witnessed which can be accounted to different methods and variables used. In addition, most of the studies are context specific, thus generalized results cannot be produced. Some studies showed more than 30% of price premiums on properties with good public transportation accessibility whereas several witnessed no or even negative effect. This implies that it is complicated to understand the dwelling price formation in a certain area without conducting a specific research on it, relying only on literature of similar areas.

# 3. TALLINN

## 3.1. INTRODUCTION

Tallinn is the capital city of Estonia, located on the Southern shore of the Gulf of Finland in the county of Harju. Population of Tallinn is approximately 440 000 which accounts for a little more than 30% of total population of Estonia ("CitizMap," n.d.). Because of its favorable location on east-west and north-south trading routes Tallinn has been of interest to several foreign rulers throughout its history. This has left its mark on the urban development of the city.

Tallinn has a medieval Old Town which is included in the UNESCO World Heritage list (UNESCO World Heritage Centre, n.d.). It is surrounded by green areas and wooden housing districts from the end of the 19$^{th}$ and beginning of the 20$^{th}$ century when Estonia was independent and Tallinn in the role of the capital city for the first time. The 1960s brought the time of rapid industrialization and under the soviet rule modernization of Tallinn started - three residential areas of panel housing – Mustamäe, Õismäe and Lasnamäe were built on the fields and in the forests on the edges of the city (Tomiste & Poopuu, 2010), accommodating nearly half of the city's population today.

In 1991 Estonia regained its independence from the Soviet Union. In 1999 Toomas Hendrik Ilves, foreign minister at the time expressed hope that Estonia will become „just another boring Nordic country" in the future (Smith, 2002). The country has been on that course. Radical reforms at the beginning of independence transformed the country in a decade „from a strict, planned economy to one of the most liberal economies in the world" (Ruoppila, 2007). In 2004 Estonia joined the European Union and NATO. Currently the country is making its name by having one of the most *tech savvy* governments in the world (Bershidsky, 2015; Tamkivi, 2014).

At the same time there are concerns about urban development processes in Estonia and in Tallinn. Most of new housing development in Tallinn is located on the edges of the city with a poor public transportation connection. Furthermore, there is little collaboration between different actors in the urban planning processes, public authorities are accused of not regulating the processes enough, not involving residents in the decision making process and letting the private sector lead the urban planning in the city (Leetmaa et al., 2009; Samarüütel, Steen Selvig, & Holt-Jensen, 2010). More recent reports (Kalamees et al., 2012; Paadam et al., 2014) state that there is a demand for more active position to be taken by the municipality in urban development processes and engagement in discussions with different stakeholders. Following, all this will be looked into in more depth.

## 3.2. URBAN STRUCTURE

For describing the development and the urban structure of Baltic cities (including Tallinn), a model (Figure 9) from (2013) can be used. According to it the urban area is divided into 3 rings: center, middle part and periphery. The center consists of the Old Town and older neighborhoods which grew organically until the 20th century. During soviet times this part was neglected, but currently it is going through the process of commercialization and has developed a new center. The second ring – middle part – was developed during the soviet times in the second half of the 20th century, it is dominated by large housing estates, has large parks and specialized campuses (e.g. universities, hospitals). The third ring – periphery – emerged after the Baltic States gained independence. This area used to be rural with some settlements and summer houses, but is currently suburbanizing. 4th ring – sub-periphery – can be presumed to be emerging soon. This is the area located more distantly from the city center, close to existing settlements, not exposing unsustainable dispersal patterns.

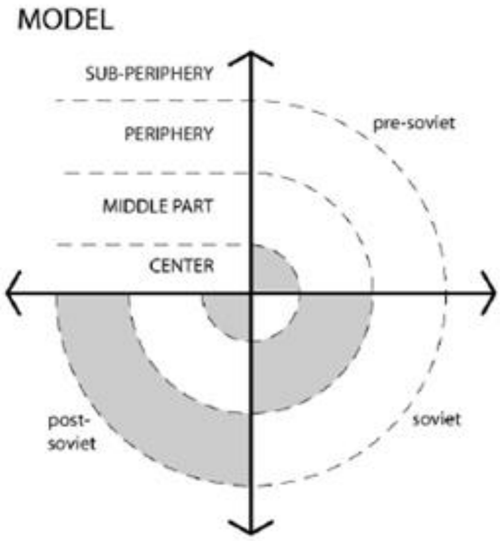



**Figure 9. Urban structure of the Baltic cities (Cirtautas, 2013)**

As explained by several authors (Cirtautas, 2013; Leetmaa et al., 2009) in the first decade of independence Estonia, Latvia and Lithuania focused on economic reforms and regeneration, neglecting urban and regional development. Due to low income, mostly commercial properties were developed. By the second decade of independence the institutional reforms were completed and the availability of bank loans pushed more active residential development. Most remarkable changes were happening on the outskirts of the city and former areas of allotment gardens (Cirtautas, 2013). Nowadays, it is often pointed out that urban development in the Baltic countries is lacking regulations and the development processes are led by private capital (Burneika, 2008; Leetmaa et al., 2009; Linnalabor, 2010).

### 3.3. Stakeholders in urban processes and the role of public authorities

Leetmaa et al. (2009) has captured the ambitions and strategies of 3 urban actors – companies, households and public authorities in Tallinn throughout three decades – 1980s, 1990s and 2000s (Table 3).

**Table 3. Ambitions and strategies of urban actors in Tallinn (Leetmaa et al., 2009)**

| | 1980s | 1990s | 2000s |
|---|---|---|---|
| *Companies* aim to ensure profit | To reach their aim in a shortage economy, priority companies became essential local actors with respect to patterns of land use and the construction of housing and infrastructure. | Liquidation and restructuring of many companies took place. Priority companies lost their role. | Real estate development became an attractive business. The financial sector began to offer affordable mortgages and the real estate development sector created an over-supply of potential suburban housing. |
| *Households* aim to have better jobs and living conditions | There were administrative restrictions on moving. It was difficult to obtain an apartment. However, the economy of shortages enabled workers to choose their jobs, which also opened up opportunities for housing careers. | Part of the Russian-speaking population left the country. People officially had freedom to move. Economic hardships and the lack of affordable housing loans restricted migration. Vacancies favoured adaptation in the housing market. | People had the freedom to migrate. This was favoured by the increase in wealth, the availability of 'cheap money', and the rapidly growing supply of suburban dwellings (new dwellings and summer homes). |
| *Public authorities* aim to increase general welfare | The aim to plan a balanced settlement system and create an egalitarian housing policy was overridden by economic (and defence) priorities. This led to conflicts between spatial and sectoral planning. | The Russian army left. The state created a legal framework for privatisation and restitution. Total withdrawal of the welfare state (including housing construction and no social housing) took place. | Public planning authorities do not respond to the supply-led suburbanisation process with efficient spatial planning. |

As the private sector inevitably aims to maximize their profit and people aim to maximize their well-being, criticism in the suburbanization process falls on public authorities. In addition to Leetmaa et al. (2009), shortcomings of public authorities are also brought out by Samarüütel et al. (2010) and Viljasaar (2013). Viljasaar (2013) brings out several complaints about the planning practices in Estonia based on personal experience as a planner and Tallinn Planning Guide (Viljasaar et al., 2012). The criticism primarily concerns the real planning power being in the hands of the private sectors, too small and late involvement of residents, secrecy of developers, complexity and low quality of planning documents, prejudices among stakeholders, etc.

## 3.4. Housing

The city of Tallinn consists of 8 districts: Haabersti, Kesklinn (City Centre), Kristiine, Lasnamäe, Mustamäe, Nõmme, Pirita, Põhja-Tallinn (Northen Tallinn). Nõmme and Pirita can be considered the garden districts as they are mainly filled with private houses. Lasnamäe, Mustamäe and a part of Haabersti called Õismäe are the panel housing districts built in 1960s-1980s. Accordingly, parts of Mustamäe, Haabersti and Lasnamäe are some of the most densely populated places in Tallinn (Tallinn City Government, 2015a), see Figure 10.

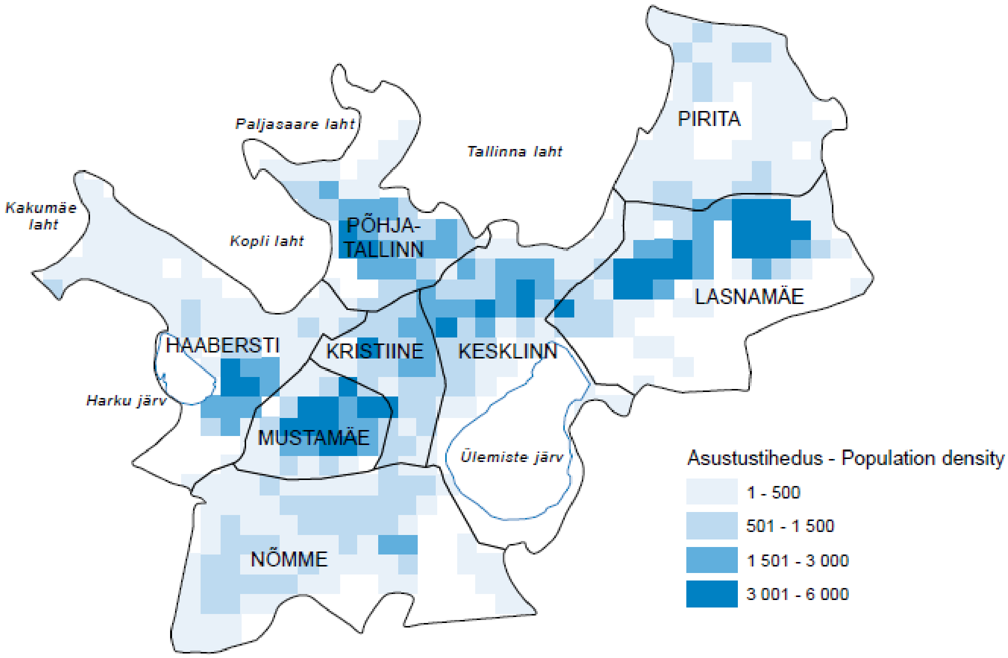



**Figure 10. Population density of Tallinn (Tallinn City Government, 2015a)**

In Estonia 63.8% of people live in apartments (Eurostat, n.d.). 80% of housing in Harju county is located in apartment buildings and for Tallinn this number is even 91% (Tiit & Servinski, 2015). There is a high rate of owner-occupancy in Estonia – 82% of conventional[1] non-vacant dwellings are occupied by the owner, whereas rest of the dwellings are rental (Pittini et al., 2015). 67% of the housing stock in Harju county dates back to the Soviet times (Tiit & Servinski, 2015). After re-gaining independence the housing construction in Estonia decreased dramatically. In the time period of 1996 to 2001 new housing supply did not meet the demand - only 1000 dwellings were added to the stock annually. Starting from 2001 housing construction accelerated and up to year 2007 the average number of dwellings completed annually increased to 3800. Mainly suburban homes and luxury apartments were built. 2008 brought the financial crisis and a decline in housing construction for several following years, although starting from 2014 an increase can been seen again. In 2015 3969 new dwellings were completed (Guide, 2016). According to the report "The State of Housing in the EU" (Pittini et al., 2015) there is an oversupply of housing in the rural areas of Estonia, whereas the two largest cities – Tallinn and Tartu – are under great demand pressure. New housing supply in Tallinn is mostly concentrated to the edges of the city or right outside Tallinn city limits, although there are several developments in the surrounding areas of the city center (see Figure 11).

[1] Conventional dwellings „are structurally separate and independent premises at fixed locations which are designed for permanent human habitation and are, at the reference date, used as a residence or vacant or reserved for seasonal or secondary use" ("Population and housing censuses in Estonia, Latvia and Lithuania - 2011," 2015).

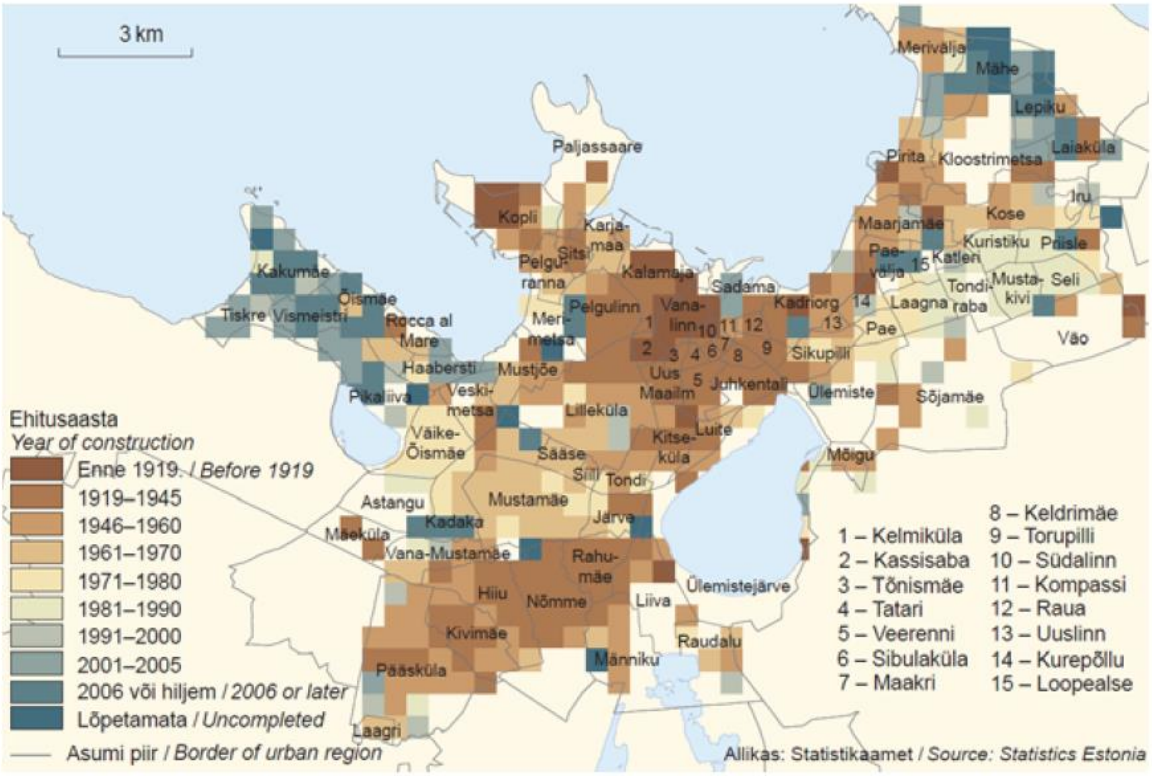



**Figure 11. Predominant time of construction of dwellings in the urban region of Tallinn, 2011 (Tallinn City Government, 2015a)**

When looking at the movement patterns in Tallinn (Figure 12), it can be seen that the highest share of new residents in the period of 2000-2011 was in Pirita (33%), followed by Haabersti, Kristiine and City Centre (Kesklinn) where the share of new residents was 18-25%. Large number of new residents in Pirita and Haabersti could be explained with the extensive new housing development in the areas (see Figure 11), lower density compared to the rest of the city and closeness to nature. New residents in Kristiine and Kesklinn could be explained with better quality housing (when compared to Mustamäe, Õismäe and Lasnamäe) and good service, retail and transportation infrastructure. At the same time Lasnamäe – the most populated district in Tallinn with approximately 118,000 inhabitants - attracts the least new residents possibly due to high criminal activity (BNS, 2012) and reputation of low living conditions and little scenery (Peensoo, 2003).

Persons who moved from one city district of Tallinn into another in the period of 31.03.2000–31.12.2011, share among the population of the new place of residence, and the main directions of movement between the city districts of Tallinn, 31.12.2011

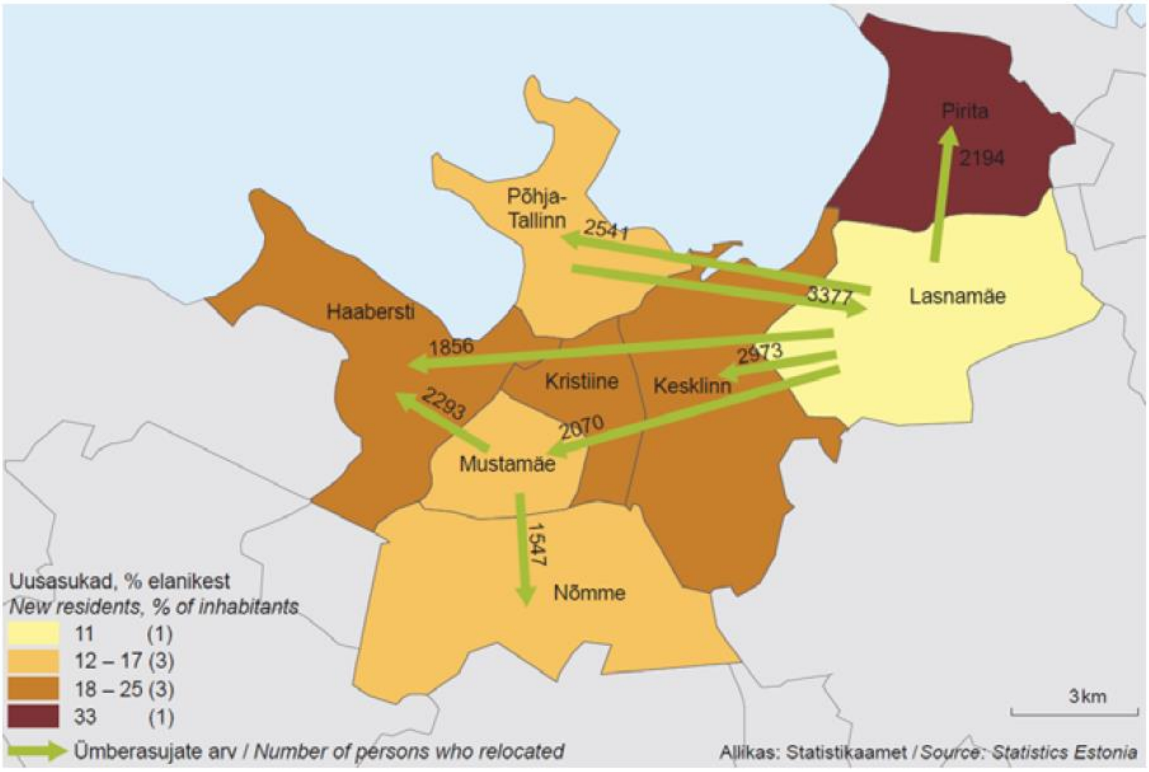



**Figure 12. Relocation patterns in Tallinn (Tallinn City Government, 2015a)**

In accordance with the changes in the urban structure and the city edge location of new developments, the average distances of households to the nearest places of interests have increased in the recent years (Table 4). E.g. in 2010 the closest public transportation stop was located 0.2 km from residential housing, whereas in 2011 and 2012 the distance was 0.3 km. The distances to stores, local municipalities, medical aid and pharmacies have also increased, which can be attributed to new housing development in the edge areas of the city (Tallinn City Government, 2015a).

**Table 4. Average distance of household to the nearest places of importance (Tallinn City Government, 2015a)**

| | | 2010 | 2011 | 2012 |
|---|---|---|---|---|
| **Tallinn** | Ühissõiduki peatus - Public transport vehicle stop | 0,2 | 0,3 | 0,3 |
| | (Statsionaarne) pood - (Stationary) store | 0,4 | 0,5 | 0,5 |
| | Algkool/algklassidega üldhariduskool - Primary school / general education school incl. primary school classes | 0,7 | 0,7 | 0,7 |
| | Linna- ja vallavalitsus - City or rural municipality government | 2,2 | 2,4 | 2,7 |
| | Postkontor - Post office | 1,2 | 1,3 | 1,2 |
| | Arstiabi võimalus - Medical aid possibility | 1,6 | 1,7 | 1,8 |
| | Pangakontolt sularaha kättesaamise võimalus - Cash withdrawal possibility | 0,5 | 0,5 | 0,6 |
| | Laste huvikool - Children's hobby group | 1,2 | 1,2 | 1,0 |
| | Apteek - Chemist's shop | 0,5 | 0,6 | 0,8 |

Mõõtühik: [km] - Unit: [km]
Leibkonna eelarve uuring, ütluspõhine - Household Budget Survey, testimony-based
Allikas - Source: Eesti Statistikaamet - Statistics Estonia

Apartment transactions form the most active section of real estate market in Estonia. In 2015, 53% (24,455 units) of all real estate purchase-sale transactions (46,188 units) were done with apartments and the rest were divided between transactions with land, residential buildings and non-residential buildings (see Figure 13). The value of apartment transactions in Estonia accounted for 48% (1.3 billion euros) of total real estate purchase-sale transactions value (2.7 billion euros) (Statistics Estonia, 2016).

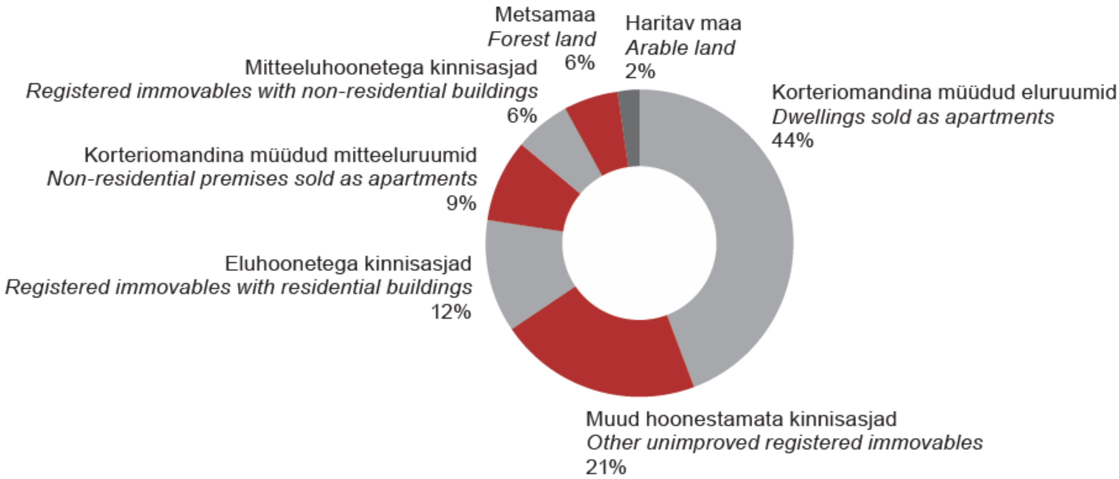



**Figure 13. Purchase-sale transactions of real estate in Estonia by object, 2015 (Statistics Estonia, 2016)**

In 2015 the apartment prices in Estonia rose by 10% compared to the year before. The average square meter price of an apartment in Estonia was 1029 euros and in Tallinn 1548 euros. When taking out apartment transactions in Tallinn of the Estonian average price calculations, the average square meter price falls to 625 euros, showing the impact the capital city has on the whole country's statistics (Statistics Estonia, 2016). Compared to 2014 the apartment prices in Tallinn rose less than in rest of the Estonia for all apartment sizes, but when looking at data since 2011, the price increases in Tallinn have been larger than in rest of the country. Since 2011 the square meter value of very small apartments (10-29 $m^2$) has risen the most – 70% in Estonia and 76% in Tallinn. The lowest rate of price increase can be seen for large apartments sized 70 or more square meters. In Estonia their average square meter price increased 34% and in Tallinn 37% (see Table 5). In Tallinn housing accounts for 19% of household's expenditures (Tallinn City Government, 2015a).

**Table 5. Average price (€) per square meter of purchase-sale transactions with apartments by size of apartment, 2011-2015, in euros (Statistics Estonia, 2016)**

| | 2011 | 2012 | 2013 | 2014 | 2015 | Price change 2011-2015 (%) | Price change 2014-2015 (%) |
|---|---|---|---|---|---|---|---|
| *All apartments* | | | | | | | |
| Estonia | 706 | 760 | 843 | 933 | 1029 | 46 | 10 |
| Tallinn | 1035 | 1103 | 1256 | 1451 | 1548 | 50 | 7 |
| *10-29 m2* | | | | | | | |
| Estonia | 626 | 719 | 817 | 997 | 1067 | 70 | 7 |
| Tallinn | 844 | 963 | 1101 | 1384 | 1482 | 76 | 7 |
| *30-40 m2* | | | | | | | |
| Estonia | 607 | 659 | 744 | 834 | 919 | 51 | 10 |
| Tallinn | 941 | 1027 | 1212 | 1397 | 1475 | 57 | 6 |
| *41-54 m2* | | | | | | | |
| Estonia | 646 | 706 | 776 | 846 | 948 | 47 | 12 |
| Tallinn | 991 | 1074 | 1236 | 1407 | 1498 | 51 | 6 |
| *55-69 m2* | | | | | | | |
| Estonia | 722 | 771 | 845 | 913 | 999 | 38 | 9 |
| Tallinn | 1046 | 1091 | 1206 | 1394 | 1498 | 43 | 7 |
| *70-249 m2* | | | | | | | |
| Estonia | 969 | 1001 | 1107 | 1175 | 1297 | 34 | 10 |
| Tallinn | 1304 | 1347 | 1514 | 1689 | 1790 | 37 | 6 |

Some Estonian real estate experts state the main factor in apartment's value is its location and surroundings, accounting up to 40% of apartment's price (Tammistu, 2015). The same author states that in long term it is useful to buy an apartment in Tallinn close to forest and sea with taking into account the share of planned new developments in the area. Supposedly, there are only 4 of these areas in Tallinn – Kopli, Pelguranna (sub-districts of Northern Tallinn), Rocca al Mare (sub-district of Haabersti) and Pirita.

There is very little research about the factors affecting apartment price in Tallinn or Estonia in general. Võhandu (2015) investigated the factors influencing the rental apartment prices in Tallinn and stated that they can be considered the same as the factors influencing the selling prices. In her study she tested the following variables:

- Apartment's floor area ($m^2$);
- Number of rooms;
- Floor that the apartment is located on;
- Building year of the house that the apartment is located in;
- Distance from the city center (km);
- Distance from the closest public transportation stop (km);
- Condition of the apartment (is the apartment renovated).

Võhandu (2015) concluded that the floor area, building year, distance from the city center and condition of the apartment have a significant effect on its rental price. As expected, rental price is higher for apartments in good condition, bigger floor area and which are located close to the city center. Surprisingly, the results of Võhandu (2015) showed that the newer the building, the lower the rental price. This could be accounted for the associations that people make between the building year and building quality in Tallinn and needs further research. No significant impact on rental price was seen by the number of rooms, apartment's floor or distance to the public transportation stop. The author accounted the first to the fact that most rental apartments in Tallinn have either 1 or 2 rooms and their floor area can vary widely and often be the same, thus making the number of rooms insignificant; importance of the floor that the apartment is located on she suggested to be important when buying an apartment, rather than when renting; and insignificance of public transportation proximity was attributed to the good coverage of Tallinn's public transportation system.

Berg (1998) brings out numerous characteristics affecting apartment price: apartment's location, condition, area of the kitchen and its layout, building material, clean stairway, security of the building's front door, neighbors, noise level, roof condition, existence of attic or basement, parking place, view and furniture that is left in by the previous owners. Like Tammistu (2015), Berg (1998) also considers location the most important factor in apartment's price. She states that there usually is a certain hierarchy of preferred districts and sub-districts in the city and areas with higher living standards and homogeneous inhabitants are favored.

Kuhlbach et al. (2002), on the other hand, states that apartment price is affected by the proximity to public transportation stops, schools, stores, kindergartens etc.; condition of the building, apartment's floor; balcony; heating type; building year; included furniture; noise and pollution levels and planned changes in the area. The work does not specify the exact effect of these factors.

No previous research on the interaction of property (dwelling) price and public transportation proximity in Tallinn or in Estonia was found.

### 3.5. PUBLIC TRANSPORTATION

Increased usage of private vehicles in Tallinn has been pointed out by several authors (Antso, 2010; Jüssi, 2004; Viljasaar, Grišakov, Männi, Koppel, & Pehk, 2014) and Tallinn City Government also considers it a problem (Tallinn City Government, 2013b, 2013a). Although the number of passenger cars per 1000 inhabitants in Estonia is amongst EU average, over the period of 2009-2013 a 15% growth was noted, which makes it one of the highest growths in EU ("Passenger cars in the EU," n.d.).

Jüssi (2004) argues that increased automobile dependency in Estonia is due to the characteristics of country's transportation system and the tendencies of spatial development. These include decrease of local services and jobs (especially in rural areas); suburbanization; mono-functional developments; absence of consistent planning; several so called hidden subsidies for road transport and private vehicle users. This has led to increased distances; adoption of car-oriented solutions both in private and public sector; decreased travel options; increased dependency on cars; reduced share of walking, cycling and public transportation usage and decreased safeness of walking and cycling. This increases the automobile dependency furthermore, resulting in higher travel costs, increased environmental impact, decreased access options and an unpleasant living environment.

According to the draft document of Public Transportation Development Plan of Tallinn (Tallinn City Government, 2011), public transportation needs to be a real alternative to cars as it enables to:

- Decrease the need for private vehicles;
- Decrease traffic congestion, resulting in lower travel times;
- Save money for the city;
- Decrease the environmental impact of transportation sector and provide a healthier living environment for the city's residents.

Transportation (incl. public transportation) in Tallinn is planned by Transport Department of the City of Tallinn. Public transportation is funded by the city in cooperation with Estonian government, other municipalities, EU, carriers and private investors. Public transportation services in the city are provided by two companies: Tallinna Linnatranspordi AS and MRP Linna Liinid OÜ. The public transportation network dates back to 1980 and has not been analyzed as a whole since then (Namm, 2015; Tallinn City Government, 2011). In 2014 Tallinn had 61 bus, 4 tram and 7 trolley lines with accordingly 357, 39 and 64 vehicles in traffic (Tallinn City Government, 2015a). Their coverage area can be seen in Figure 14.

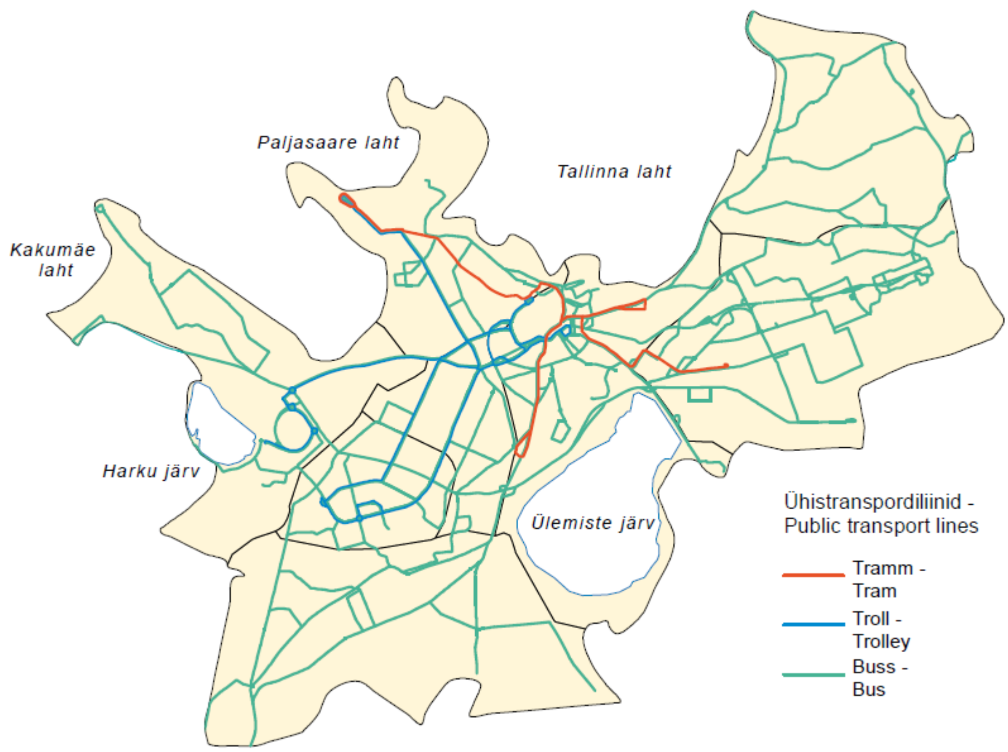



**Figure 14. Public transportation coverage in Tallinn, 2015 (Tallinn City Government, 2015a)**

Since 2010 the number of users has increased for bus traffic, whereas it decreased for tram and trolley traffic (Table 6). Household's average distance from a public transportation in 2012 (newest available information) was 0.3 km (Tallinn City Government, 2015a). Public transportation coverage of the city is often considered good (Võhandu, 2015).

**Table 6. Public transport by different transport means in Tallinn (Tallinn City Government, 2015a)**

| | | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|
| **Tallinn** | Ühistransport kokku - Public transport total | | | | | |
| | Liinide arv - Number of lines | 69 | 69 | 70 | 71 | 72 |
| | Liinide pikkus [km] - Length of lines [km] | 744 | 744 | 763 | 781 | 777 |
| | Sõidukite arv liikluses - Vehicles in traffic | 433 | 436 | 456 | 477 | 460 |
| | Liini läbisõit [1 000 km] - Vehicle km [1,000 km] | 28 700 | 28 868 | 29 006 | 30 879 | 30 793 |
| | Kohtkilomeetrid [mln kkm] - Place kilometres [Mio pkm] | 2 846 | 2 879 | 2 889 | 3 077 | 2 980 |
| | Sõitude arv [mln] - Number of boardings [Mio] | 114 | 140 | 134 | 151 | |
| | Bussiliiklus - Bus traffic | | | | | |
| | Liinide arv - Number of lines | 57 | 57 | 59 | 60 | 61 |
| | Liinide pikkus [km] - Length of lines [km] | 644 | 644 | 671 | 688 | 684 |
| | Sõidukite arv liikluses - Vehicles in traffic | 299 | 299 | 332 | 354 | 357 |
| | Liini läbisõit [1 000 km] - Vehicle km [1,000 km] | 20 376 | 20 360 | 20 625 | 23 037 | 23 558 |
| | Kohtkilomeetrid [mln kkm] - Place kilometres [Mio pkm] | 1 957 | 1 969 | 1 990 | 2 221 | 2 198 |
| | Sõitude arv [mln] - Number of boardings [Mio] | 61 | 69 | 65 | 97 | 97 |
| | Trammiliiklus - Tram traffic | | | | | |
| | Liinide arv - Number of lines | 4 | 4 | 4 | 4 | 4 |
| | Liinide pikkus [km] - Length of lines [km] | 33 | 33 | 33 | 33 | 33 |
| | Sõidukite arv liikluses - Vehicles in traffic | 52 | 55 | 54 | 53 | 39 |
| | Liini läbisõit [1 000 km] - Vehicle km [1,000 km] | 2 921 | 3 019 | 3 014 | 3 037 | 2 594 |
| | Kohtkilomeetrid [mln kkm] - Place kilometres [Mio pkm] | 397 | 411 | 410 | 413 | 353 |
| | Sõitude arv [mln] - Number of boardings [Mio] | 24 | 33 | 33 | 26 | 20 |
| | Trolliliiklus - Trolley traffic | | | | | |
| | Liinide arv - Number of lines | 8 | 8 | 7 | 7 | 7 |
| | Liinide pikkus [km] - Length of lines [km] | 67 | 67 | 59 | 59 | 59 |
| | Sõidukite arv liikluses - Vehicles in traffic | 82 | 82 | 70 | 70 | 64 |
| | Liini läbisõit [1 000 km] - Vehicle km [1,000 km] | 5 404 | 5 489 | 5 367 | 4 805 | 4 642 |
| | Kohtkilomeetrid [mln kkm] - Place kilometres [Mio pkm] | 492 | 499 | 489 | 443 | 429 |
| | Sõitude arv [mln] - Number of boardings [Mio] | 29 | 39 | 37 | 28 | 26 |

Seisuga 31.12 - As of 31st of December

Since September 2012 Tallinn and Harju county use ticketing system based on Ühiskaart for their public transport[2]. Since 1 January 2013 all public transport is free for the residents of Tallinn ("Transport Department," n.d.). Until 2013 free public transportation had only been applied in small cities (10,000-50,000 people) due to economic reasons (maintaining the ticketing system is more expensive than running it for free), but never in larger cities, although several cities provide free transportation for certain groups of people (Villemi, 2012). The first result in Tallinn was seemingly positive (Andrews, 2013), but the long term-results show that free public transportation has only lead to 1.2% increase in public transportation demand. Little impact is seen due to fairly high PT usage rate already before the free provision of transit (Ferro, 2014). Currently, 48% of Tallinn's residents use public transportation as their main mean of transportation (Namm, 2015).

[2] Ühiskaart is a contact free public transportation card which replaced previously used paper and ID tickets. For using public transport, money needs to be loaded to the card and the card has to be validated every time when entering a bus, trolleybus or tram. The card can be anonymous or connected to a certain person. The latter is necessary for discounts which are applicable to students, seniors, handicapped and parents of 3 and more children.

SWOT analysis of public transportation presented in the draft of Public Transportation Development Plan 2011-2020 (Tallinn City Government, 2011) can be seen in Appendix F . The strengths of the public transportation system are considered to be: its coverage, ticketing system, new vehicles, integration with surrounding parishes, etc. At the same time, the weaknesses include concerns about weak link of public transport and land use planning, speed of development, preferences towards private vehicles in street network, by people and by real estate developers, financial capability of local government, etc. Opportunities that Tallinn City Government identified in 2011 were collaboration improvements between urban actors, changing the mobility habits of the residents, optimizing Tallinn’s public transportation network, learning from other cities experiences and several more. Various threats described in the development plan are mostly connected with insufficient funding and worry about suburbanization and increasing car dependency.

Interestingly, this development plan is available on the city’s webpage only in a draft version since 2011 without any further information. The most general strategic document currently in force – Tallinn Development Plan 2014-2020 (Tallinn City Government, 2013a) – does not cover the issues of public transportation almost at all. Although, in the introduction of the document it is stated: “In the transport field, the preferential development of public transport is most important, including providing free public transportation for residents of Tallinn, developing the contactless ticket system and developing light traffic routes. Priority infrastructure projects include the construction of the Haabersti intersection, construction of Põhjaväil and developing the tramway system to Ülemiste and Lasnamäe“ (Tallinn City Government, 2013a), there are almost no objectives for promoting public transportation. Furthermore, infrastructure project Põhjaväil, which was mentioned above as priority project has caused a lot of tension in the city. Andres Sevtšuk, an assistant professor of urban planning at Harvard University has compared the project to tackling obesity with buying an elastic belt (i.e. trying to decrease traffic jams by building wider roads), also stating that the project should be stopped and started again from scratch including all stakeholders (Peegel, 2016). Kaja Kallas, member of the European Parliament, expresses her opinion that the project in its current form does not correspond to the EU funding principles (the project applies for funding from EU), as opposed to sustainable transportation, it promotes car usage (Kallas, 2016).

In contrast to Põhjaväil, the city of Tallinn and Estonian Centre of Architecture are currently working on the Main Street project which is a step towards more sustainable city planning as seen in other European capitals (“Peatänav,” n.d.). This project aims to transform 1.5 km street section in the heart of Tallinn from a multi-lane boulevard to a pedestrian and bicycle friendly lively hub with increased public transportation. The first changes in the urban space should be seen in 2018.

The Strategy of Sustainable Development of Tallinn Urban Area (Tallinn City Government, 2015b) signed by the City of Tallinn together with surrounding parishes also includes public transportation to a certain extent. In the field of transportation, the stakeholders agree to jointly develop the cycling and walking routes and to widen the opportunities of public transportation use through increasing public transportation usage by creating new “Park and Ride" parking lots; developing the public transportation infrastructure (stops, information systems, traffic lights, ticketing systems); and formulating joint long-term vision for mobility development in Tallinn urban area.

Tallinn residents' PT usage and satisfaction is captured most recently by Namm (2015), who performed a quantitative study with more than 500 respondents. Approximately half of these use public transportation for their daily trips, most common mode being the bus (69%), which was also the most preferred mode of transport. The overall satisfaction with PT service levels is captured in Table 7, highest possible score being 5. Highest average was attributed to ticket buying convenience, followed by stop locations and temperature in the PT. Lowest scores were given to PT fullness and cleanness, both receiving the average below 3.

**Table 7. PT service level satisfaction in Tallinn (Namm, 2015)**

| Criteria | Average score |
|---|---|
| Ticket buying convenience | 3.83 |
| Stop locations | 3.71 |
| Temperature in the PT | 3.66 |
| Ticket prices | 3.5 |
| Accordance with the time schedule | 3.48 |
| Speed | 3.44 |
| PT frequency | 3.29 |
| Safety | 3.21 |
| PT fullness | 2.63 |
| PT cleaness | 2.55 |

To raise the PT quality and increase the number of PT users following suggestions considering the land-use and PT planning were made (Namm, 2015):

- Current PT lines are outdated and not taking into account new areas of housing. A research is needed to determine residents' mobility needs.
- Schedules are not compiling with each other and change times are long, schedules need to be reviewed to make the change times as short as possible.
- PT frequency is not convenient to users, at times PT leaves in very short intervals which is followed by a long waiting time.
- Research respondents brought out that the schedules should be more frequent in the evenings and on weekends, thus counting needs to be conducted to determine how many people are moving on certain times.

## 3.6. Discussion

Urban structure of Tallinn is similar to the other cities in the Baltic states, active parts being the commercialized center and periphery, where the most of housing development takes place (Cirtautas, 2013). For more sustainable urban development public authorities should take a more active role in development processes. Currently, the development of the city is largely led by real estate developers (Viljasaar et al., 2012). Deriving from country's recent history of being under the Soviet rule, the participation culture in Estonia is still weak, allowing the mentioned state of affairs (Kalamees et al., 2012).

Large share (approx. 64%) of Estonian residents live in apartments (Eurostat, n.d.). In Tallinn, the share of people living in apartments is even higher - 91% (Tiit & Servinski, 2015). Apartment market is thus the most active segment of the real estate market in Estonia. In 2015 approximately 50% of real estate transactions were apartment transactions accounting for a bit less than half of the total real estate transaction value (Statistics Estonia, 2016). This implies that property price formation tendencies in Estonia can be revealed by investigating the apartment market, especially in Tallinn. As in rest of the world, location is considered one of the most important factors in apartment price – local experts (Tammistu, 2015) claim its value to be up to 40% of total price in Estonia. There have not been many researches on apartment price formation. Most recent of these (Võhandu, 2015) investigates the factors affecting the rental price of apartments in Tallinn. It was found that good condition, bigger floor area and proximity to CBD increase the price, whereas no significant impact on price was seen by the number of rooms, apartment’s floor or distance to the PT stop. Interestingly, building age affected the price controversially to what was expected – the newer the building, the lower the rental price. It was explained by people’s association of building year with building quality, but remained somewhat unclear, proving the need for further research.

In terms of transportation, Tallinn faces the increasing car dependency. Although the city has implemented several good public transportation initiatives, e.g. free public transportation for residents, its bigger vision in terms of transportation remains unclear - Public Transportation Development Plan 2011-2020 is in the draft version since 2011 and Tallinn Development Plan 2014-2020 does not cover public transportation almost at all. Furthermore, some current projects (e.g. Põhjaväil) are considered to be another step towards more car oriented city. At the same time, the Main Street project and the Strategy of Sustainable Development of Tallinn Urban Area both aim to promote public transportation. The city needs a clear, stated transportation vision, as well as further investigation of controversial transportation development decisions.

Research about residents’ usage and satisfaction of PT (Namm, 2015) in Tallinn revealed that buses are the most used and preferred PT mode. This corresponds with buses having the most lines (and coverage) of the city and the newest fleet. Most people (64%) admit that their PT usage has not increased due to free transportation. These results go in hand with Ferro (2014) who stated PT demand in Tallinn increased only by 1.2% after making it free. Overall satisfaction with the service levels is a little above average. Namm (2015) suggested a research on residents’ mobility needs to update the lines, which currently have a poor coverage of new housing areas, and schedules. This is also supported by the work of Paadam et al. (2014), which clearly states a need for better public transportation connection with newly constructed housing areas.

Public transportation and apartment price interactions have not been investigated at depth in Estonia before. Researching the effect that public transportation service levels have on apartment attractiveness in Tallinn gives insight to resident's preferences in terms of transportation and housing and thus paths the way to better understanding between the stakeholders in the city. Analyzing the outcomes of the work, real estate developers can provide housing that matches the market demand, and public authorities plan their policies in terms of land-use and transportation.

# 4. RESEARCH METHOD

This thesis represents an effort to determine the attributes of apartments in Tallinn which are valued by the residents the most. Special attention is given to public transportation service levels. To determine the attributes, residents' preferences were collected by employing a stated choice approach. The collected data is analyzed by using a discrete choice model, more precisely Multinomial Logit Model (MNL).

## 4.1. DISCRETE CHOICE MODELING

Choices made by individuals between alternative products (or services) can be analyzed using a relatively new statistical technique - Discrete Choice Modeling (DCM) (Glumac, 2012). It allows the researcher to determine the impact of product and/or service composition on different target groups of individuals (van Swam, 2014). Discrete choice model describes the likelihood or probability of a particular choice of a consumer for a number of alternatives. As person's preferences are assumed to be defined over a set of alternatives (treatment combination) based on utility maximization, DCM is a technique for investigating individual or group preferences (Hensher, Rose, & Greene, 2005). In current thesis, it will allow to analyze how residents of Tallinn value different apartment characteristics.

### *4.1.1. STATED CHOICE EXPERIMENT*

In order to estimate the discrete choice model, data is needed. It can be collected using revealed preference (RP) or stated preference (SP) method. RP data represents the real market data and the data collected is limited to describing only currently existing alternative. SP data on the other hand allows analyzing choices in hypothetical situations, making it possible to study new solutions and innovation. It is necessary to keep in mind that hypothetical alternatives need to be as realistic as possible for the respondents to take their task seriously (Hensher et al., 2005). In this thesis stated preference method will be used as it will allow creating hypothetical situations showing if there is a need for apartments and/or PT service levels which currently are not available in Tallinn. Stated preference data can be collected by requesting the respondents to rate, rank, or choice between the given alternatives. In this thesis the latter will be used as it resembles the real life the most and is encouraged by academia (Hensher et al., 2005). Furthermore, it allows the researcher to vary the pre-specified attribute levels and present the respondent with multiple choice sets with different attribute levels. The influence of various attributes on dependent attribute can be measured independently from each other, thus respondents' willingness to pay for a certain product can be calculated (Agarad, 2017).

The foundation of the experiment is the experimental design which can be seen in Figure 15.

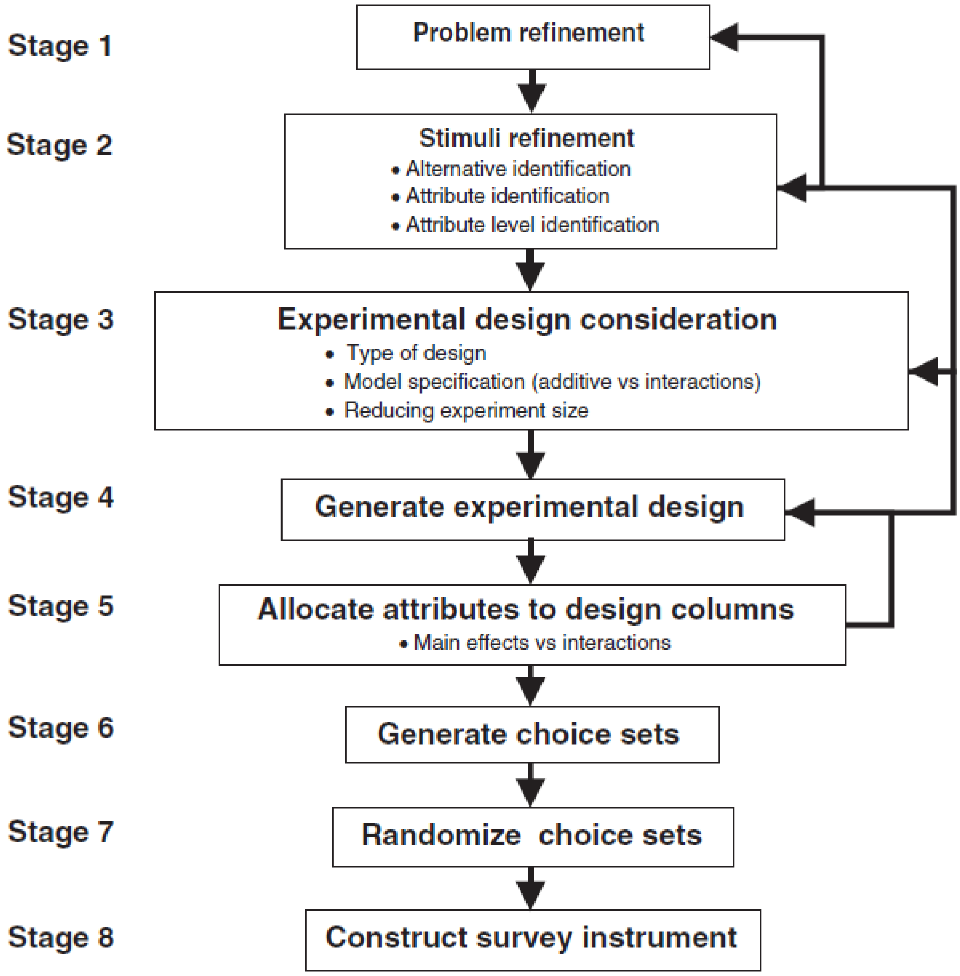



Figure 15. Experimental design (Hensher et al., 2005)

The steps of the design process are:
1) Problem refinement - The problem of this research is to determine residents' needs for apartment characteristics and public transportation service levels in Tallinn. This part is discussed in section 1.1. Problem definition.
2) Stimuli refinement - Discrete Choice Model is based on attributes, which characterize the alternatives. The literature study reveals the most important attributes, forming the input of the model. In order to keep the questionnaire as short as possible, but as long as needed only the attributes and attribute levels that are relevant and necessary for this study will be considered in the questionnaire. As part of the experimental design process each attribute is assigned attribute levels. The number of levels does not have to be the same for each attribute and is chosen by the researcher. Each attribute level may be mapped to a point in utility space. The more levels an attribute has, the more information (accuracy) is captured in utility space (Hensher et al., 2005).
3) Experimental design consideration - Several design characteristics have to be considered. There are a number of different classes of designs (full factorial or fractional factorial design), coding formats (orthogonal, dummy or effects coding), labeled or unlabeled

experiments, and effects between attributes available (Hensher et al., 2005). These characteristics will be discussed within subchapter 4.2.4. Experimental design consideration.
4) Generate experimental design - When the above-mentioned steps are completed the experiment can be generated i.e. combination between the attribute levels has to be made. This can be done using the program SPSS. The attributes need to be allocated to design columns. Therefore it is required to code the attribute levels using orthogonal codes (Hensher et al., 2005). At the end of the design process, based on the book of (Hahn, Shapiro, General Electric Company, & Research and Development Center, 1966) choice sets will be generated and randomized to receive reliable data. When these choice sets are realized, the survey will be prepared and distributed to reach respondents.

### *4.1.2. MULTINOMIAL LOGIT MODEL*

The most common theoretical base of discrete choice models is the random utility theory (Ortúzar & Willumsen, 2011). The assumption of this theory is that an individual will choose from an available set of alternatives based on utility maximization. For each individual, the modeler is associating the utility of the alternative *i* ($U_i$) via two components:

$$U_i = V_i + \varepsilon_i \quad (4.1)$$

Where:
$U_i$ is the overall utility of alternative *i*;
$V_i$ is the representative component of utility, which is a function of the measured attributes;
$\varepsilon_i$ the random/error component of utility due to unobserved influences.

$$V_i = \beta_{0i} + \beta_{1i} \times f(X_{1i}) + \beta_{2i} \times f(X_{2i}) + \cdots + \beta_{ki} \times f(X_{ki}) \qquad (4.2)$$

Where:
$V_i$ is the representative component of utility of alternative *i*;
$\beta_{1i}$ is the weight associated with attribute $X_1$ and alternative *i*, which establishes the relative contribution of the attribute to the observed sources of relative utility;
$\beta_{0i}$ is the alternative-specific constant, which represents on average the role of all the unobserved sources of utility.

The probability that an alternative will be chosen is given by the relations:

$$Prob_i = Prob\left(U_i \geq U_j\right), \forall\, j \in j = 1, \dots, J; i \neq j \quad (4.3)$$

$$Prob_i = \frac{\exp(\beta_j \times X_i)}{\sum_{k=0}^{j}(\beta_j \times X_{ki})} \qquad (4.4)$$

Where:
*i* is the identifier of the alternatives;
*k, j* are the identifiers of the attribute/levels.

The MNL model falls within the standard random utility approaches and thus uses the same above mentioned formulas 4.1 to 4.4 (Vasilache, 2013). Multinomial logit modelling by means of NLOGIT software can be used to analyze the stated choice data.

### 4.1.3. GOODNESS OF FIT

Statistical model's performance can be assessed by evaluating its goodness of fit. For this log-likelihood ratio statistic and the rho-square are used, which can be derived from the output of NLOGIT software. NLOGIT calculates the log-likelihood for 2 models: the optimal ($LL_{optimal}$) and constant only ($LL_{constant}$), indicated "Log likelihood function" and "Constants only" accordingly.

Log likelihood ratio statistic (LRS) can be used to check if the optimal model including different attributes performs better than the constants only model and is calculated following:

$$LRS = -2\left[LL_{optimal} - LL_{constant}\right] \quad (4.5)$$

Rho-square is calculated following:

$$Rho - square = 1 - \frac{LL_{optimal}}{LL_{constant}} \quad (4.6)$$

The model has a good fit if the value of rho-square is between 0.2 and 0.4 and considered weak with rho-square being lower than 0.1 (Hensher et al., 2005).

### 4.1.4. WILLINGNESS TO PAY

In choice experiments the respondents are presented with two or more alternatives (attribute combinations) described by series of attributes. By indicating their preffered alternative, the respondents also express the trade-off between cost and other characteristics of the product (in this case apartment) that they are willing to make. This data allows to estimate respondents' willingness to pay (WTP) for certain attributes, i.e. the amount of money an individual is agreeing to forfeit to receive a certain attribute level. WTP can be calculated as a ratio of two parameter estimates, holding all the other parameters constant (Hensher et al., 2005):

$$WTP = \frac{\beta_{attribute}}{\beta_{cost}} \quad (4.7)$$

Where:
WTP – the willingness to pay for attribute
$B_{attribute}$ – the design related attribute's parameter
$B_{cost}$ – the cost attribute parameter
To receive meaningful results, both parameters in the WTP calculation should be statistically significant.

## 4.2. QUESTIONNAIRE DESIGN

The questionnaire consists of 3 parts covering the respondent's socio-demographic background and the stated choice experiment (see Figure 16). The questionnaire starts with the background questions about the respondents' place of residence. Following, stated choice experiment will be conducted and the last part of the questionnaire asks information about the respondent's general socio-demographics i.e. gender, age, etc.


**Figure 16. Questionnaire design**

### *4.2.1. SOCIO-DEMOGRAPHICS – RESIDENTIAL BACKGROUND*

First part of the questionnaire consists of questions which will help the researcher to determine the residential background of the respondent. Questions in the first part can be seen in Figure 17 and depending on chosen answer will lead to corresponding following question. It will be determined whether the respondent lives in Tallinn or if he/she has ever lived in Tallinn. It is also important to understand if the respondent has ever lived in an apartment, how long time ago it was and whether the apartment was located in Tallinn or not. People who have lived in an apartment or currently live in an apartment in Tallinn are asked to specify their apartment characteristics. These characteristics match the ones used in the stated choice task and will give the best overview of Tallinn residents' actual needs.

The answers of people who have not lived in Tallinn and/or who have never lived in an apartment will also be collected in order to understand their perception about Tallinn apartment market and public transportation. These results will be compared to the Tallinn residents' results. For all the questions and their flow in the residential background section, see Figure 17.

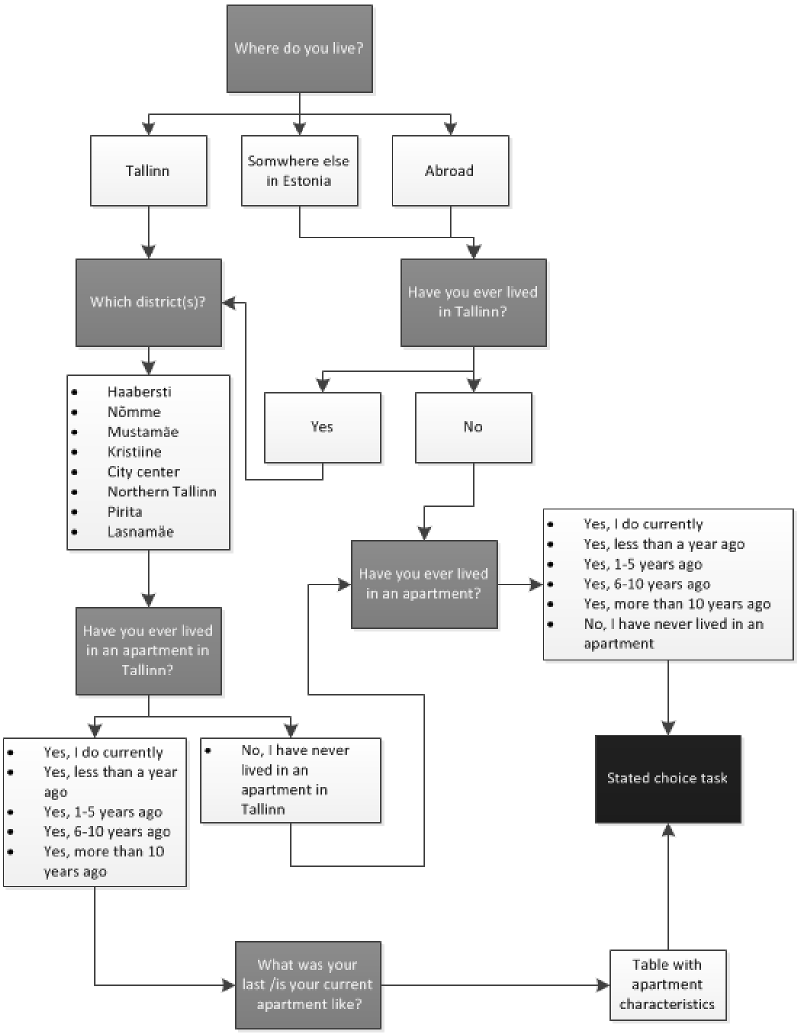



**Figure 17. Residential background questions**

### *4.2.2. Socio-demographics - profile*

The last part of the questionnaire consists of another section of socio-demographic questions. Contrarily to the first part, this section contains questions that determine the respondent's overall profile rather his/her residential background. With the profile questions respondent's gender, age, household composition, transportation habits, daily activities and income will be established. Figure 18 gives an overview of the profile section.

**What is your gender?**

- Male
- Female

**How old are you?**

- ... - 25 years
- 26 - 35 years
- 36 - 45 years
- 46 - 55 years
- 55 - ... years

**What is the composition of your household?**

- I live with my parents
- I live alone / I share an apartment or a house
- I live together with my partner
- I have a family (choose this if you have children)

**Is there a car in your household?**
*If you chose the option "I live alone / I share an apartment or a house" then household = you alone.*

- No
- Yes, 1
- Yes, 2 or more

**How often do you use public transportation?**
*Please indicate the option that matches best with your everyday life local public transportation usage.*

- Daily
- Several times per week
- Several times per month
- Several times per year
- Almost never

**What is your main daily activity right now?**

- I work
- I study
- I work and study
- I do not work or study at the moment

**What is your household's monthly income (net)?**
*Please specify the total income after the taxes.*

- ... - 1000 €
- 1001 - 1500 €
- 1501 - 2000 €
- 2001 - 2500 €
- 2501 - ... €
- I do not want to specify

**Figure 18. Profile questions**

### 4.2.3. Stated choice task

In the stated choice task the respondents are asked to choose between 2 apartment alternatives, indicating their preference in a situation when they would be looking for an apartment. These alternatives are formed using the selected attributes and attribute levels. Not all characteristics influencing the apartment price could be added to the task, thus only a selection of interesting characteristics identified in the literature study, were used.

Apartment attributes were divided into fixed and influential attributes. Fixed attributes included size, condition and kitchen furnishing, whereas 10 influential attributes included 7 attributes characterizing the apartment and 3 attributes characterizing the public transportation access. Fixed attributes had a fixed attribute level chosen by the researcher, the attribute levels of influential attributes varied between 2 to 4. The number of fixed attributes was chosen based on literature (Glumac, 2012; Hensher et al., 2005) stating that the most appropriate number of attributes for modeling is between 7 and 10.

FIXED ATTRIBUTES

**Size**

Size affects apartment price directly – the bigger the apartment, the more it will cost. The attribute level of size was fixed in this study in order to avoid conflicts with the price (which is used as influential variable to apartment attractiveness in the stated choice task). The chosen level of size was 54 square meters as this is the average size of all the apartments sold in Tallinn in 2015 (Estonian Land Board, n.d.).

**Condition**

Condition also has a great influence on the apartment attractiveness and price. Some buyers might look for an apartment in 'poor' condition in order to renovate it according to their own wishes whereas others would like to move in immediately. The price of an apartment in poor condition is always lower than the price of an apartment in good condition when all the other parameters remain the same (Kuhlbach et al., 2002). In this study, it was predefined that all the apartments are in so good condition that the potential buyers (respondents) could move in immediately.

**Kitchen furnishing**

Presence of kitchen furnishing and appliance is considered to be influencing apartment price in Estonia remarkably (Berg, 1998), especially in small and mid-sized apartments where kitchen furnishing and appliances can make up 10% of apartment's total price ("New apartment development projects in Tallinn," n.d.). In the current study, it was chosen that the entire kitchen is already furnished and appliances installed.

INFLUENTIAL ATTRIBUTES

**Price**

Price is an important attribute in each buying decision and is affected by number of attributes as shown in literature review in section 2.4. Public transportation and property value interactions. Price is directly reflecting apartment's attractiveness as more attractive the apartment the more are buyers are willing to pay for it. Introducing price as one of the influential attributes in the thesis, will allow analyzing if there are attributes that are even more important than the price.

Estonian Land Board price statistics for apartment selling prices show that the average square meter price for 41-55 square meter apartments in Tallinn in 2015 was 1,497.65 € (Estonian Land Board, n.d.) meaning that the average selling price for a 54 $m^2$ apartment was approximately 80,000 €, which was chosen to be one of the attribute levels for this work. In addition, levels below and above this price were chosen in order to differentiate the apartments. Attribute levels used for price were the following:

1. 60,000 €;
2. 80,000 €;
3. 100,000 €.

**City district**

Location is considered to influence apartment's attractiveness tremendously. According to some experts, location accounts even for 40% of apartment price in Tallinn (Tammistu, 2015). As the maximum number of attribute levels that could be used in the stated choice task was 4, it was not possible to specify apartment's location by the city district. In addition, in some of the districts, e.g. Lasnamäe housing can be located in the walking distance from the city center in one end and 20 minutes driving distance in the other. To still differentiate housing location in comparison to the city center, the researcher divided the city into 3 areas:

1. Center;
2. Surrounding areas;
3. Edge.

For respondents to understand these locations better an illustrative map was created (see Figure 19). The smallest circle indicates the line of city "center" in this study, second circle the "surrounding" areas and everything else categorizes as "edge".


**Figure 19. Apartment location**

**Building year**

Building year is chosen to be one of the influential attributes in the research as it is considered important by many international (Chau & Chin, 2003; Laakso, 1997) and Estonian studies (Kuhlbach et al., 2002; Võhandu, 2015). Newer buildings can be assumed to have more efficient systems and better energy class, whereas historical buildings can have more of an architectural value. Study of apartment buildings in Estonia taken into use between 1990 and 2010 shows that these buildings often also have problems with building quality, but more residents consider their apartment non-problematic when compared to the buildings from previous periods (Kalamees et al., 2012). In this thesis, the apartment buildings were divided into three eras according to their construction year:

1. … - 1940;
2. 1941 – 1990;
3. 1991 - … .

Period up to 1940s covers the time of Estonia's first independence and all housing construction before that. 1941 – 1990 covers the Soviet era with the Stalinist apartment buildings and mass produced panel housing. Finally, the period of 1991- … incorporates all the buildings which were constructed since Estonia regained its independence. This division is based on the work of Haas (2006) who reviewed the urban planning in Estonia through history.

**Heating**

Heating and cooling account for a great share of a household's energy usage. With the increasing energy prices and sustainability concerns heating type is an important factor in apartment's attractiveness. Heating types most commonly used in apartment buildings in Tallinn can be divided following:

1. Central or gas;
2. Electric;
3. Wood.

Central heating is the most typical heating type in Tallinn for apartment buildings, according to the Estonian Statistics database 300 000 residents of Tallinn lived in an apartment with central heating in 2013 ("Tavaeluruumide elanikud hoone liigi, eluruumi tehnovorustuse, soo, vanuserühma, rahvuse ja maakonna järgi," n.d.).

**Floor**

The floor level that the apartment is located on is considered important by several authors. Berg (1998) claims that the apartments in the middle floors are more preferred as the first floor has the issue of coldness as it is located directly above basement and crime due to low windows. Berg also claims that the last floor apartments are not as attractive due to possible roof leaks and crime. It needs to be taken into account that this opinion dates back to 1990s where the crime levels in Estonia were high and building quality low. These factors should not be influential anymore although people might still have a preference for living on a certain floor for other reasons (Võhandu, 2015). Floor attribute levels used in this thesis:

1. First;
2. Middle;

3. Last.

**Free parking**
Parking availability in close vicinity of apartment building determines the comfortability of car usage for its residents. This factor might not be of any value to people who prefer to use public transportation, whereas for car owners it is important to know to know about the availability and cost of parking. Apartment buildings can be located in paid parking zones or a parking space might need to be additionally purchased when buying an apartment. This attribute only has two levels:
1. Yes;
2. No.

**Distance to supermarket**
As witnessed in the literature review above apartment attractiveness is also influenced by several external (locational) characteristics, e.g. distance to the CBD, distance to school, distance to doctor, and distance to parks. As in different age groups importance of proximity to these facilities changes, this study includes distance to the supermarket in its attributes as going to supermarket is a necessity to all the apartment owners. Distance to supermarket is divided between 3 levels:
1. Up to 7 min walking;
2. 7-14 min walking;
3. More than 14 min walking.

**Distance to public transportation stop**
Average distance to the closest public transportation stop in Tallinn in 2012 was 0.3 km (Tallinn City Government, 2015a), average walking speed of a person is 5 km/h (Gehl, 2010), meaning that walking a distance of 0.3 km takes approximately 3.6 minutes. Chosen attribute levels for public transportation stop proximity are following:
1. Up to 5 min walking;
2. 5 to 10 min walking;
3. More than 10 min walking.

**Public transportation frequency**
As specified in the work of Namm (2015) public transportation frequency is something that needs to be improved in Tallinn. To understand if and how it affects housing attractiveness it was included as one of the attributes in the stated choice task with the levels of:
1. At least every 10 min;
2. Every 10 to 20 min;
3. Less than every 20 min.

**Public transportation type**
Also deriving from the work of Namm (2015) people have specific preferences of the different types of public transportation. Most used in Tallinn is the bus, followed by the trolleybus and then tram. Train is also considered as public transportation in that study, but as it only has a handful of stops in the city and is designed for Harju county or country wide

movements, it was not included in the current thesis. The public transportation attribute levels used in this study were:

1. Bus;
2. Tram;
3. Trolley;
4. Mixed.

This attribute specifies the type of public transportation servicing the closest PT stop, where "mixed" means that several different PT types serve the closest stop.

For a full overview of influential attributes and their levels, see Figure 20.

| Attribute | Attribute levels | Explanation |
|---|---|---|
| **Price** | 60 000 €<br>80 000 €<br>100 000 € | Current selling price of the apartment. |
| **City district** | center<br>surrounding<br>edge | Apartment's location in Tallinn, see map below. |
| **Building year** | ... - 1940<br>1941 - 1990<br>1991 - ... | Year that the building was built. |
| **Heating** | central or gas<br>electric<br>wood | Heating that is used in the building that the apartment is located in. |
| **Floor** | first<br>middle<br>last | The floor that the apartment is located on. |
| **Free parking** | yes<br>no | Parking opportunity by the building. "No" means that parking spot needs to be purchased or rented, meaning it requires extra payment in addition to apartment price. |
| **Distance to the supermarket** | < 7 min walking<br>7 - 14 min walking<br>> 14 min walking | Walking distance to the closest supermarket (chain store like: A&O, Kaubamaja, Maksimarket, Maxima, Prisma, Rimi, Selver, Stockmann, Säästumarket etc). |
| **Distance to public transportation stop** | < 5 min walking<br>5 to 10 min walking<br>> 10 min walking | Walking distance from the building to the closest public transportation stop. |
| **Public transportation type** | bus<br>tram<br>trolley<br>mixed | The type of public transportation servicing the closest public transportation stop. "Mixed" means that different means of public transportation go from that stop. |
| **Public transportation frequency** | at least every 10 minutes<br>every 10 to 20 minutes<br>less than every 20 minutes | The frequency of public transportation that is servicing the closest public transportation stop. |

**Figure 20. Influential attributes and their levels**

### *4.2.4. Experimental design consideration*

After identifying alternatives, attributes and attribute levels, it is necessary to decide a design for the study. The most important steps for it are described below based on Hensher et al. (2005).

Firstly, a decision between using a labeled or unlabeled experiment needs to be made. In this thesis unlabeled alternatives will be used in order to avoid identification and use of all alternatives within the universal set of alternatives, thus decreasing the number of treatment combinations and lessening the cogitative burden on respondents (Hensher et al., 2005).

When choosing between a full fractional and fractional factorial design, it needs to be taken into account that with full fractional design all possible treatment combinations are enumerated, meaning that in total $L^A$ combinations will be created, where $L$ is the number of attribute levels and $A$ number of attributes. For this thesis, it would result in $L^A=2^1x3^8x4^1=52488$ treatment combinations, which would create a questionnaire too long for the respondents to handle. Although, full fractional design allows estimating all the main effects and interaction effects independent from each other, fractional factorial design will be used for this thesis. The number of treatment combinations depends on the number of variables that need to be estimated. In this case, there are a total of 10 different variables, 8 consisting of 3 levels, 1 consisting of 1 level and 1 consisting of 4 levels resulting in 64 treatment combinations, which is remarkably less than the 52488 treatment combinations.
An effect is the impact a certain attribute level has on choice. Design used in this thesis will test for non-linear effects using effects coding. Effects coding is used as it is unlikely that the difference in utility between, as an example, electric heating and edge location, is the same as between district heating and central location. Effect coding also does not confound the base attribute level with the grand mean of utility function (Hensher et al., 2005).

The last aspect of experimental design consideration is the possible introduction of the no choice alternative. As the objective of this thesis is to study the impact of the relationships different attribute levels have upon choice then including no-choice alternative would hinder the analysis as it would not give any information on why the respondent wishes to make no choice. By forcing the respondent to make a choice, they need to make trade-offs between the available attribute levels (Hensher et al., 2005).

### *4.2.5. Generated experimental design*

64 treatment combinations are sufficient to create an orthogonal uncorrelated design. Design matrix provided by (Hahn et al., 1966) based on number of attributes and their levels, is translated into a workable and clear design matrix (see Appendix G). The matrix is tested for correlations. Orthogonal fractional factorial designs are generated in a way that the attributes of the design are statistically independent (uncorrelated). Orthogonality between the design attributes is the basic criterion in the generation process, while the statistical efficiency of the design is rarely considered. At the same time, optimal designs optimize the amount of information obtained from a design and are considered statistically efficient. By using the predefined orthogonal fractional factorial design, the amount of information obtained from a design is optimized and correlations within the design are minimized to zero (Hensher et al., 2005).

### *4.2.6. Choice sets*

To deliver information to the decision makers about the alternatives, attributes and their levels in the study, choice sets are used. See an example of generated choice sets in Figure 21. The numbers in the columns 'Alternative 1' and 'Alternative 2' refer to the profile numbers (treatment combinations) as generated by SPSS. For a full and detailed list of choice sets see Appendix H.

| Choice set | Group | Alternative 1 | Alternative 2 |
|---|---|---|---|
| **1** | 0 | 53 | 8 |
| **2** | 0 | 62 | 15 |
| **3** | 0 | 33 | 6 |
| **4** | 0 | 26 | 24 |
| **5** | 0 | 2 | 9 |
| **6** | 0 | 20 | 37 |
| **7** | 0 | 39 | 54 |
| **8** | 0 | 1 | 17 |
| **9** | 1 | 38 | 29 |
| **10** | 1 | 41 | 21 |
| **11** | 1 | 59 | 10 |
| **12** | 1 | 4 | 60 |
| **13** | 1 | 51 | 16 |
| **14** | 1 | 34 | 3 |
| **15** | 1 | 52 | 5 |
| **16** | 1 | 25 | 28 |
| **17** | 2 | 48 | 64 |
| **18** | 2 | 35 | 55 |
| **19** | 2 | 44 | 31 |
| **20** | 2 | 30 | 61 |
| **...** | ... | ... | ... |

**Figure 21. Generated choice sets**

Gathering respondents' preferences on choice sets allows the researcher to gather information about sample group's choices. A choice set consists of two or more treatment combinations, i.e. a set of attribute levels related to attributes. Choice sets are created with Excel by randomizing the treatment combinations over choice sets. An example of a choice set used in questionnaire can be seen in Figure 22.

Please select the apartment that suits your preferences the best.

*Keep in mind that: both apartments are 54 square meters, in good condition (it is possible to move in straight away) and that kitchen furniture and appliances are included in the price.*

*NB! Apartments are hypothetical.*

| Attribute | Apartment 1 | Apartment 2 |
|---|---|---|
| **General characteristics** | | |
| Price | *100 000 €* | *100 000 €* |
| City district | *centre* | *centre* |
| Building year | *1941-1990* | *1991 - ...* |
| Heating | *central/gas* | *wood* |
| Floor | *first* | *first* |
| Free parking | *yes* | *yes* |
| Distance to supermarket | *> 14 min walking* | *7 - 14 min walking* |
| **Public Transport characteristics** | | |
| Distance to public transportation stop | *5 - 10 min walking* | *< 5 min walking* |
| Public transportation frequency | *less than every 20 min* | *at least every 10 min* |
| Public transportation type | *mixed* | *tram* |
| **Your choice:** | ◉ | ○ |

Previous Next

**Figure 22. Stated choice task example**

Ideally, every respondent would randomly face all 64 of treatment combinations presented with different sets of choices. In current case, this would mean that each respondent would face either 32 sets of 2 alternatives, 16 sets of 4 alternatives, 8 sets of 8 alternatives, 4 sets of 16 alternatives, etc. which would make the stated choice task for the respondent either too long or incomprehensible. It was chosen that each respondent would face 8 sets of 2 alternatives (16 treatment combinations) meaning that the whole set of 64 treatment combinations would be distributed between 4 persons. To create random combinations of treatment combinations in choice sets, 24 groups of choice sets were created, i.e. 192 choice sets. This allows each treatment combination (alternative) to appear in three different choice sets (192/64=3).

## 4.3. Data collection

The choice of sample is related to the research problem. The sampling frame represents the set of decision makers to whom the survey is directed. As current research focuses on the housing market and public transportation in Tallinn, the sampling frame consists of any Estonian who has a connection with Tallinn, i.e. lives there currently or has lived in Tallinn during some point of his/her life.

There are principles of determining the sample size based on statistics, although experienced researchers often consider rules-of-thumb and budget or time constraints (Vasilache, 2013).

For revealed preference experiments the rule of thumb suggests sampling 50 decision makers for each alternative, whereas for stated preference choice data the minimum sample size most commonly is the number of choice sets required to estimate robust models. The rule of thumb developed Orme (2010) is:

$$n \geq 500\frac{L}{Sa}, \tag{5.1}$$

where:
L – highest number of attribute levels;
S – number of choice sets provided to one respondent;
a – number of alternatives included in a choice set.

Considering equation 5.1 the minimum number of respondents for this study is $n \geq 500\frac{4}{8\times 2} = 125$.

The data was gathered using an online survey tool Berg Enquête System © 2007. The questionnaire was open to public from 23.02.2016 to 25.03.2016 and promoted via social media, more specifically Facebook, and email. The questionnaire was opened 452 times and finished 154 times. This exceeds the minimum threshold of responde4=3nts (125) needed to analyze the results, although the overall success rate was low - 34%. The target group for this questionnaire included people who live/have lived in Tallinn, thus 17 more questionnaires were excluded from the further analysis, resulting in 137 complete questionnaires to be analyzed.

As stated in 4.2.4. Experimental design consideration, effects coding is used in order to test for linear and nonlinear effects of attributes. The attributes are recorded based on Table 8**Error! Reference source not found.**. After the data is cleaned and coded, it needs to be formatted for analysis with statistical and data analysis software NLOGIT5 (*NLOGIT 5*, 2012). For this each alternative within a choice set is allocated to a separate row of data, meaning that for each respondent, 16 rows (8 choice sets with 2 alternatives) of data will be gathered.

**Table 8. Effects coding (van Swam, 2014)**

| | | Variable 1 | Variable 2 | Variable 3 |
|---|---|---|---|---|
| 2 levels | Level 1 | 1 | | |
| | Level 2 | -1 | | |
| 3 levels | Level 1 | 1 | 0 | |
| | Level 2 | 0 | 1 | |
| | Level 3 | -1 | -1 | |
| 4 levels | Level 1 | 1 | 0 | 0 |
| | Level 2 | 0 | 1 | 0 |
| | Level 3 | 0 | 0 | 1 |
| | Level 4 | -1 | -1 | -1 |

# 5. RESULTS

This chapter presents the results of the questionnaire. Overview of respondents' profile and residential background will be given and MNL model outcomes analyzed. MNL model will be analyzed from two perspectives: 1) the whole sample; and 2) by sample groups based on public transportation usage; latter enabling to look at differences between car and PT users in terms of apartment attractiveness. Finally, respondents' willingness to pay for different apartment characteristics will be examined.

## 5.1. RESPONDENTS' PROFILE

The respondents can be characterized using the socio-demographic information obtained from the profile and residential background sections of the questionnaire. This data can then be analyzed using statistical analysis software SPSS23 (*SPSS23*, 2015).

According to the information available on Tallinn's statistics webpage ("CitizMap," n.d.)Tallinn's population in 2016 was 54.9% female, 45.1% male. The respondents' gender in this thesis was 54.7% female and 45.3% male, thus representing well the general gender division in Tallinn. The majority of respondents were young people up to age 35 (83.2%, see Figure 23), which does not go in hand Tallinn's general age division (…-24 year olds – 25.1%; 25-34 year olds – 17.9%; 35-44 year olds – 15.0%; 45-54 year olds – 12.2% and 55 - … - 29.8% ("CitizMap," n.d.). This discrepancy arose most likely due to topic of the study – finding housing is common issue for every person moving out of their parents' home for the first time – and chosen distribution method of the questionnaire.

| | Frequency | Percent |
|---|---|---|
| ... - 25 years | 36 | 26.3 |
| 26 - 35 years | 78 | 56.9 |
| 36 - 45 years | 14 | 10.2 |
| 46 - 55 years | 6 | 4.4 |
| 56 - ... years | 3 | 2.2 |
| Total | 137 | 100.0 |

**Figure 23. Division of respondents by age group**

56.9% of the respondents work, whereas 7.3% still study and 31.4% do both. Only 4.4% people did not work or study at the moment of filling in the questionnaire.

The household status of the respondents distributed following: 32.1% of respondents live alone, 43.1% with a partner, 4.4% with parents and 20.4% on their own and have children.
The household income is an important factor affecting apartment purchasing decisions. 10.2% of the respondents did not wish to specify the net monthly income of their household, whereas the rest were quite evenly distributed between the given income groups: 21.9% households earn up to 1000€ monthly, 19.0% 1001-1500€, 19.7% more than 2500€, 17.5% 1501-2000€ and 11.7% between 2000 and 2500€.

Car ownership amongst the respondents is high – there is 1 car in more than half (54%) of the households, 2 or more cars in 19% of the households and no car in 27% of respondents' households.

| | | PT | | | | |
|---|---|---|---|---|---|---|
| | | Daily | Several times per week | Several times per month | Several times per year | Almost never |
| | | Row N % | Row N % | Row N % | Row N % | Row N % |
| Car | No | 59.5% | 24.3% | 13.5% | 2.7% | 0.0% |
| | Yes, 1 | 28.4% | 20.3% | 23.0% | 13.5% | 14.9% |
| | Yes, 2 or more | 7.7% | 15.4% | 11.5% | 30.8% | 34.6% |

**Figure 24. Relationship between the PT usage and car ownership**

Nevertheless, public transportation usage of respondents is quite high with 32.8% using public transportation daily, 20.4% several times per week and only 14.6% almost never. The most active public transportation users are people with no cars – 59.5% use public transportation daily and 24.3% several times per week. Interestingly, even in households with 1 car the biggest share of people (28.4%) use public transportation daily. In households with 2 or more cars only 7.7% of people use public transportation daily, whereas even 34.6% almost never and 30.8% use PT couple of times per year (see Figure 24).

## 5.2. Respondents' residential background

75.9% of the respondents are currently living in Tallinn, 19.7% are living somewhere else in Estonia and 4.4% outside of Estonia. Almost quarter of the respondents have lived in the City Center and Mustamäe (24.7% and 21.9% respectively), whereas very few in Pirita (2.8%) (see Figure 25).

| | Frequency | Percent |
|---|---|---|
| City Center | 71 | 24.7 |
| Mustamäe | 63 | 21.9 |
| Northen Tallinn | 37 | 12.8 |
| Kristiine | 37 | 12.8 |
| Nõmme | 25 | 8.7 |
| Lasnamäe | 25 | 8.7 |
| Haabersti | 22 | 7.6 |
| Pirita | 8 | 2.8 |
| Total | 288 | 100.0 |

**Figure 25. Division of respondents based on Tallinn's city districts**

5.8% of the respondents have not lived in an apartment in Tallinn and thus could not specify the characteristics of their apartment. The rest answered basic criteria about their apartments. Based on these criteria the most common apartment in Tallinn is:

31-60 m$^2$ apartment located on the edge area of Tallinn, in a building built between 1941 and 1990, which has central heating and free parking. The apartment is on not on the first nor the highest floor and the closest supermarket is less than 7 minutes walking distance away. The closest public transportation stop is less than 5 minutes walking distance away and served by different types of public transportation with the frequency of at least every 10 minutes. The ownership of the apartment divides quite equally between owning (48.8%) and renting (51.2%). Most common square meter price of the apartment is not possible to tell as 25.6% of the respondents chose the answer "do not know" and rest divided equally between the suggested ranges, i.e. 24.8% of respondents estimate their apartment to be worth up to 1600 €/m$^2$, 24.8% 1601-1900 €/m$^2$ and 24.8% more than 1901 €/m$^2$. Another interesting find was that no-one reported the closest public transportation stop to be more than 10 minutes walking distance away from their apartment building.

## 5.3. Model Evaluation

Data analysis is based on the Multinomial Logit model (MNL). Three different models are created:

1) The whole sample - all the respondents who have ever lived in Tallinn
2) Subgroup 1 (frequent PT users) - people who use PT daily or several times per week (53.2% of the sample), from here on "frequent PT users"
3) Subgroup 2 (infrequent PT users) - people who use PT several times per month or less (46.7% of the sample).

The model performance of all three models are shown in Figure 26. Model performances.

| Nlogit output (whole sample) | |
|---|---|
| Observations | 1096 |
| Estimated parameters | 20 |
| Log likelihood optimal model | -629.35 |
| Log likelihood constant only model | -758.96 |
| Degree of freedom (DF) | 19 |
| Log likelihood ratio statistic (LRS) | 259.22 |
| Rho-square | 0.17 |
| Adjusted rho-square | 0.16 |
| Critical Chi-square ratio | 30.14 |

| Nlogit output (frequent PT users) | |
|---|---|
| Observations | 584 |
| Estimated parameters | 20 |
| Log likelihood optimal model | -340.89 |
| Log likelihood constant only model | -403.92 |
| Degree of freedom (DF) | 19 |
| Log likelihood ratio statistic (LRS) | 126.07 |
| Rho-square | 0.16 |
| Rho-square adjusted | 0.13 |
| Critical Chi-square ratio | 30.14 |

| Nlogit output (infrequent PT users) | |
|---|---|
| Observations | 512 |
| Estimated parameters | 20 |
| Log likelihood optimal model | -272.84 |
| Log likelihood constant only model | -354.83 |
| Degree of freedom (DF) | 19 |
| Log likelihood ratio statistic (LRS) | 163.98 |
| Rho-square | 0.23 |
| Rho-square adjusted | 0.20 |
| Critical Chi-square ratio | 30.14 |

**Figure 26. Model performances**

Log-likelihood ratio statistic (LRS) is 259.22 for the whole sample, 126.07 for frequent PT users and 163.98 for infrequent PT users. Critical Chi-square value of these models at the 95 percent confidence level is equal to 30.14, meaning that the optimal models fit data better than constant only models for all above mentioned target groups. This satisfies the first criteria of models' goodness of fit as described in chapter 4.1.3. Goodness of fit. Secondly, rho-square value needs to be checked. The rho-square and adjusted rho-square fall between 0.2 to 0.4 only for infrequent PT users' model, portraying its good fit. For the models of the whole sample and frequent PT users' rho-square and adjusted rho-square values fall between 0.1 and 0.2, and can still be considered satisfactory, but the models are not as strong as the model of infrequent PT users.

## 5.4. ATTRIBUTE EVALUATION

Using the MNL model, respondents' answers can be analyzed and visualized. Three important descriptive characteristics in attribute evaluation are the significance level, the influence and the range of attributes. All of these will be considered below for the whole sample and two sub-groups created based on PT usage.

### *5.4.1. WHOLE SAMPLE*

Figure 27 presents the results received for the whole sample using the program NLOGIT 5.

| ICHO | Coefficient | Standard Error | z | Prob. \|z\|>Z* | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| PRIC1 | -.43310*** | .08204 | -5.28 | .0000 | -.59389 | -.27231 |
| PRIC2 | .11580 | .07822 | 1.48 | .1387 | -.03750 | .26910 |
| DISTR1 | .32204*** | .06568 | 4.90 | .0000 | .19331 | .45077 |
| DISTR2 | -.49212*** | .08107 | -6.07 | .0000 | -.65101 | -.33322 |
| AGE1 | .28958*** | .07576 | 3.82 | .0001 | .14109 | .43807 |
| AGE2 | -.07265 | .06211 | -1.17 | .2421 | -.19438 | .04909 |
| HEAT1 | .64675*** | .07002 | 9.24 | .0000 | .50951 | .78400 |
| HEAT2 | -.41641*** | .08430 | -4.94 | .0000 | -.58163 | -.25120 |
| FLOOR1 | .27814*** | .08008 | 3.47 | .0005 | .12119 | .43509 |
| FLOOR2 | -.36189*** | .07203 | -5.02 | .0000 | -.50306 | -.22072 |
| PARK | .23343*** | .04863 | 4.80 | .0000 | .13812 | .32874 |
| SUP1 | .03837 | .06231 | .62 | .5381 | -.08377 | .16050 |
| SUP2 | .06574 | .07525 | .87 | .3824 | -.08176 | .21324 |
| STOP1 | .05677 | .06930 | .82 | .4127 | -.07907 | .19260 |
| STOP2 | .02703 | .07511 | .36 | .7190 | -.12018 | .17424 |
| FREQ1 | .30117*** | .07291 | 4.13 | .0000 | .15827 | .44407 |
| FREQ2 | .04956 | .07185 | .69 | .4903 | -.09126 | .19039 |
| TYP1 | -.07351 | .08665 | -.85 | .3962 | -.24334 | .09632 |
| TYP2 | .11665 | .08154 | 1.43 | .1525 | -.04316 | .27646 |
| TYP3 | -.09223 | .08853 | -1.04 | .2975 | -.26576 | .08129 |

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

**Figure 27. MNL model of the whole sample estimated with NLOGIT**

The stars (*, **, ***) in the coefficient column indicate parameter's significance. Parameters with three stars (***) display a significance level of 99% of higher, two stars (**) the significance of 95-99% and one star (*) the significance of 90-95%. Lastly, parameters with no stars have a significance of less than 90%, thus are considered insignificant.

For the whole sample, half of the attribute levels are considered significant at 1% confidence level (e.g. PRIC1, DISTR1 etc.), whereas half are not significant at all (e.g. PRIC2, AGE2, see Figure 27). Attributes having significant outcomes for the target group on all levels are city district (DISTR1, DISTR2), heating (HEAT1, HEAT2), floor (FLOOR1, FLOOR2) and parking (PARK). Attributes being significant on some levels are the price (PRIC1, PRIC2), age (AGE1, AGE2) and PT frequency (FREQ1, FREQ2). Distance to supermarket (SUP1, SUP2), distance to PT stop (STOP1, STOP2) and PT type (TYP1, TYP2, TYP3) are not significant and it can be concluded that these attributes play no role in apartment choice for the target group.

Table 9 displays the interpretation of data received from MNL model estimated with NLOGIT, resulting in part-worth utilities of each attribute level. These part-worth utilities are comparable with each other and demonstrate the attribute level's influence on apartment choice. Attribute Price has 3 levels – 100,000€, 80,000€ and 60,000€ coded 1 0, 0 1 and -1 -1 accordingly. Coefficients are retrieved from the Figure 27 above, keeping in mind that PRIC2 is not significant and thus equals to 0. These values are then multiplied by the coding value of attributes to obtain the part-worth utilities of the three attribute levels of size. The influences of these three attribute levels can be interpreted following: price of 100,000€ decreases the probability that the apartment will be chosen with 0.4331, price of 80,000€ has no effect on respondents' choice and the price of 60,000€ increases the probability with 0.4331.

**Table 9. Data interpretation**

| Attribute level | Coding | | Coefficient | | Part-worth utility |
|---|---|---|---|---|---|
| | Variable 1 | Variable 2 | PRIC1*** | PRIC2 | |
| 100000 | 1 | 0 | -0.4331 | 0 | -0.4331 |
| 80000 | 0 | 1 | | | 0 |
| 60000 | -1 | -1 | | | 0.4331 |

The results can also be visualized in a graph as shown in Figure 28, displaying the change of probability depending on the price. Tables of data interpretation and visualization for all attributes are presented in Appendix I. In essence, the figure shows that the higher the apartment price, the lower the probability the apartment will be chosen.

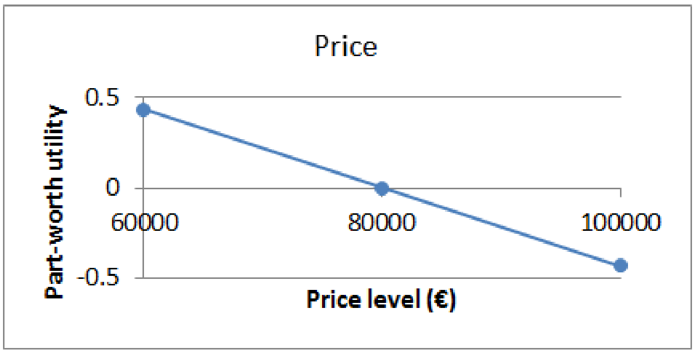



**Figure 28. Data visualization**

The significant attributes' part-worth utility values of the whole sample can be seen in Figure 29. These values present the influence that corresponding attribute levels have on respondents' apartment choice. Central heating has the highest positive effect on apartment choice, whereas electric heating is one of the characteristics that brings the largest dislike of the dwelling. In accordance with literature, location has a strong effect on respondent's housing choice. Edge areas of Tallinn are disliked, whereas central location increases the apartment attractiveness. The highest price level in this thesis also affects attractiveness negatively as does location on the first floor, latter agreeing with the studies of Tallinn's housing market. Whereas PT proximity or type is not significant, the high frequency of PT affects people's choices positively. Other characteristics increasing apartment's attractiveness are if the building is relatively new (built between 1991 and today), the apartment is located on the middle floor and there is free parking close to the building.

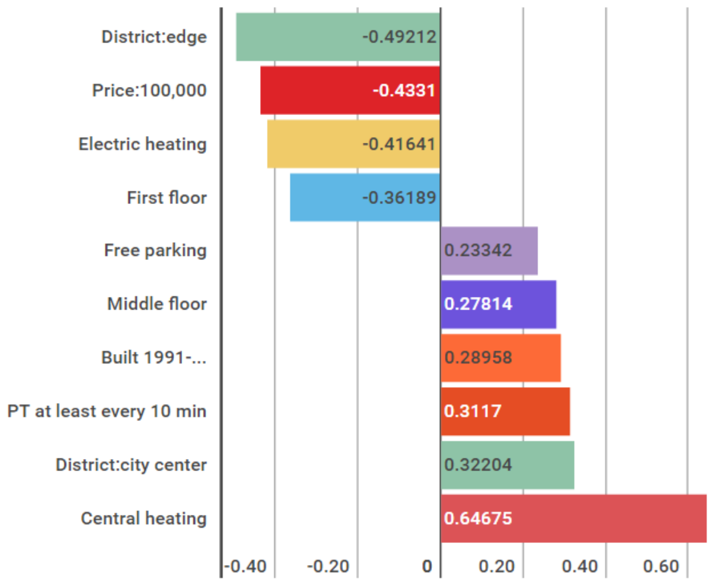



**Figure 29. Attribute level importance**

The level of impact of a certain attribute as a whole is determined by the range between the highest and lowest part-worth utility value, i.e. the larger the range between the lowest and highest part-worth utility of the attribute levels, the larger the impact it has. Figure 30 lists the significant attributes of the whole sample based on their level of impact (range). Interestingly, heating type has the most effect on respondents' choice, preceding other apartment characteristics like location, floor level and price. Heating is even over 2 times more important than price. Lower and almost equal effect on choice is seen in PT frequency, apartment building's age and parking availability.

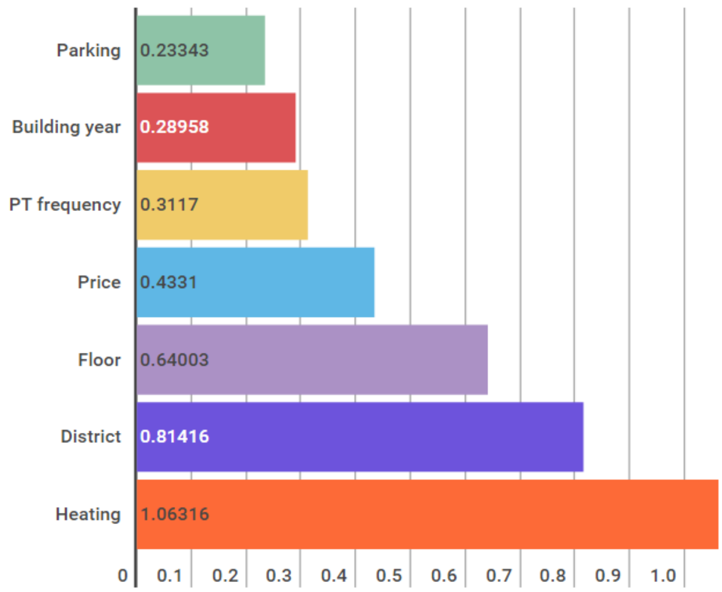



Figure 30. Attribute importance

### *5.4.2. Sub-groups based on PT usage*

Output of NLOGIT for frequent and infrequent PT users in presented in Appendix J, overview of the significant coefficients of the whole sample, frequent PT users and infrequent PT users is given in Table 10.

Table 10. Significant attribute levels for three models retrieved from NLOGIT output

| | Coefficients with significance | | |
|---|---|---|---|
| | The whole sample | Frequent PT users | Infrequent PT users |
| PRIC1 | -0.4331*** | -0.35764*** | -0.53157*** |
| PRIC2 | | | |
| DISTR1 | 0.32204*** | 0.30524*** | 0.36228*** |
| DISTR2 | -0.49212*** | -0.50340*** | -0.56449*** |
| AGE1 | 0.28958*** | 0.19130* | 0.43002*** |
| AGE2 | | | -0.16501* |
| HEAT1 | 0.64675*** | 0.50941*** | 0.85084*** |
| HEAT2 | -0.41641*** | -0.33526*** | -0.52396*** |
| FLOOR1 | 0.27814*** | 0.33557*** | |
| FLOOR2 | -0.36189*** | -0.36967*** | -0.31385*** |
| PARK | 0.23343*** | 0.12552* | 0.37696*** |
| SUP1 | | | |
| SUP2 | | | |
| STOP1 | | | |
| STOP2 | | | |
| FREQ1 | 0.30117*** | 0.32062*** | 0.30355** |
| FREQ2 | | | |
| TYP1 | | | |
| TYP2 | | | |
| TYP3 | | | |

For frequent PT users, the significant attributes are exactly the same as for the target group: district (DISTR1, DISTR2), heating type (HEAT1, HEAT2), floor (FLOOR1, FLOOR2) and parking (PARK) have significance on all levels; price (PRIC1), age (AGE1) and PT frequency (FREQ1) on one level and again distance to supermarket (SUP1, SUP2), distance to PT stop (STOP1, STOP2) and PT type (TYP1, TYP2, TYP3) are not significant. When all the attributes of the whole sample had a significance of 99% or higher, then for frequent PT users the significance of building's age (AGE1) and parking availability (PARK) is lower – 90-95%. Although it is interesting that PT proximity and PT type are not significant characteristics in apartment choice even for daily and weekly PT users, the lower significance of free parking availability goes in hand with the groups transportation preferences.

For the infrequent PT users, the results have more differences in significance compared to the results of the whole sample. Attributes that are significant for infrequent PT users on all levels are district (DISTR1, DISTR2), age (AGE1, AGE2), heating (HEAT1, HEAT2) and parking (PARK). Significance on some levels is recorded for price (PRIC1), floor (FLOOR2) and PT frequency (FREQ1), whereas distance to supermarket (SUP1, SUP2), distance to PT stop (STOP1, STOP2) and PT type (TYP1, TYP2, TYP3) are again not significant at all. Reflecting groups rarer habit of using PT – the significance of PT frequency is lower (i.e. 95-99%) than for frequent PT users and the whole sample. Interestingly, the building age is significant for infrequent PT users on all levels, whereas for the other 2 groups only on one level.

Examining the part-worth utility of attribute levels for frequent and infrequent PT users (Figure 31), it can be observed that apartment choice for these groups is the most positively influenced by central heating and the most negative influence is brought by apartment located in the edge areas of Tallinn. For infrequent PT users, almost equally strong negative influence is seen in electric heating and high cost of apartment (in this thesis 100,000€), which decreases the apartment attractiveness for frequent PT users, too, but to a lower extent. Apartments on the first floor are disliked by both groups. Infrequent PT users also tend not to choose apartments in buildings built in 1941-1991 – an aspect, which was not witnessed for frequent PT users. Positive influences on both groups are mostly the same with an exception of frequent PT users preferring the apartments on middle floors, which on the other hand was not a significant factor in infrequent PT users' choices. Overall, both groups' choices correspond with few mentioned dissimilarities, however most of the attributes and their levels have much stronger influence on infrequent PT users.

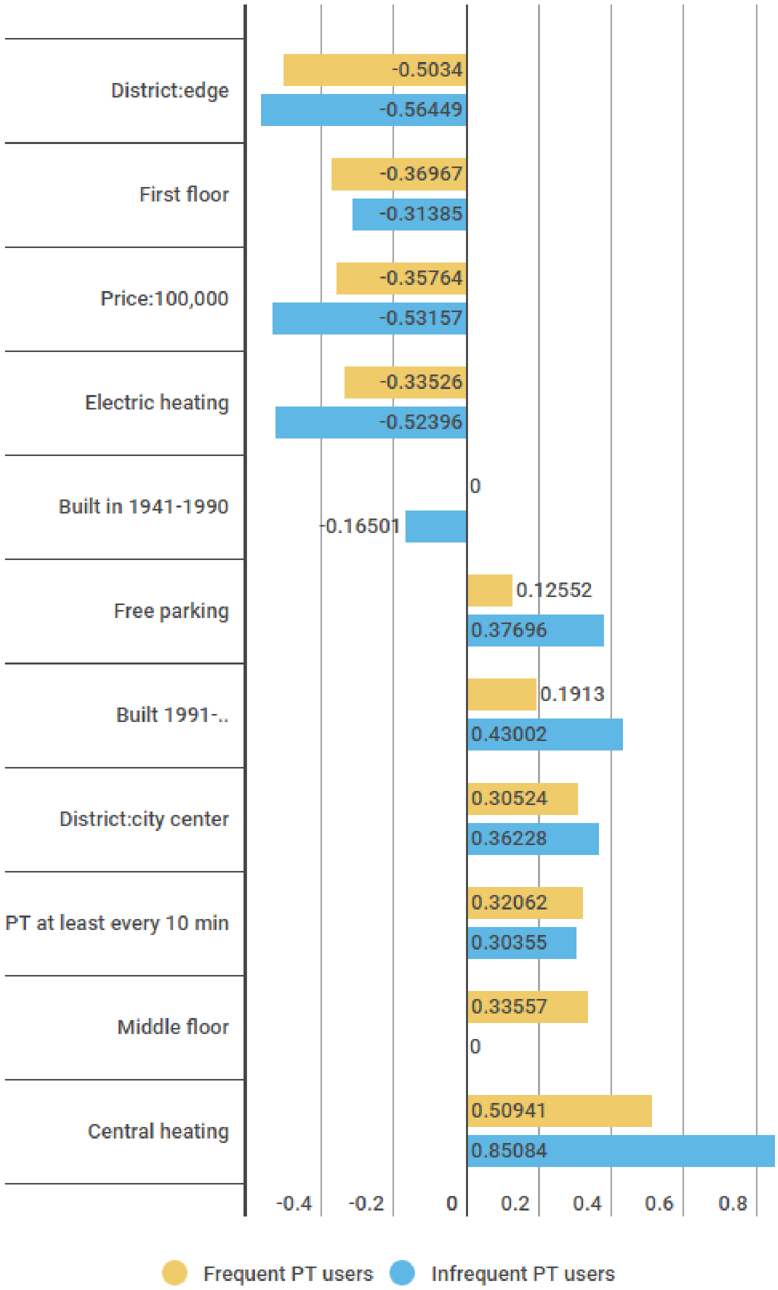



**Figure 31. Attribute level importance comparison**

Comparing the level of impact (represented by the range in part-worth utility) of different attributes for frequent and infrequent PT users (see Figure 32), several interesting aspects can be observed. First of all, as expected, parking availability has much higher impact on apartment attractiveness for infrequent PT users, who are more likely to use a car for daily travel. Secondly, PT frequency and floor have the lowest impact on infrequent PT users' apartment choice. Former supports the mobility preferences of the group, whereas latter creates a fascinating contrast with frequent PT users to whom apartment floor is one of the top 3 most important characteristics affecting apartment attractiveness. Disparity is also observed in importance of the building's age, which has considerably higher effect on infrequent PT users' choices. Finally, despite the fact that heating type and apartment location are two of the most influential attributes for apartment attractiveness for both groups, their impact on infrequent PT users' choices in substantially higher.

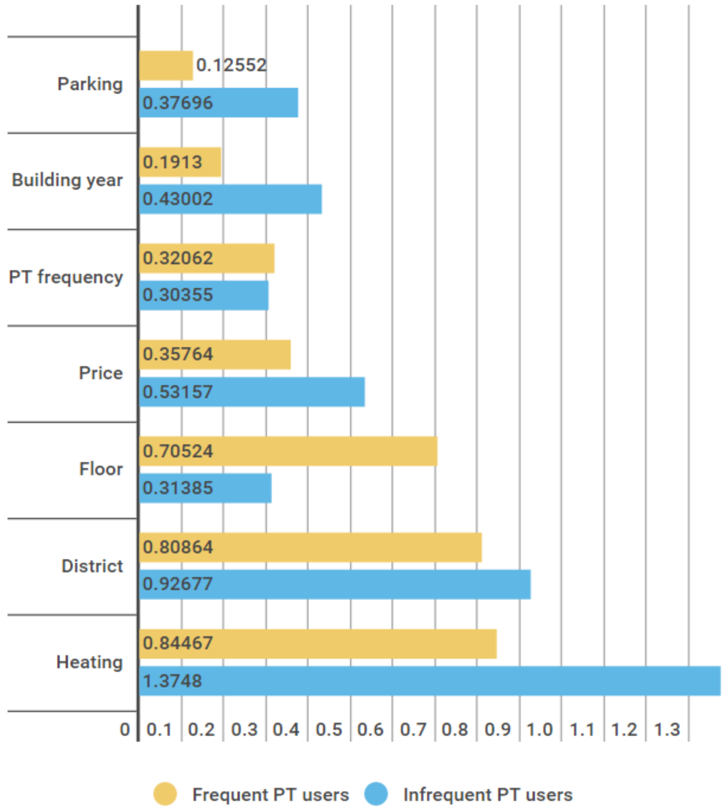



**Figure 32. Attribute importance comparison**

## 5.5. Willingness to pay

Following, the willingness to pay (WTP) for the whole sample and two sub-groups will be described. Calculations are based on chapter 4.1.4. Willingness to pay. WTP of a certain attribute is calculated as a ratio attribute's utility parameter ($\beta_j$) to cost attribute's utility parameter ($\beta_c$). Cost attribute's utility parameter ($\beta_c$) is the range of the cost attribute's utility shown in Table 11 and equal to 0.8662. In monetary terms this range equals to 40,000€ (100,000€-60,000€). Thus, in WTP calculation, the final outcome equals to $\beta_j$ divided by $\beta_c$ and multiplied by 40,000€ (see calculations 5.1 and 5.2).

**Table 11. Cost attribute's utility parameter**

| Cost attribute | Utility estimate | | |
|---|---|---|---|
| Apartment price | The whole sample | Frequent PT users | Infrequent PT users |
| 100,000 € | -0.4331 | -0.35764 | -0.53157 |
| 80,000 € | 0 | 0 | 0 |
| 60,000 € | 0.4331 | 0.35764 | 0.53157 |
| Utility parameter ($\beta_{ci}$) | 0.8662 | 0.71528 | 1.06314 |

The willingness to pay of the whole sample for significant attributes and their levels is shown in Table 12. The willingness to pay for apartment location is calculated following:

$$WTP = \frac{0.81416}{0.8662} \times 40{,}000€ = 37{,}597€ \quad (5.2)$$

Meaning that the monetary range of location impact on the apartment's total value is 35,597€. The WTP for apartment located in the city center WTP is calculated following:

$$WTP = \frac{0.32204}{0.8662} \times 40{,}000€ = 14{,}871€ \quad (5.3)$$

The positive value of WTP for city center location indicates that respondents are willing to pay extra 14,871€ for an apartment in the city center when all other attribute levels remain the same. On the other hand, the WTP of an apartment in edge area of Tallinn is -22,725€ indicating a sum of money that the respondents would pay less for apartments in these areas.

**Table 12. The whole sample's willingness to pay**

| Attribute | Part-worth utility | Utility parameter | WTP |
|---|---|---|---|
| Apartment location | | 0.81416 | 37,597 € |
| city center | 0.32204 | | 14,871 € |
| surrounding | 0.17008 | | 7,854 € |
| edge | -0.49212 | | -22,725 € |
| Building year | | 0.57916 | 26,745 € |
| 1991-... | 0.28958 | | 13,372 € |
| 1941-1990 | 0 | | 0 € |
| ...-1940 | -0.28958 | | -13,372 € |
| Heating type | | 1.06316 | 49,095 € |
| central | 0.64675 | | 29,866 € |
| electric | -0.41641 | | -19,229 € |
| wood | -0.23034 | | -10,637 € |
| Floor | | 0.64003 | 29,556 € |
| first | -0.36189 | | -16,712 € |
| middle | 0.27814 | | 12,844 € |
| last | 0.08375 | | 3,867 € |
| Free parking | | 0.46686 | 21,559 € |
| yes | 0.23343 | | 10,779 € |
| no | -0.23343 | | -10,779 € |
| PT frequency | | 0.6234 | 28,788 € |
| at least every 10 min | 0.3117 | | 14,394 € |
| every 10-20 min | 0 | | 0 € |
| less than every 20 min | -0.3117 | | -14,394 € |

The comparison of WTP of the whole sample and two sub-groups is seen in Table 13. The most valued apartments have central heating for which all target groups are willing to pay

28,487€-32,012€ extra. Central location of an apartment raises its value by 13,631€-17,070€, new building (built in 1991-...) by 10,698€-16,179€, location on the last floor by 1,907€-3,867€, free parking by 7,019€-14,183€ and frequent PT (PT at least in every 10 minutes) by 11,421€-17,930€. Apartment's location in the edge area has the greatest negative impact, lowering its value by 21,239€-28,151€. Buildings built before 1940 lower the value by 9,971€-13.372€, location on the first floor 11,808€-20,673€, no free parking by 7,019€-10,779€ and infrequent PT (less than every 20 min) by 11,421€-17,930€. Both heating types besides central – electric and wood – have a great negative impact on the price, lowering the apartment value by 18,784€-19,714€ and 9,739€-12,299€ accordingly.

**Table 13. WTP of the whole sample and two sub-groups**

| Attribute | The whole sample | Frequent PT users | Infrequent PT users |
|---|---|---|---|
| Apartment location | 37,597 € | 45,221 € | 34,869 € |
| city center | 14,871 € | 17,070 € | 13,631 € |
| surrounding | 7,854 € | 11,082 € | 7,608 € |
| edge | -22,725 € | -28,151 € | -21,239 € |
| Building year | 26,745 € | 21,396 € | 32,358 € |
| 1991-... | 13,372 € | 10,698 € | 16,179 € |
| 1941-1990 | 0 € | 0 € | -6,208 € |
| ...-1940 | -13,372 € | -10,698 € | -9,971 € |
| Heating type | 49,095 € | 47,236 € | 51,726 € |
| central | 29,866 € | 28,487 € | 32,012 € |
| electric | -19,229 € | -18,748 € | -19,714 € |
| wood | -10,637 € | -9,739 € | -12,299 € |
| Floor | 29,556 € | 39,439 € | 11,808 € |
| first | -16,712 € | -20,673 € | -11,808 € |
| middle | 12,844 € | 18,766 € | 0 € |
| last | 3,867 € | 1,907 € | 11,808 € |
| Free parking | 21,559 € | 14,039 € | 28,366 € |
| yes | 10,779 € | 7,019 € | 14,183 € |
| no | -10,779 € | -7,019 € | -14,183 € |
| PT frequency | 28,788 € | 35,860 € | 22,842 € |
| at least every 10 min | 14,394 € | 17,930 € | 11,421 € |
| every 10-20 min | 0 € | 0 € | 0 € |
| less than every 20 min | -14,394 € | -17,930 € | -11,421 € |

## 5.6. Conclusion

The results present several interesting findings. The target group of this thesis was Estonians who have lived in Tallinn during some point of their life for more than one month. The majority of respondents (83.2%) were young people up to the age of 35, thus this thesis mostly reflects this group's preferences in terms of apartment characteristics and public transportation service levels.

The sample was divided into three groups: the whole sample, the frequent PT users and the infrequent PT users. The two sub-groups were created in to compare the public transportation's role in apartment attractiveness for frequent and infrequent PT users.

For the whole sample, central heating, location in the city center, PT frequency of at least every 10 minutes, building year of 1991 or newer, middle floor and free parking have a significant positive influence on apartment attractiveness. Negative influence is seen by edge location, highest price level (100,000€), electric heating and first floor. Other characteristics, i.e. distance to the supermarket, distance to the PT stop and PT type do not affect apartment attractiveness.

The findings show that heating and apartment location are two of the most influential factors in apartment attractiveness for the whole sample and the two sub-groups. Heating type has the biggest influence in apartment choice with central heating being highly favorable and electric heating deeply disliked. In terms of location, city center is preferred and edge locations have negative influence on apartment attractiveness.

Compared to the respondents reported characteristics of current/last apartment in Tallinn, outcome shows that most commonly people already live in apartments with central heating, located on one of the middle floors of the building which has free parking and the closest PT stop is serviced with a frequency higher than every 10 minutes. The chosen fixed attribute level of size in the study (54 $m^2$) also matches the most commonly reported size of current/last apartment of the respondents (31-60 $m^2$). On the other hand, the current/last apartment of the respondents is usually located in the edge area of the city and in a building built between 1941 and 1990, whereas the results of the MNL model show that central location and newer buildings (built in 1991-…) are preferred. In terms of distance to the closest supermarket and the closest PT stop, the respondents' current experience already has the highest attribute levels, which might be the reason why these characteristics do not show significant influence on apartment attractiveness. Furthermore, no respondent reported the closest PT stop being more than 10 minutes walking distance from their current/last apartment in Tallinn.

Regarding the mobility of the respondents, the car ownership rate is high with 73% of the households owning one or more cars. At the same time, more than 50% of the respondents are frequently using PT (daily or several times per week). Most common PT users are the people who do not own a car, however even quite high share of car-owners also often use PT (almost 50% of respondents who have 1 car in the household and approximately 23% of respondents who have 2 or more cars in the household use PT daily or several times per week). Comparing the frequent and infrequent PT users, both groups appreciate frequent PT service – the level of impact that the PT frequency has on apartment attractiveness is approximately the same, although it needs to be kept in mind that the overall impact levels are higher for the infrequent PT users. Thus, compared to the other significant apartment attributes, the importance of PT frequency is listed a bit lower than for the frequent PT users. As mentioned above, PT type and distance to the PT stop are not significant factors of apartment choice for neither of the groups.

# 6. Conclusion and discussion

This chapter presents an overall conclusion and discussion of the study together with scientific, societal and practical relevance, research limitations and suggestions for further research.

## 6.1. Conclusion

This thesis focused on the apartment market of Tallinn, Estonia with an emphasis to determine apartment characteristics affecting its attractiveness (price) and the role of public transportation accessibility in it.

Throughout history, Estonian urban development has been influenced by the foreign rule. After regaining its independence in 1991, the essential focus of the country was on economic development and current urban development practices are criticized for being led by private capital and lacking regulations (Leetmaa et al., 2009; Linnalabor, 2010). Characteristics influencing apartment (or property) attractiveness in Estonia have not been thoroughly researched and no scientific work on connection between the property value and PT accessibility in Estonia was found.

The results of the thesis demonstrate that the most important factors affecting apartment price in Tallinn are the heating type and location of the apartment. Heating type has a great effect on apartment choice being up to 25% more important than location. Other influential factors of apartment attractiveness in Tallinn are the floor level, price, PT frequency, building year and parking availability.

In contrast to their current/latest apartment in Tallinn respondents prefer central location (currently most common area of residence is the edge area of Tallinn) and newer buildings (currently most respondents live in buildings built between 1941 and 1990).

In terms of public transportation, PT frequency is significant factor affecting apartment attractiveness in Tallinn. It's impact on apartment choice is approximately the same for frequent and infrequent PT users, suggesting that good PT service levels are appreciated by both frequent and infrequent PT users.

## 6.2. Discussion

The finding that the heating type of an apartment is considered more important than its location is unexpected as location is generally regarded as the most important factor of property price. On the other hand, raising energy prices and Estonian climate give justification to this result - heating accounts for the majority of utility costs approximately 8 months a year. Tallinn's residents can thus be considered quite rational, trying to keep their utility bills low.

Respondents' attraction to newer buildings and central location, whereas reporting themselves to currently be living in edge areas of Tallinn in Soviet time housing, suggest these two characteristics not being affordable for most of the residents. The attraction to central location as well as financial restrictions could be age-group specific as older people

often prefer to live in more quiet areas of cities and have bigger financial capabilities than people just starting their independent life. Nevertheless, this attraction indicates the positive image of the city center as a living area and the potential to raise urban density for more effective resource usage as well as the capacity to develop and sell mixed housing.
In terms of public transportation, distance to PT stop and PT type did not influence apartment attractiveness, whereas PT frequency, as mentioned above, was considered important. The low importance of distance to PT stop could display good PT coverage in Tallinn. Also, the statistics claim so – average distance of a household to PT stop is 0.3 km and the work of Namm (2015) demonstrates PT stop location being one of the PT service level characteristics that the residents of Tallinn are the most satisfied with. In this thesis, none of the respondents reported the closest PT stop being more than 10 minutes walking distance from their current/last apartment in Tallinn. At the same time, several works (Namm, 2015; Paadam et al., 2014) indicate a poor PT coverage in new housing areas, which are also considered to be areas with high car dependency. Considering that Tallinn's public transportation system as a whole has not been analyzed since 1908s, the insignificance of PT stop proximity in this study should be considered with caution, requiring further research. Furthermore, distance to PT stop is seen to have an effect on apartment rental prices in Tallinn (Võhandu, 2015).

PT type and PT frequency are important factors in PT service level studies (Namm, 2015; Redman et al., 2013), although have not been included in any of the literature covering apartment price studies in Tallinn. The importance of PT frequency shows an overall importance of PT in apartment choice. Namm's (2015) research of PT service levels in Tallinn demonstrates that people are unhappy with PT frequency which could be the reason why the attribute showed higher significance in current thesis than PT stop proximity. The reasoning behind PT type's insignificance can derive from satisfaction with current situation – most of Tallinn is covered with bus lines (Tallinn City Government, 2015a) and Namm (2015) reports buses being the most preferred PT type for Tallinn residents. The results could be highly different in case of an extensive tram network.

Comparing frequent and infrequent PT users the availability of free parking is significantly more important for infrequent PT users, reflecting the group's transportation habits, whereas the PT frequency is equally important to both groups. This suggests that good public transportation service levels are important for all the residents of the city, demonstrating the willingness to use public transportation, but at the same time suggesting certain obstacles or inconvenience of its usage today, making the respondents often opt for private vehicles.

The fact that PT frequency showed an positive correlation with apartment attractiveness implies the overall importance of PT service levels in apartment buying decisions in Tallinn. Adding the infrequent PT users willingness to use PT in certain situation, it is clear that Tallinn has great potential to continue on more transit-oriented development paths without losing attractiveness in the eyes of its residents. Furthermore, this could actually increase the attractiveness of Tallinn. The city has done a great job with promoting bus transportation (new buses, good coverage) and could think about expanding the tram coverage of the city as light-rail connection has showed a greater impact on property prices in rest of the world and can thus be considered more attractive for residents. Certainly, Tallinn needs an analysis of its current public transportation network as a whole and a strategy for public transportation development to achieve its full potential in becoming more sustainable.

For the housing developers this thesis implies the need for more affordable new housing in the central areas of Tallinn for people younger than 35 years. The results also indicate Tallinn's residents attention on utility cost, suggesting that people are more attracted to apartments that are more energy efficient. Respondents positive affiliation to PT service levels demonstrates that frequent PT already increases apartment's price and the author of this work believes that the effect will be even bigger when public authorities decide to become more transit oriented and make further improvements in the PT system. Thus, PT service levels in proximity of new developments is something that could be considered in future development project for higher margin.

**Scientific relevance**

This thesis adds insight into characteristics affecting apartment attractiveness and their importance (also in monetary terms). As the thesis focuses on Tallinn, Estonia – medium-sized city in Northern Europe with the main public transportation mode being a bus, this work also gives more information comparable to same sized cities in similar climates using the same transit type. Furthermore, the thesis has a special focus on how public transportation service levels affect apartment attractiveness, adding to the pool of studies about land-use and transportation connection.

**Practical relevance**

As the topic of apartment attractiveness is little investigated in Estonia and together with public transportation service levels not investigated at all, this thesis gives the local developers and public authorities insight into the market need of apartment characteristics and public transportation service levels for more informed urban planning and development decisions. This, on one side, could help to optimize the public transportation service, and on the other, help the developers to increase their sales by creating more suitable housing. In addition, willingness to pay for certain characteristics presents the monetary value of certain structural and locational characteristics which developers could take into account when planning new projects and the public authorities could use when planning urban transportation development.

**Societal relevance**

Information received from this thesis about Tallinn residents' housing and mobility needs can be used to develop best policies and practices for urban development in Tallinn by the decision makers to create an attractive and healthy living environment for its residents. At the same time, together with similar studies from around the world, the overall needs of urban population can be gathered. Comprehending these needs allows a wider understanding of urban development paths and creates a basis for steering the way towards more sustainable urban areas.

**Limitations**
Although, giving several valuable insights, this thesis has some limitations. First, the sample of the study was statistically sufficient, albeit bigger sample could increase the assurance level of the results. Second, the study mostly reflects the opinion of people belonging to the age group of up to 35 years. Finally, this thesis only focuses on an average-sized apartment in Tallinn (54 $m^2$).

**Suggestions for further research**
Based on the statistical results of this thesis, interviews with the residents of Tallinn, public authorities and developers could be conducted to gain further insight to the reasoning behind the results of this thesis. As the apartment attractiveness and impact of public transportation service levels on apartment attractiveness in Tallinn have not been investigated in considerable amount, more similar research with specific focus could be done, e.g. special attention could be given to new housing areas and the public transportation accessibility there. Also, research in which the respondents age would represent the age division of Tallinn, would give a better overview of the demand for apartment characteristics and public transportation service levels amongst Tallinn residents in general.

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# APPENDICES

## APPENDIX A. COMMONLY USED HOUSING ATTRIBUTES IN PRICE MODELS

Overview of commonly used housing attributes in price models (Chau & Chin, 2003)

| Attribute | | Expected effect on housing price |
|---|---|---|
| Locational | Distance from CBD | -ve |
| | View of the sea, lakes or rivers | +ve |
| | View of hills/valley/golf course | +ve |
| | Obstructed view | -ve |
| | Length of land lease | +ve |
| Structural | Number of rooms, bedrooms, bathrooms | +ve |
| | Floor area | +ve |
| | Basement, garage, and patio | +ve |
| | Building services (e.g. lift, air conditional system etc) | +ve |
| | Floor level (multi-storey buildings only) | +ve |
| | Structural quality (e.g., design, materials, fixtures) | +ve |
| | Facilities (e.g., swimming pool, gymnasium, tennis court) | +ve |
| | Age of the building | -ve |
| Neighbourhood | Income of residents | +ve |
| | Proximity to good schools | +ve |
| | Proximity to Hospitals | ? |
| | Proximity to Places of worship (e.g., mosques, churches, temples) | +ve |
| | Crime rate | -ve |
| | Traffic/airport noise | -ve |
| | Proximity to Shopping centers | ? |
| | Proximity to Forest | ? |
| | Environmental quality (e.g., landscape, garden, playground) | +ve |

+ve – positive impact oh housing prices; -ve – negative impact oh housing prices
? – varies from place to place, the actual effect is an empirical question

# Appendix B. Effect of rail transit on property values

Effect of proximity to rail transit on residential property values (Hess & Almeida, 2007)

| City–region(s) (transit system) *Authors* | Property value data source | Access measurement | Findings: effect of proximity to rail transit on property value or average home price |
|---|---|---|---|
| Atlanta (MARTA) *Nelson, 1992* | Sales prices (DeKalb County tax assessor) | Straight-line distance to station<br>Measured in 100-ft units from station | Property value increased in low-income neighbourhoods but decreased in high-income neighbourhoods |
| Atlanta (MARTA) *Bowes and Ihlanfeldt, 2001* | Sales prices (TRW-REDI data services) | Distance rings of one-quarter mile, one-quarter to one-half mile, one-half mile to one mile, one to two miles, and two to three miles from station<br>All property transactions in the city | Property value between one to three miles of stations increased relative to comparable properties located more than three miles.<br>Properties within one-quarter mile decreased by 19 per cent compared with properties beyond three miles |
| Dallas, Texas (DART) *Weinstein and Clower, 2002* | Assessed values (Dallas County Central Appraisal District) | Straight-line distance to station<br>One-quarter mile from station, compared with properties located in the control group | Property value increased 32 per cent near DART stations compared with 20 per cent in control group areas not served by rail |
| Miami, Florida (Miami Metro Rail) *Gatzlaff and Smith, 1993* | Sales prices (Dade County property tax records) | Distance to the nearest station<br>One square mile from station | Property value in high-income neighbourhoods slightly higher but unaffected in low-income neighbourhoods<br>Study conducted for eight stations |
| Queens, New York (New York City MTA) *Lewis-Workman and Brod, 1997* | Sales prices (TRW real estate database) | Network distance to station<br>One mile radius | Property value decreased $2300 for every 100 feet further from station<br>Study conducted for three stations in Queens |
| Philadelphia, Pennsylvania (SEPTA) *Voith, 1993* | Sales prices (Montgomery County tax assessment file) | Proximity to rail service measured for census tracts. | Property value of single-family homes with access to rail stations is approximately 8 per cent higher than other homes |

| | | | |
|---|---|---|---|
| Portland, Oregon (Eastside MAX) *Dueker and Bianco, 1999* | Sales prices (RLIS database) | Properties in rail corridor compared with properties along a parallel bus corridor, which serves as a control group | Median house value increases at a faster rate closer to stations.<br>A house located at a station will decrease by 5 per cent, 2 per cent and 1 per cent, if located at 400 feet, 600 feet and 800 feet further from station, respectively |
| Portland, Oregon (Eastside MAX) *Chen* et al., *1998* | Sales prices (RLIS Lite and Metroscan) | Straight-line distance to station<br>One km radius | Property value decreased $32.20 per metre further from station beginning at a distance of 100 metres from station |
| Portland, Oregon(Eastside MAX)*Lewis-Workman and Brod, 1997* | Assessed values (city property tax rolls) | Network distance to station<br>One mile radius | Property value increased $76 for every 100 feet closer (within a one-half to one mile radius) to three stations that were studied |
| Portland, Oregon (Eastside MAX) *Al-Mosaind* et al., *1993* | Sales prices | Distance rings based on walking<br>One km radius (Model 1)Network distance to station<br>One-half km radius (Model 2) | Property values were $4.32 higher within the 500 metres than outside the 500 metre radius (Model 1).<br>Property value decreased $2175 for every 100 metres further from station (Model 2)<br>Study conducted at seven suburban stations. |
| Sacramento, California (Sacramento Light Rail) *Landis* et al., *1995* | Sales prices (TRW-REDI data services) | Network distance to station<br>All property transactions in the city | No statistically significant effect on home prices |
| San Diego, California (San Diego Trolley) *Landis* et al., *1995* | Sales prices (TRW-REDI data services) | Network distance to station<br>All property transactions in the city | Property value increased $272 for every 100 metres closer to station |
| San Diego, California (San Diego Trolley) *Cervero and Duncan, 2002a* | Sales prices (Metroscan) | Distance rings of one-quarter and one-half mile from station | Property value increased 10 per cent (East Line) to 17 per cent (South Line) for multi-family homes |

| City–region(s) (transit system) *Authors* | Property value data source | Access measurement | Findings: effect of proximity to rail transit on property value or average home price |
|---|---|---|---|
| San Francisco (BART) *Lewis-Workman and Brod, 1997* | Sales prices | Network distance to station<br>One mile radius | Property value decreased $1578 for every 100 feet further from station<br>Study conducted for one station (Pleasant Hill) |
| San Francisco, California (BART) *Landis* et al., *1995* | Sales prices (TRW-REDI data services) | Network distance to station<br>All property transactions in the two counties | Property value (1990) for single-family homes decline by $1.00 to $2.00 for every metre further from BART station |
| San Jose, California (San Jose Light Rail) *Landis* et al., *1995* | Sales prices (TRW-REDI data services) | Network distance to station<br>All property transactions in the city | Property value decreased $197 for every 100 metres closer to station<br>Effect may be due to commercial and industrial uses |
| San Jose (Santa Clara VTA) *Cervero and Duncan, 2002a* | Sales prices (Metroscan) | Straight-line distance to station<br>One-quarter to one-half mile from station | Property value of apartments and homes increased 1–4 per cent, but decreased 6 per cent for condominiums |
| St Louis, Missouri (MetroLink) *Garrett, 2004* | Sales prices (First American Real Estate Solutions) | Straight-line distance to station<br>One mile buffer around the light rail route and stations | Property value increased 32 per cent or $140 for every 10 feet closer to station, beginning at 1460 feet |
| Washington, DC (Metro) *Benjamin and Sirmins, 1996* | Apartment rents (various property management and apartment locator services) | Distance to station is measured in tenths of miles from station<br>All properties in the city | Apartment rent decreased 2.5 per cent for every one-tenth mile further from station<br>There were a total of 250 observations from 81 apartment complexes |

# APPENDIX C. RELATIONSHIP BETWEEN TRANSPORTATION INVESTMENT AND LAND VALUES

## Selected studies of the relationships between transportation investment and land values 2002-2009 (Rodríguez & Mojica, 2009)

| Authors | Data source | Selected results |
|---|---|---|
| *Heavy rail rapid transit* | | |
| Du and Mulley (2007) | Asking prices of properties within 500 m of Sunderland Metro, UK extension stations relative to properties at least 1000 m from stations 1 year after opening | No changes in property values detected (using ANOVA) |
| Armstrong and Rodriguez (2006) | One thousand eight hundred and sixty single-family residential properties from four municipalities with commuter rail service and three municipalities without commuter rail service in Eastern Massachusetts, USA | Premium of 9.6% and 10.1% for municipalities with commuter rail |
| Gibbons and Machin (2005) | Seven thousand four hundred and seventy-four housing transactions from the Nationwide building society in London, UK and a wider area of South East England between 1997 and 2001 | House prices rose over the period by 9.3% points more in places affected by these transport infrastructure changes |
| Mcmillen and Macdonald (2004) | Seventeen thousand thirty-four single-family house transactions and 4056 repeat sales observations from the Illinois Department of Revenue, USA | Premium of 3% for every .25 miles closer to transit station |
| Kim and Zhang (2005) | Appraised values for 731 commercial properties in Seoul, Korea | A premium between $1.69 and $7.54 per sq. ft. was detected depending on the property location |
| Bae et al. (2003) | Budongsan Bank data of 241 properties over 4 years data in Seoul, Korea | Premium of 8.9% within 1000 m of station due to station opening |
| *Light rail transit/trolley service* | | |
| Cervero and Duncan (2002b) | One thousand four hundred and ninety-five sales of properties in multi-family housing in San Diego, USA in 2000 | Premium for multi-family units between 2% and 6% |
| BRT | | |
| Munoz-Raskin (2006) | One lakh thirty thousand six hundred and ninety-two new properties registered by the Bogotá, Colombia Department of Housing control between 2001 and 2004 and within BRT or its feeder lines | Premium for properties less than five minutes walking from BRT's feeder lines |
| Perdomo et al. (2007) | Three hundred and four residential properties and 40 commercial properties with or without access to Bogotá, Colombia's BRT | No premium was detected in five out of six tests. When significant, a 22% premium for properties with BRT access was detected |
| Rodriguez and Targa (2004) | Four hundred and ninety-four multifamily residential properties in a 1.5-km area around two corridors of Bogotá, Colombia's BRT | Premium of 6.8–9.3% for every 5 min walking time closer to BRT station |

*Note*. Results apply to area and properties studied only. Refer to each particular study for details.

# APPENDIX D. RELATIONSHIP BETWEEN PROPERTY PRICE AND TRANSPORTATION ACCESS

Overview of property price and transportation access studies

| Authors | Location | PT type | Results |
|---|---|---|---|
| Rodríguez and Mojica, 2009 | Bogota, Columbia | BRT | 13 to 14% increase of asking price of properties within 1km of BRT after BRT extensions. |
| Ibeas et al., 2012 | Cantabria, Spain | Bus, heavy rail | 1.4 to 2.2% higher price of properties within 400 m of bus transport, 2.7 to 6% decrease of property value within 500m of train station. |
| Bae et al., 2003 | Seoul, South Korea | Light rail | Positive price effects until the opening of the subway line, no significance later. |
| Forrest et al., 1996 | Manchester, UK | Light rail | Negative effect on housing price within 2 km of the railway station. |
| Hess and Almeida, 2007 | Buffalo, USA | Light rail | Properties within 0.25 miles from station have 2-5% higher asking price. |
| Bowes and Ihlanfeldt, 2001 | Atlanta, USA | Heavy rail | Properties within 0.25 miles from station sell for 19% less than properties futher than 3 miles from station. Properties within 1 to 3 miles from station have a higher value than those which are further away. |
| Debrezion et al., 2007 | the Netherlands | Heavy rail | Dwellings close to the station are about 25% more expensive than those which are more than 15 km away. Dwellings within 250 m from the railway are 5% cheaper than those which are located further than 500 m. |
| Kay et al., 2014 | New Jersey, USA | Heavy rail | Properties within 1 mile from the station have a 6.3% lower value than those within 0.5 miles. Properties within 1.5 miles have a 2.7% lower value than those within 1 mile. Properties further than 2 miles away witness a slight increase in price. |
| Efthymiou and Antoniou, 2013 | Athens, Greece | All public transport | Property values are negatively affected by a heavy rail station which is within 500 m from the dwelling. Prices of dwellings close to metro station are increased, proximity to a tram or bus stop also affects the selling price positively. |

## APPENDIX E. ATTRIBUTES USED IN STUDIES OF INTERACTION BETWEEN PROPERTY PRICE AND TRANSPORTATION ACCESSIBILITY

Physical variables used in property value and transportation access studies

| **Authors** | **Plot size** | **Dwelling size** | **Dwelling type** | **Dwelling age** | **Condition** | **Heating** | **Floor/ floors** | **No. of rooms** | **No. of bedrooms** | **No. of bathrooms / toilets** | **View** | **Fireplace** | **Elevator** | **Base-ment** | **Garden/ terrace/ balcony** | **Parking/ garage** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rodríguez and Mojica, 2009 | | x | | x | | | x | | x | x | | | | | | x |
| Ibeas et al., 2012 | | x | x | | x | | x | | x | x | | | x | | x | x |
| Bae et al., 2003 | | x | x | x | | x | | | | | | | | | | x |
| Forrest et al., 1996 | | x | x | x | | x | | | x | | | | | | | x |
| Hess and Almeida, 2007 | | x | x | x | | | | | x | x | | x | | x | | |
| Bowes and Ihlanfeldt, 2001 | x | | | x | | | | | x | x | | x | | x | | |
| Debrezion et al., 2007 | | x | | x | | x | | x | | x | | x | | | x | x |
| Kay et al., 2014 | | | | x | | | | x | | | | | | | | |
| Efthymiou and Antoniou, 2013 | | x | x | x | | x | x | | | | x | x | | x | | x |

Locational variables used in property value and transportation access studies

| **Authors** | **Distance to PT stop/ station** | **PT frequency** | **Distance to CBD** | **Distance to services (schools, stores, etc.)** | **Distance to local amnities (parks, etc.)** | **Distance to highway** | **Population density** | **Crime rate** | **Tax rate** | **Income (household, neighborhood)** | **Employment density** | **Ethnical segregation of the area** | **Neighborhood** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rodríguez and Mojica, 2009 | x | | | | | | | | | | | | |
| Ibeas et al., 2012 | x | | x | | | | x | | | | x | x | |
| Bae et al., 2003 | x | | x | x | x | | x | | | | x | | |
| Forrest et al., 1996 | x | | x | | | | | | | | | | |
| Hess and Almeida, 2007 | x | | x | | x | | | x | | x | x | | |
| Bowes and Ihlanfeldt, 2001 | x | | | | | x | | x | | | x | x | x |
| Debrezion et al., 2007 | x | x | | | | x | | | | x | | x | |
| Kay et al., 2014 | x | | | | | | x | x | x | x | | x | |
| Efthymiou and Antoniou, 2013 | x | | | | | x | x | | | | | | x |

# APPENDIX F. TALLINN PUBLIC TRANSPORTATION SWOT

## SWOT analysis of Tallinn's public transportation, 2011 (Tallinn City Government, 2011)

| STRENGHTS | WEAKNESSES |
|---|---|
| ▪ Functioning public transportation system | ▪ Weak link between public transportation and land-use planning |
| ▪ Public transportation lines cover the whole city | ▪ Spatial development outpreforms public transportation development |
| ▪ There are different modes of public transportation | ▪ Real estate development in areas which are accessible only by private vechicles |
| ▪ Relatively high share of electric transport | ▪ People's habit of using cars |
| ▪ Unified ticketing system which gives discount opportunities for regular users | ▪ Street network and traffic management favour car usage |
| ▪ Increased connection speed of public transportation (separate tracks for buses, priority system) | ▪ Funding instability |
| ▪ Relatively new vehicles | ▪ Discrepancy between the needed funding in development plans and in real life |
| ▪ Constant upgrade of vechicles | ▪ Lack of governmental support for local public transportation |
| ▪ Information availability | ▪ Uncoordinated land-use and public transportation development in Tallinn and surrounding parishes |
| ▪ Consideration of disabled people | ▪ Unfinalized building of the infrastructure of public transportation stops |
| ▪ Existance of a regional partner (Harjumaa Ühistranspordikeskus) | ▪ Vunerability of electric transportation (is affected by weather and infrastructure) |
| ▪ Integration of public transportation services with surrounding parishes | ▪ Local government has insufficient financial capability for upgrading the trams |
| ▪ Tradition of using public transportation for transportation | ▪ Lack of operative information sharing for passangers |
| ▪ "Park & Ride" system | |
| **OPPORTUNITIES** | **THREATS** |
| ▪ Improvement of collaboration between urban actors | ▪ Continuing suburbanization and increasing need for mobility |
| ▪ Increasing knowledge and changing the habits of residents | ▪ Increasing car dependency |
| ▪ Optimization of Tallinn's and its urban area's public transportation network | ▪ Decrease of public transportation users |
| ▪ Need based investements to city's public transportation infrastructure | ▪ Insufficient funding for public transportation |
| ▪ Need based investements to city's public transportation vechicles | ▪ Insufficient funding for public transportation infrastructures |
| ▪ Investments to develop tram transport | ▪ Inconsistency in priority setting |
| ▪ Creating a modern unified ticketing system | ▪ Main street network is easily vounrable and there is a lack of parallel options |
| ▪ Increasing the service quality of public transportation | |
| ▪ Creating a traffic management center for public transportation | |
| ▪ Creating changing stations | |
| ▪ Developing "Park & Ride" system | |
| ▪ Going through with mobility management projects | |
| ▪ Learning from other cities' experience | |

# APPENDIX G. SPSS

## Design matrix (retrieved from SPSS)

| Treatment combination | Parking | Price | Age | District | Supermarket | Heating | Floor | PT_stop | PT_freq | PT_type |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 |
| **2** | 2 | 1 | 1 | 3 | 1 | 3 | 3 | 2 | 3 | 1 |
| **3** | 1 | 3 | 1 | 2 | 3 | 2 | 2 | 1 | 2 | 1 |
| **4** | 2 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 4 |
| **5** | 1 | 1 | 1 | 2 | 3 | 3 | 1 | 2 | 1 | 3 |
| **6** | 2 | 1 | 1 | 3 | 3 | 1 | 1 | 2 | 2 | 2 |
| **7** | 2 | 1 | 1 | 3 | 1 | 1 | 2 | 3 | 1 | 1 |
| **8** | 2 | 3 | 2 | 2 | 1 | 3 | 1 | 3 | 1 | 1 |
| **9** | 1 | 2 | 2 | 1 | 1 | 1 | 3 | 1 | 2 | 1 |
| **10** | 1 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 1 | 3 |
| **11** | 1 | 2 | 1 | 1 | 1 | 2 | 3 | 2 | 1 | 3 |
| **12** | 2 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 3 |
| **13** | 1 | 1 | 2 | 3 | 3 | 2 | 1 | 1 | 1 | 1 |
| **14** | 2 | 1 | 1 | 3 | 2 | 2 | 1 | 3 | 1 | 2 |
| **15** | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 2 |
| **16** | 1 | 3 | 1 | 2 | 2 | 1 | 3 | 1 | 1 | 1 |
| **17** | 2 | 3 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | 3 |
| **18** | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 1 | 1 | 2 |
| **19** | 2 | 2 | 3 | 2 | 3 | 1 | 3 | 3 | 1 | 2 |
| **20** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| **21** | 2 | 3 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 3 |
| **22** | 1 | 1 | 1 | 1 | 3 | 1 | 2 | 1 | 3 | 2 |
| **23** | 1 | 1 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 2 |
| **24** | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 3 | 1 |
| **25** | 1 | 3 | 1 | 1 | 3 | 1 | 1 | 2 | 1 | 4 |
| **26** | 2 | 3 | 1 | 1 | 1 | 1 | 3 | 2 | 2 | 2 |
| **27** | 2 | 1 | 3 | 1 | 3 | 2 | 3 | 3 | 1 | 1 |
| **28** | 1 | 2 | 1 | 2 | 1 | 3 | 1 | 1 | 1 | 2 |
| **29** | 2 | 1 | 3 | 1 | 1 | 3 | 1 | 2 | 2 | 2 |
| **30** | 1 | 1 | 3 | 1 | 3 | 1 | 3 | 3 | 2 | 4 |
| **31** | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 2 | 1 | 3 |
| **32** | 1 | 3 | 1 | 1 | 2 | 3 | 1 | 3 | 2 | 4 |
| **33** | 1 | 1 | 2 | 3 | 1 | 3 | 3 | 1 | 3 | 2 |
| **34** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **35** | 1 | 1 | 1 | 2 | 1 | 1 | 3 | 2 | 1 | 4 |
| **36** | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **37** | 1 | 3 | 2 | 1 | 3 | 1 | 1 | 1 | 1 | 2 |
| **38** | 2 | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 3 | 4 |
| **39** | 2 | 2 | 1 | 3 | 3 | 1 | 2 | 1 | 1 | 4 |
| **40** | 1 | 2 | 3 | 1 | 1 | 3 | 2 | 1 | 1 | 1 |
| **41** | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 3 | 4 |
| **42** | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 3 | 1 | 1 |
| **43** | 2 | 3 | 1 | 1 | 1 | 3 | 2 | 3 | 1 | 2 |
| **44** | 2 | 1 | 1 | 1 | 2 | 1 | 3 | 1 | 2 | 3 |
| **45** | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 3 | 3 | 3 |
| **46** | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 1 | 3 | 4 |
| **47** | 2 | 3 | 2 | 1 | 1 | 2 | 3 | 1 | 1 | 4 |
| **48** | 2 | 2 | 2 | 1 | 3 | 3 | 1 | 1 | 2 | 3 |
| **49** | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 3 | 2 | 4 |
| **50** | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 3 |
| **51** | 2 | 1 | 2 | 2 | 1 | 1 | 3 | 1 | 1 | 3 |
| **52** | 1 | 1 | 2 | 1 | 2 | 3 | 2 | 2 | 1 | 4 |
| **53** | 1 | 3 | 3 | 1 | 2 | 2 | 1 | 1 | 3 | 2 |
| **54** | 1 | 2 | 3 | 3 | 1 | 2 | 1 | 2 | 1 | 4 |
| **55** | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 3 | 3 | 3 |
| **56** | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 2 |
| **57** | 2 | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 3 | 1 |
| **58** | 1 | 1 | 3 | 3 | 2 | 1 | 1 | 1 | 2 | 1 |
| **59** | 2 | 1 | 3 | 2 | 2 | 3 | 1 | 1 | 1 | 4 |
| **60** | 2 | 1 | 1 | 1 | 3 | 3 | 2 | 1 | 1 | 3 |
| **61** | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 3 | 2 | 4 |
| **62** | 2 | 1 | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 3 |
| **63** | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 1 |
| **64** | 2 | 2 | 1 | 1 | 3 | 2 | 1 | 2 | 3 | 1 |

## Explanation of symbols

| | Symbol | Explanation |
|---|---|---|
| **1** | Parking | Free parking |
| **2** | Price | Price |
| **3** | Age | Building year |
| **4** | District | City district |
| **5** | Supermarket | Distance to the supermarket |
| **6** | Heating | Heating |
| **7** | Floor | Floor |
| **8** | PT_stop | Distance to the public transportation stop |
| **9** | PT_freq | Public transportation frequncy |
| **10** | PT_type | Public transportation type |

# APPENDIX H. STATED CHOICE EXPERIMENT

Choice sets used in stated choice experiment

| Choice set | Group | Alternative 1 | Alternative 2 |
|---|---|---|---|
| **1** | 0 | 53 | 8 |
| **2** | 0 | 62 | 15 |
| **3** | 0 | 33 | 6 |
| **4** | 0 | 26 | 24 |
| **5** | 0 | 2 | 9 |
| **6** | 0 | 20 | 37 |
| **7** | 0 | 39 | 54 |
| **8** | 0 | 1 | 17 |
| **9** | 1 | 38 | 29 |
| **10** | 1 | 41 | 21 |
| **11** | 1 | 59 | 10 |
| **12** | 1 | 4 | 60 |
| **13** | 1 | 51 | 16 |
| **14** | 1 | 34 | 3 |
| **15** | 1 | 52 | 5 |
| **16** | 1 | 25 | 28 |
| **17** | 2 | 48 | 64 |
| **18** | 2 | 35 | 55 |
| **19** | 2 | 44 | 31 |
| **20** | 2 | 30 | 61 |
| **21** | 2 | 7 | 41 |
| **22** | 2 | 11 | 43 |
| **23** | 2 | 22 | 14 |
| **24** | 2 | 50 | 7 |
| **25** | 3 | 18 | 58 |
| **26** | 3 | 12 | 13 |
| **27** | 3 | 63 | 46 |
| **28** | 3 | 36 | 32 |
| **29** | 3 | 49 | 19 |
| **30** | 3 | 23 | 27 |
| **31** | 3 | 45 | 47 |
| **32** | 3 | 56 | 40 |
| **33** | 4 | 53 | 50 |
| **34** | 4 | 18 | 17 |
| **35** | 4 | 43 | 46 |
| **36** | 4 | 45 | 52 |
| **37** | 4 | 47 | 10 |
| **38** | 4 | 31 | 28 |
| **39** | 4 | 51 | 60 |

| | | | |
|---|---|---|---|
| **40** | 4 | 3 | 33 |
| **41** | 5 | 55 | 22 |
| **42** | 5 | 61 | 54 |
| **43** | 5 | 27 | 40 |
| **44** | 5 | 12 | 37 |
| **45** | 5 | 4 | 25 |
| **46** | 5 | 34 | 24 |
| **47** | 5 | 41 | 7 |
| **48** | 5 | 13 | 26 |
| **49** | 6 | 44 | 11 |
| **50** | 6 | 42 | 21 |
| **51** | 6 | 58 | 29 |
| **52** | 6 | 59 | 9 |
| **53** | 6 | 38 | 1 |
| **54** | 6 | 49 | 39 |
| **55** | 6 | 57 | 15 |
| **56** | 6 | 23 | 16 |
| **57** | 7 | 8 | 32 |
| **58** | 7 | 36 | 5 |
| **59** | 7 | 2 | 30 |
| **60** | 7 | 19 | 63 |
| **61** | 7 | 64 | 20 |
| **62** | 7 | 48 | 62 |
| **63** | 7 | 6 | 56 |
| **64** | 7 | 35 | 14 |
| **65** | 8 | 17 | 39 |
| **66** | 8 | 64 | 59 |
| **67** | 8 | 54 | 7 |
| **68** | 8 | 62 | 51 |
| **69** | 8 | 8 | 27 |
| **70** | 8 | 61 | 15 |
| **71** | 8 | 38 | 31 |
| **72** | 8 | 25 | 53 |
| **73** | 9 | 4 | 26 |
| **74** | 9 | 10 | 11 |
| **75** | 9 | 6 | 56 |
| **76** | 9 | 2 | 9 |
| **77** | 9 | 55 | 29 |
| **78** | 9 | 57 | 18 |
| **79** | 9 | 14 | 24 |
| **80** | 9 | 20 | 44 |
| **81** | 10 | 46 | 34 |
| **82** | 10 | 45 | 13 |
| **83** | 10 | 48 | 41 |

| | | | |
|---|---|---|---|
| **84** | 10 | 1 | 35 |
| **85** | 10 | 37 | 49 |
| **86** | 10 | 63 | 28 |
| **87** | 10 | 40 | 60 |
| **88** | 10 | 47 | 52 |
| **89** | 11 | 22 | 43 |
| **90** | 11 | 36 | 23 |
| **91** | 11 | 30 | 5 |
| **92** | 11 | 33 | 21 |
| **93** | 11 | 58 | 12 |
| **94** | 11 | 16 | 50 |
| **95** | 11 | 3 | 32 |
| **96** | 11 | 19 | 42 |
| **97** | 12 | 19 | 31 |
| **98** | 12 | 32 | 60 |
| **99** | 12 | 8 | 55 |
| **100** | 12 | 62 | 25 |
| **101** | 12 | 40 | 4 |
| **102** | 12 | 61 | 47 |
| **103** | 12 | 52 | 27 |
| **104** | 12 | 63 | 54 |
| **105** | 13 | 5 | 30 |
| **106** | 13 | 13 | 3 |
| **107** | 13 | 56 | 2 |
| **108** | 13 | 34 | 50 |
| **109** | 13 | 23 | 41 |
| **110** | 13 | 36 | 44 |
| **111** | 13 | 21 | 29 |
| **112** | 13 | 12 | 43 |
| **113** | 14 | 20 | 22 |
| **114** | 14 | 16 | 6 |
| **115** | 14 | 51 | 53 |
| **116** | 14 | 11 | 45 |
| **117** | 14 | 15 | 39 |
| **118** | 14 | 18 | 42 |
| **119** | 14 | 1 | 46 |
| **120** | 14 | 37 | 48 |
| **121** | 15 | 26 | 9 |
| **122** | 15 | 59 | 35 |
| **123** | 15 | 49 | 38 |
| **124** | 15 | 33 | 14 |
| **125** | 15 | 57 | 28 |
| **126** | 15 | 24 | 7 |
| **127** | 15 | 10 | 64 |

| | | | |
|---|---|---|---|
| **128** | 15 | 17 | 58 |
| **129** | 16 | 17 | 16 |
| **130** | 16 | 50 | 13 |
| **131** | 16 | 21 | 37 |
| **132** | 16 | 31 | 11 |
| **133** | 16 | 60 | 15 |
| **134** | 16 | 29 | 46 |
| **135** | 16 | 33 | 7 |
| **136** | 16 | 2 | 44 |
| **137** | 17 | 38 | 42 |
| **138** | 17 | 30 | 51 |
| **139** | 17 | 12 | 3 |
| **140** | 17 | 25 | 59 |
| **141** | 17 | 47 | 20 |
| **142** | 17 | 14 | 10 |
| **143** | 17 | 35 | 34 |
| **144** | 17 | 22 | 63 |
| **145** | 18 | 43 | 39 |
| **146** | 18 | 28 | 41 |
| **147** | 18 | 23 | 6 |
| **148** | 18 | 54 | 48 |
| **149** | 18 | 61 | 18 |
| **150** | 18 | 26 | 27 |
| **151** | 18 | 40 | 52 |
| **152** | 18 | 9 | 58 |
| **153** | 19 | 24 | 4 |
| **154** | 19 | 53 | 62 |
| **155** | 19 | 55 | 56 |
| **156** | 19 | 1 | 45 |
| **157** | 19 | 8 | 5 |
| **158** | 19 | 32 | 36 |
| **159** | 19 | 19 | 49 |
| **160** | 19 | 57 | 64 |
| **161** | 20 | 47 | 7 |
| **162** | 20 | 41 | 30 |
| **163** | 20 | 4 | 32 |
| **164** | 20 | 13 | 26 |
| **165** | 20 | 10 | 3 |
| **166** | 20 | 50 | 44 |
| **167** | 20 | 15 | 59 |
| **168** | 20 | 18 | 24 |
| **169** | 21 | 48 | 17 |
| **170** | 21 | 29 | 11 |
| **171** | 21 | 19 | 5 |

| | | | |
|---|---|---|---|
| **172** | 21 | 43 | 39 |
| **173** | 21 | 46 | 20 |
| **174** | 21 | 51 | 52 |
| **175** | 21 | 31 | 8 |
| **176** | 21 | 9 | 28 |
| **177** | 22 | 64 | 34 |
| **178** | 22 | 55 | 40 |
| **179** | 22 | 33 | 63 |
| **180** | 22 | 38 | 21 |
| **181** | 22 | 36 | 57 |
| **182** | 22 | 61 | 45 |
| **183** | 22 | 62 | 16 |
| **184** | 22 | 27 | 2 |
| **185** | 23 | 12 | 23 |
| **186** | 23 | 53 | 60 |
| **187** | 23 | 58 | 35 |
| **188** | 23 | 1 | 22 |
| **189** | 23 | 42 | 54 |
| **190** | 23 | 56 | 49 |
| **191** | 23 | 6 | 25 |
| **192** | 23 | 37 | 14 |

# APPENDIX I. DATA INTERPRETATION OF THE WHOLE SAMPLE

Data interpretation of the whole sample[3]

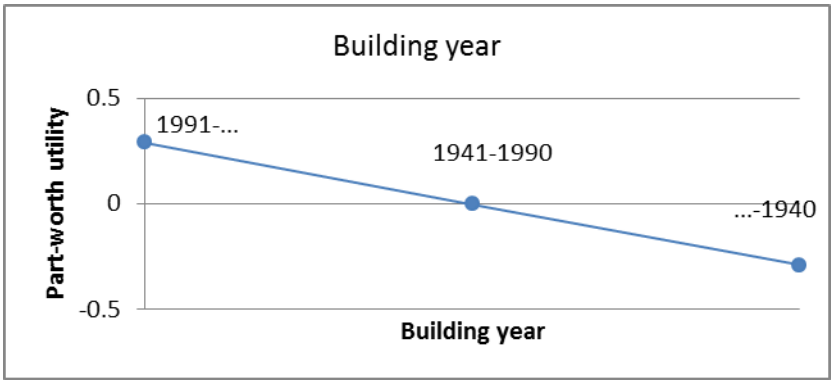
| Attribute level | Coding | | Coefficient | | Result |
|---|---|---|---|---|---|
| | Variable 1 | Variable 2 | DISTR1*** | DISTR2*** | |
| city center | 1 | 0 | 0.32204 | -0.49212 | 0.32204 |
| edge | 0 | 1 | | | -0.49212 |
| surrounding | -1 | -1 | | | 0.17008 |
| Attribute level | Coding | | Coefficient | | Result |
| | Variable 1 | Variable 2 | AGE1*** | AGE2 | |
| 1991-... | 1 | 0 | 0.28958 | 0 | 0.28958 |
| 1941-1990 | 0 | 1 | | | 0 |
| ...-1940 | -1 | -1 | | | -0.28958 |
| Attribute level | Coding | | Coefficient | | Result |
| | Variable 1 | Variable 2 | HEAT1*** | HEAT2*** | |
| central | 1 | 0 | 0.64675 | -0.41641 | 0.64675 |
| electric | 0 | 1 | | | -0.41641 |
| wood | -1 | -1 | | | -0.23034 |
| Attribute level | Coding | | Coefficient | | Result |
| | Variable 1 | Variable 2 | FLOOR1*** | FLOOR2*** | |
| middle | 1 | 0 | 0.27814 | -0.36189 | 0.27814 |
| first | 0 | 1 | | | -0.36189 |
| last | -1 | -1 | | | 0.08375 |

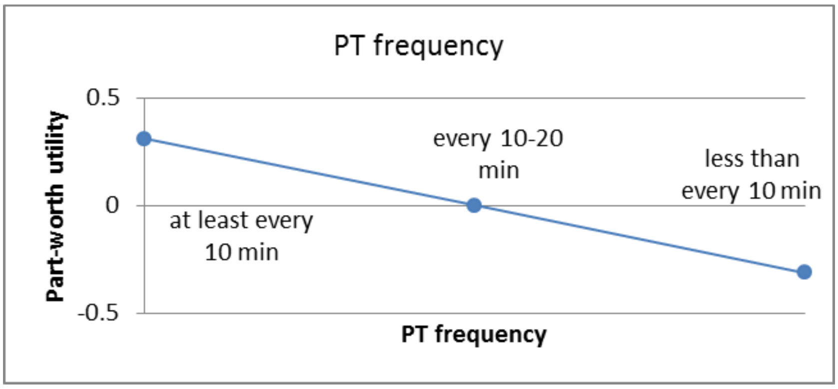
| Attribute level | Coding | Coefficient | Result |
|---|---|---|---|
| | Variable 1 | PARK*** | |
| yes | 1 | 0.23343 | 0.23343 |
| no | -1 | | -0.23343 |

| Attribute level | Coding | | Coefficient | | Result |
|---|---|---|---|---|---|
| | Variable 1 | Variable 2 | FREQ1*** | FREQ2 | |
| at least every 10 min | 1 | 0 | 0.3117 | 0 | 0.3117 |
| every 10-20 min | 0 | 1 | | | 0 |
| less than every 20 min | -1 | -1 | | | -0.3117 |

[3] Due to the chosen coding of different levels for some attributes, the order of attribute levels in data interpretation tables may differ from the logic used in the rest of the thesis. The author confirms that this has been noted in all calculations and the calculations are correct.

Data visualization of the whole sample



# APPENDIX J. NLOGIT OUTPUTS

## NLOGIT output for frequent PT users

```
-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -340.88577
Estimation based on N =    584, K =  20
Inf.Cr.AIC  =    721.8 AIC/N =    1.236
Model estimated: Jan 29, 2017, 09:49:54
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -403.9208  .1561 .1261
Response data are given as ind. choices
Number of obs.=   584, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
    ICHO|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   PRIC1|    -.35764***      .11195    -3.19  .0014     -.57705   -.13822
   PRIC2|     .07818         .10767      .73  .4678     -.13285    .28922
  DISTR1|     .30524***      .09032     3.38  .0007      .12822    .48226
  DISTR2|    -.50340***      .11158    -4.51  .0000     -.72210   -.28470
    AGE1|     .19130*        .10173     1.88  .0601     -.00810    .39070
    AGE2|     .00981         .08463      .12  .9077     -.15606    .17568
   HEAT1|     .50941***      .09187     5.55  .0000      .32935    .68947
   HEAT2|    -.33526***      .11240    -2.98  .0029     -.55556   -.11496
  FLOOR1|     .33557***      .10803     3.11  .0019      .12383    .54731
  FLOOR2|    -.36967***      .09549    -3.87  .0001     -.55683   -.18251
    PARK|     .12552*        .06634     1.89  .0585     -.00450    .25554
    SUP1|    -.03602         .08622     -.42  .6761     -.20501    .13296
    SUP2|     .03866         .10420      .37  .7106     -.16557    .24289
   STOP1|     .13373         .09900     1.35  .1768     -.06031    .32777
   STOP2|     .03394         .10357      .33  .7431     -.16904    .23693
   FREQ1|     .32062***      .09368     3.42  .0006      .13701    .50423
   FREQ2|     .12545         .09943     1.26  .2071     -.06943    .32033
    TYP1|    -.11178         .11737     -.95  .3409     -.34181    .11826
    TYP2|     .14311         .11004     1.30  .1934     -.07255    .35878
    TYP3|    -.17326         .11388    -1.52  .1282     -.39645    .04994
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
-----------------------------------------------------------------------------
```

NLOGIT output for infrequent PT users

```
-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function      -272.84134
Estimation based on N =    512, K =  20
Inf.Cr.AIC  =    585.7 AIC/N =    1.144
Model estimated: Jan 29, 2017, 10:13:16
R2=1-LogL/LogL* Log-L fncn R-sqrd R2Adj
Constants only   -354.8289  .2311 .1998
Response data are given as ind. choices
Number of obs.=   512, skipped    0 obs
--------+--------------------------------------------------------------------
        |                  Standard            Prob.      95% Confidence
    ICHO|  Coefficient       Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   PRIC1|    -.53157***      .12501    -4.25  .0000     -.77659   -.28655
   PRIC2|     .13984         .11840     1.18  .2376     -.09221    .37189
  DISTR1|     .36228***      .10123     3.58  .0003      .16388    .56067
  DISTR2|    -.56449***      .12561    -4.49  .0000     -.81067   -.31831
    AGE1|     .43002***      .12033     3.57  .0004      .19418    .66586
    AGE2|    -.16501*        .09624    -1.71  .0864     -.35363    .02362
   HEAT1|     .85084***      .11414     7.45  .0000      .62712   1.07455
   HEAT2|    -.52396***      .13334    -3.93  .0001     -.78530   -.26262
  FLOOR1|     .16784         .12509     1.34  .1797     -.07734    .41301
  FLOOR2|    -.31385***      .11614    -2.70  .0069     -.54148   -.08622
    PARK|     .37696***      .07652     4.93  .0000      .22699    .52694
    SUP1|     .11217         .09400     1.19  .2328     -.07208    .29641
    SUP2|     .09132         .11412      .80  .4236     -.13236    .31500
   STOP1|    -.01315         .10165     -.13  .8971     -.21238    .18609
   STOP2|     .04222         .11580      .36  .7154     -.18475    .26919
   FREQ1|     .30355**       .12227     2.48  .0130      .06391    .54320
   FREQ2|    -.03332         .11056     -.30  .7631     -.25001    .18337
    TYP1|    -.03123         .13595     -.23  .8183     -.29768    .23522
    TYP2|     .06897         .12527      .55  .5819     -.17656    .31451
    TYP3|     .04890         .14794      .33  .7410     -.24105    .33886
--------+--------------------------------------------------------------------
Note: ***, **, * ==>  Significance at 1%, 5%, 10% level.
-----------------------------------------------------------------------------
```