


HENRIK LÖNNQVIST

ON THE EFFECTS OF URBAN NATURAL AMENITIES, ARCHITECTURAL QUALITY AND ACCESSIBILITY TO WORKPLACES ON HOUSING PRICES

5
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Urban Facts

An empirical study on the Helsinki Metropolitan Area

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ACKNOWLEDGEMENTS

If we all chose a career based solely on our childhood dream jobs, I would have grown up to be an architect. It became clear relatively early that I had the desire but not the talent to match. Before long, however, I found another path to follow, and a good one at that: economics. Around the time when I was looking for a subject for my master's thesis I bumped into an interesting (and, in Finland, relatively little studied) branch of the discipline: urban economics. On hearing about my choice of thesis topic, Professor Markku Ollikainen, the supervisor of my thesis seminar at Helsinki University, instructed me to turn to Professor Heikki A Loikkanen. As it turned out, Heikki would act as one of the examiners for my thesis work and would later become one of the supervisors for my doctoral dissertation. His support to my efforts has been invaluable and he has headed a series of Academy of Finland-funded research projects which have played a part in making possible this dissertation work. Research projects led by Heikki have always combined societal relevance and different research approaches in interesting ways. In the course of these projects, I have also had the opportunity to receive valuable feedback for my work. My particular thanks go to Dr Essi Eerola, Dr Teemu Lyytikäinen and Dr Tuukka Saarimaa.

As I began my postgraduate studies in Real Estate Economics at the Helsinki University of Technology, currently Aalto University, Professor Kauko Viitanen was appointed supervisor of my dissertation work. His endless patience has been admirable as the finalisation of this thesis has dragged on almost indefinitely. The silver lining is that this delay has presented me several opportunities to have fascinating discussions with Kauko on a number of questions related to urban development and real estate economics. I deeply value our conversations. During my postgraduate studies I have also had the chance to acquaint myself more thoroughly with Real Estate Economics and see the research field of this discipline, including in Asia, which has been for me an extremely useful and interesting experience.

The pre-examiners of my dissertation, Professor Hans Lind and Professor Martin Haran, have given me a plethora of good advice and the corrections they suggested have improved my dissertation immensely. I want to express my sincere thanks for their contribution.

My dissertation is based on collaboration with a number of researchers from various disciplines. Professor Liisa Tyrväinen, together with her research group, has made possible the section on urban natural amenities in this work. As much as I am a nature lover, I would not have been able to 'see the forest for the trees' without Liisa and her team. Luckily, my path crossed again with architecture at the time of writing this dissertation when I met the architect Janne Pihlajaniemi. Later, when we celebrated Janne's PhD defence afterparty in December 2014, I was able to thank him for having had the opportunity to take a peek in the world of architecture. I now repeat those thanks to Professor

Pihlajaniemi. The third essential collaboration partner for this dissertation work has been Professor Tuuli Toivonen and her MetropAccess research group. Their pioneering work with accessibility calculation models has been immensely useful for me. Finally I would like to extend my heartfelt thanks to Dr Seppo Laakso for fruitful cooperation over many years. This cooperation has benefited my dissertation project to a very significant degree.

During the entire length of this process, I have worked at City of Helsinki Urban Facts. Besides this dissertation, my years at this department have been filled with extremely interesting research projects in the field of Urban Studies. The work community has always been inspiring and the work conditions have been outstanding. My warm thanks go to all my colleagues and especially Director Timo Cantell and his predecessor Asta Manninen. A special thanks to Statistics and Information Services Manager Ari Jaakola with whom I carried out a research project that had a significant impact on the orientation of my dissertation work. I am indebted to Ari also for many important conversations over the years on topics related both to work and to private life. My further thanks to researchers Jenni Väliniemi-Laurson and Faris Alsuhail whose contribution in modifying the research data has been very valuable. The expertise and hard work of Pirjo Lindfors and Tarja Sundström-Alku in editing this dissertation for print deserves a bow of gratitude. I am also grateful to Teemu Vass for the language revision which undoubtedly makes this work a more pleasant reading experience.

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Finally I wish to thank my most loved ones, my family and my nearest. They have had to endure a lot during this long project. First of all I want to thank my wife Ursula. Not only have you led us through one house construction project, you have also borne much of the responsibility for our family's everyday life in the past few years. Together with our sons Oskar and Topias, you have always found the energy to support me. I cannot express how lucky and grateful I am to have you all in my life.

Helsinki, 18 November 2015

Henrik Lönnqvist

FOREWORD

Helsinki and the Helsinki Region are currently experiencing a period of rapid population growth. Population projections indicate that this growth is set to continue for the next couple of decades. The expected growth is conditional on the availability of housing in the region and would thus necessitate significant new construction.

In this Doctoral Dissertation, Henrik Lönnqvist, acting research director at City of Helsinki Urban Facts, analyses the effects of urban nature, accessibility, architecture and architectonic quality on the prices of dwellings in Helsinki and the Helsinki Region.

The development of the urban structure and the mechanisms that affect it are a topic of constant debate amongst the academic community, urban planners and citizens in a number of ways. In this respect, the research at hand deals with highly topical issues but is also rooted in the classical tradition of the analysis of urban development. The results offer possibilities of direct application in any urban research that accompanies the development of the city. In this sense, the themes of this study are at the core of the activities of City of Helsinki Urban Facts.

This work is based on extensive cooperation both in terms of the research data and the research approach. Experts from several universities, institutes and disciplines have contributed to the process. These connections imply not only that the research theme is a multifaceted one but also that the author himself has a broad and versatile scope and research orientation.

Helsinki, November 2015

Timo Cantell
Director
City of Helsinki Urban Facts

ESIPUHE

Helsinki ja Helsingin seutu elävät voimakkaan väestönkasvun aikaa. Väestöennusteiden mukaan tämä kasvu tulee jatkumaan lähivuosikymmenet. Odotettu kasvu on ehdollista sille, että seudulle kyetään rakentamaan merkittävä määrä uusia asuntoja.

Tässä väitöskirjatutkimuksessa Helsingin kaupungin tietokeskuksen vs. tutkimuspäällikkö Henrik Lönnqvist selvittää kaupunkiluonnon, arkkitehtuurin ja arkkitehtonisen laadun sekä saavutettavuuden vaikutuksia asuntojen hintoihin Helsingissä ja Helsingin seudulla.

Kaupunkirakenteen kehitys ja siihen liittyvät vaikutusmekanismit keskusteluttavat niin tutkijayhteisöä, kaupunkisuunnittelijoita kuin kaupunkilaisia eri tavoin. Tältä osin käsillä oleva tutkimus on hyvin ajankohtainen ja toisaalta klassinen tarkasteltaessa kaupunkikehitystä. Samalla tuloksilla on suoria sovellettavia kaupunkitutkimuksellisia mahdollisuuksia kaupunkia kehitettäessä. Siten teemat sijoittuvat Helsingin kaupungin tietokeskuksen toiminnan ytimeen.

Tutkimus perustuu hyvin laajaan yhteistyöhön niin tutkimusaineistojen kuin tutkimusotteen osalta. Yhteistyössä on mukana useita yliopistoja ja tutkimuslaitoksia ja tieteenaloja. Nämä yhteydet kertovat paitsi tutkittavan teeman moninaisuudesta, myös tutkijan itsensä laajasta ja moninaisesta orientaatiosta.

Helsingissä marraskuussa 2015

Timo Cantell
johtaja
Helsingin kaupungin tietokeskus

AUTHOR'S CONTRIBUTION TO THE CHAPTERS

Chapter 1

Henrik Lönnqvist is responsible for this chapter. Kauko Viitanen, Heikki A. Loikkanen and Heidi Falkenbach provided comments and suggestions on the chapter.

Chapter 2

Henrik Lönnqvist is responsible for this chapter. Kauko Viitanen and Heikki A. Loikkanen provided comments and suggestions on the chapter.

Chapter 3

Henrik Lönnqvist is responsible for this chapter. Kauko Viitanen and Heikki A. Loikkanen provided comments and suggestions on the chapter.

Chapter 4

Henrik Lönnqvist is responsible for the formation of the research data set (except environmental variables), has participated in planning the construction of environmental variables and is responsible for econometric analysis and the writing this chapter. Liisa Tyrväinen initiated the research the project on urban natural amenities and housing prices and provided comments and suggestions on the chapter. Olli Leino is responsible for the formation of the environmental variables. Kauko Viitanen and Heikki A. Loikkanen provided comments and suggestions on the chapter.

Chapter 5

Henrik Lönnqvist is responsible for the formation of the research data set (except the architectural variables), the participated in planning the construction of the architectural variables and is responsible for the econometric analysis and writing this chapter. Janne Pihlajaniemi and Emma Koivuranta are responsible for the formation of the architectural variables and related figures. Kauko Viitanen, Heikki A. Loikkanen and Janne Pihlajaniemi provided comments and suggestions on the chapter.

Chapter 6

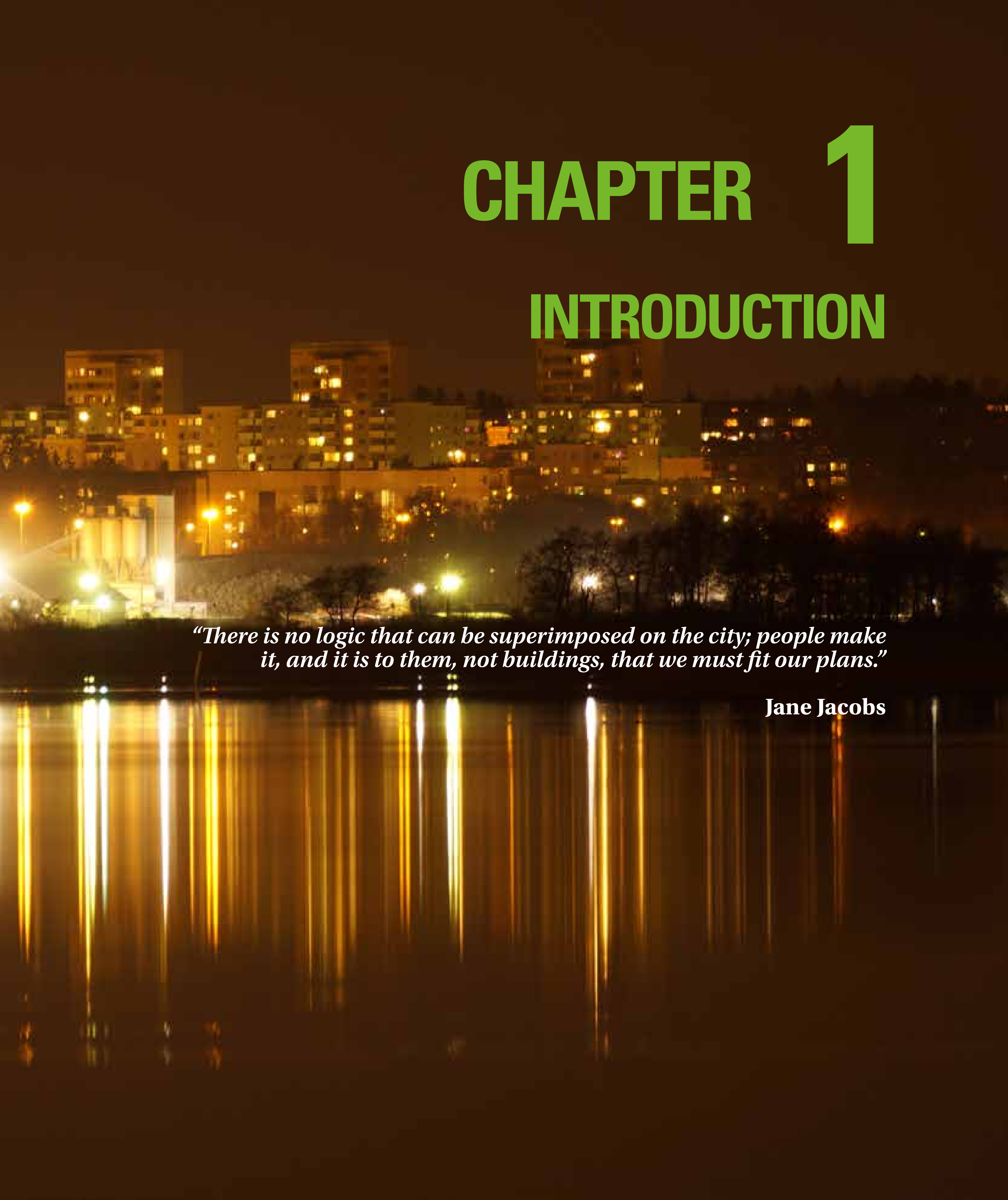
Henrik Lönnqvist is responsible for the formation of the data set (majority of control variables, see below), the participated in planning of the accessibility variables and is responsible for the econometric analysis and writing this chapter. Tuuli Toivonen and the MetropAccess project team is responsible for the construction of the traffic related accessibility variables. Ari Jaakola and Seppo Laakso are responsible for the land use variables. Seppo Laakso is responsible for the service-level variables. Jenni Väliniemi-Laurson is responsible for those accessibility variables that are not related to traffic, and for distance variables. Faris Alsuhail has given technical assistance in data processing and is responsible for maps related to accessibility. Kauko Viitanen and Heikki A. Loikkanen provided comments and suggestions on the chapter.

Chapter 7

Henrik Lönnqvist is responsible for this chapter. Kauko Viitanen, Heikki A. Loikkanen and Heidi Falkenbach provided comments and suggestions on the chapter.

ABBREVIATIONS

AIC (AICC)	Akaike information criteri on (with a correction for finite sample sizes)
ARK	Finnish Architectural Review
BIC	Bayesian information criterion
CAD	Computer-aided design
CBD	Central business district (Chapter 2), Central Helsinki (Chapters 4 and 6)
Cov	Covariance
CR	Cluster robust
Dr	Doctor
EUR	Euro
FE	Fixed effects
GIS	Geographical information systems
GWR	Geographically weighted regression
HCC	Heteroskedasticity consistent standard errors
HMA	Helsinki Metropolitan Area
HSL	Helsinki Region Transport Authority
HSY	Helsinki Region Environmental Authority
ICC	Interclass correlation
ICT	Information and communications technology
m	Meter
N	Number of observations
OECD	Organization for Economic Development and Cooperation
OLS	Ordinary least squares
Param.est.	Parameter estimate
RE	Random effects
RQ	Research question
SBD	Secondary business district
sqm	Square meter
SSR	Sum of squared residuals
SUB	Suburb
VIF	Variance inflation factor
VTT	VTT Technical Research Centre of Finland Ltd
YTV	Helsinki Metropolitan Area Council



CHAPTER 1

INTRODUCTION

“There is no logic that can be superimposed on the city; people make it, and it is to them, not buildings, that we must fit our plans.”

Jane Jacobs

1 INTRODUCTION

1.1 Motivation

It is often said that urbanisation in Finland took place late but all the more rapidly. Since the Second World War, the Helsinki region has been one of Europe's fastest growing urban areas, and there is no end in sight to this development in the coming decades (OECD 2003, Laakso 2012). The growth of the Helsinki region has continued even during times of economic recession, while the number of growth centres elsewhere in Finland appears to be diminishing. This growth creates considerable pressure on housing construction. In order for housing construction to be able to respond to the demand for housing, urban planning and land policy must function smoothly and be responsive. The Helsinki region needs new residential areas, as studies show that infill development in those properties where there still is unutilised building rights, cannot alone ensure sufficient housing production (Laakso et al. 2011).

Responding to the population growth pressure with sufficient housing production is a quantitative as well as a qualitative challenge. Construction and urban planning involve decisions whose effects extend far into the future. New production not only means new dwellings for new and old residents; it changes established neighbourhoods and creates needs for new services and traffic systems. For urban planning, this means balancing different interests. What kinds of dwellings and residential environments should be built? Housing preference surveys provide one answer to this question (see for example Strandell 2011). However, they can be criticised for not providing information based on people's actual choices, and the questions on housing preference are not conditioned by economic boundary conditions (debate on stated vs. revealed preferences, see Jansen et al. 2008). Housing markets are often considered a better source of information.

Housing prices and rents are a good starting point for the assessment of the housing market, but, on their own, they do not reveal the whole truth about the structure of housing demand. This is because housing prices are not merely the result of housing demand but also housing supply. Market prices can be used to assess the balance between demand and supply in housing.

The flexibility of housing supply is a key factor affecting housing prices. In conditions of inflexible housing supply, an increase in housing demand is mostly channelled into housing prices. Housing demand as a whole is comprised of the demand created by different individuals and households. With the supply of the housing market as a given, individual factors affect what types of dwellings the demand of each household is directed at, and housing demand cannot be understood simply on the basis of, say, the floor area of a dwelling or its accessibility. Housing quality can be considered to encompass a variety of factors, some of which are related to the actual dwelling and its structural properties, and some to the housing environment and its accessibility. (Rothenberg et al. 1991)

There are solid grounds for utilising market information in housing policy decisions. In an urban environment, many externalities, both negative and positive, are constantly present. The impact they have on 'third parties' can be significant, and their scale may be difficult to estimate. Because externalities may be capitalised in housing prices, housing market information, if appropriately used, can provide support for urban planning. In fact, the management of externalities may be regarded as one of the key economic arguments for urban planning. With regard to negative externalities, this means the differentiation of land use forms that are adverse to each other; with regard to positive externalities, it means bringing together forms of land use that provide mutual synergies, as well as the creation of institutional and structural conditions that improve economic productivity and efficiency. (Webster 2009)

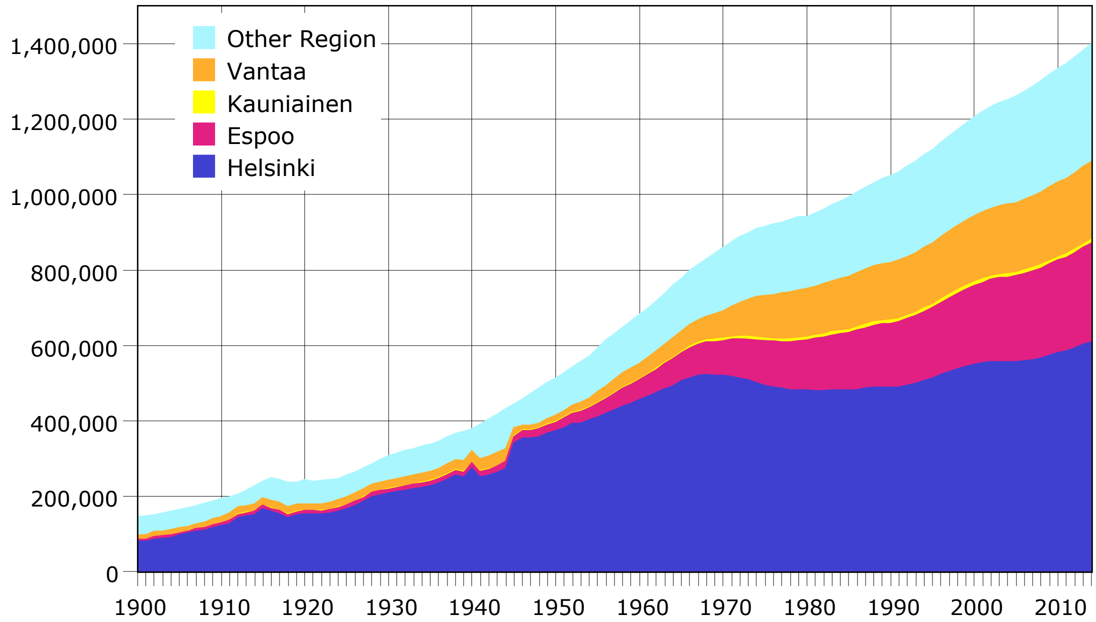
This study focuses on the assessment of the market prices of the different characteristics of dwellings in blocks of flats and row houses on the basis of price data on owner-occupied housing markets in Helsinki and the Helsinki Metropolitan Area. Particular attention is paid to the effects of urban natural amenities, architectural quality and the accessibility of workplaces on housing prices. The empirical analysis is based on the use of the hedonic model. This is based on the idea that the total price of a dwelling is comprised of the shadow prices of its various characteristics. The structure of the study is described in more detail in Sections 1.4 and 1.5.

1.2 Study area

The study area of this study is the Helsinki Metropolitan Area, comprising four municipalities (Helsinki, Espoo, Vantaa and Kauniainen). Functionally, however, the area is wider. The Helsinki Region, as it is commonly defined, consists of 14 municipalities and has a population of approximately 1.4 million in 2012 (Figure 1.1). The population of the core of the region, the four municipalities that make up the metropolitan area, was approximately 1,059,000. The Helsinki Region is Finland's most important growth centre, home to just over 25% of the population of the country and over 30% of the jobs. The Helsinki region accounts for more than a third of the country's gross domestic product. The annual population growth in the region has been around one per cent per year in recent years. (Helsinki Region Environmental Service Authority 2012, Laakso 2012, City of Helsinki Urban Facts 2013)

Housing production in the Helsinki Region has fluctuated a good deal since 1990. In 1996, annual housing production amounted to less than 6,000 dwellings, rising to 11,000 dwellings at the turn of the millennium. In the last decade, housing production in the region decreased until 2009, when fewer than 6,000 dwellings were completed. Since 2010, housing pro-

Figure 1.1 Population development in the Helsinki Region in 1900–2014 (Aluesarjat database)



duction has again grown strongly. Over the years, the focus of production has been on the region's three largest cities (Helsinki, Espoo and Vantaa). The share of housing production in the municipalities outside the Helsinki Metropolitan Area has been around one-quarter at most. New production in the largest cities of the region, particularly Helsinki, focused on flats, while the surrounding municipalities focused on detached houses. (Helsinki Region Environmental Service Authority 2012)

Housing prices in the Helsinki region and Helsinki, in particular, are considerably higher than elsewhere in the country. This general regional price differentiation has continued for a long time (Lönnqvist 2004, Lönnqvist & Vaattovaara 2009). In addition, differences within the region are considerable. The average price per square metre of an owner-occupied flats in the southern part of central Helsinki was more than EUR 6,100 in the autumn of 2015, while in the cheaper blocks of flats in the outer suburbs of Helsinki, it was approximately EUR 2,700. The average price of flats in the outer Helsinki Region (outside the Helsinki Metropolitan Area) was about EUR 2,000. The price level of housing in the rest of Finland was about EUR 1,700 per square metre (City of Helsinki Urban Facts 2015).

The strong population growth in the Helsinki region has resulted in the expansion of the built-up urban area. While the population density in the most densely built-up areas, in the central Helsinki, has decreased, the number of more sparsely inhabited areas has increased. In European terms, the Helsinki region is sparsely populated. In contrast to most European cities, however, the population density in the populated areas has grown. At the same time, the geographical population focus has shifted further from the inner city. (European Environmental Agency 2006, Jaakola & Lönnqvist 2009, Laakso & Lönnqvist 2012)

The housing stock of the Helsinki region is relatively young. There is little older housing stock outside central Helsinki, and even that has been built as recently as the end of the 19th century. After the Second World War, in response to the strong population growth in the urban region, housing was built in the form of suburban estates. These are residential areas separate from the older, dense urban structure: small satellite cities, as it were, surrounded by row or detached housing. Partly due to these suburban estates, population growth shifted from Helsinki to the neighbouring municipalities, first to Espoo and then to Vantaa, from the 1970s. Thanks to the construction of single-family houses, the peripheral municipalities also increased in terms of population. The housing stock of Espoo and Vantaa comprises a higher proportion of row houses and single-family houses, accounting for 40% of dwellings, while in Helsinki, only 12% of dwellings are row houses and single-family houses. In the peripheral municipalities, the majority of dwellings are in single-family houses. (Hankonen 1994, Helsinki Region Environmental Service Authority 2012)

The development of jobs has been somewhat different than that of the population structure. The main centre, central Helsinki, continues to be the most important work location, but most of the increase in jobs in the last decades has taken place in the subcentres. Especially office jobs continue to be located in close proximity to each other (see Section 6.3 for details). New concentrations of jobs outside central Helsinki have risen in easily accessible locations, such as Espoo, largely due to the growth of the ICT sector, and Vantaa, thanks to the development of the airport city, Aviapolis. Industrial operations and logistics operations requiring a great deal of space have moved out of the regional core. The former industrial and harbour areas in the central Helsinki have been or are being converted into residential use. The main centre, central Helsinki, still has a significant role for service-sector jobs, but the general trend has been the decentralisation of service-sector jobs into the new shopping centres, along with the expansion of residential areas. (Jaakola & Lönnqvist 2009, Lönnqvist 2009, Laakso et al. 2011, Laakso & Lönnqvist 2012)

The challenge faced by urban planning, in addition to quantitative growth, is maintaining the quality of the housing environment. The intensive urbanisation after the Second World War has occasionally caused pressure on the green spaces in Helsinki (Clark & Hietala 2006). The pressure to construct has been addressed partly through a series of land annexations, of which the one undertaken in 1946 increased the area of Helsinki the most and enabled suburban development within the boundaries of Helsinki. The most recent land annexation was made in 2009 (Kervanto Nevanlinna 2012).

After a long period of spatial expansion of the built area in the Helsinki Region, the current trend in urban planning favours densifying the existing urban structure. Densification of spacious city districts, however, often generates local resistance, as unbuilt areas tend to be perceived by residents as green areas, regardless of their designated function in the plan. A significant proportion of infill potential is located on land with existing buildings. Despite the financial gains for the property owners, infill development is a relatively slow process, which often instigates resistance (Nurmi 2006, Arvola & Pennanen 2014, Puustinen & Viitanen 2015). In addition, geography sets its own restraints on the growth of Helsinki city centre, in particular, as the inner city is located on a peninsula that just out to sea. In spite of the strong population growth and construction in Helsinki and the entire region, the availability of green areas has remained abundant, especially in the suburbs, and there is also a relatively large amount of unbuilt shoreline in public use. In the most recent plans, looking decades ahead, the aim is to retain existing green areas and concentrate construction by densifying the urban structure (City of Helsinki City Planning Department 2013).

In Finland, municipalities are largely responsible for land use planning, drawing up the master plans and detailed plans. Municipalities have extensive rights on land use planning and, as a rule, decide on all land use in their area regardless of the landowner. The construction of dense development always requires a detailed plan as the basis for construction. Planning decisions do not of course guarantee that all areas and properties are built according to the plan. In addition to the market demand for the area, the role of land ownership is a key factor. With regard to land ownership, Helsinki differs significantly from all the other municipalities in the region. In Helsinki, the City owns roughly two-thirds of the land area. The state also owns significant amounts of land in Helsinki. The city's land policy provides a tool to steer the construction of residential areas. The starting point in Helsinki has been to offer a variety of different forms of tenure for dwellings in all new residential areas. In the other municipalities in the region, the role of the municipality in land ownership and, hence, the possibility of the municipalities to steer housing construction, is smaller than in Helsinki. (Loikkanen & Lönnqvist 2007)

The ongoing growth of Helsinki and the Helsinki region requires large amounts of new housing production. In practice, this means both densification of existing housing areas and brownfield development, and also opening new areas to housing production. New construction affects old housing areas in many ways. It can, for example, reduce open space and green areas but also enhance services and accessibility (e.g. public transportation).

1.3 Orientation

Housing markets are often analysed without taking location into account. Housing markets are usually analysed on the level of the job market area, for example, without further consideration of the structural characteristics of the housing market. Such a perspective is often adequate for the analysis of macroeconomic issues. In the housing market, however, location, measured on a more detailed level than the urban region, is a significant factor. Location has a great impact on households' choices, for example. In addition, location factors are clearly reflected in housing prices and, hence also affect other consumption possibilities through the household's budget constraint. Location factors also have a considerable impact on businesses. Consequently, standard, non-spatial economics as such is not an appropriate analysis tool for local housing markets. An approach is needed that takes location factors into account. Urban economics, the research area this thesis contributes to, was developed to satisfy this need. Urban economics borrows its key tools from standard microeconomics theory, but complements the analysis with factors that take spatial aspects into account.

Professor John M. Quigley (1942–2012), recognised as a pioneer of urban economics research, describes the field of urban economics as follows:

"Urban economics emphasises: the spatial arrangements of households, firms, and capital in metropolitan areas; the externalities which arise from the proximity of households and land uses; and the public policy issues which arise from the interplay of these economics forces." ***(Quigley 2006)***

The key theoretical framework of this study is the model framework created in urban economics on the location of households in urban areas and the formation of land use in urban areas (through market decisions) on the basis of these choices. This theory can be considered to be founded on William Alonso's pioneering work Location and Land Use in 1964. Almost as widely known are the works of Muth (1969) and Mills (1972), which created the microeconomic foundation on which models describing land use in urban areas were based for a long time and, to some extent, still are. In the early monocentric models, the location of businesses is taken as a given, with attention focused primarily on households' choice of housing location. Monocentric urban models are usually partial equilibrium models by nature. A general equilibrium framework also requires the inclusion of other sectors in the model framework in addition to the household sector. Several general equilibrium models have been developed, with Mills (1967) providing an early example. As early as the 1970s, models based on the concept of general equilibrium were also developed that were not tied to the assumption of monocentricity (Mills 1972). Later, the model framework has developed significantly in other aspects as well, including the location decisions of households, the impact of public sector actions and the modelling of the location of business activities. (Laakso et al. 2002) The theoretical housing market framework especially that on the urban housing market, is described in more detail in Chapter 2.

Urban areas are not of equal quality in terms of the housing environment. Geographical conditions vary, and urban construction also shapes housing environments. The availability of certain desirable housing environment characteristics may be scarce, and not even high demand will necessarily generate significantly increased production of them.

In an urban environment, the quality factors of the built environment are particularly highlighted, as a city is specifically a built environment. The life cycle of buildings is often long, and inertia is common in the development of the urban structure. Therefore, what is built and how, affects the quality of the living environment of many people, including future generations. Although the urban environment is largely shaped by human hand, the natural element has not disappeared from the city. It may well be claimed that, in a dense environment, the importance of urban natural amenities is heightened.

As was noted earlier, in mainstream economics, location generally plays no role at all. This applies to analyses of both consumption and production. The situation is different in urban economics, which focuses on the birth of cities and the development of their structure. In research on the urban environment, accessibility is a key aspect of analysis. There are also several other interesting questions related to the urban environment from an economics perspective. Firstly, public goods are strongly present in the urban environment. Many recreational areas in cities, for example, are public goods by nature. It is difficult to exclude anyone from using them and, at least to some extent, consumption by one person does not exclude others from consuming the same good. Some public goods may be local by nature, in which case the possibility for their consumption may be limited to the residents of the respective municipality, or their consumption is only possible in practice if one lives close enough to the public good. Secondly, the role of externalities in cities is considerable, whether the environment is regarded as a built entity or an economic environment from the perspective of production. Traffic noise and air pollution are examples of negative externalities. On the other hand, a beautiful building mostly likely creates a positive externality for its environment. Its aesthetic value extends beyond the building owners and users (public goods and externalities are described in more detail in Section 2.4). Thirdly, a high-quality urban environment can be seen as a luxury good. According to the common definition, their income elasticity is positive and greater than one. As income increases, the demand for luxury goods increases more rapidly than for necessity goods, which have a positive income elasticity, but less than one (Glaeser et al. 2001, Laakso & Loikkanen 2004).

As a result of structural economic changes, the growth of cities requires considerable housing production. Is it possible in such conditions to create a high-quality environment, or will quality be overridden by quantity? This applies to private as well as public sector operations. One might think that everyone benefits from a high-quality environment. In practice, however, if uncertainty reigns, it may initially be difficult to attract the first investors if there is uncertainty as to the realisation of the entire development project and the participation of others. In game theory, this is referred to as the prisoner's dilemma, a situation in which both parties maximise their own advantage without making commitments, resulting in a suboptimal outcome. Only by involving a sufficiently large number of players – the critical mass – can a process independently develop towards an optimal solution. (Schelling 1978, Shimomura & Matsumoto 2010)

The public sector plays its own key role in the creation of a high quality urban environment mainly through land use planning. Urban planning aims to create a functional and efficient urban structure, for example by controlling the location of land use forms adverse to each other in the urban area. The preconditions for housing construction and business operations are created by investing in infrastructure (such as traffic infrastructure, public utilities and parks) and public services and the buildings required by them. Land use planning does not naturally guarantee the realisation of private investments. However, planning can reduce the uncertainty related to private investments, as planning signals the future development trend of the area, thus increasing the predictability of development. Together with necessary infrastructure building, planning can be considered to reduce the costs related to uncertainty and the organisation of the necessary coordination between different economic sectors. Land use planning naturally has limits set by market demand. Not everything that can be planned can be realised. Demand conditions that change over time also create tension in relation to land use plans made earlier, under different conditions and with different values and expectations. (Klosterman 1985, Evans 2004, Brooks 2011)

1.4 Research aim and research questions

This study focuses on three broad categories of housing qualities potentially affecting quality of life - namely, accessibility, aesthetic quality and environment. These topics are at the centre of urban development, and this study aims to evaluate, by using housing market information, the effects of these factors on housing prices. The study area is Helsinki and Helsinki Metropolitan Area.

The first research question (RQ) (Chapter 4) is related to the price effects of natural amenities.

RQ 1: What are the price effects of open space, parks, recreational areas and coastline areas on housing prices? Especially

- What is the relative magnitude of price effects of natural amenities if closeness (to natural amenity) and relative share (of amenity) in land use are compared?
- Are there differences in price effects of urban natural amenities between densely built areas (central Helsinki) and suburban areas (of Helsinki)?

The second research question is related to the price effects of architecture and architectural quality on housing price (Chapter 5).

RQ 2: What are the price effects of different features of architectural quality on housing prices? Especially:

- What kind of effects do the characteristics of the planner have on housing prices?
- How well do architects' values correspond to the values of consumers in the housing market?
- What kind of differences are there between the effects of different architectural style on housing prices?
- Do different features of architectural quality have external effects, effects on 'third parties' (see Subsection 2.4.2), in housing markets?

The third research question is related to price effects of accessibility on housing prices (Chapter 6).

RQ 3: What are the price effects of accessibility to workplaces on housing prices? Especially

- Do alternative measures of accessibility offer a better way to model the price effects of accessibility on housing prices when compared to the traditional 'distance to Central Business District' measure?
- Are there differences in price effects of different accessibility measures between densely built areas (central Helsinki) and suburban areas (of Helsinki)?

The empirical analysis of this study leans on the hedonic price method. The method is based on the idea that the price of a dwelling is formed as a sum of the quantities of its various characteristics and the shadow prices of these characteristics. The differences in quality factors of the housing environment, for which no separate market exists as such, are thought to capitalise on housing prices. This study does not attempt to study urban planning itself or to evaluate the effects of urban land use planning or land policy on prices of housing characteristics or on urban spatial structure.

1.5 Detailed structure of the study

Following this introductory chapter, Chapter 2 reviews the general characteristics of the housing market and, in particular, the location of households in urban areas, as well as the monocentric urban model that describes the characteristics of the urban structure, including its main extensions. At the same time, we will briefly consider some of the key economic concepts relevant to an explanation of the price formation of dwellings (public goods, externalities, amenities and capitalisation). The analysis of the price effects of a dwelling's various characteristics is based on the hedonic price method described in Chapter 3, along with issues related to the estimation of the regression model. Some methods are described in more detail later in the chapters concerning empirical analysis. The research data is mentioned in each chapter containing empirical analysis. The key research data is additionally described in a separate appendix(Appendix A).

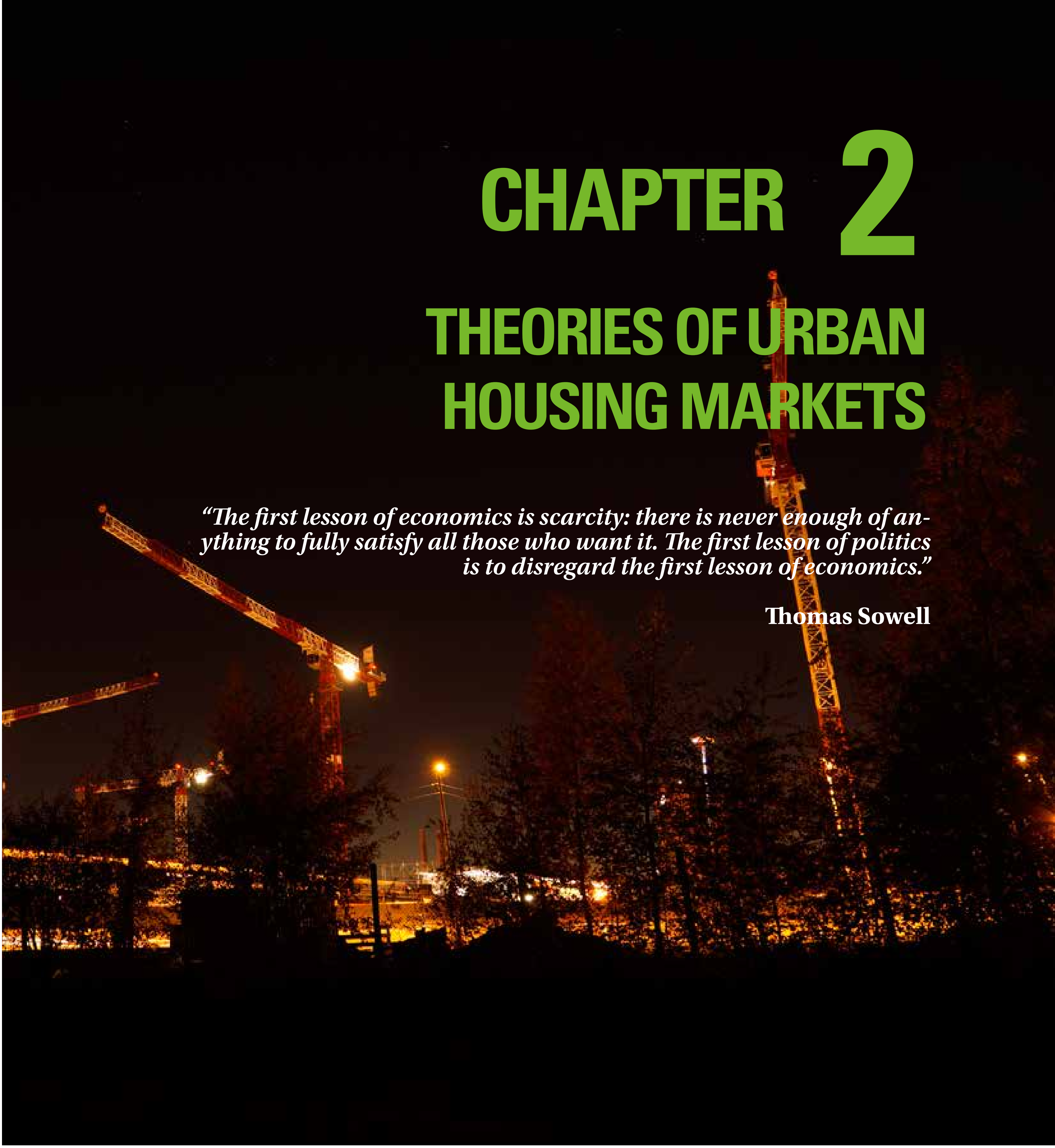
The empirical part of the study is divided into three chapters (Table 1.1). Chapter 4 will focus on the effect of urban natural amenities on housing prices. The research data was compiled in Helsinki and covers the transactions of flats and row house dwellings sold by the major real estate agencies. In addition to the standard variables describing the structural characteristics of the dwelling and its accessibility, the data contains a number of variables describing urban natural amenities. Some of these measure the proportion of specific forms of land use in the vicinity of the dwelling, while others measure the distance from the dwelling to specific forms of land use. The analysis covers the entire city of Helsinki. The research questions concern the price effects of urban natural amenities (open space, parks, recreational areas and coastline). First, the effect of urban natural amenities on housing prices is analysed by using common regression model applications. The analysis is then expanded using techniques based on the bootstrap method and multilevel models. The research area and housing stock is also divided into sections in order to evaluate any spatial differences in the shadow prices of a dwelling's characteristics.

The second research theme, in addition to urban natural amenities, is the effect of architecture on housing prices (Chapter 5). The effect of the style of the dwelling, the architectural prestige of the building as well as designer's age, education and success in competitions of the designer are assessed using regression models. In addition, the externalities of architectural quality are assessed by including variables in the regression models that describe the views opening from the property to architecturally valued buildings. The research area is the southern part of central Helsinki. The data covers the years 1980–2008. A comprehensive database of building designers at the building level is available for the Helsinki southern central area. The material is additionally supplemented with information on important architectural sites, design competitions and whether the buildings have been featured in the Finnish Architectural Review. The views opening up from the buildings have been analysed with a CAD (computer-aided design) tool. The price modelling techniques are the ordinary regression model (OLS) and, as a robust estimation technique, median regression.

The third research theme is the effect of accessibility to workplaces on housing prices (Chapter 6). The common method for including accessibility in housing price models is to include in the model the distance to the centre, for example, and possibly distance to the subcentre. This study aims for a more comprehensive analysis of accessibility by applying the concept of gravitation potential (Hansen 1959) to the accessibility of jobs. The study uses this measure, partly in place of and partly parallel to more traditional accessibility measures, to assess the effect of job accessibility on housing prices. The research data covers the Helsinki metropolitan area (Helsinki, Espoo, Vantaa and Kauniainen) and dates to 2010. The job accessibility data is calculated with a calculation tool based on route optimization. Chapter 7 summarises the results of the empirical chapters of this study.

Table 1.1 Structure of chapters containing empirical housing price analysis

	CHAPTER 4	CHAPTER 5	CHAPTER 6
Title	Urban natural amenities and housing prices	Architecture and housing prices	Accessibility, gravitational potential and housing prices
Research question	What are the price effects of open space, parks, recreational areas and coastline areas on housing prices?	What are the price effects of different features of architectural quality?	What are the price effects of accessibility to workplaces on housing prices?
Theoretical perspectives	Local public good capitalization, submarkets	Local public good capitalization, externalities, submarkets	The effect of accessibility on housing prices, submarkets
Research area	Helsinki	Southern part of central Helsinki	Helsinki, Espoo, Vantaa and Kauniainen
Temporal scope of the study	2002–2004	1980–2008	2010
Housing types	Old dwellings in blocks of flats and row houses	Old dwellings in blocks of flats	Old dwellings in blocks of flats and row houses
Estimation techniques	OLS, mixed models	OLS, median regression	OLS



CHAPTER 2

THEORIES OF URBAN HOUSING MARKETS

“The first lesson of economics is scarcity: there is never enough of anything to fully satisfy all those who want it. The first lesson of politics is to disregard the first lesson of economics.”

Thomas Sowell

2 THEORIES OF URBAN HOUSING MARKETS

This chapter takes a look at housing as a commodity and presents the urban economics analysis framework for describing urban area housing markets. First, the special characteristics of housing as a commodity and housing markets are reviewed (Section 2.1). Then, the issues of households' housing choices from a non-spatial perspective are discussed (Section 2.2). In Section 2.3 spatial analysis of housing markets and a somewhat wider discussion of the perspectives of urban economics to households' location choices are reviewed, alongside short discussion of the operation of the housing market and urban structure. To complement the urban economics framework, Section 2.4 reviews the key concepts of public goods and externalities as well as some approaches that can be used to analyse the impact of housing environment quality on housing prices. Finally, Section 2.5 addresses some aspects of accessibility and factors that affect it and briefly reviews alternative measurement methods for accessibility.

2.1 Perspectives on housing and urban housing markets

A review of housing markets should begin with the basic housing market concepts. It is essential to understand the nature of commodities bought and sold on the housing market. Housing is a unique type of commodity, and the operation of the housing market has several distinctive features that differ from those of other commodity markets. (Arnott 1987)

A dwelling is a long-term commodity and can usually only be divided into smaller units (dwellings) at a significant cost, if at all. As a commodity, a dwelling is also indispensable, although the level of housing and social norms applying to housing differ considerably in time and between different societies. Dwellings are quite heterogeneous in terms of their characteristics. There may be significant differences between dwellings even within the same property with regard to their microlocation, equipment and condition, for example. (Arnott 1987, Muth & Goodman 1989, Sheppard 1999, Whitehead 1999)

The costs related to searching for a dwelling as well as transaction and moving costs are considerable, which restricts the adaptation of housing consumption to changing needs and circumstances. This has led to search models of housing demand and mobility (Loikkanen 1982). There is also a degree of asymmetry in terms of information in the housing market. Dwellings and properties are all somewhat different. Consequently, a homeowner presumably knows more about the dwelling for sale than the buyer (or tenant). Moreover, the market parties may not necessarily regularly follow market trends, which can make it difficult to estimate the market price of dwellings and their characteristics. The state of the housing market, the number of transactions and the quality of the sales objects may be such that the market price of certain dwellings may be difficult to determine. The housing supply can be considered to consist of the entire housing stock, both old and new dwellings. Most households, however, are in an equilibrium with regard to the housing market instead of being active actors, i.e. changing homes. The markets for certain housing types may be very thin overall, and consequently the number of market parties may be low. (Arnott 1987, Garmaise & Moskowitz 2004, Evans 2004)

In addition to the type of housing and its location, one of the most basic choices in the selection of a dwelling is the form of tenure. An owner-occupied dwelling is both an investment and consumption good, often a household's most important asset. Owner-occupied housing can therefore be analysed not just as consumption of a housing commodity but also as a savings and investment decision. For this reason, expectations on changes in the value of the dwelling, insofar as they are not already capitalised in the price of the dwelling on the housing market, can affect the choice of housing from an investment perspective. It is also worth noting that, in the real world, the choice of the form of tenure and the household's choice of investment portfolio are interconnected. Especially with regard to owner-occupied housing, the choice is not necessarily based solely on the optimisation of consumption structure during residence; it may also be affected by expectations of the dwelling's future increase in value. Moreover, some dwellings are acquired solely as investment objects. (Arnott 1987, Rothenberg et al. 1991, Ioannides & Rosenthal 1994, Flavin & Yamashita 2002)

The acquisition of a dwelling often requires debt financing, which also connects housing markets to capital markets and macroeconomic developments. It is not just a question of macroeconomic developments being reflected in housing markets in the form of changes in housing demand, for instance; the developments in the housing market may also affect macroeconomic developments through various mechanisms, such as through the wealth effect created by the increase in the value of housing wealth. The rise in housing costs resulting from the inflexibility of the housing supply in conditions of growing demand restricts other consumption demand, as the money spent on housing is diverted from other forms of consumption. On the other hand, the wealth effect created by the value increase of a debt-free owner-occupied dwelling can lead to increased consumption demand. The inflexibility of the housing supply is reflected in the functioning of the job market as a friction factor that slows down structural change. The effects of the inflexibility of the housing supply are conveyed in the national economy through this mechanism. Numerous different forms of social subsidy, both direct and indirect, are channelled to housing. Subsidies can be directed at either the dwelling or the resident. These subsidies affect the incentives for the choice of housing tenure, housing location decisions, the amount of housing consumption and the maintenance of the condition of the dwelling, and can eventually be reflected in the urban structure. To counterbalance the subsidies, housing is subject to various taxes, such as property tax and asset transfer tax, which also have an impact on behaviour (Miles 1995, Laakso & Loikkanen 2004).

A long period of residence in the same dwelling and in the same residential area often creates an attachment in the resident towards the dwelling and the area. Consequently, moving to another dwelling or area may involve psychic costs in addition to actual monetary moving and search costs. For this reason, a certain degree of place loyalty can be observed in moving behaviour. It is not always possible to find a suitable dwelling in the same area, as only a small part of the housing supply is actively on the market at a given time, and the housing supply in an individual area does not necessarily match a household's changing needs. Furthermore, dwellings with a specific combination of characteristics may only be available in a few locations. (Galster 1987, Sheppard 1999, Whitehead 1999)

The majority of the housing supply is based on a housing stock consisting of old dwellings. In the owner-occupied housing market, a seller is often also a buyer. A change of dwelling is part of a longer chain of dwelling changes in which the housing stock is reallocated. Hence, new housing production launches moving chains of various lengths in the old housing stock. Housing production is also a considerably lengthy process. The time from the initiation of land use planning to the completion of new houses inevitably takes several years. It should additionally be noted that new production typically only represents 1–2 % of the housing stock. Therefore, in the case of an unexpected increase in housing demand, for example, the price level reacts first, and only in the longer term, through the increase of building activities, the housing stock. The flexibility of the housing supply through new production, in turn, is affected not only by geographical constraints but also several other factors, such as urban planning, land ownership conditions and the competitiveness of the building sector, as well as the functioning of the financial markets. Depending on the circumstances, housing supply, in particular the supply of specific individual housing characteristics, may be considerably inflexible. (Rothenberg et al. 1991, Laakso & Loikkanen 2004, Laakso et al. 2011)

The market price of structurally similar dwellings varies significantly according to their location. The price of a dwelling can be considered to consist of two different components, the value of its physical structure and land value. The replacement cost of the dwelling is often used as the value of its physical structure, taking depreciation into account. The value of land, on the other hand, varies according to its accessibility and the appeal of its microlocation, the size of the plot and its construction potential (including existing infrastructure) and building rights. Expectations of the future development of the area also play a role. (Sheppard 1999)

The location of a dwelling is fixed, which means that the housing environment and accessibility of the dwelling are chosen along with its structural characteristics. Hence, accessibility-related costs, i.e. travel costs, can be regarded as part of housing costs. Other factors related to the location of the dwelling, as described below in more detail, also have an effect on the desirability of the dwelling and, hence, the willingness of households to pay for the dwelling. There may be significant differences between households in their valuation of the housing environment. In part, this may involve accessibility-related factors and, in part, the various services offered by the area and its socioeconomic structure. These factors may also explain the selection of different household types in different areas and consequently, the socioeconomic differences between different areas of a city. (Haig 1926, Brueckner et al. 1999, Costa & Kahn 2000, Cheshire 2006)

Due to the heterogeneity of housing, the choice of housing is a rather complex decision, involving considerable information problems and uncertainties. It is far-reaching to assume that a house searcher is capable of comparing all the available dwellings. There are costs involved in the collection of information, and processing all the information is likely to be an overpowering cognitive task. Therefore, it can be assumed that a house searcher will resort to various decision-making rules that reduce information costs and circumvent cognitive limitations. The housing decision process may occur in phases; for example, the residential area, form of tenure and dwelling type are selected first, after which the dwellings available in the area that meet the initially set prerequisites are compared. According to the approach know as restricted rationality, in practice, consumers resort to various rules of thumb in a decision-making situation in order to control the related costs and, in general, to be able to reach a decision. (Loikkanen 1982, Pingle 1994, Conlisk 1996, Tu & Goldfinch 1996)

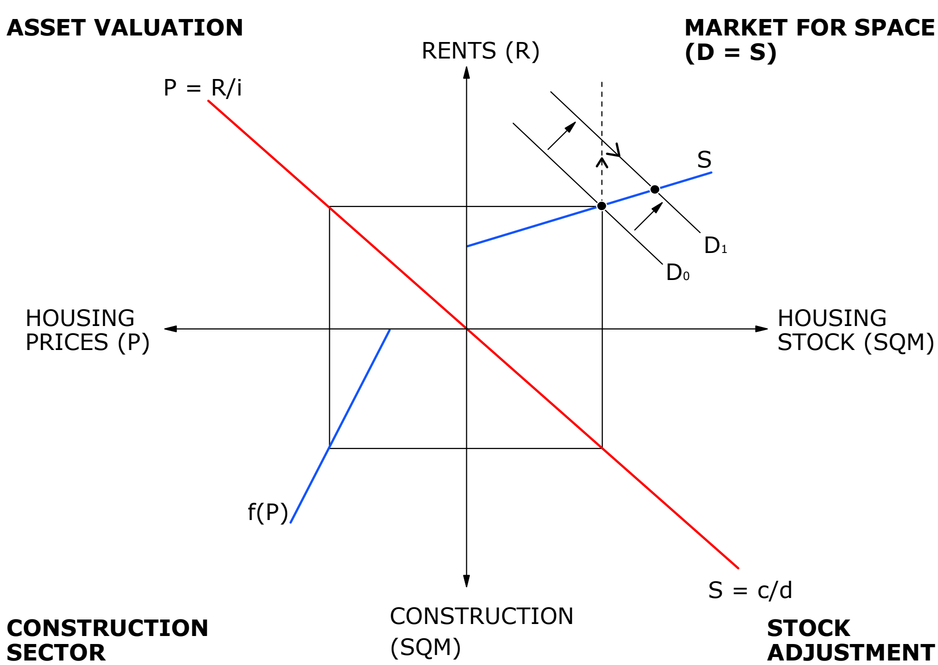
It is obvious that the valuations related to housing are, to a significant extent, socially determined. The measure for a satisfactory housing standards can be the housing standard of a specific reference group, for example. Sometimes, choices that appear to be contrary to a person's own interest from an outsider's perspective may be caused by social pressure and the peer effect. In the housing market context, the Veblen effect refers to the fact that the demand for certain – as a rule, very high-quality – dwellings increases as their price rises. This phenomenon has been explained by the fact that living in such a dwelling communicates the wealth of the resident to others. In addition to the characteristics of the dwelling, the resident structure of the area may play a role in the choice of a home. As a result, the socioeconomic development of an area may involve non-linear development paths in which the changes in the socioeconomic structure can be rapid, once a critical threshold value is crossed. (Bagwell & Bernhein 1996, Quercia & Galster 2000, Meen & Meen 2003, Heffetz 2011, Lee & Mori 2013)

From the perspective of the dynamics of the housing market, these deviations from the strong assumptions of a consumer theory based on expected utility maximisation regarding the optimisation ability of the consumer are difficult to assess. Some empirical research on the topic has been conducted, however. For example, studies indicate that expectations in the housing market are often formed on the basis of past developments. This may result in the tendency of the housing market for cyclical development (Muellbauer & Murphy 1997, Wheaton 1999, Schiller 2006).

Housing markets are always to some degree local, usually limited by job market areas. Although housing markets are often discussed as if they were an entity, in reality, they are formed of a number of submarkets linked to each other in various ways. A key factor dividing housing markets into submarkets is the form of tenure. Although the form of tenure divides the housing market, the tenure segments are not isolated from each other. Consumers must make choices with regard to the form of tenure when satisfying their housing needs. Owner-occupied housing requires adequate payment ability with regard to loan payments and, in many cases, advance savings. In growing urban regions, where the housing price level is high, this can steer housing demand towards rental housing, and this makes rental dwellings more interesting as investments.

The interdependency of the forms of tenure can be illustrated, for example, with the four-quadrant model of real estate markets. This depicts the interaction and equilibrium of the different segments of the housing market, the rental and owner-occupied housing markets (Figure 2.1). In the four quadrant model, the growth of

Figure 2.1 Four-quadrant model of real estate (DiPasquale & Wheaton 1994).



housing demand, for example, is conveyed in the short term through the rise of rents into the housing prices. In the longer term, the increase in housing prices increases the size of the housing stock through new production, which eventually creates the preconditions for a new equilibrium of housing rents and, consequently, prices. If the housing supply is flexible, the increase in market rents and housing prices is smaller than if the housing supply reacts more weakly to rising housing and rent prices. (DiPasquale & Wheaton 1994)

Because housing markets are always local, the regional economic development is reflected in the demand for housing. Together with the local supply conditions and the sensitivity of housing productions to changes in demand, these forces determine the housing market prices and rent level. Empirical studies show that housing production is not always particularly sensitive to the rise in the price level, for example, and there are significant differences between OECD countries. Although geographical factors play a certain role in restricting the housing supply, the restrictions set by land use planning to the housing supply is usually considered a more significant factor. (Hwang & Quigley 2006, Vermeulen & Rouwendal 2007, Saiz 2010, Caldera & Johansson 2011)

2.2 The household's choice of housing quality

Dwellings are rarely exactly identical in terms of their characteristics. These characteristics may vary even within the same property. In macroeconomic surveys, the housing market is often discussed from the perspective of the price level, the number of dwellings or the size of living area across the entire country. By contrast, in microeconomic housing price studies, the qualitative characteristics of dwellings cannot be ignored. From a household's perspective, the quality of the dwelling is a key selection criterion for housing and a key factor that determines housing prices. In the following, we will review households' choice of housing by applying a microeconomic theory optimisation framework. The starting point is the idea that a dwelling as such is a composite commodity with characteristics that cannot be bought separately.

Let us assume that a household benefits from the consumption of the different characteristics of the dwelling, indicated by vector $\bar{x} = (x_1, x_2, \dots, x_n)$, and the consumption of composite commodity y, which represents other consumption. We will assume that the household income, term w, is fixed. Hence, the utility maximisation problem of a household is

$$(2.1) \quad Max_{x,y} U(\bar{x}, y) \; s.t. \; w = p(\bar{x}) + y$$

In the household's budget constraint, the income (w) is used on housing (the price of which, p, is a function of the vector describing qualitative factors $\bar{x} = (x_1, x_2, \dots, x_n)$ and the composite commodity, the price of which is scaled to one. In this static framework, the price of housing, in which the income generated by the dwelling (ultimately, land) is not redistributed to the residents, must be understood as the operating cost or rent of housing. This could be called the price of the housing service. The term indicating other consumption, y, can be eliminated from the utility function by solving the budget constraint with respect to y and substituting this into the utility function. We will assume households to be identical, so that their utility level is constant. In this case, the utility function (2.1) can be written in the form $U(\bar{x}, w - p(\bar{x})) = \hat{u}$. The first-order conditions describing a household's optimal consumption basket are then

(2.2) $$U^{x_i} - p'(x_i)U^y = 0 \ \forall i$$ and

(2.3) $$U^{x_i} - \frac{p'(x_i)}{p'(x_j)}U^{x_j} = 0 \ \forall i, j.$$

The demand for each characteristic of a dwelling increases up to the point at which the marginal utility of the increase in the consumption of that characteristic is as great as the marginal disutility of the decrease in consumption of all the other characteristics of the dwelling (2.3) or the composite commodity (2.2). Housing location can also be considered a characteristic of a dwelling. However, as location involves the accessibility aspect in addition to the quality of the housing environment, the analysis of location requires a broader approach than is described here. This is because accessibility affects a household's budget constraint through travel costs.

2.3 Monocentric model and beyond

The location of housing is fixed, and, consequently, location factors, both in terms of the accessibility and environment of the dwelling, are key characteristics affecting the desirability of the dwelling. Next, we will supplement the review of households' choice of housing by linking the accessibility of a dwelling to a theoretical model of housing choice. We will also shortly describe the monocentric urban model, which is built on a model based on household choice. The model is based on the idea that land use in a market-driven city is based on competition between different forms of land use for locations at different distances to the centre.

The analysis presented below is based on the monocentric urban model, which is often regarded as the basic model of urban economics. This model allows us to analyse the conditions of a household's optimal housing choice and the location of different household types in an urban area. The model can also be used as a basis for an analysis of the structure of a market-driven city and the effect of various externalities on the urban structure. As the mathematical structure of the monocentric model has already frequently been presented in the literature (e.g. Fujita 1989), the focus here is on a description of a household's choice of location, with only a brief review of the monocentric urban model's key results in describing the urban structure.

The household's location model is described in Subsection 2.3.1, the formation of the urban structure and the comparative statics of the model in Subsection 2.3.2, empirical testing of the monocentric model in Subsection 2.3.3, and the limitations of the static approach and the change in the urban structure from monocentric to polycentric in Subsection 2.3.4.

2.3.1 Housing consumption and household location choice in urban areas

In the following, the model describing household location choice in an urban area is presented. The model is based on a number of simplifying assumptions, on basis of which the conditions of a household's optimal location are deduced.

It is assumed that the households are identical in terms of their structure, preferences and income. It is also assumed that all jobs are located in the central business district (CBD) and all household travel is between the home and the workplace. The utility level of the household depends on its degree of housing consumption and consumption of the composite commodity, which indicates other consumption. In the basic version of the model, it is assumed that land is used directly for housing, but in Subsection 2.3.2., we will widen the analysis to include the business sector that produces housing services. In section 2.4, the model is expanded with local public goods. Geographical factors have been abstracted from the model by assuming that the city is located on a featureless plain.

Following the model by Fujita (1989), the household has both a budget constraint $wn - e(k) = r(k)x + y$ and a time constraint $tn + t(k) + z = 1$. In the budget constraint, the income term w should be understood as a full-income term, which describes how much a household could earn if it spent all its time on work. In reality, a household naturally works less, as part of the time is used on commuting and part on leisure time. In the budget constraint, the term n that acts as a coefficient indicates the proportion of available time that is used for work. The income is reduced by the monetary commuting expenses *e(k)*, which depend on the length of the journey. The net income is used on housing *x*, the unit price *r* of which depends on the distance from the centre k, and on other consumption *y*. In the time constraint, the total time is scaled to one and is used for working (*n*), commuting *t(k)* and leisure time (*z*). The constraints can be combined by first solving the time constraint relative to the working hours n and substituting this into the budget constraint, which results in a new budget constraint

$$w\big(1 - t(k)\big) - e(k) = r(k)x + y + wz. \qquad (2.4)$$

Based on this new budget constraint, a household uses its total income, from which travel costs and the time costs of commuting are subtracted, on housing (by consuming an *x* amount of housing services at price *r*, which depends on the distance from the centre *k*), other consumption (*y*) and free time *z*, the price of which is indicated by the proportion of free time of the maximum income. Hence, the utility maximisation problem of a household is

(2.5) $$Max_{x,y,z}U(x,y,z)\ s.t.\ w\big(1-t(k)\big)-e(k)=r(k)x+y+wz.$$

In order for the utility level to be the same at all distances from the centre, as assumed, $(\bar{u})$, the housing price level, $r(k)$, must vary as a function of the distance from the centre k, i.e. in this case $U(x,w(1-t(k))-e(k)-r(k)x)=\bar{u}$ applies. The first-order condition is obtained by derivation of the utility function that generates the standard utility level relative to housing consumption x and setting this to zero, so that

(2.6) $$U^x-r(k)U^y=0.$$

Using the first-order condition (2.6) and deriving the utility function that generates the standard utility level relative to the distance from the centre k results in:

(2.7) $$\big(-wt'(k)-e-r'(k)x(k)-r(k)x'(k)\big)U^y+x'(k)U^x=0 <=>$$
$$\left(-wt'(k)-e-r'(k)x(k)-\frac{U^x}{U^y}x'(k)\right)U^y+x'(k)U^x=0 <=>$$

(2.8) $$r'(k)=-\frac{wt\prime(k)+e}{x(k)}<0.$$

Expression 2.8 is known as the Muth condition, based on which it can be observed that the willingness of a household to pay for housing decreases as the distance from the centre increases. This is intuitively understandable, as the increase in the distance from the centre increases the cost of commuting in terms of time and money. To obtain the condition for a household's optimal distance to the centre, we can modify Expression 2.8 as

(2.9) $$-r'(k)x(k)=wt'(k)+e.$$

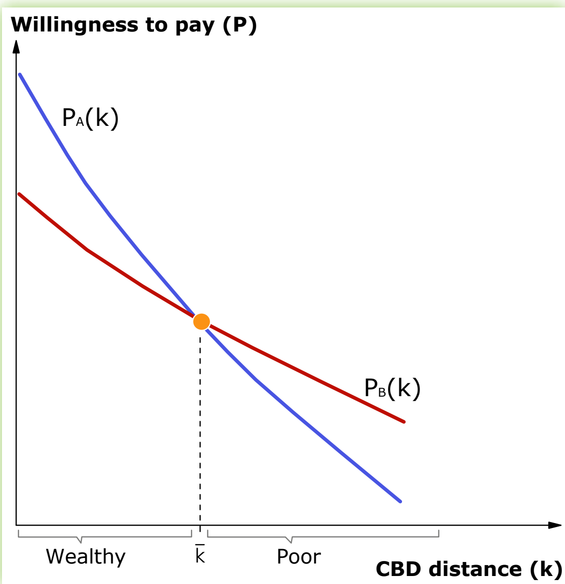
The left side of Expression 2.9 indicates the marginal utility of distance to the centre, which follows from the decrease in the unit price of the housing service. The right side of Expression 2.9 indicates the marginal cost of distance, which follows from the increase in travel costs resulting from the increase in the distance from the centre. The optimal location of a household is such that the marginal utility of the distance from the centre is equal to the marginal cost of distance from the centre. (Muth, 1969, Fujita 1989)

In the above, we made the assumption that households are identical. In the following, we will widen our analysis by assuming that there are two types of households: wealthy (A) and poor (B). Since we assumed that land use is determined on the basis of the highest bid, the location of household types in an urban area can be deduced by analysing the difference between bid rent functions (cf. Brueckner et al. 1999). Let us determine the difference between type A and B bid rent functions as follows:

$$(2.10)\quad \Delta \equiv p'_B(x) - p'_A(x) = \frac{w_A t'_A(k)+e}{x_A(k)} - \frac{w_B t'_B(k)+e}{x_B(k)}.$$

Wealthier households are located closer to the centre if Δ<0, as the bid rent curve of wealthier households is then steeper than the bid rent curve of poorer households (Figure 2.2).

Figure 2.2 Bid rent curves in the case of two household types



The theoretical model described above does not, however, provide an unequivocal prediction of the location of households representing different income categories. There are several reasons for this. The first involves the relationship between the demand for housing production services and an increase in travel costs. In the basic model, housing services are measured by the size of the dwelling. Based on this assumption, it can be noted that an increase in income increases both the demand for housing services and travel costs. As wealthier households consume housing services more than the poor, the growth in the distance from the centre as such induces them to settle at a more distant location. On the other hand, an increase in income also leads to an increase in the time costs of commuting (e(k)). The respective weight of the forces pulling in different directions cannot be deduced on the basis of a theoretical model. It is crucial for the location of a household how the relationship between travel costs (per km) and housing consumption (sqm) changes with an increase in income. If this relationship increases along with an increase in income, wealthier households will locate closer to the centre, and if this relationship decreases along with an increase in income, wealthier households will locate further away from the centre (Glaeser & Kahn 2004, Baum-Snow 2007).

It should also be noted that the relationship between travel costs and housing consumption may depend on family structure as well as income. For example, Fujita (1989) analyses a situation in his model in which the number of people in gainful employment in a family varies, showing that when the proportion of people in gainful employment in a household decreases, the bid rent function of the household becomes flatter. In this case, a household's optimal distance from the centre grows.

In the basic model, the location of the household is only affected by travel costs, which, based on the assumption made, only consist of the costs of commuting between home and a job located in the centre. Brueckner et al. (1999) argue that it is difficult to explain the differences in the location of the population in urban areas in European and North American cities on the basis of this alone. They suggest that these differences can potentially be explained by amenities, which, according to their categorisation, can be natural, historical or modern (see Subsection 2.4.4). Brueckner et al. (1999) consider the differences between older European cities that have long invested in the development of the central areas and North American cities, which are based on the growth of suburban areas and shopping centres, to be representative of these amenities. They argue that an increase in income may be linked to the growing appreciation of the proximity of these factors.

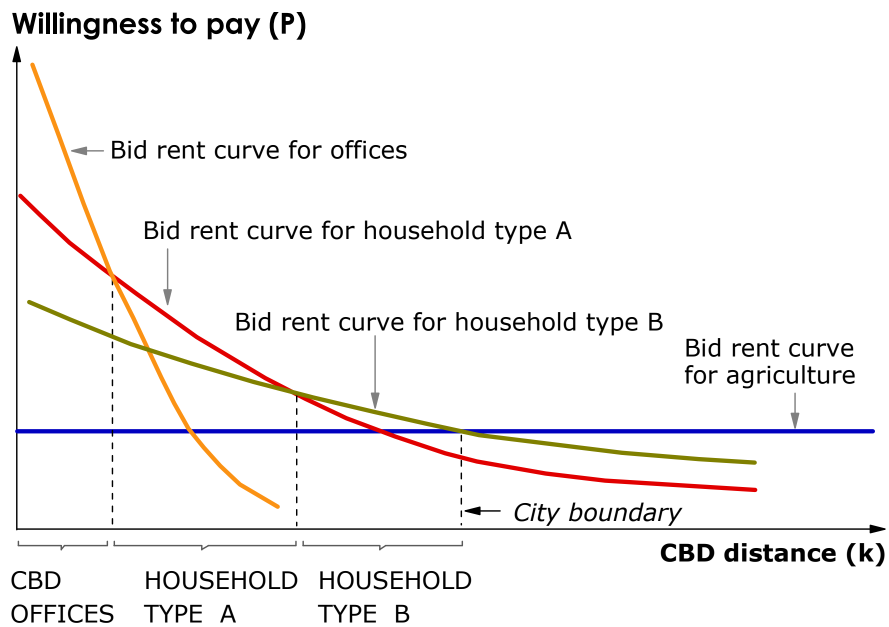
The increase in housing demand that results from an increase in income may thus be targeted at the qualitative features of housing, not merely the size of the dwelling (Rothenberg et al. 1991). This approach, which supplements the basic model, could partly solve the question left open by an analysis of the relationship between travel costs and housing consumption with regard to the location of different income groups in urban areas. It should also be noted that household location can vary by income as well as by factors such as family type. Research on this theme includes that by Gutierrez-i-Puigarnau and van Ommeren (2013), who estimate on the basis of German data that for one-earner households, the income flexibility for the distance from the centre is negative, while for two-earner households, it is positive. We will return to household location in more detail in section 2.4

2.3.2 Urban land use in the monocentric model

In the monocentric urban model, urban land use is formed as a market decision on the basis of competing price offers. Each form of land use possesses a specific bid function of land dependent on the distance from the centre. The land form use that makes the highest bid will acquire the land at each distance from the centre. The basic assumption of the model is that the bid rent curve made by businesses for land is highest in the CBD. This is why business operations are located in the CBD. If it is assumed that all households are identical, the bid rent curve of a representative household forms the bid rent curve of the housing market in an urban area. However, if it is assumed that there are several types of households, land use is determined on the basis of bid rent curves in such a manner that the highest bid at each distance from the CBD will win. The price gradient of housing services in urban areas is formulated as an envelope on the basis of the bids made by competing forms of land use (Figure 2.3). It is assumed that businesses nearest to the CBD offer the most for the land and the building stock to be built on it. If the bid rent curve of wealthier households (A) is steeper than the bid rent curve of poorer households (B), wealthier households are located closer to the CBD. The location of the outer boundary of a market-driven city is determined as the intersection of the flattest urban land use form bid rent curve and the bid rent curves of alternative land use, usually agriculture.

On the grounds presented above and leaning on the basic assumptions of the monocentric model, it can be concluded that households' willingness to pay for housing (per floor area unit) decreases as the distance from the centre increases. Living space per person, on the other hand, increases as the distance from the centre increases. The analysis can be expanded by including the sector that provides housing services, investors in housing as well as developers and construction companies. In this case, the function describing a company's optimal housing service production can be derived from a construction company's profit maximisation target.

Figure 2.3 Land use in urban areas



A business operating in a competitive market is assumed to use two types of input for the production of housing services: land and capital. Capital represents the building stock. Land located close to the centre becomes more expensive in the market than in areas located farther away and in housing production, land is replaced by capital. As a result, building efficiency increases closer to the centre, which, together with decreasing living space per person, leads to an increase in population density towards the centre. (Muth 1969, Brueckner 2011)

2.3.3 Empirical testing of the monocentric model

The monocentric urban model generates several predictions of parameters describing the urban structure. The model predicts that housing unit prices and land prices decrease relative to the distance from the centre; correspondingly, building density and population density are expected to decrease as the distance from the centre increases. Earlier studies have already confirmed that the negative exponential function, which the monocentric model also generates under certain assumptions, is an accurate indicator of population density in many urban areas (Stewart 1947, Clark 1951, Newling 1969). Small and medium-sized cities in particular are often strongly oriented towards the main centre. Using relatively common assumptions, all the gradients dependent on the distance from the centre predicted by the monocentric model follow the negative exponential function. (Anas et al. 2000) There are two basic versions of the monocentric model, with many variations. In the open-city model, the city is seen as part of a wider whole. Free migration to and from the city levels out the utility differences between the city and other areas. The population is thus endogenous. In the closed-city model, the focus is on a city whose population is exogenous, i.e. the migration perspective is ignored. In this case, the utility level of consumers is an endogenous variable. (Fujita 1989)

According to the comparative statics of the basic version of the closed-city monocentric model (e.g. Wheaton 1974), a rise in the income level expands the urban area, flattens the population density gradient and lowers the bid rent curve near the central area. More complex models in which land rents in the urban area are redistributed to the residents, for example, (Sasaki 1987), or where income formation is endogenous (Pines & Sadka 1986), produce results that are in part more difficult to interpret. In a model in which travel costs not only comprise monetary costs but also time costs as a constant share of income, a general rise in the income level can also raise the bid rent curve even in proximity to the central area, if the time cost of commuting is sufficiently high (Kwon 2005).

The explanatory power of the factors affecting city size produced by the monocentric model for explaining the growth of cities' geographical size has been tested in empirical studies. A population growth, income growth, travel cost decrease and decrease in the alternative yield from land (the price of farmland) is expected to increase the size of cities. Brueckner and Fansler (1983), using data collected in the United States, reach a conclusion according to which the predictive ability of the monocentric model is relatively good. A similar conclusion was reached by Deng et al. (2008) with data collected in China. However, on the basis of data collected in the United States, McGrath (2005) is quite critical of the monocentric model in his interpretation of the results, concluding that the growth of urban land areas has been excessive in relation to the predictions provided by the monocentric model.

When interpreting the results of the monocentric model, it should be noted that many presumably key factors related to urban structure, such as local public goods, land use planning and externalities, are not included in the basic model of the monocentric model, or as explanatory factors in the aforementioned empirical studies. These expansions have since been made to the theoretical models. In Section 2.4, the expansion of the monocentric model with local public goods is discussed in more detail.

Some of the criticism of the monocentric model is related to the fact that it is a static model. Urban spatial equilibrium is continuously changing, and equilibrium is hardly ever achieved. Even if the exogenous forces behind urban change remain constant, after an exogenous shock, urban structure (buildings, infrastructure, etc.) has a long life span and adapts slowly. The static model can be interpreted in at least two ways. One could consider the model as a short-run equilibrium model, where the physical structure of the city is being continuously replaced. On the other hand, and perhaps more realistically, it is also possible to consider the monocentric model as a long-term equilibrium model which the real-world city would approach if there were no exogenous shocks. (Anas et al. 1998)

As a static equilibrium model, the monocentric model is unable to model phenomena that are dynamic in nature. One such phenomenon is the so-called vintage effects of the building stock (Brueckner 1980). The monocentric model predicts that building intensity (the relationship between capital and land, building efficiency) will decrease relative to the distance from the centre. However, there may be older building stock located in the cities' central districts or in their proximity, which has been built using lower building efficiency than in the newer areas further from the centre. Each building represents its own time of construction with regard to building efficiency. As the city grows, perhaps along with the development of building technology, building efficiency increases. The oldest housing stock, however, is often located nearer the centre, so in some situations, the building efficiency of areas closer to the centre may be lower than that of areas further from the centre, although according to the basic findings of the monocentric model, building efficiency increases the further one moves towards the CBD. (Brueckner 2000)

The monocentric model is also incapable of explaining why unbuilt properties sometimes remain in the middle of built urban areas. In a world depicted by the monocentric model, all areas at the same distance from the centre are built with the same efficiency. Phenomena observable in the real world, such as unbuilt land planned for building in the middle of built properties, are a reality. This can be explained by the fact that building stock has a long life span, and in the context of a growing city (demand), it may be optimal for the landowner to keep the land unbuilt for a lower return and later build with greater efficiency. In this case, the return on the land will also be greater than for a less efficiently built property. (McDonald & Siegel 1986, Brueckner 2000)

As noted above, in a closed monocentric model, the job structure is exogenous and all jobs are located in the CBD. The model does not explain how the job structure is born, and it its most simplified form, the model also makes a very strong assumption on households' location criteria in assuming that only commuting (to the centre) has an impact on the household's choice of location. The location of businesses in the CBD, i.e. their presumed higher willingness to pay for a central location, is naturally also a broad generalisation, which does not accurately reflect reality. There are considerable differences between different sectors with regard to their appreciation of different locations. Business operations that require space are usually located outside the central area.

2.3.4 From a monocentric to a polycentric city

Urban structure is rarely purely monocentric; in large cities, it is often polycentric. The growth of the urban population beyond certain critical thresholds is likely to change the central structure in the long term. A theoretical model should be able to depict the structural features of real cities, including polycentric structures. From a political perspective, we should be able to understand the factors that influence the formation of the urban structure – what the various forces are that produce different types of urban structure.

The theoretical basis for the birth of an (endogenous) central structure was formulated in Starrett's article (1978), which listed the preconditions required in a theoretical model for the endogenous formation of centres to be possible. According to Starrett's spatial impossibility theorem, at least one of three elements – heterogeneous space, non-market externalities (in production/consumption) or imperfectly competitive markets – must be included in a model in order for one or several agglomerations to be born.

The models proposed by Ogawa and Fujita (1980) and Fujita and Ogawa (1982) were the first steps towards constructing a theoretical model in which the urban structure is formed by the interaction between businesses and households and which could generate several centres. These models have a clear connection to Beckman's (1976) model, which showed the birth of one centre as a result of the interactive utilities of consumers and congestion. In Fujita's and Ogawa's models, urban structure is determined by the advantages of interaction that boost agglomeration and the disadvantages of centralisation that boost decentralisation, together with transport costs. The interaction of these factors can produce either a decentralised urban structure or a central structure with one or more centres. A monocentric structure is formed if the agglomeration benefits of companies only extend to their immediate environment. If this effect extends a long way, no centres are born in the structure at all, as it is not profitable due to the avoidance of congestion costs. High travel and congestion costs, in turn, produce a polycentric structure. Fujita and Ogawa (1982) model was constructed in a linear city framework, making the analysis one-dimensional.

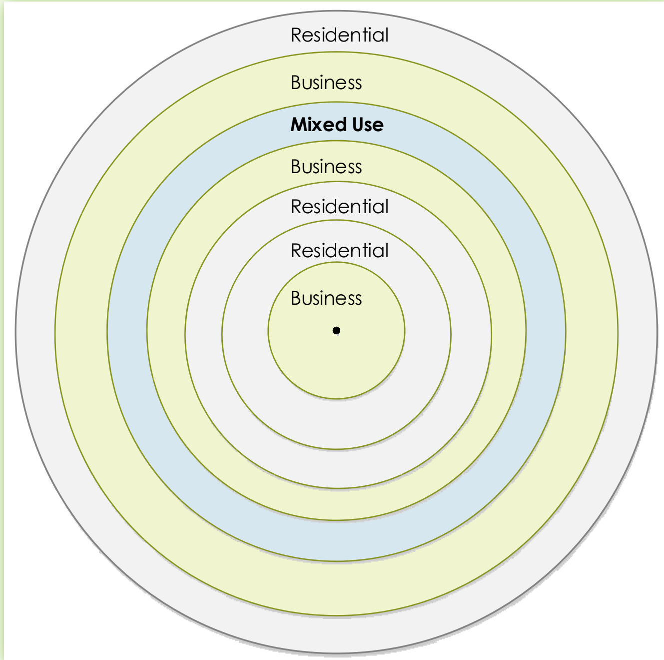
Anas and Kim (1996) extended the factors affecting companies' and households' location decisions by taking household shopping trips into consideration in addition to commuting, and further incorporated traffic congestion and congestion fees into the model. According to their conclusions, congestion (and its avoidance), as well as businesses' goal to be located close to their customers, both decentralise the job structure, even if the CBD continues to be the area with the highest job density. Henderson and Slade (1993) approached the birth of the subcentre structure from a perspective which relinquishes the assumption of perfect competition. Their model, in which the structure of two subcentres eventually steals away jobs from the main centre, is based on strategic competition between property developers. Henderson and Mitra (1996) and Fujita et al. (1997) studied the birth of a subcentre in the urban structure through the location decision of a large company.

In the 1990s, a new research tradition developed alongside urban economics, partly focusing on the same research questions. The key impetus for this new line of research, known as new economic geography, was provided by Krugman (1991), applying the monopolistic competition theory appropriate for differentiated goods markets developed by Dixit and Stiglitz (1977), used for analysing how agglomeration factors affect the regional formation of urban structures. From this starting point, the model developed by Fujita et al. (1999), for example, analysed how cities with different degrees of specialisation are located relative to each other. As the population size is increased in increments, the solutions provided by the model change: first a small new town is formed in proximity to and around the original city; then, as the population is sufficiently increased, several towns of different sizes and with different degrees of specialisation are born at different distances. The urban system formed in this model is a network of towns of different sizes, similar to Christaller's (1933) central place theory. The main focus in the new economic geography models is on the description of the formation of the network of cities and its structural change. The internal land use of the cities, their urban structure, does not generally play an important role in new economic geography models.

Based on the urban economics framework, Lucas and Rossi-Hansberg (2002) developed their model starting from the approach provided by Fujita and Ogawa (1982). Their model analyses land use in circular cities (cf. Fujita & Ogawa (1982) and Ogawa's one-dimensional analysis). In this model, the population of the city is endogenous, and the extent of the urban area is an exogenous variable. The productivity of goods production at each location is assumed to increase as a function of the number of workers, while the increase in the workers' commuting costs in order to obtain the labour force required by a larger centre decreases the workers' welfare. In Lucas and Rossi-Hansberg (2002) model, the optimal land use solution does not need to be a simplifying monocentric one, but may also include a subcentre circle in which the land use forms – residential and employment – may be mixed (Figure 2.4). This does not occur in the basic model, as the "highest bid wins" principle produces only one land use form for each location.

Berliant and Wang (2008), in their dynamic model, analysed urban structure change as a result of growth. In their model, the positive externalities resulting from the location of business relative to other businesses depend on the amount of capital (not labour) and are independent of job density. The population is assumed to be an exogenous variable and the extent of the urban area an endogenous variable. Using numerical simulations, Berliant and Wang (2008) showed that, as the population increases, subcentres are born in the urban area in addition to the main centre.

Figure 2.4 Land use in a circular city in the model by Lucas et al. (2002)



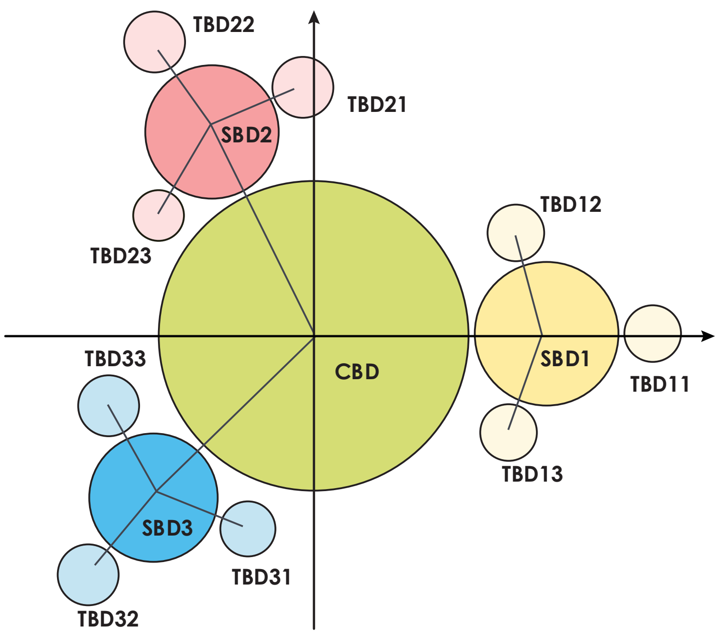
Cavailhès and Gaigne (2007) constructed a two-city model in which the internal land use, i.e. central structure, of an urban area is also studied. Businesses' location choices determine the urban structure. In this model, the wage level can vary within the urban area, while it is assumed that travel costs will possibly affect workers' wage requirements. By locating in a subcentre, a business can take advantage of workers' lower wage levels, but, on the other hand, it must accept higher information costs compared to a main centre location. The analysis is made on the assumption of two subcentres. According to the results, polycentric development is more likely if communication costs are low and commuting costs high. In this case, population growth increases the size of the subcentres more than the main centre. Sidorov (2012) expands the analysis of Cavailhès and Gaigne (2007) into a two-dimensional one. Based on the results provided by the model, it can be seen that a small population does not create a polycentric model. On the other hand, subcentres can help a city grow and take advantage of the benefits of centralisation without the increase in travel costs arresting the growth of the city (Figure 2.5).

Even complex theoretical economic models have their limitations. Models presented in this chapter describe urban development based on market forces. Urban land use is seldom, if ever, an outcome of market forces operating alone. For example urban land use planning and municipal structure, different kind of taxes and subsidies, infrastructure and geography all have their effects on urban spatial structure. Physical structures have also long life span whereas demand conditions change sometimes rapidly. So the urban structure is hardly ever in an equilibrium state.

The development of the central structure of cities has also been charted in many empirical studies. In the above-mentioned article, Anas et al. (1998) highlighted the observation that large cities are increasingly polycentric. The main centre does not usually lose its importance, but the growth of the city takes place largely through the subcentres. It can even be said that the subcentric structure enables the growth of the cities (McMillen & Smith 2003, Sidorov 2012).

Based on studies conducted in the United States and Canada, polycentric development is the dominant trend in most of

Figure 2.5 Polycentric urban structure, Sidorov's model (2012) (CBD=central business district, SBD=secondary business district, TBD=tertiary business district)



the analysed urban regions, although there are a few exceptions (Coffey & Shearmur 2001, Giuliano et al. 2007, Lee 2007). According to Lee (2007), for example, New York and Boston are relatively main centre driven. Whereas Aquilera and Mignot (2004), who studied French cities, recognised the clear development of the subcentre structure, Garcia-Lopez and Munitz (2010) observed that Barcelona continues to develop strongly on the basis of its main centre.

An emerging subcentre structure can be observed in Helsinki, even though the role of the main centre continues to be very strong (Jaakola & Lönnqvist 2009). Office-sector jobs continue to be concentrated in one place, to some extent strengthening the subcentres, and service-sector jobs are decentralising along with the spread of housing (Laakso & Lönnqvist 2012; in more detail in Chapter 6).

2.4 Public goods, externalities and amenities

2.4.1 Local public goods and capitalisation hypothesis

One way of expanding the model framework provided by the monocentric model into a more realistic direction is by including public goods in it. By definition, a public good is a freely available good, the consumption of which does not diminish the possibility of others to consume that good. There are problems with the supply of public goods, as there are no incentives for individuals to reveal their preferences or willingness to pay with respect to public goods. In game theory, this is called the prisoner's dilemma, in which the dominant strategy of each individual is not to reveal their willingness to pay for to the good. This leads to the "free rider" problem, which means that the public goods supply is too low relative to the social optimum. (Samuelson 1954, Hochman 1982)

Public goods are often seen as equal to public services. Only a part of the services provided by the public sector, however, are pure public goods, whereas a part belongs to private goods or other goods categories (Table 2.1).

Table 2.1 Different types of goods, classification based on rivalry in consumption and excludability

Excludability	Rivalry in consumption	
	High	Low
High	Private good	Club good --- Local public good
Low	Common resource	(Pure) Public good

A local public good is a good that can only be consumed by the members of a specific community, such as a municipality or those living in proximity of the good. A local public good, therefore, has features similar to those of a club good, with the difference being that excludability is not an unconditional requirement for a local public good. For example, a work of art on public display can be enjoyed by anyone present, but those living in its vicinity or households with a view from their residence of the artwork can enjoy it more easily and with less direct costs. In this sense, a local public good is not a pure public good, even if its production costs are independent of the number of users (in the sense of low-value rivalry in consumption, Table 2.1).

The assumption applied to many goods regarded as public goods - that their production costs are entirely independent of the amount of users - is not true. For example, an urban park appears to be a pure public good, but on closer inspection, it possesses characteristics of both club goods and common resources. In some situations, the set up resembles repeated game, for example when the demography of the neighbourhood is relatively constant, and the number of parties is not very large. In these cases the market solution in production of public goods might work and the free rider problem might be possible to avoid. (Cornes & Sandler 1996, McNutt 2000, Wolitzky 2010)

With regard to local public goods, competition between municipalities and residents' tendency to vote with their feet have been presented as possible solutions to the free rider problem. This is referred to as the Tiebout hypothesis, according to which migration acts as a mechanism for revealing preferences. According to another hypothesis known as the capitalisation hypothesis, households voting with their feet not only leads to them moving to another municipality in order to gain access to tax and service packages (including public goods) most appropriate for them, but it also leads to the capitalisation of local public goods in housing prices, depending on the flexibility of the housing supply. There is more demand for desirable locations. (Tiebout 1956, Oates 1969, Starrett 1981)

The capitalisation of public goods is external if it is a question of an ordinary public good that all residents of the municipality can consume, regardless of their place of residence in the municipality. In order for capitalisation – in this case external capitalisation – to occur, there must be more demand for the public good than there is housing supply available in the municipality providing the public good. In such cases, the increase created by the public good in housing demand raises the price level of all housing in the municipality. If the good is a local public good whose consumption potential depends on the location of the household residence relative to the good, the possibility for internal capitalisation is born. In this case, the capitalisation mechanism can also serve to differentiate between housing prices in the municipality. This also requires that there is more demand for the local public good in question than there is housing available in proximity to the local public good. (Starrett 1981, Laakso 1997)

Based on empirical research, it can be concluded that local public goods are capitalised in housing prices. However, it is difficult to determine to what extent the demand for a local public good is capitalised in housing prices and how well housing prices can be used to estimate the demand for local public goods. Appreciation of local public goods can vary by population group, and the population may locate in different areas according to their values. In addition, the degree of capitalisation of a public good is not only affected by housing demand but also by housing supply. The degree of capitalisation of a local public good is therefore unlikely to be the same everywhere, as the flexibility of the supply of housing and various housing characteristics varies by area. The role of geographical constraints is sometimes considerable, but the constraints created by land use planning are usually more significant. Capitalisation is also linked to the urban structure. The more densely the environment is built, the fewer opportunities there are for infill development, and the higher the degree of capitalisation becomes. It can therefore be expected that capitalisation in the CBD is greater than in suburban areas, when the impact of land use planning is standardised. Poor infill development potential may create incentives for land and housing owners to act so as to decrease infill development. From a homeowner's perspective, strict land infill planning and more restrictive infill policy may, in some situations, be advantageous from the perspective of the maximisation of the value of one's own dwelling. For owners of undeveloped land, the lack of infill development potential creates an expectation of a later increase in the value of the land, a real option which can encourage the postponement of construction decisions. (Mayer & Somerville 2000, Hwang & Quigley 2006, Saiz 2010, Hilber 2011)

The capitalisation discussion above approaches the matter from an intra-urban perspective. The differences between different labour market areas (the inter-urban perspective) in the supply of local public goods may also be seen in wages. Low wage level, or at least a wage level low in real terms, taking into account housing costs, can be accepted as compensation for the desired public goods. In conditions where there is free mobility, such wage differences between areas act as a compensating differential for the quality of the housing environment. (Tiebout 1956, Oates 1969, Starrett 1981, Roback 1982, Hiller & Lerbs 2014)

The capitalisation of urban nature in housing prices also provides an opportunity to assess the economic value of natural amenities. It must be noted, however, that it is not realistic to expect housing prices to reveal the full value of nature. In environmental economics, the services provided by natural amenities are often divided into use values and other values. Use values refer to the value of the direct services provided by nature sites. Other values refer to the value produced by a natural site by its mere existence on the one hand, and the option value of the nature site on the other. The latter refers to circumstances in which a consumer is not currently using the nature site or the service it provides, but which the consumer values for its potential use. Existence value is sometimes referred to as passive use value. Housing price information is considered to be connected to the use values of nature. (Krutilla 1967, Turner et al. 1990, Gowdy 1997)

2.4.2 Externalities and housing prices

In addition to public goods, another important concept for the purposes of this study is the concept of externalities. Externalities refer to the utility (positive externality) or disutility (negative externality) resulting from a building decision, such as one made to a third, external party. In the case of negative externalities, a market decision that does not take into account the disutilities caused to a third party may, in the case of polluting industrial production, for example, lead to socially excessive production. This is because the disutilities caused by the pollution created in production are not included in the calculation on which the production decision is based. In other words, the private utility from production does not take the social costs of production into consideration. (Evans 2004)

Even though traffic infrastructure may be considered to possess effects that increase housing prices through accessibility, there are negative externalities related to traffic congestion and emissions from traffic, which have a negative effect on housing prices. During the congestion peak, every additional car on the roads slows down not just the driver's own journey but also that of everyone else. For this reason, it is a negative externality. In the case of positive externalities, the situation is the opposite: in a market decision, production remains below the social optimum. In an urban environment, positive externalities may be produced by high-quality architecture, for instance (Chapter 5). It can be thought that many public goods possess positive externalities. (Evans 2004)

In the literature, several different solution models have been proposed for the problems caused by negative externalities. The internalisation of externalities can be seen as being arranged through economic incentives (negative externalities) or subsidies (positive externalities). This approach, based on Pigovian taxes or subsidies, is a common approach to externalities in environmental economics (Baumol & Oates 1988).

Another approach based on economic incentives is based on a comprehensive definition of ownership. This approach to solving the problems related to externalities is built on the idea that well-defined ownership rights provide their owners with an incentive to monitor their interests so that the negative impact affecting a third party, for example, is compensated to the suffering party. In fact, this model presented by Coase (1960) concludes that the optimality of the end result is not conditional with respect to who originally possessed the ownership, even if the original division of ownership has a significant impact on the division of income.

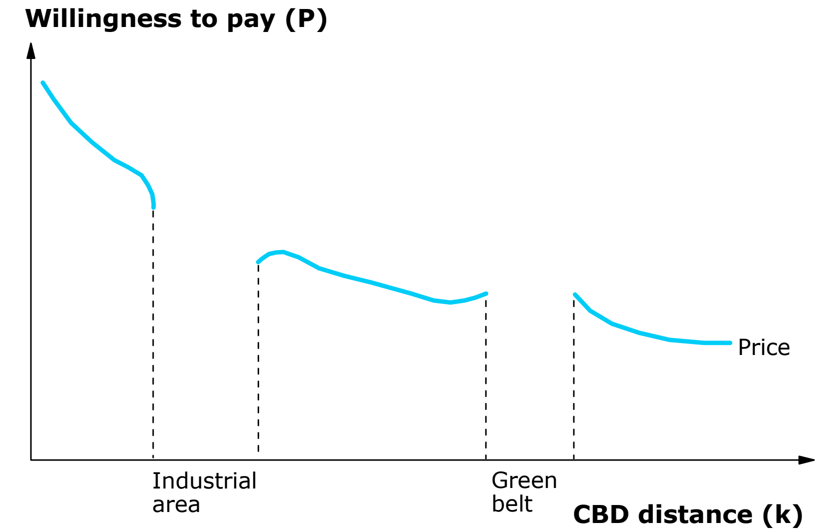
Coase's approach has also been criticised (Medena & Zerde 2000), probably more than the solution model based on Pigovian taxes and subsidies. One of the key criticisms is that the negotiated solution on the basis of ownership proposed in Coase's model cannot succeed in complex real-world situations, where there may a great number of parties, due to the high cost of negotiation. It is also often likely to be an overpowering task to define ownership in such a manner that different ownership rights are in no way conflicting. Even so, a market decision based on ownership may be a socially effective method in cases limited to a very low number of parties.

In practice, externalities are often sought to enable control through administrative steering. This also applies in an urban environment, in which one of the key tasks of land use planning is to separate land use forms adverse to each other and to steer land use forms that benefit each other to the same areas. The restrictive effect of land use planning is a strong mechanism in comparison to economic steering, in the sense that its implementation is controlled by central government. In order to achieve positive externalities, however, land use planning is often only an enabling factor. A legally effective land use plan does not guarantee that the plan is implemented, as many construction projects are backed by the independent decisions of the private sector. (Evans 2004)

Land use planning can in principle have positive or negative net effects on welfare. By fixing market failures, for example by promoting production of public goods, land use planning can enhance welfare. At the same time, land use planning can cause welfare reduction by, for example, limiting opportunities to build houses and offices. Though limiting development might have some positive welfare effects, it almost certainly has also some negative effects on welfare. These negative effects comes in many cases in the form of limited supply of space for different purposes. These effects might, in turn, have various types of consequences on consumption opportunities, productivity and income distribution. Even if the management of externalities is based on administrative steering, the utilisation of market information is beneficial, as it can provide decision-makers with information (that would otherwise be difficult or impossible to obtain) for the basis of welfare analysis of different planning decisions. (Heikkila 2000, Cheshire & Sheppard 2005, Rouvendal & van der Straaten 2008, Webster 2009, Cheshire 2012)

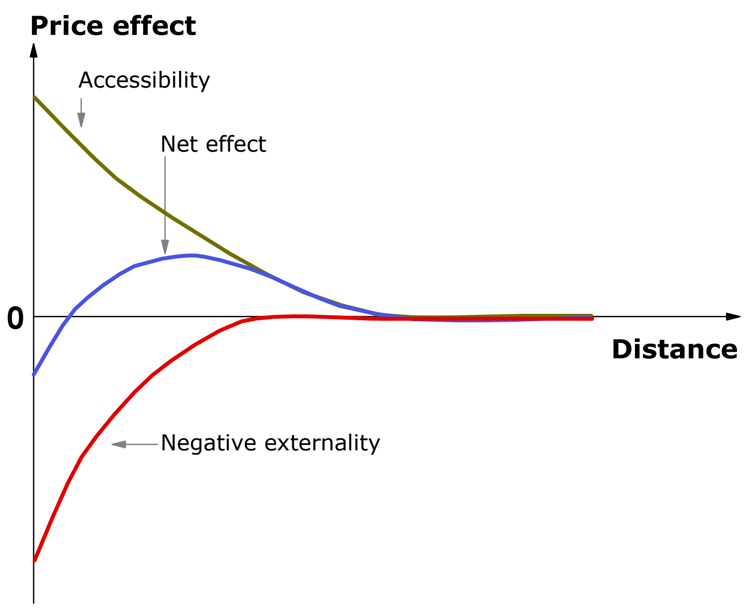
Land use planning in urban areas aims to locate functions that cause considerable harm to housing in separate areas. For example, areas along motorways are not usually allocated for housing construction. In the following, the monocentric urban model described above is used as a tool to demonstrate the possible price effects of externalities. As shown above, using common assumptions, the bid rent curve in an urban area – in practice the curve depicting housing prices – decreases monotonically as the distance from the centre grows. Busy roads and power plants are forms of land use that produce such potentially negative externalities (Figure 2.6). House prices near these sources of disutility is probably lower than house prices in other similar locations (at a similar distance from the centre). Correspondingly, prices could be assumed to be somewhat higher near green areas than other comparable houses in different areas at the same distance from the centre.

Figure 2.6 Effect of positive and negative externalities on the bid rent curve



Housing in proximity to the local public good can be more expensive than housing at the same distance from the centre in general. However, there may be distance-dependent disutility factors related to some local public goods. A dwelling on the edge of a busy park, for example, may be desirable as such, but the amount of traffic caused by the large number of visitors to the park may result in the optimal location not necessarily being the nearest location. In this case, as a result of accessibility and a negative externality, the (positive) price effect of the local public good may be greatest a little further off (Figure 2.7).

Figure 2.7 Accessibility, negative externality and the capitalisation of a local public good (Laakso 1997)



2.4.3 Local public goods in the monocentric model

We will continue the examination of the quality of the housing environment using a theoretical model. We will expand the model discussed in Subsection 2.4.1 describing households' choice of an optimal consumption basket (housing consumption, location) in the manner described by Brueckner et al. (1999), in which a local public good relevant to the quality of the living environment is added to the basic model and indicated with a, referred to by Brueckner et al. (1999) as amenities. As this is a public good, albeit a local one, it does not appear in households' budget constraints. Hence, the utility maximisation problem of a household is

(2.11) $$Max_{x,y,a} U(x, y, a)\ s.t.\ w - t(k) = r(k)x + y.$$

By using the budget constraint, we can eliminate term y, indicating other consumption, from the utility function, so that the utility function is $U(x, w - t(k) - r(k)x, a)$. From a household's perspective, the unit price of housing $r(k)$ is a given. In order for the utility level to be equal at all distances from the centre, as assumed, $(\bar{u})$, the housing price level, $r(k)$, must vary as a function of the distance from the centre k. Then, $U(x, w - t(k) - r(k)x, a) = \bar{u}$. The first-order conditions are obtained by derivation of the utility function U, which produces the standard utility level, i.e.

(2.12) $$U^x - r(k)U^y = 0.$$

By deriving the utility function that produces the standard utility relative to the distance from the centre k and applying the first-order condition (2.12), we can deduce a function depicting a household's willingness to pay:

(2.13) $$[-t'(k) - r'(k)x(k) - r(k)x'(k)]U^y + x'(k)U^x + a'(k)U^a = 0 <=>$$
$$\left(-t'(k) - r'(k)x(k) - \frac{U^x}{U^y}x'(k)\right)U^y + x'(k)U^x + a'(k)U^a <=>$$

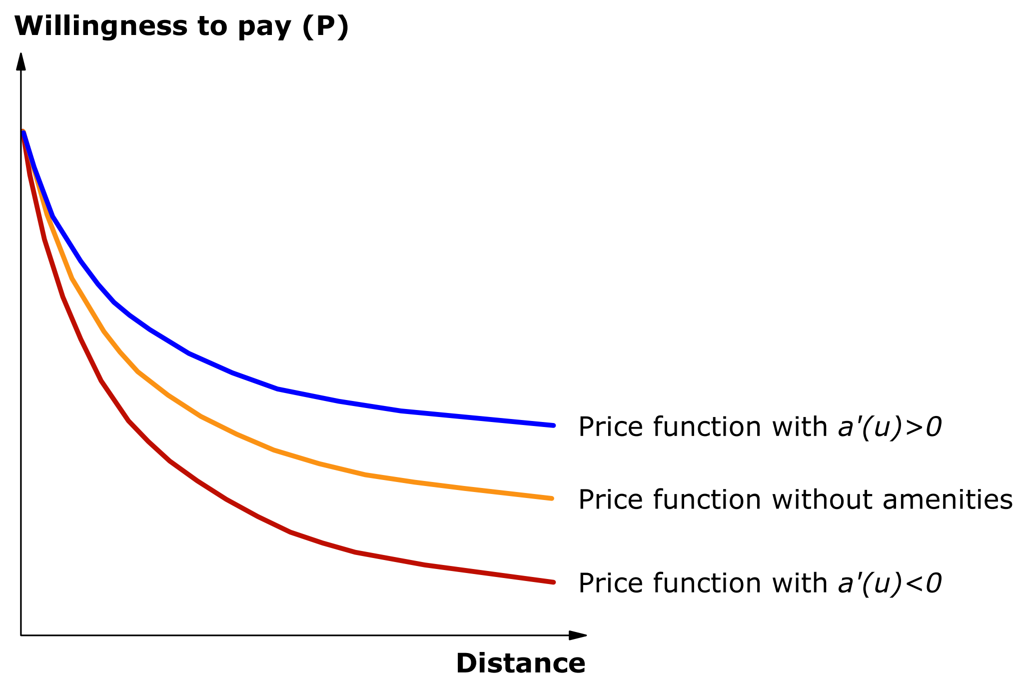
(2.14) $$r'(k) = -\frac{t\prime(k)}{x(k)} + \frac{U^a}{x\prime(k)U^y}a'(k).$$

Depending on the marginal value of amenity, a'(u), the price function with amenities might be above or below the price function without amenities (Figure 2.8). The location of households according to their income level in an urban area can be analysed in a corresponding manner to the basic model (2.9, section 2.3). In this case, the function indicating the difference between the bid rent functions of different household types is of the form

$$\Delta \equiv p'_B(x) - p'_A(x) = \frac{w_A t'_A(k)+e}{x_A(k)} - \frac{w_B t'_B(k)+e}{x_B(k)} + a'(k)\left(\frac{U^a}{x'_B(k)U^y} - \frac{U^a}{x'_A(k)U^y}\right), \tag{2.15}$$

where subscript A refers to wealthy households and subscript B refers to poor households. As in the basic model (2.10), the interpretation is that wealthy households are located nearer the centre than the poor households if $\Delta<0$.

Figure 2.8 The effect of amenities on the bid rent curve



2.4.4 Different types of amenities

With the exception of the general definitions of public goods and local public goods, local public goods have not yet been described in detail. Housing price studies often make reference to amenities that are often said to also be local public goods. Amenities may be the aesthetic characteristics or functional features of the housing environment, or they may be the services that are available. Brueckner et al. (1999) divide amenities into three groups. The first group is referred to as natural amenities, which, accordingly, are naturally formed amenities such as the sea and the seashore. The second group they refer to as historical amenities. This group includes man-made constructions such as historical buildings, monuments and parks. The third group in the categorisation is modern amenities, which include restaurants, theatres and sports arenas.

Glaeser et al. (2001) divide amenities into four groups. In the first group, they include the variation of available services and goods. The underlying assumption is that consumers value a versatile range of services and goods. Their second group consists of (the city's) aesthetic and physical characteristics. Aesthetic characteristics refer to architecture, for example, while physical characteristics refer to climatic conditions. The third group includes public services and, particularly in the American context, schools. The fourth and final group includes the ease and speed of mobility in the urban area.

Clark (2003) also divides amenities into four groups. The first, natural physical amenities, is considered by Clark to include climatic factors and natural conditions, for example. The second group is referred to as constructed amenities and includes museums, schools and other cultural institutions, as well as a number of commercial services, such as certain types of bookshops, restaurants and grocery stores as well as various organised events. The third group of amenities, according to Clark, is comprised of the population's socioeconomic structure and diversity. The fourth group includes the attitudes of the population, especially features such as broad-mindedness, the willingness to take risks and individualism.

2.4.5 Amenities and intercity sorting

It is obvious that amenities influence the location and differentiation of the population within urban regions. It is just as obvious that amenities have a connection to the sorting of the population among urban regions. This phenomenon can be examined directly by comparing the population structure of urban regions or indirectly by analysing job structures. For example, Falck et al. (2010), based on German data, show that the proximity of Baroque opera buildings considerably increases the proportion of jobs with a high human capital in the area. Similarly, Kourtit et al. (2013) demonstrate the link between creative sector jobs and the cultural heritage (theatres, museums, cinemas, historical monuments) of the area.

According to Florida's (2002) research, amenities are particularly important for the location decisions of the so-called creative class. Florida argues that places of residence that are experienced as appealing attract not just residents but also businesses. In the framework of the Roback-Blanchflower-Oswald model, describing the equilibrium of the regional economy, an increase in the demand for labour can lead to a decrease in the real wage level (taking housing costs into account as well as the wage level) in an amenity-rich city, especially if the housing supply is inflexible (Roback 1982, Blanchflower & Oswald 1994, Deller 2009).

The valuations of different population groups with respect to amenities may vary greatly (OECD Regional Outlook 2014). On the basis of the power couples research tradition (Costa & Kahn 2000, Compton & Pollak 2007), highly educated couples typically locate in mid-size to large cities and have shorter commutes (and more expensive housing) in comparison to otherwise similar households. Moretti (2004) has proposed, on the basis of his research, that workers with a higher level of human capital greatly value amenities, whereas those with a lower level of human capital have little appreciation for them. On the other hand, not all amenity-rich cities automatically become concentrations of highly-skilled workers and businesses (Moretti 2012).

The challenge is to distinguish the degree to which an increase in the supply of amenities results from an increase in jobs and a certain type of workforce, and to which extent this is due to the amenities which appeal to a certain type of workforce. Based on Canadian data, Brown and Scott (2012) have studied the location of highly educated workers. In their categorisation, amenities may include a pleasant climate, restaurants, sports teams and cultural offerings. Brown and Scott (2012), referring to Layard et al. (2008), argue that as income levels increase, the marginal benefit of the increase in the wage level should decrease and the marginal benefit of non-pecuniary factors, in which they include many amenities, should increase. Amenities should thus be a key factor driving the location of highly educated, and usually better paid, individuals. The study of Brown and Scott (2012), however, show that thick labour markets are a key factor in attracting an educated workforce, while the role of amenities is a secondary factor.

2.5 Accessibility-related perspectives to the monocentric model

The basic version of the monocentric urban model (Subsections 2.3.1–2.3.3) is based on a number of simplifying assumptions related to, among others, the location logic of households in urban areas. With regard to models that allow for polycentric development (Subsection 2.3.4), some of the assumptions on the factors affecting location decisions were expanded. Similarly, public goods were highlighted as factors influencing households' location in Subsection 2.4. This chapter will focus on accessibility as a factor influencing households' location in more detail. Various aspects and measurement methods of accessibility are considered alongside brief analysis of the effects of externalities, especially traffic congestion, as well as uncertainty and expectations on location decisions. The link between accessibility and the urban structure is also considered from the perspective of the concept of connectivity and the space syntax method.

2.5.1 Family structure and non-work travel

In addition to commuting, the location of households is likely to be influenced by the household's transportation needs, which, in turn, depends on the household's income, family structure, lifestyle and other factors. In the following, some complementary perspectives are presented.

The impact of family structure adds one complementary perspective to accessibility. Subsection 2.3.1 above already referred to Fujita's (1989) model, which analysed the impact of family structure on households' bid rent curves and optimal location. When the share of employed members of the family increases, assuming that all jobs are located in the main centre, the distance from the centre (ceteris paribus) decreases and living space per person drops.

The location decision of a two-earner household, for example, in a situation in which jobs are not located in the same place (the same centre), results in a new type of optimisation problem. In such situations, it can be questioned whether the decision-making problem of a household with several earners can even be described as a decision-making problem of one entity, the household, without taking into account how the household income is distributed within the family. The previous question can be followed by another related to whether households minimise combined travel costs in their location decision, or whether the job of one earner functions as an anchor, which drives the housing location decision. What are the factors that explain the systematic differences related to the commuting distance of the different sexes? Based on earlier empirical research, women's commuting journeys are clearly shorter than those of men. (Madden 1981, Camstra 1996, Crane 2007).

The commuting-based modelling of the location question requires a better consideration of real world phenomena in general. The increase in remote working and mobile work are such factors (Talvitie 2003). It should also be noted that, in addition to commuting journeys, households travel for other reasons as well. The basic model of the monocentric model completely ignores these perspectives, although empirical studies show that in Helsinki, for example, commuting typically only accounts for about 25 % of all trips (Turja & Mervola 2014). Even if commuting, as a regularly occurring form of travel, is a significant factor in the choice of housing, we can also assume that non-work travel has an impact. Some models on household location and the formation of the urban structure take non-work travel into account as one perspective (Anas & Kim1996).

2.5.2 Traffic network and congestion

In the monocentric model, travel costs are usually assumed to be a function of the length of the journey, or in some cases, of the time costs of the journey. However, the traffic network used in the basic model is very simplified. In some models, traffic networks and forms of transport attempt to approach the real world. For example, Yinger (1993) presents an analysis in which the traffic network includes both connections to the centre and cross connections. Kilani et al. (2010) also studied the impact of the public transport network on urban structure and land rent. In their model, commuting is directed at the job areas in the centre either directly (as in the basic model) or via public transport nodes, so that travel is first circumferential and then as mass transit towards the centre. They show that both population density and land prices are higher in the proximity of mass transit stations than in other areas at the same distance from the centre.

As a rule, the basic monocentric model does not include externalities, and, therefore, the urban structure created in the model as a market decision within the model framework is efficient from the perspective of economics. In reality, externalities are naturally present in cities in a variety of ways. A negative form of externalities is traffic congestion. In a study based on the numerical simulation of the monocentric model, Wheaton (1998) shows that if congestion costs are taken into account the optimal population density in a city is higher and the size of urban area is smaller in comparison to market city.

Traffic congestion can also affect the socioeconomic breakdown of the population in different parts of the city. LeRoy and Sonstelie (1983) suggested that the development of transport technology, i.e. motorisation, in the United States initially led to the migration of wealthy households to the suburbs. The decrease in the cost of motoring, however, enabled the migration of larger groups to the suburbs, creating the traffic congestion phenomenon, despite massive road investments. Leroy and Sonstelie (1983) predicted that, as a result, the time costs of travel would considerably increase, especially for the wealthy, which would create an incentive for wealthier households to move back to the CBD.

In addition to the possible effect of traffic congestion on the location decisions of individual households, the impact of congestion on the development of the urban structure can also be considerable. The impact is not necessarily restricted to the size of the city (cf. Wheaton's 1998 conclusion above) but may also affect the urban structure by changing its number of centres. In addition to traffic congestion, there may naturally also be other congestion mechanisms that create pressure for the change of the urban structure.

In Subsection 2.3.4 above, some perspectives were presented on the change of a monocentric urban structure towards a polycentric structure. This is a question of the relative weight of the benefits of agglomeration and the drawbacks of congestion. The birth of the polycentric structure is promoted by the length of work and non-work journeys in a growing urban region, as well as the disadvantages brought about by congestion. Through the subcentre structure, businesses can retain at least some of the advantages of centralisation while locating closer to their customers and workers. The birth of a subcentre structure does not, however, automatically reduce the length of commuting journeys. From the perspective of workers, the lack of suitable housing stock in the proximity of the workplace, for example, may become a problem. In households with several earners, the location of jobs in different centres may also result in the subcentre structure not shortening commuting journeys. (Wheaton 2004)

2.5.3 Wasteful commuting debate

One critical perspective on the monocentric model is based on the empirical studies of the location of households and length of commuting journeys. It can be considered that this discussion was kicked off by the wasteful commuting debate initiated by Hamilton (1982). Based on data collected in the United States, Hamilton applied the framework of the monocentric model, assuming that both population and job density would decrease the further one travelled from the centre. According to Hamilton's criticism of the monocentric model, households' location logic does not match the model's assumption of the minimisation of travel costs. According to him, the lengths of households' commuting journeys in the United States were several times longer than predicted by the monocentric model.

White (1988) responded to Hamilton's article, criticising his analysis. White's key argument is that Hamilton's assumption of the workplace structure was false. White contends that jobs outside the centre are located in subcentres instead of being dispersed. By taking this as well as other travel by households into account, White concluded that the commuting journeys were only 11% longer than predicted by the model. Later, Hamilton (1989), Cropper and Gordon (1991), Giuliano and Small (1991) , Small and Song (1992), Giuliano and Small (1993) and Thurston and Yezer (1994) continued to analyse the same question. In general, they all came to the conclusion that the observed length of commuting journeys clearly exceeds the predictions provided by the monocentric model, even if the location of jobs in subcentres is also taken into account. In a comprehensive review article, Anas et al. (1998) noted that

"It appears that at least in auto-dominated cities, there is more "cross-commuting" in which commuters pass each other in opposite directions, than there is commuting "up the rent gradient". Cross-commuting does not occur under standard assumptions because if it did, people could reduce commuting costs without incurring higher rents, simply by interchanging houses."

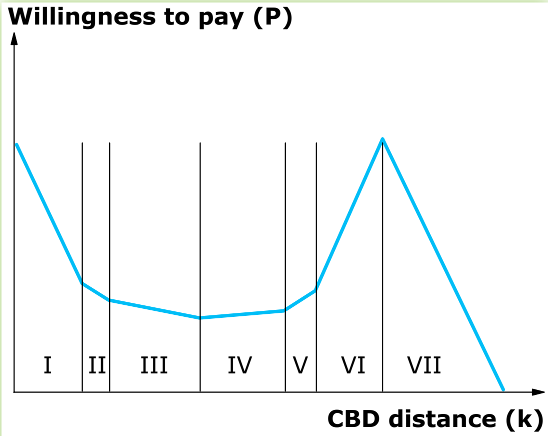
One explanation for the phenomenon of wasteful commuting may be related to the increasing prevalence of two-earner families. In their case, the choice of place of residence must be optimised with regard to commuting by both parties, which considerably reduces wasteful commuting (Kim 1995, Buliung & Kanaroglou 2002; Ma and Banister 2006 presented an extensive review of the wasteful commuting literature).

2.5.4 Uncertainty, expectations and search

Incorporating the dimension of time as well as uncertainty and assumptions into the monocentric model in addition to the subcentre structure provides a new perspective on the above-mentioned wasteful commuting debate. The basic version of the monocentric model, being static, does not allow for a household's location decision to be made in conditions of uncertainty. However, from the point of view of households, the major uncertainty factor is perhaps job stability. In an urban structure in which jobs are available not only in the main centre but also outside of it, changing jobs may also result in significant changes to commuting.

Crane (1996) constructs a two-period version of the monocentric model, supplementing its structure with a subcentre in which some of the jobs are located. With regard to the first period, the model is standard, but with regard to the second period, uncertainty is related to the location of a worker's job. As in the static main centre/subcentre model, the bid rent curve has two peaks, but it is not comprised of the bid rent curves of two different groups (those working in the main centre and those working in the subcentre) but in sections, based on the location and certainty of the current job, and the expected location of the job in the second period (Figure 2.9).

Figure 2.9 Bid rent curve in the two-period model, in which there is a subcentre in addition to the main centre and the location of the job in the second period is not known for certain (adapted from Crane 1996).



I = CBD with stable jobs.
II = CBD workers with medium job stability.
III = Suburban workers with unstable jobs.
IV = CBD workers with unstable jobs.
V = Suburban workers with medium job stability.
VI = Suburban workers with stable jobs.
VII = Unsorted Suburban workers

As a result of the uncertainty with regard to the household location, commuting is not necessarily directed at the nearest centre. This is because the choice of job and housing location choice is not only based on the situation in the first period, the present time, but is also influenced by expectations of the future.

van Ommeren et al. (1999) consider the key problem of the wasteful commuting literature to be the fact that it largely ignores the costs and uncertainties related to the search for both a job and a dwelling. van Ommeren et al. (1999), leaning on the search theory and supported by empirical data, argue that market imperfections (imperfect information, moving costs) have a major effect on job market and moving decisions and, hence, the length of commuting journeys. According to them,

"...workers voluntarily accept commuting costs which are not compensated by the current characteristics of jobs and residences. The reason for this is that workers realise that commuting costs are temporary as they may change job or residence in the future. We show that theories which ignore future job or residential moving behaviour overstate the compensation for commuting which workers wish to receive to accept longer commuting distances, and they also overstate the payment which workers wish to forego to obtain shorter commuting distances." (**van Ommeren et al.1999**)

The connection, or distance, between workplace and dwelling, is therefore often given too large a role in studies on commuting behaviour. The analysis must also include uncertainty and expectations as well as moving costs, which all play a role in location decisions. It is not necessarily worthwhile for a household to constantly change homes due to the related costs, even if a dwelling marginally more optimal than the current one were available. On the other hand, because of the search costs, a sufficiently good dwelling is likely to be accepted even if it were clear that a slightly better option might be available on the market. The static monocentric model does not incorporate these perspectives. (Loikkanen 1982, van Ommeren et al. 1999, Rietveld et al. 2000, van Ommeren et al. 2005)

2.5.5 Accessibility and urban spatial configuration

Accessibility is usually defined as the distance or travel time between two locations. The costs incurred by distance could actually be considered to consist of two different components: monetary and time-related travel costs. It can additionally be considered that there are different comfort and certainty factors involved in different forms of transport. Based on empirical studies, it is known that changing public transport vehicles or the form of transport is considered to be a factor that decreases comfort, and the disadvantage of change is experienced to be greater than any increase in travel length they may cause (Guo & Wilson 2011). To summarise, it can be said that the usual way of modelling the effect of accessibility on housing prices is to use distance in terms of time as a measure of accessibility, usually in terms of the distance to the CBD or a larger group of centres. Service clusters, usually the distance to the one in closest proximity, are often represented in the factors depicting accessibility.

Thanks to comprehensive location information data, however, job structures can now be described in greater detail and also taken into account more comprehensively than is allowed by an approach through individual centres. The accessibility of jobs, and naturally other functions, can also be calculated more accurately by constructing variables indicating the average accessibility of jobs from each dwelling, for example (Giuliano et al. 2010). Such a variable can be said to measure gravitation potential (Law et al. 2013, originally Hansen 1959) and can be expressed as

$$\text{(2.16)} \quad \mathbf{G_i} = \sum_{\mathbf{J=1}}^{\mathbf{n}} \frac{\mathbf{E_j}}{\mathbf{d_{ij}}}$$

where $\mathbf{E_j}$ indicates the number of jobs at location *j* and $\mathbf{d_{ij}}$ indicates the distance between a dwelling at location *i* and job area *j*. The variables can also be constructed to separate jobs by category, thus testing the effect of the accessibility of different types of jobs on housing prices by housing type, for example.

The concept of accessibility can also be considered to be more versatile than a mere measurement of distance. Hillier and Iida (2005) describe an approach to measuring urban structure, or any networked structure, in which the distance between locations can be studied through three dimensions: i) metric distance, ii) topographical distance and iii) geometric distance. The first of these, metric distance, indicates the usual distance between two locations as measured by travel. The second, topographical distance, reflects how many turns (changes of direction at intersections) need to be made on the journey between two locations. The third, geometric distance, combines the absolute value degrees of the turns (changes of direction at intersections) included in the journey between two locations. These three measurements can be calculated between all locations. Then, an index can be calculated for the accessibility of each location, using each of the three measurement methods described above, indicating the accessibility of each location. Observations on the first, closeness, $\mathbf{P_i}$ is calculated as follows

$$\text{(2.17)} \quad \mathbf{C_C(P_i)} = \frac{\mathbf{1}}{\sum_{\mathbf{k}} \mathbf{d_{ik}}}$$

where the term $\sum_{\mathbf{k}} \mathbf{d_{ik}}$ is a sum of distance (using the chosen distance measurement method) from observation *i* to all other observations. A greater index value corresponds to greater closeness. Correspondingly, the second index, betweenness, is calculated as

$$\text{(2.18)} \quad \mathbf{C_B(P_i)} = \frac{\sum_{\mathbf{j}} \sum_{\mathbf{k}} \mathbf{g_{jk}(P_i)}}{\mathbf{g_{jk}}} \quad \forall \mathbf{j} < \mathbf{k}$$

where $\mathbf{g_{jk}}$ $\mathbf{(P_i)}$ indicates the number of connections (routes) between locations *j* and *k* via location *i* and $\mathbf{g_{jk}}$ indicates the total number of routes between locations *j* and *k*. A greater index value here indicates greater betweenness. In the literature (Xiao 2012, Law et al. 2013), the method described above to measure accessibility in a network is known as the space syntax method.

CHAPTER 3

RESEARCH METHODS

“Essentially, all models are wrong, but some are useful.”

George E.P. Box

3 RESEARCH METHODS

This chapter focuses on issues related to methodological issues related to housing price studies. First, in Section 3.1, different approaches to housing market valuation are discussed. Then, in Section 3.2, the basic ideas and assumptions to which hedonic method is based are introduced. In Section 3.3, perspectives to the elusive concept of housing submarkets are presented. Lastly, in Section 3.4, econometric issues of estimation of hedonic price models are reviewed.

3.1 Different approaches to economic valuation in housing market context

In this chapter, economic valuation methods related to housing market analysis are reviewed. Economic valuation is defined as the assignment of monetary values to goods that cannot be bought and sold separately in the markets. Economic valuation in the housing market context applies variety methods depending on the research question. For example, in the analysis of overall price level development, hedonic method (Lancaster 1966, Rosen 1974) or repeated sales method (Bailey et al. 1963) is usually applied. These methods are used to produce quality-corrected price indexes. The repeated sales method is a so called matched-model and in its basic form no information on housing characteristics is needed whereas the hedonic method is based on detailed housing market transaction data. (Eurostat 2013)

In this study, the focus is on the prices of individual housing characteristics. Because housing is a composite commodity, there are no markets for individual housing characteristics. Another feature of housing is that the price of dwelling depends also on factors related to its location. Locational attributes are capitalized into housing prices. For this reason, housing market information can also be used to evaluate the value of location and to some extent also the value of environment, though housing market information can only reveal so called use values of environment (McConnell & Walls 2005, Carson 2012).

There are several methods to evaluate the economic value of different characteristics of housing. These methods can be divided into two main groups. Methods based on revealed preferences utilizes information on real choices in the housing market. The most commonly used method in housing market studies is the hedonic pricing method. The method derives so-called shadow prices for each housing attribute from the total prices of dwellings. Also the discrete choice model can be applied to derive marginal willingness to pay for housing attributes (Earnhart 2002).
Methods based on stated preferences utilise information gained from hypothetical markets. There are two main categories of

research in this category. Contingent valuation methods are based on surveys. Respondents are asked to attach value to different features of housing. Furthermore, contingent valuation methods can be divided into two sub-categories. In "willingness to pay" studies, respondents are asked their willingness to pay for some characteristics of dwellings. In "willingness to accept" studies, respondents are asked the amount of compensation they require in order tolerate the loss of some characteristics of dwelling. (Carson & Hanemann 2005, Mattia et al. 2012)

The second main category of stated preference methods is contingent choice analysis. Like the contingent valuation method, the contingent choice method is also based on hypothetical markets. But unlike contingent valuation, in contingent choice analysis respondents are not asked to attach monetary values to different characteristics of housing. Instead the method is based on choices that respondents make between different scenarios. Based on trade-offs expressed in choosing between different scenarios (if these scenarios also include monetary terms), it is possible to derive willingness to pay measures on housing characteristics. (Molin 2011)

All methods have their advantages and disadvantages. In this study the hedonic pricing method is applied. This choice is based on two distinctive factors. First, the hedonic pricing method is based on actual market transactions. In the literature, there are some doubts whether consumers are able to reveal their preferences in studies based on hypothetical markets (McConnell & Walls 2005). Second, data for studies based on the hedonic method is readily available at a reasonable cost. For stated preference studies, costly surveys must be made.

3.2 Hedonic method

In the standard consumer theory in economics, if commodities are bundles of characteristics and their amounts vary, the standard approach is not applicable unless each variable is defined as a separate commodity. In an alternative model proposed by Lancaster (1966), the amounts of the characteristics of the good determine consumer utility. It is assumed in Lancaster's model that there is a linear relationship between the characteristics of the good and its market price. Rosen's model (1974) describes how, in a multi-characteristic setting, market equilibrium and the related hedonic prices of characteristics are determined. In Rosen's model, the relationship between the characteristics of the good and its market price can also be non-linear. The fundamental idea is that the price of a certain good, such as a housing unit, is a combination of the implicit prices of the different characteristics of that particular good. The relationship between the amount of characteristics and their implicit prices can be non-linear and non-monotonous. In an urban context, the amount of services from amenities can rarely be measured directly. Rather, it is assumed that their benefits depend on the distance between dwellings and amenities. Next, we will present the theoretical basis of the hedonic price analysis.

Housing is a multidimensional commodity. As already noted in Section 2.1 above, it is rare for two exactly identical dwellings to be available on the housing market. In addition to their structural properties, dwellings often also differ with regard to location and accessibility. Let us describe the different characteristics of a dwelling with vector

(3.1) $\bar{x} = (x_1, x_2, \ldots, x_n)$

where $x_1, x_2, \ldots, x_n$ are the different characteristics of the dwelling. The housing supply is assumed to be fixed in the short term. Hence, a household choosing a home may not be able to purchase a dwelling with the precise combination of characteristics optimal for its needs, but instead must choose from among the dwellings available. Not all the possible combinations of characteristics of a dwelling may be available on the market. As a result, the arbitrage taking place in the market does not necessarily lead to the marginal prices of a dwelling's characteristics being constant. In addition, it is possible that the price of an individual characteristic depends on the amount of some other characteristic.

Households choose their dwelling from among the housing available on the market that, taking the household's budget constraint into account, maximises the household's level of utility. The households' optimisation problem is

(3.2) $Max_{x,y} U(\bar{x}, y; \bar{s}) \ \ s.t. \ w = p(x) + y$

where $\bar{x}$ refers to the consumption of the housing commodity, whose price p depends on the characteristics of the dwelling. Other consumption is represented by the composite commodity y, whose price is scaled to one. Vector $\bar{s}$ refers to the characteristics of the household and the term w depicts the household's (exogenous) income level. On the basis of the first-order conditions, the condition of a household's optimal consumption bundle is

(3.3) $U^{x_i} - p'(x_i)U^y = 0$

where U^{x_i} is the change in the household's utility level if one unit of characteristic x_i is added to the household's dwelling, while U^y represents how the household's utility level changes if the household consumes one additional unit of composite commodity y. $p'(x_i)$ indicates the price of the dwelling's characteristic x_i, i.e. how much the price of the dwelling will change if one unit of characteristic x_i is added to it. Based on Equation 3.3, it can be seen that, in an optimal situation, a household chooses housing characteristic x_i and other consumption y in such a proportion that the utility obtained from the additional consumption of one unit of characteristic x_i, i.e. the marginal utility, U^{x_i} is equal to the marginal cost $p'(x_i)U^y$ incurred from the success of other consumption. A household's indifference curve is defined as

(3.4) $U(\bar{x}, y; \bar{s}) = u$

where u is a fixed (specific) level of utility. The content of the household's consumption basket varies in the indifference curve, but the utility level, experienced by the household remains the same. Based on Equation 3.4, the consumption of a composite commodity can be solved as a function of consumption of housing when the characteristics and utility level, of a household are given, i.e.

(3.5) $$y \equiv y(\bar{x}; \bar{s}, u).$$

The consumption possibilities of a household are limited (budget constraint in households' optimisation problem 3.2). Let us denote the share of income used for housing by term θ.The term indicates the maximum level a household can consume on housing, when utility level u is given. In this case, the following applies:

(3.6) $$\theta = w - y(\bar{x}; \bar{s}, u) = \theta(\bar{x}; y, \bar{s}, u).$$

Function 3.6 is a bid rent function that depicts the maximum bid of a household for a dwelling equipped with the characteristic combination $\bar{x}$, assuming the utility level is u. By solving Equation 3.6 relative to the composite commodity y and substituting this into the utility function that gives standard utility u, we obtain

(3.7) $$U(\bar{x}, w - \theta(\bar{x}; y, \bar{s}, u); \bar{s}) = \mathrm{u}.$$

If we assume that the marginal utility of both the dwelling characteristic x_i and the consumption of the composite commodity is positive, we obtain

(3.8) $$U_{x_i} - U_y \theta_{x_i} = 0 \rightarrow \theta_{x_i} = \frac{U_{x_i}}{U_y} > 0,$$

(3.9) $$U_y(-\theta_u) = 1 \rightarrow \theta_u = -\frac{1}{U_y} < 0 \text{ and}$$

(3.10) $$U_y[1 - \theta_y] = 0 \rightarrow \theta_y = 1.$$

In addition, according to Rosen (1974), the value of the second derivative of the bid curve $\theta(\bar{x}; y, \bar{s}, u)$ is negative, i.e.

(3.11) $$\theta_{x_i x_i} = \frac{U_y^2 U_{x_i x_i} - 2U_y U_{x_i} U_{y x_i} + U_{x_i}^2 U_{yy}}{U_y^3} < 0.$$

In this case, a household's bid function relative to dwelling characteristic x_i is a concave function (Figure 3.1). The willingness of a household to pay for one additional unit of dwelling characteristic x_i decreases as the quantity of the characteristic in question x_i increases.

If all households are equal in terms of both preferences and income, the market bid function of dwelling characteristic x_i will be identical to the bid function of a (representative) household. In the case of several household types, the market bid function (offer curve) for dwelling characteristic x_i will be an envelope of the bid functions of different household types (Figure 3.2).

In many studies, the housing market supply is assumed to be fixed. The housing supply (the supply of the characteristics of dwellings) can be incorporated into an analysis of the hedonic price function, however, in the same way as housing demand (demand for different dwelling characteristics). In the analysis of supply presented later in this chapter, the starting point is the assumption that the housing supply is generated by new housing production. In reality, the majority of the housing supply is provided by the old housing stock. In the owner-occupied housing market, a house seller is often the buyer of another house. Dwellings are not built separately for each buyer, although new production can be assumed to be channelled according to demand in the housing market.

Like the monocentric urban model described in Chapter 2, a model depicting the housing supply is static. Let us assume that the profit function of a company providing housing is

$$\pi = mP(\bar{x}) - C(\bar{x}, m, r) \tag{3.12}$$

Figure 3.1 Household's bid curve (adapted from Day 2001)

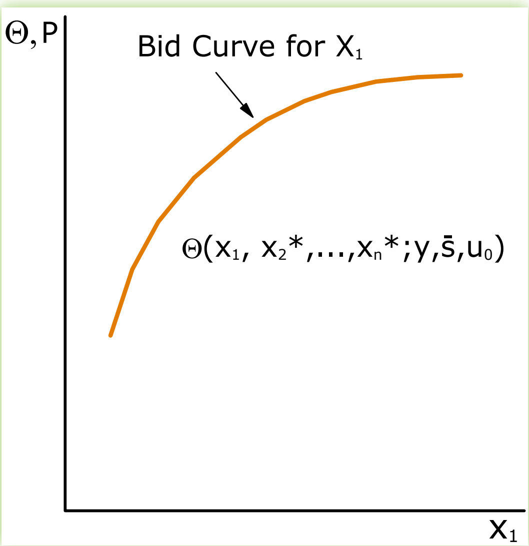
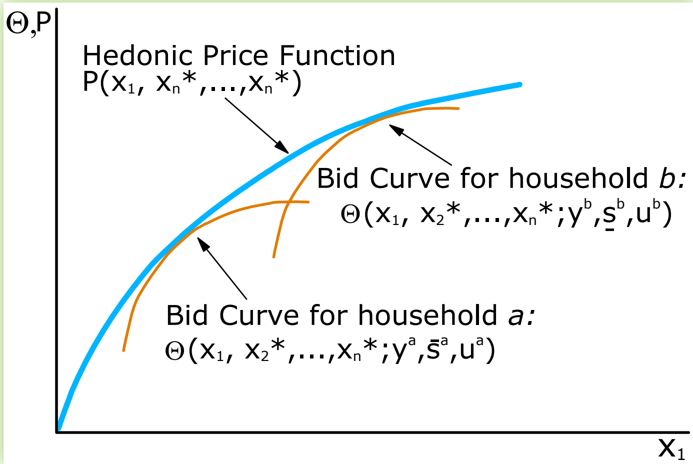


Figure 3.2 Formation market bid function (adapted from Day 2001)



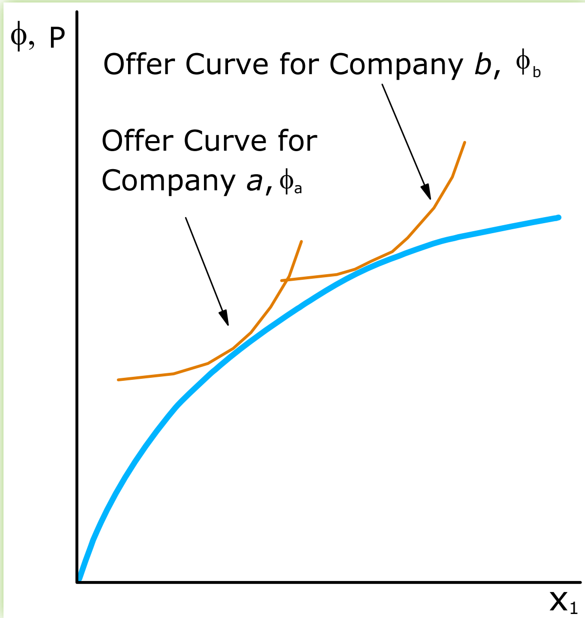
where the term π indicates the company's profit, which depends on the company's production volume m, the price level of housing $P(\bar{x})$, which depends on the quality level $\bar{x}$, and, on the other hand, the costs of housing production $C(\bar{x}, m, r)$, which, in addition to the quality level $\bar{x}$ and production volume m, depend on the company's production technology r. The company is assumed to operate in perfectly competitive conditions, so that the price level is given. The first-order conditions for the company's optimum are

(3.13) $mP_{x_i} - C_{x_i} = 0$ and

(3.14) $P(\bar{x}) - C_m = 0$.

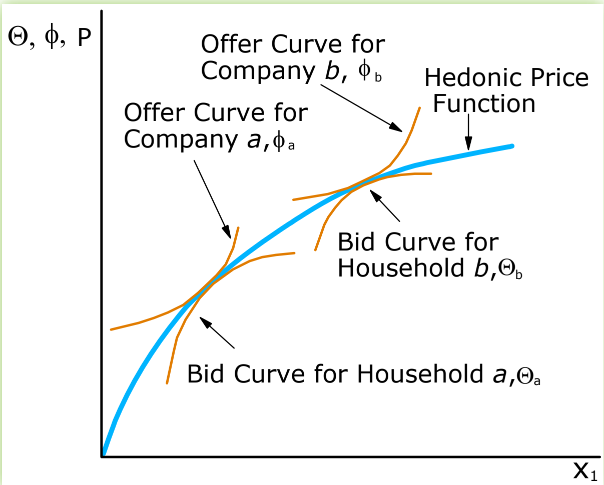
On the basis of Condition 3.13, in an optimum situation, the marginal cost of dwelling characteristic is equal to the marginal return of that characteristic. Condition 3.14 indicates that, in an optimum situation, the company will produce so many dwellings that the price of the dwelling $P(\bar{x})$ is equal to the marginal cost C_m of housing production. Supply functions can be derived for companies producing housing with respect to the different dwelling characteristics in the same way as for housing demand (demand for the qualitative characteristics of housing). These are convex in form. If the companies are identical, the market offer curve relative to dwelling characteristic x_i is identical to the offer curve of a (representative) company. If the companies' production technologies are different, the market offer curve relative to dwelling characteristic x_i is formed as an envelope of the companies' offer curves (Figure 3.3).

Figure 3.3 Formation of offer curve (adapted from Day 2001)



The equilibrium of the housing market relative to the dwelling's characteristic is depicted by the hedonic price function of that characteristic. It is formed of dots where the bid functions representing housing demand and the supply functions representing housing supply are tangential to each other (Figure 3.4).

Figure 3.4 Formation of hedonic price function (adapted from Day 2001)



In Figure 3.4, the hedonic price function is presented as a concave function. Because the hedonic price function is formed as an envelope of the demand for and supply of dwelling characteristics, its form is non-linear. This is due to the fact that a dwelling cannot be disassembled into its separate characteristics to be sold separately. Hence, there is no mechanism in the housing market to eliminate the fluctuation in the shadow prices of the different characteristics of a dwelling relative to the fluctuation in the quantity of the characteristic in question. (Parmeter & Pope 2012)

3.3 Defining urban housing submarkets

3.3.1 Different approaches to housing submarkets

A recurring theme in urban housing price studies is the question of the boundaries and structures of the housing market area. The first question is how the housing market in an urban region should be defined. In his article, Parr (2007) argued that, from an economic perspective, the spatial extent of the urban region can be defined in at least four different ways. The first way to define the city is based on the extent of the built area. A city can also be defined on the basis of employment or the area from which the workforce is drawn for the jobs in the city. Often, however, the city is defined on the basis of its administrative boundaries. In housing price studies, the definitions are often based on administrative boundaries due to the nature of the research data. A definition based on the labour market area would often be more justified and would also fit the logic of the monocentric model described above.

Once the extent of the urban housing market is defined in one way or another, another definition problem arises. The hedonic price method based on the shadow prices of housing characteristics starts from the assumption that the price of a dwelling can be explained by the prices of its characteristics and their quantities. Most housing price studies applying the hedonic method are based on an assumption of the urban region as a single housing market area (Palmquist 2005).

It has been recognised since the early years of housing studies that an urban housing market consists of a number of interconnected submarkets (Grigsby 1963, Straszheim 1975, Rothenberg et al. 1991). The starting point in studies based on submarkets is the idea of the close substitution of dwellings within the submarkets. Submarkets are comprised of a group of dwellings that are close substitutes for each other to consumers. Although this principle is recognised as a general starting point when attempting to identify the submarkets of housing markets, there are major problems involved in the application of this principle. How should submarkets be identified and defined in practical research? Several alternative approaches have been proposed. These include spatial definitions and definitions related to the structural characteristics of dwellings, as well as combinations thereof. Criteria for the definition have also been sought from housing demand research by defining submarkets on the basis of the characteristics of the households buying dwellings. Submarkets can further be defined based on the similarity between the shadow prices of housing characteristics. This concept of the same price level as a determiner of the extent of the market is known as the **Law of One Price** (Stigler & Sherwin 1985, Galster 1996, Watkins 2001, Pryce 2013).

In practical research, the definition of submarkets has often been based on regional definitions or the characteristics of dwellings (Straszheim 1975, Goodman 1978, Dale-Johnson 1982, Watkins 2001). The structural characteristics of dwellings and the prices of these characteristics vary between submarkets (Schnare & Struyk 1976). In more recent studies, the similarities and differences between different dwelling characteristics have often served as the basis for the differentiation of submarkets (Pryce 2009). The differentiation of submarkets can be a challenging task due to the limitations imposed by the data, as in the case of conducting analyses on the basis of administrative statistical regions, as they often ignore the fact that administrative boundaries are not necessarily based on the structural differences in the housing stock.

The same problem applies to studies in which submarkets are identified on the basis of the differences between the shadow prices of the characteristics of dwellings. In this case, it can also be difficult to reveal the actual price structures, as there is no guarantee that administrative boundaries reflect the boundaries of the submarkets. (Bitter et al. 2006, Wheeler et al. 2007) Neither are the boundaries between submarkets necessarily break points with regard to factors affecting housing prices in the manner assumed. Instead, they may be types of transition zones (Long et al. 2007, Buyong 2010).

3.3.2 Submarkets and hedonic prices

Before discussing an approach to submarkets based on the differences between hedonic prices, it should be noted that the existence of submarkets can also be refuted. It can be considered, for example, that in the framework of the hedonic model, regional differences between the shadow prices of housing characteristics can be explained by the impact of missing or undetected factors. However, based on the special characteristics of the housing market, it has also been suggested that not all the spatial variation in the prices of dwelling characteristics is necessarily the result of missing or undetected variables. It can also be due to the inflexibility of both the housing supply and demand.

The housing supply, which is steered and constrained by numerous market factors independent of housing demand, is only able to react to changes in demand somewhat slowly, with a delay. To some extent, supply can even be almost inflexible. In this case, instead of making quantity adjustments, the markets react mainly through the pricing level. The housing market is typically not in an equilibrium, i.e. in a state in which the demand and supply of housing, specifically the different characteristics of dwellings, are in an equilibrium (Watkins 2001). This is also due to the long life span of the housing stock, in which the annual new production only represents 1-2% of the entire housing stock, and, in many cases, the high costs of conversion if the characteristics of dwellings were to be significantly changed. Against this background, the ability of the supply to react to changes in demand is understandably very limited. The differentiated demand for housing (their characteristics and characteristic combinations) can be directed at both the structural features of dwellings and location factors.

As the housing stock is not randomly located, but dwellings in the same neighbourhood are typically more alike than dwellings on average, it is highly likely that the non-stationarity related to the structure of the housing stock correlates to its spatial non-stationarity (Yu et al. 2007). This phenomenon can be explained by search theory. If dwellings located in the same area are likely to be more similar to each other than dwellings in general, the demand (price offers) for them is likely to originate from bidders with similar backgrounds in terms of preferences and budget constraints. This makes the shadow prices of dwelling characteristics within the same area similar. (McMillen & Redfearn 2007) In a state of non-stationarity, a study of the shadow prices of the different characteristics of dwellings (hedonic prices) that ignores submarkets will produce average multipliers, as it were, which do not necessarily apply to any individual submarket (Redfearn 2009).

This argument is based on the observation that, due to the market imperfections and friction factors characteristic of different housing markets (Section 2.1), even long-term states of disequilibrium are possible. There is only a limited quantity of combinations of dwelling characteristics available in the housing market. As demand conditions change, the housing supply often lags behind. It may be difficult to produce more of certain housing characteristics and combinations of characteristics. At the same time, their demand in certain population groups may be very inflexible with respect to prices. Housing demand in general is tied to the socioeconomic status and demographic structure of households (Laakso 1997) as well as to factors such as the location of jobs (Huff 1986). As a joint effect of these factors, the shadow prices of housing characteristics may diverge among different submarkets. (Maclennan & Tu 1996, Goodman & Thibodeau 2003, Watkins 2001, Pryce 2013)

3.3.3 Submarket – an elusive concept

The methods for defining submarkets described above have been criticised. Present submarket boundaries, in particular, have been regarded as implausible, and the concept of the law of one price as an attribute of submarket boundaries has also been criticised. The replaceability of a dwelling with another does not, as such, require the dwellings to be similar in terms of their structural characteristics or location. Even very different commodities may serve to satisfy the same needs. At the same time, it must be noted that the utility provided by the individual characteristics of certain dwellings may depend on the amount of the characteristics of certain other dwellings. The closeness, but not similarity, of the characteristics of dwellings is not sufficient to guarantee that they could be substitutes for each other. For this reason, caution is advisable in the interpretation of hedonic prices. If the price of a dwelling is divided into its components with a regression model, the results may not necessarily enable us to make conclusions as to which dwellings are substitutes for each other, i.e. which belong in the same submarket. It can also be considered that, due to the constantly changing demand and supply factors in the housing market, the market – here, the shadow prices of the different characteristics of dwellings – is constantly in a state of change. Consequently, the shadow prices of the different characteristics of dwellings in different submarkets can only be identical by coincidence. The nature of the spatial boundaries of submarkets may also vary. Spatial submarkets, if they are regarded to exist, do not need to form a unified geographical region, and the boundaries of submarkets are not necessarily clearly defined, but may, in some cases, resemble transition zones. (Pryce 2013)

Nor is there reason to assume the submarkets to be fixed in such a manner that a group of substitutes close to each other could not also change over time. This can be caused by changes in housing demand and supply. Although the housing stock has a long life span and housing conversion costs from one quality level to another (from one submarket to another) are high, these changes do occur. These transitions are based on the dwelling's own structural characteristics and how cost-efficiently the dwelling can be maintained at a certain quality level, as well as on changes in the demand conditions in different segments. The decrease in demand for lower-quality housing, for example, may result in the loss of incentives for the maintenance of the quality level in dwellings in their current use, i.e. at the current rate of return. If the quality deteriorates to a sufficiently low level, it may be worth demolishing the unit and replacing it with a new, more productive one. On the other hand, an increase in demand for a higher level of quality can create an incentive to improve the quality of the dwelling so that it is positioned in a higher quality category, in which case its return rate is also higher. (Rothenberg et al. 1991)

3.4 Empirical implementation of the hedonic model

3.4.1 Assumptions of the ordinary least squares model

In housing price studies that apply the hedonic price method, the key empirical research method is a regression model based on the ordinary least squares method (OLS). In this chapter, we will examine questions related to the estimation of the hedonic price model. The unbiasedness of the coefficient estimates generated by the OLS model and the efficiency of the estimators are based on a group of assumptions known as the Gauss-Markov assumptions.

The first question involves the model specification. The number of variables affecting housing prices may be considerably large. On the one hand, the variables may be strongly intercorrelated, and on the other, not all the variables considered significant may be available. Using too large a group of variables, i.e. in a situation in which the model includes irrelevant variables, leads to the inefficiency of the estimator. The standard errors of the model increase and the coefficient of determination of the model decreases. The problem with omitted variables, a situation in which a variable included in the model is correlated with an omitted variable, is more serious. This is called the endogeneity problem. The effect of an omitted variable on the dependent variable is, in this case, introduced by an error term. As the impact of the omitted variable correlates with the explanatory variable included in the model, one of the basic assumptions of the OLS model, the lack of correlation between the explanatory variables and the error term, does not apply. Estimation in the model produces biased coefficient estimates, as part of the omitted variable's effect on the dependent variable is conveyed to the coefficient estimate of the variable included in the model.

One solution to the endogeneity problem is provided by the instrument variable method, in which a variable correlated with the error term is replaced with an instrument variable. The instrument variable correlates with the original replaced variable but not with the error term. This enables unbiased estimation. In order to reduce the bias in the estimation of the hedonic price models caused by the spatially clustered omitted variables, which results from the fact that also the spatial error terms are clustered, a spatial variable, such as a statistical area specific indicator variable, is often added to the models to control the fixed variables. This significantly reduces the bias caused by omitted variables in coefficient estimates. (Verbeek 2008, Kuminoff et al. 2010). In addition, a multilevel model can be used which, unlike the fixed effects model, explicitly takes the variation between groups at the top level (such as residential area) into account. (Orford 2000, Costello et al. 2011). This is disregarded by the standard fixed effects model, which assumes that observations are independent of each other. The models can also be estimated using methods in which the errors in the model are cluster robust. (Cameron 2013)

Model specification also involves the question of the functional form of the estimating model. Choice of the wrong functional form can lead to the model being unable to explain a phenomenon, even if there is a link between the explanatory variables and the dependent variable used in the model. Basic models in the hedonic method tradition (Lancaster 1966, Rosen 1974) and subsequent literature only offer a limited amount of guidance for the choice of functional form (Orford 1999, Chin & Chau 2003). Drhymes (1971) argued that the limited amount of combinations of housing characteristics and the spatial clustering of similar units limits the models to covering only a small part of the equilibrium surface, so that there is probably no superior functional form that outperforms all others (Rothenberg et al. 1991). In many cases, a log-linear function (i.e. semi-log function) is chosen due to its many desirable features. First, the semi-log model allows the monetary value of each housing attribute to vary. From this, it follows that the attribute composition of a unit can influence the price of a single attribute. Second, the model has an intuitive interpretation. Third, the semi-log model allows the use of indicator variables as explanatory variables. (Halvorsen & Pollakowski 1981, Malpezzi 2002, Kuminoff et al. 2010).

Some studies also use the Box-Cox transformation for variables. When the Box-Cox transformation is applied, the functional form is not based on economic theory (a priori). Instead, it is estimated along the regression coefficients. The model estimated is

$$(3.15) \quad \frac{Y^{\delta}-1}{\delta} = \beta_0 + \sum_{j=1}^{q} \beta_j \frac{X_j^{\theta}-1}{\theta} + \varepsilon_i \,,$$

where Y is the dependent and X the explanatory variable, β_0, β_j, δ and θ parameters to be estimated and the error term. There is a family of transformations depending on the values of control parameters δ and θ. There are problems related to the use of the Box-Cox transformation, however. On the basis of an examination based on simulations, Cropper et al. (1988) suggested that, in a situation in which variables are missing from the model, a simple linear model (linear, log-linear, log-log) produces more accurate results describing marginal effects than a model based on the Box-Cox functional form, which is very flexible, but sensitive to missing variables. Neighbourhood level indicator variables considerably reduce the problem with regard to the spatial autocorrelation caused by the missing variables, however (Kuminoff et al. 2010). The interpretation of the Box-Cox model coefficient estimates is not straightforward, as a non-linear transformation is performed on the variables.

The final question related to model specification concerns measurement errors. We could assume that measurement errors are involved in the measurement and recording of variables correct as such. Obvious errors are easy to identify in the research data using various limit values, but lesser errors may be overlooked. There are several statistical models for testing a model specification. For example, endogeneity can be tested using the Hausmann test. The functional form can be tested using the reset test (Ramsey 1969), in which higher-order terms of explanatory variables are accommodated into the model and the F test is used to test whether one or more of these complementary terms are statistically significant. If this is the case, the model is deemed to be incorrectly specified. It can be regarded as a weakness of the method that it does not indicate the type of incorrect specification (Asteriou & Hall 2006).

The basic assumptions of the OLS model, i.e. the Gauss-Markov assumptions, include the assumption that the error terms in the model are normally distributed. If this assumption is not fulfilled, the unbiasedness of the coefficient estimates is reduced. Variable transformations are a common method to reduce the non-normal residuals problem, but even this may not be sufficient. A key factor in research data that distorts the distribution of the error terms is deviating observations. With regard to individual observations, for example, the so-called Cook test can be used to assess whether the observation is deviating. The Jarque-Bera test is often used to test the normality of the distribution; in the case of asymmetrical and, in general, less typical forms of distribution, the Cramer-von Mises or Shapiro-Wilk tests are applied (Thadewald Büning 2007).

Once the deviating observations (outliers) in the data are identified, there are several possible courses of action. The simplest method is to remove the outliers from the research data. In criticism of this course of action, it can be asked whether the removal of observations in the research data also reduces the amount of information. There are also alternatives to the removal of outliers. If the outliers are related to the dependent variable, it can be considered that an explanatory variable or variables affecting the dependent variable in an essential way is missing from the model. In this case, the outliers should be re-examined to assess whether complementary variables could be added to the model. If the outliers are related to the explanatory variables, various estimation methods re-weighting the data can be applied. So called outlier resistant regression methods offer an alternative to methods based on re-weighting. (Rousseeuw 2003)

The variance term of the error term is assumed to be independent of the model's dependent variables as well as of the missing variables. If this assumption does not apply, there is heteroscedasticity in the model. The coefficient estimates remain unbiased, but the estimators are inefficient. Heteroscedasticity can be caused by variables missing from the model, an incorrectly chosen functional form or measurement errors in the data. Heteroscedasticity can be tested with a variety of tests. The Breusch-Pagan test can be used to test heteroscedasticity if its form is linear, i.e. if the variance of the error term is in a linear relationship to one or more explanatory variables. If the form of heteroscedasticity is not known, the White test can be applied. As a solution to the heteroscedasticity problem, another type of functional form, variable transformations or the weighted least squares method can be used. The standard errors of the variables can also be estimated in a heteroscedasticity-consistent way, in which case the coefficient estimates of the model do not change, but the statistical inference takes the additional uncertainty caused by heteroscedasticity into account. It should be noted, however, that when applying this estimation, the standard error estimator is inefficient if there is no heteroscedasticity in the error term. (Asteriou & Hall 2006).

The least squares method is also based on the assumption that there is no full correlation between the variables in the model. If this assumption does not apply and there is perfect correlation between the variables, the least squares method is unable to distinguish the independent effect of the variables on the dependent variable. A strong but imperfect correlation between explanatory variables, on the other hand, makes the coefficient estimates unstable and sensitive to minor changes in the data. At the same time, it increases population variance, reducing the efficiency of the estimators. There are several methods to detect the correlation between variables. A correlation matrix can be used to detect the correlation between individual variables. The variance inflation factor method, for example, can be used for analysing higher-order correlation structures. A specific variable can be omitted from the model on the basis of a strong correlation between the variables. At the same time, however, the bias of the coefficient estimates increases due to the correlation between variables omitted from and included in the model. The amount of variables can also be reduced by using main component analysis, for example. (Asteriou & Hall 2006).

A basic assumption of the OLS model is also the lack of correlation between error terms, i.e. an assumption that $Cov\left(\varepsilon_i, \varepsilon_j\right) = 0$. In the case of cross-section datasets, this assumption is contradicted mainly by the spatial autocorrelation of error terms. There are several possible reasons for spatial autocorrelation. An incorrect functional form may have been chosen (for example, a non-linear relation is described using a linear function), or a spatially correlated explanatory variable may be missing from the model. There may also be an ecological bias related to a region-level variable. (Dubin 1998)

As described in this chapter above, the problem of a missing variable is often addressed by using the fixed effects technique, in which area-specific indicator variables, for example, are added to the model in an attempt to control the effect of the explanatory variables missing from the model. There are problems involved in the application of the fixed effects model, however. First, the addition of variables that describe fixed effects to the model significantly reduces the variation occurring in the data, hence increasing the (distorting) effect of incorrectly measured variables on the regression coefficients. Secondly, it is challenging to identify the correct areal level that accurately reflects the missing explanatory variables and the spatial division with which to add indicator variables to the model. Thirdly, applying the fixed effects technique in the form of area-specific indicator variables may cause problems if the variables under examination are also related to the residential area (and also vary by area). In this case, the fixed effects variables may absorb the effects of the variables under examination (Abbott & Klaiber 2011). Fourthly, in areas where there are very few observations, possibly just one, an indicator variable describing the area becomes a variable describing a single observation.

As a consequence of the spatially clustered error terms, the variance estimates are biased, most likely downward. As a result, the statistical standard errors of the coefficient estimates are too small and the obtained results too strong for some coefficient estimates in terms of statistical significance. In other words, coefficients in the regression model that, in reality, are not statistically significant, may be given t-test statistical values that indicate statistical significance. As a result of the spatial autocorrelation in the error terms, the OLS estimators are not efficient. It should be noted that adding indicator variables depicting fixed effects into the model does not necessarily eliminate the problems caused by the clustering of error terms and heteroscedasticity. One method is to estimate the standard errors, with the regression model coefficients as given, so as to correct the effect produced by error term clustering on the standard errors in the model. In the case of an ideal cluster structure, this method barely distorts the statistical standard errors, even if the error terms are not spatially clustered. However, the method is sensitive to the cluster structure of the data in the sense that an inadequate number of clusters, especially combined with imbalance in cluster-specific observation quantities, can produce highly inaccurate statistical standard error values. (Kezdi 2004, Cameron 2013)

In addition to the problems involved with the data and model specification as described above, there may also be spatial autocorrelation related to the dependent variable, which is problematic from the perspective of statistical inference and estimation. This is called spatial dependency.

3.4.2 Modelling submarkets

The definition of submarkets and the related difficulties were described in section 3.2. Empirical housing price studies often bypass this question altogether, instead choosing to model the housing market in an urban area as a whole. Of course, some studies do consider the aspect of submarkets.

If we are to understand submarkets as resulting in differences in the shadow prices of various dwelling attributes in the housing market within a certain area, this can be used in many different ways in housing price modelling. At the most basic level, we attempted to consider area-specific differences by means of district-specific indicator variables (fixed effects models, provided that the areas' standard terms are different). However, this excludes the possibility of area-specific differences occurring in the magnitude of factors influencing housing prices. The standard term should rather be regarded as encompassing the types of factors affecting housing prices that vary on area-specific basis and are missing from the model. If, instead, a random effects model is estimated, this allows area-based variation in the effects of factors affecting housing prices. However, the problem with this method is the way in which the boundaries of submarkets are defined. In many cases – usually as a result of limited data – various types of district boundaries based on statistical areas are used, and these may not correlate in any meaningful way with the boundaries created in the housing market.

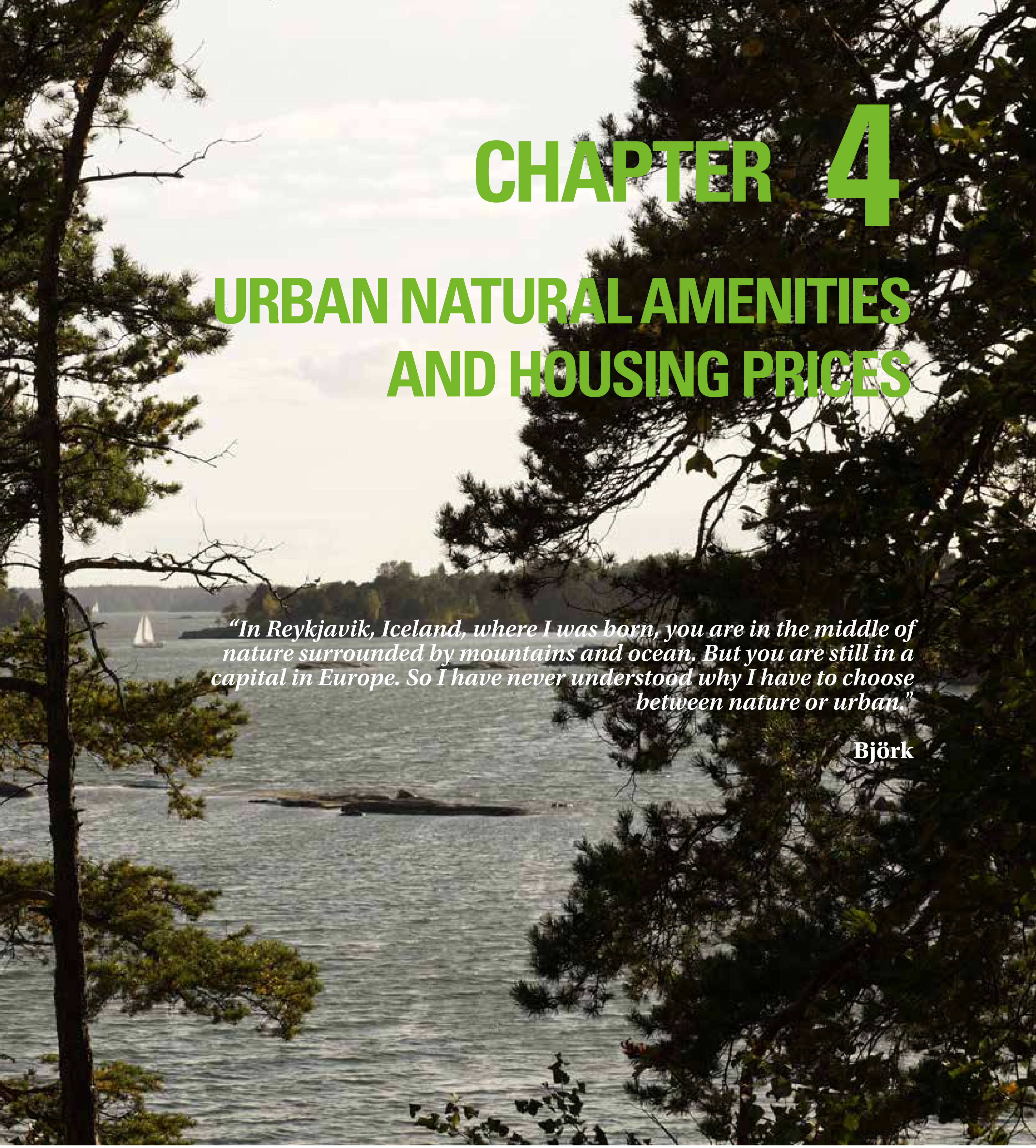
Orford (2000) based his analysis on fixed district boundaries, but depicted the dwelling as a commodity that, in accordance with the basic principles of the hedonic model, comprises several different attributes with different spatial levels. The structural attributes of dwellings are dwelling- and property-specific, but several dwellings and properties share the same residential area. This was the concept Orford employed to explain the use of multilevel modelling. (Orford 2000, Costello et al. 2011). Multilevel modelling is used in Chapter 4 of this work.

The division of a housing market into submarkets may not necessarily have to be defined in advance. An interaction term consisting of a variable describing location – e.g. distance to centre – and (another) explanatory variable that is being focused on, allows estimation of the impact of distance (in this case, distance to the centre) on the effects of the other explanatory variable. Yet on the other hand, variations between areas can only be discovered by utilising the pre-determined location variable's dimension (cf. Theriault et al. 2003). The interaction terms related to the pre-determined division into sub-areas (interaction between the indicator variables indicating districts and the explanatory variable being concentrated on) can also be used, but here, again, the definition of submarket boundaries becomes a problem.

One of the methods used in the research literature to account for spatial variation is Casetti's (1972) spatial expansion method. This method is based on the idea that the parameters of the global model can be a function of spatially variable factors. In this way, spatial variation can be introduced to coefficients. However, the method is not adequate in situations in which complex spatial variation occurs in parameter values. The reason for this is that, in the method, the form of spatial dependency is determined on the basis of assumptions made in the initial stages of modelling, and the method actually has more to do with spatial trend adaptation (Fotheringham et al. 1998, Carlton et al. 2009).

The most flexible widely used modelling method that takes spatial heterogeneity into account is the geographically weighted regression (GWR) model. Instead of sub-models based on the global model or pre-determined sub-market boundaries, the geographical regression model estimates a designated local model for each observation point. The key components of the geographically weighted regression model are moving window regression, including bandwidth selection, and the weighting scheme, which are used for weighting observations. The geographically weighted regression model is based on the idea that the impact of various factors (on the price of a dwelling, for example) decreases as the distance increases (distance decay). In geography, this phenomenon is known as **Tobler's First Law**. According to this "Everything is related to everything else, but near things are more related than distant things" (Tobler 1970). (Fotheringham et al. 2007; for an application on urban housing markets, see McCord et al. 2012)

A version of the geographically weighted regression model in which some parameters are stationary and others vary geographically has also been created. This model is called mixed GWR (Brundson et al. 1999). As a result of estimations, the mixed GWR model produces coefficients expressing the entire research area for some variables, and a set of models whose results can be expressed by means of variable-specific (map) interfaces for some variables. Geographically weighted regression models were also tested as part of this work (Chapter 4). However, the results obtained were rather sensitive to model specification, and these models are not included in the final version of the work.



CHAPTER 4

URBAN NATURAL AMENITIES AND HOUSING PRICES

"In Reykjavik, Iceland, where I was born, you are in the middle of nature surrounded by mountains and ocean. But you are still in a capital in Europe. So I have never understood why I have to choose between nature or urban."

Björk

4 URBAN NATURAL AMENITIES AND HOUSING PRICES

4.1 Introduction

In international terms, Finnish cities are not densely built. Some of this can be explained by Finland's late urbanisation, the result of which means that the urban spatial structure outside city centres reflects post-war ideas and ideals concerning urban construction. Due to the sparsely constructed building stock, the population densities in cities are also low by international comparison. For instance, the population density in Stockholm is twice that of Helsinki (Söderström et al. 2014). With the exception of the central areas of the largest cities, Finnish cities are characterised by clusters of blocks of flats surrounded by low-rise housing. As a counterbalance to the low building density, the availability of green areas in Finnish cities, including Helsinki, is rather substantial. For instance, calculated on the basis of research data included in this chapter (collected from the City of Helsinki), the distance between a green area – for our purposes: a park or recreational area measuring a minimum of one hectare – and any one dwelling is 284 metres on average. The share of unbuilt land within a 300-metre range of dwellings is 45% on average.

According to questionnaire surveys assessing valuations concerning housing, urban natural amenities form an important quality element of residential areas (Tyrväinen et al. 2007). Not only do people value them highly, but green areas also offer scientifically proven benefits. In addition to recreational opportunities, green areas reduce the adverse effects of urbanisation by improving air quality and the microclimate as well as reducing noise levels, for instance (Dwyer et al. 1992, Ridder et al. 2004, Tyrväinen et al. 2005). According to numerous studies, green areas also have positive effects on the physical and mental well-being of residents (Hartig et al. 2003, Korpela et al. 2008).

The effect of an attractive environment on housing prices may seem evident when looked at intuitively, but it is unclear which environmental factors make a location seem like a high-quality, pleasant place to live in, and how much people are willing to pay in order to obtain these amenities. According to the capitalisation hypothesis, housing prices should reflect differences in local public goods. However, it can be assumed that the value of nature is not capitalised into housing prices in full. Market prices can be expected to reflect the use values of nature, and not ones related to the existence of nature (Freeman 2003).

In this chapter, the hedonic pricing method is applied on housing price data collected in Helsinki, while also estimating regression models by means of which the effect of urban natural amenities on housing prices will be assessed. The focus is in price the price effects of proximity to parks, recreational areas and the coastline The research area was Helsinki and our research data covers the period between 2002 and 2004. Assessment only covers old dwellings in blocks of flats and row houses. The rest of this chapter is structured as follows: After the introduction (Section 4.1), earlier literature related to this research subject is reviewed (Section 4.2). Following chapters introduces estimation methods (Section 4.3) and research data (Section 4.4). The model estimation results will be introduced in Section 4.5 and discussed in Section 4.6.

4.2 Related literature

The following is a brief review of the research into the effects of urban natural amenities on housing prices. This review will concentrate on literature concerned with the price effects of green areas and water bodies.

Dombrow et al. (2000) studied data collected in Baton Rouge, Louisiana, between 1985 and 1994. In addition to variables related to the attributes of dwellings, the real estate agent's estimate of the lot's tree cover was included. They observed that fully-grown trees located on a lot had a positive price effect. It should be noted, however, that the research data used by the authors was relatively limited in scope. Moreover, factors pertaining to location and accessibility were controlled for at a rather modest level – by means of just one indicator variable. On the basis of research data from the Netherlands, Luttik (2000) observed that recreational areas have a distinct positive price effect when located within walking distance of a dwelling. Luttik (2000) concludes that "walking distance" may vary between 400 and 600 metres. According to some studies conducted in the United States regarding sales of detached houses (Shultz & King 2001, Lutzenhiser & Netusil 2001), the proximity of a park may also reduce the price of a house, which can be at least partially explained by congestion and anti-social behaviour occurring in parks and near them, according to the authors. Kestens et al. (2004) analysed data on sales of detached houses collected in Quebec, Canada. Information related to tree cover based on satellite and aerial photography data was included in the housing price data in their study. According to their results, trees located on the lot substantially increased the value of a house, but trees located near the lot but outside of it had the reverse effect. The latter result is somewhat surprising, since the effect of factors such as accessibility were controlled for in the model.

In addition to the proximity of green areas, their size may have a separate effect on housing prices. The proximity and size of green areas may also have a joint effect. Powe et al. (1997) used this perspective to analyse data collected in Southampton in the United Kingdom. They construed a forest access index. This index combines accessibility and the size of a forest area in one figure. Increasing proximity to forest area and size of forest area elevate the index value. Powe et al. (1997) found a clear-cut positive relationship between housing prices and the forest access index. On the other hand, Anderson and West (2006) argued that the price effect of open space varies a great deal depending on the area's distance from the centre and population density. They analysed housing transaction data on detached houses collected in the Minneapolis-St. Paul area in the United States. The price effect of open space was significant in densely constructed areas located closer to the city centre, whereas in sparsely constructed areas on the outskirts of the city it was almost entirely inconsequential.

Cho et al. (2006) used housing transaction data covering the period between 1991 and 2004 collected in Knox County, Tennessee to analyse the effect of green areas and water bodies on housing prices. They used the conventional OLS method and a geographically weighted regression model. The results of the OLS method were compared with the median of the regression models' coefficient estimates calculated using the geographically weighted method. According to their results, the effects of green areas and water bodies exhibit notable regional variation. However, interpretation of the coefficients measuring distance from green areas and water bodies is somewhat problematic in connection with the weighted regression model, since some of these obtained a positive prefix symbol. Therefore, the question arises: were variables with strong correlation with these variables missing from the model?

The type of green area and water body may also impact on what kind of price effect on housing is generated. Of the studies analysing the price effect of open spaces, Bolitzer and Netusil (2000), Irwin and Bockstael (2001) and Irwin (2002) concluded that open spaces having a conservation status had the greatest positive effect on housing prices.

In addition to the proportional share of distances and forms of land use, the view from a dwelling also had a notable impact on the price of that dwelling. In studies conducted in the United States, Bond et al. (2002) and Benson et al. (2000) proved that a view of a water body entailed a clear positive price effect. Luttik (2000) analysed data collected in the Netherlands and reached the same conclusion. Jim and Chen (2006) analysed data collected in Guangzhou, China. According to their results, the view from a dwelling had a significant effect on its sale price. A view of a green area increased a dwelling's price by 7.1 per cent, while that of a water body increased its price by 13.2 per cent. Also, based on data from Jinan, Kong et al. (2007) applied several different measures of urban natural amenities (size-distance index, accessibility and land use variables). They found clear evidence for the positive effects of urban natural amenities on housing prices. Zhang et al. (2012) analysed data from Beijing. They used district level average price of a dwelling as a dependent variable and used different environment related variables, including distance to nearest park and the coverage rate of green space, as explanatory variables. They found that urban natural amenities have clear impact on housing prices. McCord et al. (2014) analysed data from Belfast housing markets. They used distance to open space, alongside control variables, as explanatory variable. Models were estimated separately for different property types. Their results implicated that flats and row houses close to open space were substantially more expensive than units further away. Especially strong was the effect of open space to price of dwellings in flats. For detached and semi-detached properties price effects were much smaller and mostly statistically insignificant.

The effects of urban natural amenities, open spaces and water bodies on housing prices have also been studied in Finland. Tyrväinen (1997) and Tyrväinen and Miettinen (2000) studied the effect of factors such as urban forests on housing prices. Tyrväinen (1997) analysed housing price data collected in Joensuu in Eastern Finland and found that the proximity of recreational areas had a distinct increasing effect on housing prices. On the other hand, small forest-like parks had a negative effect, which Tyrväinen interpreted as resulting from the shade they might throw on buildings. Tyrväinen and Miettinen (2000) studied housing price data collected in Salo in south-western Finland. According to their research, a view of a forest and proximity to a forest-like area both had a positive effect on housing prices. Laakso (1997), using data collected in Helsinki, and Tyrväinen (1997), analysing data collected in Joensuu, have proved the positive price effect of proximity to a shoreline. Moreover, Laakso (1997) proved that the proportion of open space had a positive relationship with housing prices. Tyrväinen et al. (2006) and Tyrväinen and Lönnqvist (2007) analysed data from eastern and northern suburbs of Helsinki. According to their results, coastline distance (eastern Helsinki) and Central Park distance (northern Helsinki) had statistically significant effect on housing prices.

4.3 Methods

The hedonic pricing model is used as the research method. The principles of this method were outlined in Chapter 3. As regards the first research question – the general effects of urban natural amenities on housing prices – the normal OLS method and the mixed models method are applied to the estimation of price models. Two approaches are applied to the second research question, which is related to potential spatial variation in shadow prices of urban natural amenities. Price models are estimated for the entire research area and separately on the basis of area (central part of the city and suburbs) and building type (flats and row houses). In addition to OLS models, price models are estimated using the mixed models method.

In a previous chapter on research methodology (Section 3.2), it was argued that neither the basic theory of hedonic pricing (Lancaster 1966, Rosen 1974) nor subsequent applications of the theory provide many guidelines for selecting the functional form of the estimating model (Orford 1999, Chin & Chau 2003). Either log-linear specification or log-log specification is normally used in research in this field. The preliminary analyses of the data included in this study revealed that, based on Ramsey's Reset-test (Verbeek 2008), quadratic functional forms outperform the simple linear model. However, since simple log-log specification is a more robust method with regard to distortions created by missing variables, log-log specification is applied. Another factor supporting this selection is the heightening of the problems related to the correlation between explanatory variables when using the quadratic functional form (Cropper et al. 1988). Reported standard errors in OLS models are heteroskedasticity-consistent (HCC) and cluster-robust (CR). Problems related to the estimation of cluster-robust mean errors were discussed in Subsection 3.4.1.

Multicollinearity is assessed using the variance inflation factor (VIF). High VIF values indicate a potential multicollinearity problem. In spite of this, it is difficult to find a specific limit value for problematic multicollinearity in the field's literature (Draper & Smith 1998). Furthermore, 0.8 is considered to be a critical value in pair correlations between variables. The structural stability of coefficients – e.g. variables' difference between two different areas – is tested by means of the Chow test (Verbeek 2008). OLS models comprise district-specific fixed effects variables that are used in an attempt to reduce the impact of explanatory variables that vary on a district-specific basis and are missing from the model. In addition, the bootstrapping technique applied. In this method, sampling with replacement is used on representative samples. This simulates a situation in which sampling is performed on the entire population. Regression models are estimated on the basis of these samples. The averages of the different models' coefficient estimates are presented as results (Appendix C).

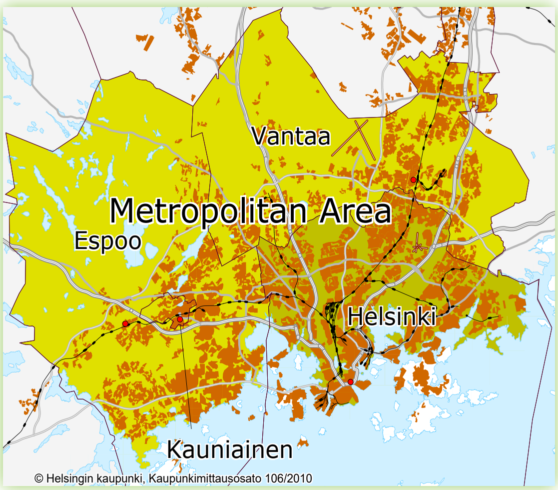
The mixed models method is used as an alternative approach to the normal one-tier OLS model. The starting point for the mixed models method is the assumption of the multilevel, hierarchical structure of the fundamental set. The fundamental set can be seen as being divided into clusters. Observations belonging to the same cluster are often quite similar to one another, as a result of which observation units are not independent of one another. Intraclass correlation is used for expressing similarity within clusters. If this intracluster correlation structure is not taken into account in modelling, it results in erroneous regression coefficients in the statistical model as well as erroneous mean errors of the coefficient estimates. The sub-district level is used as the clustering level. In Appendices D and E, the estimation results of the models based on alternative clustering levels are also presented.

4.4 Study area and data

The study area is the city of Helsinki (Map 4.1). Since the focus of this study is on blocks of flats and row houses, there are very few observations from some areas which have a preponderance of detached houses. The building stock in central Helsinki almost exclusively comprises blocks of flats. On the other hand, suburban areas is more diverse.

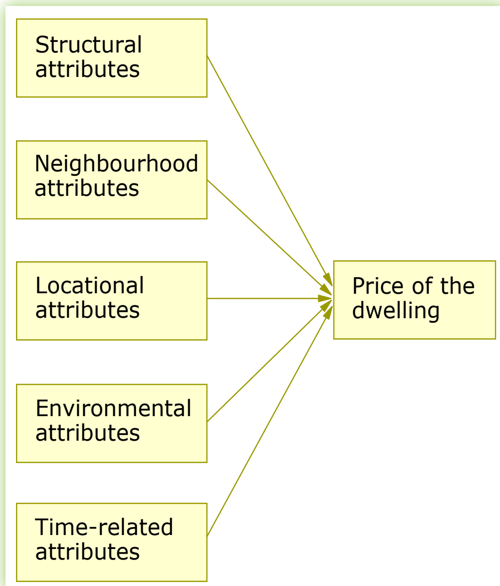
The share of green space is 29% of the total administrative land area of the city. Helsinki is one of the five European cities (of 26 investigated) where the inhabitants still have large amounts of green area, at least 100 square metres per capita, at their disposal (Bono et al. 2006). A large uninterrupted recreational area extends from central Helsinki to the city's border in the north. The seashore can be found in the eastern and south-eastern suburban areas, central parts, and some parts of western Helsinki.

Figure 4.1 Study area



VTT Technical Research Centre of Finland Ltd's data on dwellings sold in time period 2002–2004 was used as the research data, and is presented in more detail in Appendix A. The data includes a rather comprehensive set of variables pertaining to the sold dwellings (Table 4.1). In addition to these, a group of accessibility variables, a variable indicating the socioeconomic status of the district, and a group of variables expressing the natural elements of the residential environment were calculated for each observation, or dwelling. The research data includes five types of explanatory variables (figure 4.2).

Figure 4.2 Variable types



Environmental variables were constructed from remote sensor images, digitalised town plan maps and digital maps, and socioeconomic data was obtained from data is based on the Helsinki Region Statistics Database (Aluesarjat). Theaerial image data dates from 2003, which was the middle of the research period. The classification of green areas is based on forest inventory data compiled by the City of Helsinki. The infrastructure data was obtained from the Seutu-CD database maintained by the now-defunct Helsinki Metropolitan Area Council (YTV). This database comprises map data as well as information on the road network and building stock. Map data on recreational areas and plan data related to city planning was used to supplement this digital data.

All green areas used by the public (totalling over 0.3 hectares) were categorised into three categories: recreational areas (over 50 hectares), local recreational areas (under 50 hectares), and other green areas (Figure 4.3). The last category comprises areas of greatly varying sizes that are not actual recreational areas or are unsuitable for such use, including various kinds of bumper zones between streets and buildings. Esri's ArcView software was used as the primary tool for construing environmental variables. (Tyrväinen et al.2006)

Variables related to residential environment and location of dwelling can be divided into the following categories: distance via the street network, straight line distance, proportional variables, and indicator variables (Table 4.1). Distances via the street network were calculated using the ArcGIS Network Analyst extension tool. Logarithm transformation of distance variables was used in regression models. The proportional variables indicating proportional land use were calculated for ranges of both 100 and 101 - 300 metres, with the property in question as the central point.

The majority of control variables were obtained directly from the housing price

Figure 4.3 Example of formation of land use variables: measuring green space around dwellings

Olli Leino

data. These variables included the size and age of the dwelling, type of building, number of floors, floor of dwelling, and an indication of the maintenance charge. Data on lot ownership was originally obtained from the housing transaction data, but the data was later harmonised and corrected using map data on the lots rented out by the city. The variable indicating area's socioeconomic structure was composed by applying principal component analysis to five background variables, which were the unemployment rate, the share of the foreign language-speaking population, income level, the share of single-parent families, and the share of social rental dwellings of the building stock. The data was collected at the district level. The factor point number of primary component analysis was used as an indicator of the socioeconomic status of a district. General developments in housing prices were controlled for by including quarter-level indicator variables in the models. In the case of some variables, missing information was encoded into dedicated variables for each variable group.

4.5 Results

4.5.1 Descriptive statistics

The research data comprised 7,090 housing transactions. Some 6,292 (88.7%) of these were sold dwellings in blocks of flats, while 798 (11.3%) were sold dwellings in row houses. One in four of the dwellings were located in properties built on rented lots. Over 70 per cent of the housing transactions included in the data were of a kind where the real estate agent had recorded information on the condition of the sold dwelling. Measured on a three-tier scale, almost 40 per cent of the sold dwellings were classified as being in good condition, nearly 30 per cent were rated as being in fair condition, and only three per cent were classified as being in poor condition. The majority of the sold dwellings were not being leased at the time of purchase. The average distance from central Helsinki was around 6.5 km, while the average distance from the nearest secondary business district (SBD) was some 3.2 km. The nearest park or other type of green area was located at an average distance of some 280 metres, and the nearest recreational area was located 1.6 km away.

Table 4.1 Descriptive statistics

Variable	Continuous variables				Dichotomous variables
	Mean	Standard deviation	Min.value	Max. value	Relative share, %
Floor area (sqm)	59.43	31.90	15.00	360.00	
Age of dwelling (years)	45.89	22.90	1.00	150.00	
Own lot					75.70
Rented lot					24.30
Condition, good					39.60
Condition, satisfactory					28.80
Condition, poor					3.30
Condition, unknown					28.30
Rental status, rented					3.30
Rental status, free					86.40
Rental status, unknown					10.30
Row house					11.30
Location 1.floor					17.8
Location 2.floor					21.7
Location 3.floor					20.3
Location 4.floor					12.2
Location 5.floor					6.7
Location 6.floor					4.8
Location 7.floor					2.1
Location 8.floor or higher					1.1
Location unknown					2
Block of flats, number of floors 2					3.5
Block of flats, number of floors 3					19.3
Block of flats, number of floors 4					21.6
Block of flats, number of floors 5					10.1
Block of flats, number of floors 6					13.7
Block of flats, number of floors 7					8.7
Block of flats, number of floors 8 or more					8.5
Block of flats, number of floors unknown					3.2
Distance to CBD (m)	6,544.51	4,305.50	280.02	16,239.15	
Distance to SBD (m)	3,216.97	1,726.83	108.81	8,830.96	

Table 4.1 Descriptive statistics *(cont.)*

Variable	Continuous variables				Dichotomous variables
	Mean	Standard deviation	Min.value	Max. value	Relative share, %
Socioeconomic status, index	0.08	0.82	-2.31	2.40	
Distance to nearest metro or railway station (m)	1,366.65	910.70	0.36	6,182.30	
Distance to coastline (m)	1,574.83	1,699.39	10.00	8,127.64	
Distance to nearest park or forest (m)	284.11	253.18	9.51	1,510.19	
Distance to recreational area (m)	1,641.95	1,405.26	10.00	6,551.39	
Green space %, 100m buffer	33.18	13.31	6.15	80.01	
Green space %, 101-300m buffer	28.30	9.90	7.64	78.63	
Recreational areas %, 100m buffer	8.38	11.15	0.00	61.00	
Recreational areas %, 101-300m buffer	16.89	13.64	0.07	77.33	
Maintenance charge, 0 e/sqm/month					7.60
Maintenance charge, 1 e/sqm/month					5.70
Maintenance charge, 2 e/sqm/month					32.60
Maintenance charge, 3 e/sqm/month					40.00
Maintenance charge, 4 e/sqm/month					8.80
Maintenance charge, 5 e/sqm/month					2.30
Maintenance charge, over 5 e/sqm/month					3.00
Transaction time 1/2002					7.20
Transaction time 2/2002					6.40
Transaction time 3/2002					6.70
Transaction time 4/2002					6.70
Transaction time 1/2003					8.40
Transaction time 2/2003					8.30
Transaction time 3/2003					8.50
Transaction time 4/2003					8.60
Transaction time 1/2004					8.00
Transaction time 2/2004					10.00
Transaction time 3/2004					9.50
Transaction time 4/2004					11.60

Table 4.2 Correlation matrix, selected variables

	Unbuilt area, % 100 meter buffer	Unbuilt area, % 101-300 meter buffer	Parks and yards, % 100 meter buffer	Parks and yards, % 101-300 meter buffer
Unbuilt area, % 100 meter buffer	1.00	0.85	0.77	0.59
Unbuilt area, % 101–300 meter buffer	0.85	1.00	0.68	0.57
Parks and yards, % 100 meter buffer	0.77	0.68	1.00	0.72
Parks and yards, % 101–300 meter buffer	0.59	0.57	0.72	1.00
Recreational areas, % 100 meter buffer	0.64	0.51	0.00	0.07
Recreational areas, % 101–300 meter buffer	0.61	0.80	0.31	-0.02
Distance to CBD	0.69	0.68	0.62	0.58
Distance to closest SBD	0.48	0.49	0.42	0.35

	Recreational areas, % 100 meter buffer	Recreational areas, % 101-300 meter buffer	Distance to CBD	Distance to closest SBD
Unbuilt area, % 100 meter buffer	0.64	0.61	0.69	0.48
Unbuilt area, % 101–300 meter buffer	0.51	0.80	0.68	0.49
Parks and yards, % 100 meter buffer	0.00	0.31	0.62	0.42
Parks and yards, % 101–300 meter buffer	0.07	-0.02	0.58	0.35
Recreational areas, % 100 meter buffer	1.00	0.58	0.32	0.25
Recreational areas, % 101–300 meter buffer	0.58	1.00	0.41	0.35
Distance to CBD	0.32	0.41	1.00	0.28
Distance to closest SBD	0.35	0.35	0.28	1.00

The building stock in the urban area features significant structural variation. The building stock in central Helsinki (Map 4.1) comprises virtually only blocks of flats, whereas about 20 per cent of the dwellings in suburban areas are in row houses or are single-family houses. Significant differences between the areas also exist with regard to urban natural amenities. In Helsinki's central areas, the nearest park or other type of green area is located at an average distance of 415 metres, while in the suburban areas this distance is only 190 metres. The share of green space - private yard areas, parks and other small green areas - is substantially higher in the suburban areas than in central Helsinki. In the suburban areas, they amount to some 40 per cent of the surface area at an average distance of 100 metres from dwellings. In city centre, this figure is 23 per cent. The seashore is significantly closer in central Helsinki than in the city's suburban areas. In central Helsinki, the average distance to the seashore is some 570 metres; in the suburban areas it is 2,270 metres away.

Logarithm-transformed forms of the majority of the aforementioned continuous variables were used in the price models. These variables were the purchase price, size and age of the dwelling, as well as variables related to accessibility and land use in the residential environment. The alternative to logarithm transformation would have been to use various levels of function transformation. This kind of model specification would have enabled more flexible consideration of non-linear relations than logarithm transformation. These models were indeed tested. However, the modelling method based on logarithm transformation was selected since, due to the rather strong correlation between variables, the coefficient estimates are quite unstable in the modelling method based on different powers of the same variable.

The correlation structures between variables were analysed in pairs between variables (Table 4.2) and by means of the variance inflation method (VIF) in connection with regression modelling. In the pair analysis, no high correlations (over 0.8) were found between variables measuring distance to central business district (distance to CBD) or to closest secondary business district (distance to SBD) and land use variables. The only significant, potentially problematic VIF coefficients connected to regression modelling resulted from sub-district-level indicator variables. Their inclusion in the model also increases the VIF values expressing distance to main centre and sub-centre, socioeconomic status and distance to seashore to a relatively high level (values exceeding 10). With the exception of distance to seashore, the role of these variables is to act as control variables in the models, which means that the problem posed by correlation structures is a relatively minor one.

4.5.2 OLS models

The estimated price equation in the case of the one-tier OLS model is

$$\mathbf{P} = \boldsymbol{\alpha} + \mathbf{X}\boldsymbol{\beta}_1 + \mathbf{D}\boldsymbol{\beta}_2 + \mathbf{e} \tag{4.1}$$

wherethe **P** the (log) price vector of dwellings, **X** is a (log) vector of continuous variables describing the structure, environmental features, socioeconomic structure and accessibility of dwellings and **D** is a vector of dummy variables for the type of building, lot ownership, condition of the dwelling, maintenance costs, number of floors, location (floor) and transaction year and quarter. $\boldsymbol{\beta}_1$ and $\boldsymbol{\beta}_2$ are the respective vectors of regression coefficients to be estimated and **e** is the vector of error terms.

Area-specific indicator variables (district-level indicator variables) and variables indicating the date of purchase explain around 33 per cent of the variation in a dwelling's purchase price (Table 4.3, Model 4.1). From this starting point, variables are added to the model in stages. Model 4.2, comprising only variables indicating a dwelling's attributes, explains almost 93 per cent of the variation in the explained variable. Subsequently, variables indicating a dwelling's general accessibility and sub-district-specific indicator variables are included (Model 4.3). In the fourth stage, distance variables related to urban natural amenities (Model 4.4) and variables related to land use (Model 4.5) are included in the model. Finally, a model including both distance variables pertaining to urban natural amenities and variables related to land use is estimated (Model 4.6). The inclusion of variables pertaining to urban natural amenities has only a marginal impact on the models' coefficient of determination. Some of this may be explained by the fact that the price effects of variables pertaining to urban natural amenities may be transferred to area-specific (district-level) indicator variables in models in which the said variables are not included.

The regression coefficients of control variables complied with expectations. Such factors as increased size of dwelling, row house as type of house, good condition of dwelling, and location of dwelling on upper floors all increased the price of a dwelling. As anticipated, increased distance to both the main centre and sub-centre reduce the price of a dwelling. Maintenance charge variables also behaved in accordance with expectations. A maintenance charge exceeding EUR 5 per square metre had a strong impact on the purchase price of dwellings.

Of the distance-related variables pertaining to urban natural amenities (Model 4.4), distance to seashore and distance to nearest green area functioned as expected, and obtained negative statistically significant prefix symbols, with distance to seashore having the strongest impact on housing prices. On the other hand, distance to recreational area obtained a positive prefix symbol. This unexpected result is difficult to explain.

When analysing the model that only comprises variables pertaining to land use in a residential area (Model 4.5), these variables all obtain positive and, for the main part statistically significant, prefix symbols. The positive price effect of the share of green space – yard areas, parks and other small green areas – is greater than that of recreational areas. However, the inclusion of both variable groups in the same model (Model 4.6) yields somewhat different results. The most significant change in this event is that the price effect of the nearest green area becomes statistically insignificant.

The bootstrapping method was used for supplementing results obtained using the normal OLS method (Appendix C). Sampling with replacement was used for picking 1,000 samples from the original data. These results are very close to results obtained using normal OLS estimation. The positive price effect of a short distance to a seashore, green space located within a range of 101–300 metres and recreational areas located within 100 metres of a dwelling is evident in both the normal OLS model and the OLS model based on the bootstrapping method.

Table 4.3 OLS models

	MODEL 4.1			MODEL 4.2		
	ONLY FIXED EFFECTS			CONTROLS WITHOUT LOCATION		
	Param.est.	**Pr > |t| (HCC)**	**Pr > |t|(CR)**	**Param.est.**	**Pr > |t| (HCC)**	**Pr > |t|(CR)**
Intercept	12.0071	<.0001	<.0001	8.7788	<.0001	<.0001
Log floor area				0.8374	<.0001	<.0001
Log age of dwelling				-0.0319	<.0001	0.0024
Own lot				ref.		
Rented lot				-0.0739	<.0001	<.0001
Row house, no				ref.		
Row house, yes				0.1454	<.0001	<.0001
Condition, good				0.0832	<.0001	<.0001
Contition, satisfactory				ref.		
Condition, poor				-0.0749	<.0001	<.0001
Condition, unknown				0.0317	<.0001	<.0001
Rental status, free				ref.		
Rental status, rented				-0.0453	<.0001	0.0001
Rental status, unknown				-0.0185	0.0003	0.0167
Location 1. floor				ref.		
Location 2. floor				0.0329	<.0001	<.0001
Location 3. floor				0.0386	<.0001	<.0001
Location 4. floor				0.0644	<.0001	<.0001
Location 5. floor				0.0675	<.0001	<.0001
Location 6. floor				0.0887	<.0001	<.0001
Location 7. floor				0.0889	<.0001	<.0001
Location 8. floor or upper				0.0322	0.0467	<.0001
Location unknown				0.0237	<.0001	0.0666
Block of flats, number of floors 2				ref.		
Block of flats, number of floors 3				-0.0514	<.0001	0.0069
Block of flats, number of floors 4				-0.0507	<.0001	0.0175
Block of flats, number of floors 5				-0.0508	<.0001	0.0349
Block of flats, number of floors 6				-0.0606	<.0001	0.0304
Block of flats, number of floors 7				-0.0617	<.0001	0.0187
Block of flats, number of floors more than 7				-0.0920	<.0001	0.0005
Block of flats, number of floors unknown				-0.0508	0.0002	0.0513
Log distance to CBD						
Log distance to closest SBD						

Table 4.3 OLS models *(cont.)*

	MODEL 4.1			MODEL 4.2		
	ONLY FIXED EFFECTS			CONTROLS WITHOUT LOCATION		
	Param.est.	**Pr > |t| (HCC)**	**Pr > |t|(CR)**	**Param.est.**	**Pr > |t| (HCC)**	**Pr > |t|(CR)**
Log distance to nearest metro or railway station (m)						
Socioeconomic status index						
Log distance to coastline						
Log distance to nearest park or forest						
Log distance to nearest recreational area						
Log % of green space in 100m buffer						
Log % of green space in 101-300m buffer						
Log % of recreational areas in 100m buffer						
Log % of recreational areas in 101-300m buffer						
Maintenance charge, 0e/sqm/month				-0.0210	0.0428	0.0931
Maintenance charge, 1e/sqm/month				ref.		
Maintenance charge, 2e/sqm/month				-0.0126	0.1467	0.2403
Maintenance charge, 3e/sqm/month				-0.0258	0.0036	0.0246
Maintenance charge, 4e/sqm/month				-0.0304	0.0033	0.0218
Maintenance charge, 5e/sqm/month				-0.0609	0.0002	0.0007
Maintenance charge, over 5e/sqm/month				-0.2919	<.0001	<.0001
Sub-district level fixed effects	yes			yes		
Transaction time fixed effects	yes			yes		
Adjusted R2	0.3246			0.9234		
N	7091			7091		
Estimation method (SAS)	PROC REG/PROC SURVEYREG			PROC REG/PROC SURVEYREG		

HCC SE = heteroskedasticy consistent standard errors

CR = cluster robust

Table 4.3 OLS models (*cont.*)

	MODEL 4.3			MODEL 4.4		
	CONTROLS WITH LOCATION			CONTROLS AND DISTANCES		
	Param.est.	**Pr > |t| (HCC)**	**Pr > |t|(CR)**	**Param.est.**	**Pr > |t| (HCC)**	**Pr > |t|(CR)**
Intercept	9.5141	<.0001	<.0001	9.6994	<.0001	<.0001
Log floor area	0.8345	<.0001	<.0001	0.8337	<.0001	<.0001
Log age of dwelling	-0.0369	<.0001	<.0001	-0.0353	<.0001	<.0001
Own lot	ref.			ref.		
Rented lot	-0.0686	<.0001	<.0001	-0.0690	<.0001	<.0001
Row house, no	ref.			ref.		
Row house, yes	0.1445	<.0001	<.0001	0.1421	<.0001	<.0001
Condition, good	0.0833	<.0001	<.0001	0.0832	<.0001	<.0001
Contition, satisfactory	ref.			ref		
Condition, poor	-0.0767	<.0001	<.0001	-0.0762	<.0001	<.0001
Condition, unknown	0.0318	<.0001	<.0001	0.0309	<.0001	<.0001
Rental status, free	ref.			ref		
Rental status, rented	-0.0430	<.0001	<.0001	-0.0423	<.0001	<.0001
Rental status, unknown	-0.0177	0.0005	0.0065	-0.0169	0.0008	0.0096
Location 1. floor	ref.			ref		
Location 2. floor	0.0226	<.0001	<.0001	0.0219	<.0001	<.0001
Location 3. floor	0.0323	<.0001	<.0001	0.0315	<.0001	<.0001
Location 4. floor	0.0359	<.0001	<.0001	0.0361	<.0001	<.0001
Location 5. floor	0.0633	<.0001	<.0001	0.0633	<.0001	<.0001
Location 6. floor	0.0663	<.0001	<.0001	0.0653	<.0001	<.0001
Location 7. floor	0.0875	<.0001	<.0001	0.0868	<.0001	<.0001
Location 8. floor or upper	0.0825	<.0001	<.0001	0.0810	<.0001	<.0001
Location unknown	0.0310	0.0559	0.0748	0.0290	0.0719	0.0930
Block of flats, number of floors 2	ref.			ref		
Block of flats, number of floors 3	-0.0549	<.0001	0.0005	-0.0520	<.0001	0.0008
Block of flats, number of floors 4	-0.0533	<.0001	0.0040	-0.0479	<.0001	0.0081
Block of flats, number of floors 5	-0.0563	<.0001	0.0052	-0.0542	<.0001	0.0057
Block of flats, number of floors 6	-0.0673	<.0001	0.0014	-0.0622	<.0001	0.0024
Block of flats, number of floors 7	-0.0632	<.0001	0.0029	-0.0598	<.0001	0.0038
Block of flats, number of floors more than 7	-0.0954	<.0001	<.0001	-0.0936	<.0001	<.0001
Block of flats, number of floors unknown	-0.0556	<.0001	0.0120	-0.0536	<.0001	0.0136
Log distance to CBD	-0.1334	<.0001	<.0001	-0.1188	<.0001	<.0001
Log distance to closest SBD	-0.0156	0.2098	0.3632	-0.0245	0.0503	0.1615

Table 4.3 OLS models *(cont.)*

	MODEL 4.3			MODEL 4.4		
	CONTROLS WITH LOCATION			CONTROLS AND DISTANCES		
	Param.est.	Pr > |t| (HCC)	Pr > |t|(CR)	Param.est.	Pr > |t| (HCC)	Pr > |t|(CR)
Log distance to nearest metro or railway station (m)	0.0194	0.0001	0.0024	0.0167	0.0007	0.0092
Socioeconomic status index	0.1978	<.0001	<.0001	0.1395	0.0003	0.0001
Log distance to coastline				-0.0313	<.0001	0.0006
Log distance to nearest park or forest				-0.0061	0.0016	0.0265
Log distance to nearest recreational area				0.0079	0.0030	0.0182
Log % of green space in 100m buffer						
Log % of green space in 101-300m buffer						
Log % of recreational areas in 100m buffer						
Log % of recreational areas in 101-300m buffer						
Maintenance charge, 0e/sqm/month	-0.0185	0.0625	0.0682	-0.0192	0.0525	0.0623
Maintenance charge, 1e/sqm/month	ref.			ref		
Maintenance charge, 2e/sqm/month	-0.0108	0.2044	0.2278	-0.0125	0.1388	0.1611
Maintenance charge, 3e/sqm/month	-0.0241	0.0055	0.0075	-0.0262	0.0025	0.0038
Maintenance charge, 4e/sqm/month	-0.0293	0.0042	0.0078	-0.0322	0.0016	0.0038
Maintenance charge, 5e/sqm/month	-0.0602	0.0002	0.0002	-0.0627	<.0001	0.0001
Maintenance charge, over 5e/sqm/month	-0.2917	<.0001	<.0001	-0.2909	<.0001	<.0001
Sub-district level fixed effects	yes			yes		
Transaction time fixed effects	yes			yes		
Adjusted R2	0.9248			0.9256		
N	7,091			7,091		
Estimation method (SAS)	PROC REG/PROC SURVEYREG			PROC REG/PROC SURVEYREG		

HCC SE= heteroskedasticy consistent standard errors

CR = cluster robust

Table 4.3 OLS models *(cont.)*

	MODEL 4.5 CONTROLS AND LAND USE			MODEL 4.6 FULL MODEL		
	Param,est,	Pr > |t| (HCC)	Pr > |t|(CR)	Param,est,	Pr > |t| (HCC)	Pr > |t|(CR)
Intercept	9.4492	<.0001	<.0001	9.6189	<.0001	<.0001
Log floor area	0.8345	<.0001	<.0001	0.8339	<.0001	<.0001
Log age of dwelling	-0.0377	<.0001	<.0001	-0.0359	<.0001	<.0001
Own lot	ref.			ref.		
Rented lot	-0.0694	<.0001	<.0001	-0.0681	<.0001	<.0001
Row house, no	ref.			ref.		
Row house, yes	0.1404	<.0001	<.0001	0.1398	<.0001	<.0001
Condition, good	0.0841	<.0001	<.0001	0.0839	<.0001	<.0001
Contition, satisfactory	ref.			ref.		
Condition, poor	-0.0755	<.0001	<.0001	-0.0754	<.0001	<.0001
Condition, unknown	0.0323	<.0001	<.0001	0.0315	<.0001	<.0001
Rental status, free	ref.			ref.		
Rental status, rented	-0.0452	<.0001	<.0001	-0.0435	<.0001	<.0001
Rental status, unknown	-0.0169	0.0009	0.0084	-0.0163	0.0012	0.0243
Location 1. floor	ref.			ref.		
Location 2. floor	0.0227	<.0001	<.0001	0.0220	<.0001	<.0001
Location 3. floor	0.0320	<.0001	<.0001	0.0314	<.0001	<.0001
Location 4. floor	0.0355	<.0001	<.0001	0.0357	<.0001	<.0001
Location 5. floor	0.0630	<.0001	<.0001	0.0632	<.0001	<.0001
Location 6. floor	0.0658	<.0001	<.0001	0.0651	<.0001	<.0001
Location 7. floor	0.0875	<.0001	<.0001	0.0870	<.0001	<.0001
Location 8. floor or upper	0.0806	<.0001	<.0001	0.0798	<.0001	0.0002
Location unknown	0.0307	0.0566	0.0852	0.0295	0.0654	0.0745
Block of flats, number of floors 2	ref.			ref.		
Block of flats, number of floors 3	-0.0546	<.0001	0.0004	-0.0516	<.0001	0.0016
Block of flats, number of floors 4	-0.0541	<.0001	0.0022	-0.0480	<.0001	0.0105
Block of flats, number of floors 5	-0.0541	<.0001	0.0041	-0.0522	<.0001	0.0121
Block of flats, number of floors 6	-0.0643	<.0001	0.0013	-0.0605	<.0001	0.0034
Block of flats, number of floors 7	-0.0611	<.0001	0.0024	-0.0589	<.0001	0.0036
Block of flats, number of floors more than 7	-0.0960	<.0001	<.0001	-0.0936	<.0001	<.0001
Block of flats, number of floors unknown	-0.0566	<.0001	0.0086	-0.0547	<.0001	0.0183
Log distance to CBD	-0.1492	<.0001	<.0001	-0.1361	<.0001	<.0001
Log distance to closest SBD	-0.0167	0.1798	0.4869	-0.0232	0.0637	0.3032

Table 4.3 OLS models *(cont.)*

	MODEL 4.5			MODEL 4.6		
	CONTROLS AND LAND USE			FULL MODEL		
	Param,est,	**Pr > |t| (HCC)**	**Pr > |t|(CR)**	**Param,est,**	**Pr > |t| (HCC)**	**Pr > |t|(CR)**
Log distance to nearest metro or railway station (m)	0.0137	0.0091	<.0001	0.0136	0.0089	0.1169
Socioeconomic status index	0.2019	<.0001	0.0714	0.1423	0.0002	0.0007
Log distance to coastline				-0.0286	<.0001	0.0156
Log distance to nearest park or forest				-0.0027	0.2064	0.4572
Log distance to nearest recreational area				0.0080	0.0030	0.0582
Log % of green space in 100m buffer	0.0197	0.0232	0.0088	0.0167	0.0554	0.1487
Log % of green space in 101-300m buffer	0.0381	0.0006	<.0001	0.0342	0.0021	0.0646
Log % of recreational areas in 100m buffer	0.0106	<.0001	0.0102	0.0098	<.0001	0.0002
Log % of recreational areas in 101-300m buffer	0.0058	0.0054	0.0994	0.0025	0.2564	0.4779
Maintenance charge, 0e/sqm/month	-0.0173	0.0801	0.2824	-0.0183	0.0632	0.1102
Maintenance charge, 1e/sqm/month	ref.			ref.		
Maintenance charge, 2e/sqm/month	-0.0100	0.2372	0.0109	-0.0119	0.1587	0.2171
Maintenance charge, 3e/sqm/month	-0.0230	0.0079	0.0120	-0.0253	0.0034	0.0124
Maintenance charge, 4e/sqm/month	-0.0281	0.0058	0.0005	-0.0311	0.0022	0.0130
Maintenance charge, 5e/sqm/month	-0.0573	0.0003	<.0001	-0.0608	0.0001	0.0008
Maintenance charge, over 5e/sqm/month	-0.2928	<.0001	<.0001	-0.2923	<.0001	<.0001
Sub-district level fixed effects	yes			yes		
Transaction time fixed effects	yes			yes		
Adjusted R2	0.9255			0.9259		
N	7,091			7,091		
Estimation method (SAS)	PROC REG/PROC SURVEYREG			PROC REG/PROC SURVEYREG		

HCC SE = heteroskedasticy consistent standard errors

CR = cluster robust

4.5.3 Structural stability of OLS models

The previous assessment was based on the assumption that the entire research area comprises one housing market area in which the shadow prices of dwellings' various attributes are the same. One model where the coefficients of explanatory variables were assumed to be fixed was adjusted for the data covering the entire research area. This is a rather bold assumption that merits testing. As proposed in Section 3.2, the housing market in an urban area can be considered to comprise several overlapping sub-markets that may be rather difficult to distinguish. Next, the housing market will be analysed by means of divisions based on geography (central Helsinki and suburbs of Helsinki, Map 4.1) and type of building.

To test the joint model versus separate models, the Chow test was applied (Verbeek 2008). For example, the test statistic for geographical dimension (central Helsinki (CBD) and versus suburbs of Helsinki (SUB)) is

$$(4.2)\quad \frac{(SSR_J - (SSR_{CBD} + SSR_{SUB}))/(k+1)}{(SSR_{CBD} + SSR_{SUB})/(n_{CBD} + n_{SUB} - 2k - 2)}$$

where SSR refers to sum of squared residuals, J refers to joint model, n refers to number of observations and k refers to number of parameters in the model. The test statistics follows the F-distribution (with *k* degrees of freedom).

Table 4.4 Chow test statistics

	Break point	F-value	Pr>F
Central Helsinki vs suburbs of Helsinki	4,199	4.34	<.0001
Block of flats vs row houses	6,293	3.33	<.0001

Based on the test statistic values calculated for the research data by means of Chow tests (Table 4.4), the data is divided into different segments according to type of building and location in such a way that significant statistical differences are created in at least some coefficient estimate values between these segments (Verbeek 2008). Therefore, models estimated separately for blocks of flats in the central parts of the city and for blocks of flats and row houses in the suburban areas (Table 4.5) are analysed next.

As far as dwellings located in blocks of flats are concerned, some interesting differences can be found with regard to control variables between the city's central areas and suburban areas (Models 4.7 and 4.8). For instance, in the central parts, a robust connection exists between housing prices and the floor a dwelling is located on, whereas in suburban areas this connection is much weaker. In both cases, upper floors are more valuable than lower ones. In central Helsinki, increased distance to the centre has a distinct negative effect on prices. However, in the suburban areas, the coefficient of distance to the centre is statistically insignificant and features an unexpected prefix symbol. The latter result can be explained by the fact that sub-district-specific indicator variables apparently absorb the price effect of distance to the centre. As far as dwellings in row houses are concerned, the price-reducing effect is clearly more pronounced than in the case of blocks of flats (Models 4.7–4.9).

As regards urban natural amenities, only the variables expressing the share of recreational areas in the surroundings of a dwelling were statistically significant and complied with expectations. On the other hand, variables such as the one indicating distance to a seashore were not statistically significant and the variable expressing distance to a recreational area, although statistically significant, featured a positive prefix symbol, which did not comply with expectations.

In the model for blocks of flats in suburban areas (Model 4.8) and the model for row houses (Model 4.9), increased distance to a seashore is clearly linked to reduced housing prices. As regards blocks of flats in the city's suburban areas, distance to the nearest green area obtained a negative prefix symbol, as expected, whereas distance variables were not statistically significant in the model for row houses. In the case of dwellings located in blocks of flats in the city's suburban areas, green space located within 100 metres of a dwelling entailed a positive connection to the price of the dwelling. As regards the variables indicating land use in the vicinity of a dwelling, only the variable expressing the share green space within 101–300 metres of the dwelling was statistically significant in the model for row houses. The price effect was strong and positive.

4.5.4 Alternative land use variables

The land use variables related to urban natural amenities were divided into two groups in Subsections 4.5.2 and 4.5.3. Dedicated variables were created for green space – yards, parks and other small green areas – as well as for recreational areas. As an alternative to this approach, models in which the previous variables were combined into variables indicating unbuilt land in the vicinity of a dwelling (in the 100 metre and 101–300 metre ranges) were also assessed.

In the case of both the model covering the entire city (Table 4.6, Model 4.10) and the models used for blocks of flats (Models 4.11–4.12), the positive price effect of the share of unbuilt land was quite significant in both distance ranges (under 100 metres and 101–300 metres). As regards the central areas, the results concerning the share of unbuilt land were even more pronounced than those for the suburban areas, particularly in the 101–300 metre range. With regard to row houses (Model 4.13), unbuilt land within the 101–300 metre range also significantly increased housing prices.

Table 4.5 Separate models

	MODEL 4.8			MODEL 4.9		
	CBD FLATS			SUBURBAN FLATS		
	Param,est,	Pr > |t| (HCC)	Pr > |t|(CR)	Param,est,	Pr > |t| (HCC)	Pr > |t|(CR)
Intercept	8.8844	<.0001	<.0001	8.2547	<.0001	<.0001
Log floor area	0.8734	<.0001	<.0001	0.7871	<.0001	<.0001
Log age of dwelling	-0.0069	0.4661	0.6968	-0.0607	<.0001	<.0001
Own lot	ref.			ref.		
Rented lot	-0.0380	0.0380	0.1169	-0.0547	<.0001	<.0001
Condition, good	0.0838	<.0001	<.0001	0.0791	<.0001	<.0001
Contition, satisfactory	ref.			ref.		
Condition, poor	-0.0925	<.0001	<.0001	-0.0612	<.0001	<.0001
Condition, unknown	0.0091	0.2110	0.3430	0.0375	<.0001	<.0001
Rental status, free	-0.0192	0.0740	0.1345	-0.0527	<.0001	0.0003
Rental status, rented	ref.			ref.		
Rental status, unknown	-0.0226	0.0026	0.0632	-0.0060	0.3872	0.4224
Location 1. floor	ref.			ref.		
Location 2. floor	0.0384	0.0001	0.0030	-0.0523	0.0008	0.0192
Location 3. floor	0.0622	<.0001	<.0001	0.0130	0.0160	0.0145
Location 4. floor	0.0601	<.0001	<.0001	0.0138	0.0090	0.0211
Location 5. floor	0.0894	<.0001	<.0001	0.0206	0.0055	0.0077
Location 6. floor	0.0864	<.0001	<.0001	0.0381	0.0034	0.0638
Location 7. floor	0.1211	<.0001	<.0001	0.0310	0.0352	0.1404
Location 8. floor or upper	0.1067	<.0001	0.0013	0.0261	0.1611	0.0836
Location unknown	0.0552	0.0647	0.0694	0.0473	0.0111	0.3515
Block of flats, number of floors 2	ref.			ref.		
Block of flats, number of floors 3	0.0186	0.5502	0.6934	-0.0551	<.0001	0.0001
Block of flats, number of floors 4	0.0218	0.4130	0.6674	-0.0471	<.0001	0.0018
Block of flats, number of floors 5	0.0150	0.5880	0.7685	-0.0515	0.0002	0.0087
Block of flats, number of floors 6	0.0250	0.3655	0.6226	-0.1010	<.0001	<.0001
Block of flats, number of floors 7	0.0211	0.4551	0.6749	-0.0656	<.0001	0.0106
Block of flats, number of floors more than 7	-0.0261	0.3927	0.6634	-0.0629	<.0001	0.0012
Block of flats, number of floors unknown	0.0227	0.4496	0.7029	-0.0523	0.0008	0.0029
Log distance to CBD	-0.1466	0.0022	0.0760	0.0477	0.2446	0.4609
Log distance to closest SBD	0.0007	0.9875	0.9938	0.0308	0.0419	0.2554
Log distance to nearest metro or railway station (m)	0.0498	0.1474	0.3421	0.2487	0.0227	0.9721
Socioeconomic status index	0.0112	0.1182	0.1254	0.0004	0.9599	0.0537

Table 4.5 Separate models *(cont.)*

	MODEL 4.8			MODEL 4.9		
	CBD FLATS			SUBURBAN FLATSL		
	Param,est,	Pr > |t| (HCC)	Pr > |t|(CR)	Param,est,	Pr > |t| (HCC)	Pr > |t|(CR)
Log distance to coastline	0.0166	0.0817	0.3337	-0.0612	<.0001	0.0028
Log distance to nearest park or forest	0.0084	0.0953	0.2291	-0.0072	0.0038	0.0893
Log distance to nearest recreational area	0.0356	<.0001	0.0261	0.0057	0.0659	0.2469
Log % of green space in 100m buffer	0.0091	0.5352	0.5983	0.0307	0.0081	0.0528
Log % of green space in 101-300m buffer	-0.0139	0.5599	0.6820	0.0070	0.6394	0.7587
Log % of recreational areas in 100m buffer	0.0227	<.0001	<.0001	0.0050	0.0320	0.1112
Log % of recreational areas in 101-300m buffer	0.0088	0.0021	0.0258	-0.0199	0.0001	0.0388
Maintenance charge, 0e/sqm/month	-0.0074	0.6696	0.7054	0.0212	0.5954	0.5820
Maintenance charge, 1e/sqm/month	ref.			ref.		
Maintenance charge, 2e/sqm/month	-0.0024	0.8620	0.8645	0.0373	0.3465	0.3448
Maintenance charge, 3e/sqm/month	-0.0123	0.3824	0.4209	0.0294	0.4565	0.4577
Maintenance charge, 4e/sqm/month	-0.0220	0.1787	0.2516	0.0251	0.5310	0.5310
Maintenance charge, 5e/sqm/month	-0.0196	0.3845	0.3893	-0.0303	0.4878	0.4930
Maintenance charge, over 5e/sqm/month	-0.1876	<.0001	0.0013	-0.3035	<.0001	<.0001
Maintenance charge, over 5e/sqm/month	-0.2928	<.0001	<.0001	-0.2923	<.0001	<.0001
Sub-district level fixed effects	yes			yes		
Transaction time fixed effects	yes			yes		
Adjusted R2	0.9307			0.9009		
N	2,884			3,408		
Estimation method (SAS)	PROC REG/PROC SURVEYREG			PROC REG/PROC SURVEYREG		

HCC SE = heteroskedasticy consistent standard errors

CR = cluster robust

Table 4.5 Separate models *(cont.)*

	MODEL 4.10		
	ROW HOUSES		
	Param,est,	Pr > |t| (HCC)	Pr > |t|(CR)
Intercept	9.3002	<.0001	<.0001
Log floor area	0.6986	<.0001	<.0001
Log age of dwelling	-0.0788	<.0001	<.0001
Own lot	ref.		
Rented lot	-0.1064	<.0001	<.0001
Condition, good	0.0460	0.0001	0.0009
Contition, satisfactory	ref.		
Condition, poor	-0.1089	0.0661	0.0710
Condition, unknown	0.0399	0.0028	0.0093
Rental status, free			
Rental status, rented			
Rental status, unknown			
Location 1. floor			
Location 2. floor			
Location 3. floor			
Location 4. floor			
Location 5. floor			
Location 6. floor			
Location 7. floor			
Location 8. floor or upper			
Location unknown			
Block of flats, number of floors 2			
Block of flats, number of floors 3			
Block of flats, number of floors 4			
Block of flats, number of floors 5			
Block of flats, number of floors 6			
Block of flats, number of floors 7			
Block of flats, number of floors more than 7			
Block of flats, number of floors unknown			
Log distance to CBD	-0.0525	0.6003	0.6623
Log distance to closest SBD	-0.0187	0.4476	0.5727
Log distance to nearest metro or railway station (m)	-0.0349	0.7211	0.0169
Socioeconomic status index	0.0470	0.0060	0.6827

Table 4.5 Separate models *(cont.)*

	MODEL 4.10		
	ROW HOUSES		
	Param,est,	**Pr > |t| (HCC)**	**Pr > |t|(CR)**
Log distance to coastline	-0.0517	0.0008	0.0030
Log distance to nearest park or forest	0.0003	0.9581	0.9625
Log distance to nearest recreational area	-0.0029	0.6371	0.6436
Log % of green space in 100m buffer	0.0383	0.1640	0.2846
Log % of green space in 101-300m buffer	0.0743	0.0089	0.0096
Log % of recreational areas in 100m buffer	0.0021	0.6498	0.7238
Log % of recreational areas in 101-300m buffer	0.0094	0.1523	0.2531
Maintenance charge, 0e/sqm/month	0.0171	0.2142	0.2620
Maintenance charge, 1e/sqm/month	ref.		
Maintenance charge, 2e/sqm/month	-0.0051	0.6401	0.6751
Maintenance charge, 3e/sqm/month	-0.0457	0.0163	0.0637
Maintenance charge, 4e/sqm/month	-0.0358	0.1954	0.3419
Maintenance charge, 5e/sqm/month	-0.1746	0.0639	0.1253
Maintenance charge, over 5e/sqm/month	-0.3947	0.0002	0.0202
Maintenance charge, over 5e/sqm/month	-0.2928	<.0001	<.0001
Sub-district level fixed effects	yes		
Transaction time fixed effects	yes		
Adjusted R2	0.9031		
N	799		
Estimation method (SAS)	PROC REG/PROC SURVEYREG		

HCC SE = heteroskedasticy consistent standard errors

CR = cluster robust

Table 4.6 Alternative land use variables

	MODEL 4.11 FULL DATA			MODEL 4.12 CBD FLATS		
	Param,est,	Pr > |t| (HCC)	Pr > |t|(CR)	Param,est,	Pr > |t| (HCC)	Pr > |t|(CR)
Intercept	9.5764	<.0001	0.2782	8.8359	<.0001	<.0001
Log floor area	0.8332	<.0001	0.0102	0.8753	<.0001	<.0001
Log age of dwelling	-0.0360	<.0001	0.0089	-0.0055	0.5625	0.7671
Own lot	ref.			ref.		
Rented lot	-0.0698	<.0001	0.0079	-0.0371	0.0426	0.1588
Row house, no	ref.					
Row house, yes	0.1388	<.0001	0.0178			
Condition, good	0.0835	<.0001	0.0044	0.0846	<.0001	<.0001
Contition, satisfactory	ref.			ref.		
Condition, poor	-0.0762	<.0001	0.0075	-0.0934	<.0001	<.0001
Condition, unknown	0.0316	<.0001	0.0060	0.0103	0.1548	0.2869
Rental status, free	-0.0422	<.0001	0.0099	-0.0193	0.0799	0.1489
Rental status, rented	ref.			ref.		
Rental status, unknown	-0.0157	0.0019	0.0073	-0.0207	0.0057	0.0888
Location 1. floor	ref.			ref.		
Location 2. floor	0.0222	<.0001	0.0054	0.0365	0.0004	0.0047
Location 3. floor	0.0321	<.0001	0.0061	0.0615	<.0001	<.0001
Location 4. floor	0.0359	<.0001	0.0079	0.0596	<.0001	<.0001
Location 5. floor	0.0637	<.0001	0.0083	0.0897	<.0001	<.0001
Location 6. floor	0.0648	<.0001	0.0118	0.0865	<.0001	<.0001
Location 7. floor	0.0875	<.0001	0.0137	0.1213	<.0001	<.0001
Location 8. floor or upper	0.0805	<.0001	0.0211	0.1045	<.0001	0.0025
Location unknown	0.0294	0.0673	0.0164	0.0524	0.0841	0.0942
Block of flats, number of floors 2	ref.			ref.		
Block of flats, number of floors 3	-0.0531	<.0001	0.0161	0.0094	0.7711	0.8639
Block of flats, number of floors 4	-0.0483	<.0001	0.0186	0.0153	0.5897	0.7927
Block of flats, number of floors 5	-0.0514	<.0001	0.0207	0.0118	0.6880	0.8414
Block of flats, number of floors 6	-0.0603	<.0001	0.0204	0.0138	0.6382	0.8157
Block of flats, number of floors 7	-0.0580	<.0001	0.0201	0.0148	0.6203	0.7994
Block of flats, number of floors more than 7	-0.0943	<.0001	0.0228	-0.0398	0.2120	0.5521
Block of flats, number of floors unknown	-0.0546	<.0001	0.0232	0.0213	0.5028	0.7506
Log distance to CBD	-0.1476	<.0001	0.0295	-0.1524	0.0014	0.0862
Log distance to closest SBD	-0.0240	0.0536	0.0221	-0.0314	0.4690	0.7395

Table 4.6 Alternative land use variables *(cont.)*

	MODEL 4.11			MODEL 4.12		
	FULL DATA			CBD FLATS		
	Param,est,	**Pr > |t| (HCC)**	**Pr > |t|(CR)**	**Param,est,**	**Pr > |t| (HCC)**	**Pr > |t|(CR)**
Log distance to nearest metro or railway station	0.0119	0.0194	0.0085	0.0098	0.1615	0.4561
Socioeconomic status index	0.1502	<.0001	0.0409	0.0358	0.2969	0.2389
Log distance to coastline	-0.0221	0.0010	0.0111	0.0221	0.0286	0.1637
Log distance to nearest park or forest	-0.0029	0.1432	0.0033	-0.0003	0.9533	0.9709
Log distance to nearest recreational area	0.0096	0.0002	0.0041	0.0233	0.0049	0.1028
Log % of unbuilt land 100m buffer	0.0527	<.0001	0.0127	0.0599	<.0001	0.0008
Log % of unbuilt land 101-300m buffer	0.0281	0.0359	0.0220	0.0908	0.0003	0.0072
Maintenance charge, 0e/sqm/month	-0.0178	0.0695	0.0115	-0.0078	0.6528	0.6941
Maintenance charge, 1e/sqm/month	ref.			ref.		
Maintenance charge, 2e/sqm/month	-0.0111	0.1874	0.0096	-0.0010	0.9457	0.9479
Maintenance charge, 3e/sqm/month	-0.0250	0.0036	0.0102	-0.0124	0.3778	0.4389
Maintenance charge, 4e/sqm/month	-0.0300	0.0031	0.0125	-0.0236	0.1474	0.2247
Maintenance charge, 5e/sqm/month	-0.0608	<.0001	0.0177	-0.0216	0.3348	0.3448
Maintenance charge, over 5e/sqm/month	-0.2899	<.0001	0.0474	-0.1904	<.0001	0.0013
Maintenance charge, over 5e/sqm/month	-0.2928	<.0001	<.0001	-0.2923	<.0001	<.0001
Sub-district level fixed effects	yes			yes		
Transaction time fixed effects	yes			yes		
Adjusted R2	0.9261			0.9302		
N	7,091			2,884		
Estimation method (SAS)	PROC REG/PROC SURVEYREG			PROC REG/PROC SURVEYREG		

HCC SE = heteroskedasticy consistent standard errors

CR = cluster robust

Table 4.6 Alternative land use variables *(cont.)*

	MODEL 4.13			MODEL 4.14		
	SUBURBAN FLATS			ROW HOUSES		
	Param,est,	**Pr > |t| (HCC)**	**Pr > |t|(CR)**	**Param,est,**	**Pr > |t| (HCC)**	**Pr > |t|(CR)**
Intercept	8.3123	<.0001	<.0001	9.3388	<.0001	<.0001
Log floor area	0.7861	<.0001	<.0001	0.6987	<.0001	<.0001
Log age of dwelling	-0.0611	<.0001	<.0001	-0.0802	<.0001	<.0001
Own lot	ref.			ref.		
Rented lot	-0.0569	<.0001	<.0001	-0.1159	<.0001	<.0001
Row house, no						
Row house, yes						
Condition, good	0.0795	<.0001	<.0001	0.0454	0.0001	0.0010
Contition, satisfactory	ref.			ref.		
Condition, poor	-0.0614	<.0001	<.0001	-0.1135	0.0677	0.0724
Condition, unknown	0.0387	<.0001	<.0001	0.0390	0.0037	0.0112
Rental status, free	-0.0548	<.0001	0.0002			
Rental status, rented	ref.					
Rental status, unknown	-0.0051	0.4648	0.4939			
Location 1. floor	ref.					
Location 2. floor	0.0134	0.0136	0.0170			
Location 3. floor	0.0147	0.0057	0.0086			
Location 4. floor	0.0209	0.0046	0.0174			
Location 5. floor	0.0375	0.0048	0.0098			
Location 6. floor	0.0312	0.0319	0.0599			
Location 7. floor	0.0277	0.1301	0.1055			
Location 8. floor or upper	0.0513	0.0050	0.0615			
Location unknown	0.0164	0.2976	0.3174			
Block of flats, number of floors 2	ref.					
Block of flats, number of floors 3	-0.0574	<.0001	<.0001			
Block of flats, number of floors 4	-0.0490	<.0001	0.0012			
Block of flats, number of floors 5	-0.0498	0.0003	0.0126			
Block of flats, number of floors 6	-0.1020	<.0001	<.0001			
Block of flats, number of floors 7	-0.0704	<.0001	0.0070			
Block of flats, number of floors more than 7	-0.0637	<.0001	0.0013			
Block of flats, number of floors unknown	-0.0518	0.0008	0.0027			
Log distance to CBD	0.0222	0.5751	0.7185	-0.0736	0.4604	0.5530
Log distance to closest SBD	0.0270	0.0731	0.3169	-0.0161	0.5114	0.6213

Table 4.6 Alternative land use variables *(cont.)*

	MODEL 4.13			MODEL 4.14		
	SUBURBAN FLATS			ROW HOUSES		
	Param,est,	**Pr > |t| (HCC)**	**Pr > |t|(CR)**	**Param,est,**	**Pr > |t| (HCC)**	**Pr > |t|(CR)**
Log distance to nearest metro or railway station	0.0005	0.9420	0.9613	0.0452	0.0098	0.0180
Socioeconomic status index	0.2950	0.0073	0.0210	0.0542	0.5715	0.5363
Log distance to coastline	-0.0550	<.0001	0.0059	-0.0475	0.0020	0.0053
Log distance to nearest park or forest	-0.0038	0.1084	0.3135	0.0054	0.2345	0.3059
Log distance to nearest recreational area	0.0084	0.0055	0.0915	0.0054	0.3394	0.3123
Log % of unbuilt land 100m buffer	0.0616	<.0001	0.0030	0.0253	0.4415	0.5727
Log % of unbuilt land 101-300m buffer	-0.0387	0.0247	0.2230	0.1100	0.0083	0.0505
Maintenance charge, 0e/sqm/month	0.0140	0.7242	0.7141	0.0176	0.2039	0.2676
Maintenance charge, 1e/sqm/month	ref.			ref.		
Maintenance charge, 2e/sqm/month	0.0316	0.4214	0.4160	-0.0064	0.5627	0.6003
Maintenance charge, 3e/sqm/month	0.0233	0.5515	0.5513	-0.0460	0.0160	0.0630
Maintenance charge, 4e/sqm/month	0.0203	0.6096	0.6077	-0.0394	0.1570	0.2859
Maintenance charge, 5e/sqm/month	-0.0366	0.3984	0.4020	-0.1755	0.0654	0.1282
Maintenance charge, over 5e/sqm/month	-0.3030	<.0001	<.0001	-0.3987	0.0002	0.0190
Maintenance charge, over 5e/sqm/month	-0.2928	<.0001	<.0001	-0.2923	<.0001	<.0001
Sub-district level fixed effects	yes			yes		
Transaction time fixed effects	yes			yes		
Adjusted R2	0.9007			0.9032		
N	3,408			799		
Estimation method (SAS)	PROC REG/PROC SURVEYREG			PROC REG/PROC SURVEYREG		

HCC SE = heteroskedasticy consistent standard errors

CR = cluster robust

4.5.5 Mixed models

As an alternative to the OLS modelling of the previous figures, the mixed models method will next be applied to the same data. This method is used in an attempt to take the hierarchical nature of the data into account. In one-tier regression models, higher-level variables – such as district-level variables – are disaggregated to a lower level. However, in this event, the assumption of independence between the variables is not realised. In the preceding Subsections 4.5.2–4.5.4, district-level indicator variables and variables indicating the socioeconomic status of a district represented district-level variables. It could be considered that some variables expressing residential area, land use in this area and the accessibility of dwellings also resembled district-level variables, even though these variables were measured on a property-specific basis. Distance to the centre from dwellings in the same district was very similar, and less-than-average variation was also seen in land use in the residential environment. For this reason, attempts were made to take the reduction of information caused by the clustering of observations into account by also estimating cluster-robust mean errors in addition to heteroskedasticity consistent standard errors in connection with the OLS models.

In the following, the mixed models method is applied to the housing price data. In a departure from the models generally applied to housing price data modelling, the model employed here features a two-tier structure. Both explanatory variables and error terms – and therefore, variance terms – exist on two levels. In this work, explanatory variables were handled as individual-level variables, with the exception of the standard term. Model estimation was performed by means of the maximum likelihood method, and the comparison of expressiveness was based on the Akaike information criterion (AIC and AICC) and Bayesian information criterion (BIC).

The basic principle of the mixed models method used in this work can be expressed as follows, starting with the one-tier model equation included earlier in Section 4.1.

$$\mathbf{P} = \boldsymbol{\alpha} + \mathbf{X}\boldsymbol{\beta}_1 + \mathbf{D}\boldsymbol{\beta}_2 + \mathbf{e} \qquad (4.3)$$

When district-level random effects are added to the standard term in the previous Model (4.3), the model obtains the form

$$\mathbf{P} = \boldsymbol{\alpha} + \mathbf{X}\boldsymbol{\beta}_1 + \mathbf{D}\boldsymbol{\beta}_2 + \mathbf{u}_1 + \mathbf{e}\,. \qquad (4.4)$$

In this case, the fixed part determining regression coefficients is $\boldsymbol{\alpha} + \mathbf{X}\boldsymbol{\beta}_1 + \mathbf{D}\boldsymbol{\beta}_2$ and the random part determining error terms is $\mathbf{u}_1 + \mathbf{e}$. The final model is obtained by adding the random terms $\mathbf{X}\mathbf{u}_2$ and $\mathbf{D}\mathbf{u}_3$, which are dependent on the error term – to the previous Model (4.4), yielding

$$\mathbf{P} = \boldsymbol{\alpha} + \mathbf{X}\boldsymbol{\beta}_1 + \mathbf{D}\boldsymbol{\beta}_2 + \mathbf{u}_1 + \mathbf{X}\mathbf{u}_2 + \mathbf{D}\mathbf{u}_3 + \mathbf{e} \qquad (4.5)$$

The variance terms of the mixed models method are independent of one another, and they can be used to ensure the hierarchical nature of the data. This is performed by estimating an empty model from the data. This is a model that only includes the random standard term (random effects for intercept). The co-variance estimates obtained through empty model estimation can be used to calculate interclass correlation, which indicates the degree to which variation in the explained variable results from higher-level factors with respect to hierarchy. Interclass correlation (ICC) is obtained when the variance between groups is divided by the sum of interclass variance and interclass correlation. OLS model is based on assumption that ICC=0. In the literature, ICC greater than 0.01 is considered to be an indicator of clustering in the data (Cohen et al. 2003).

Defining the correct spatial scale for calculating group-level variance is not self-evident in housing price research. Several different district levels (district, sub-district, small district) were tested for calculating interclass correlation. This resulted in the discovery that the choice of district level had a noticeable effect on the results. The smaller – i.e. the more specific in terms of district – the chosen district level, the higher the share of group-level variance with respect to total variance. In order to maintain the comparability of results, the same district level was used in the mixed models method as in the aforementioned OLS models – i.e. sub-district was used as the district level.

The price models were created in stages, starting with an empty model, which only comprises the standard term, and gradually advancing to a model that includes all variable groups as both fixed variables and random variables varying by district.

Table 4.7 Mixed models

	MODEL 4.15 EMPTY MODEL		MODEL 4.16 LEVEL 1 FE		MODEL 4.17 LEVEL 1 FE + RANDOM	
	Param.est.	Pr > |t|	Param.est.	Pr > |t|	Param.est.	Pr > |t|
Intercept	11.81	<.0001	8.3867	<.0001	8.5874	<.0001
Log floor area			0.8375	<.0001	0.8001	<.0001
Log age of dwelling			-0.03212	<.0001	-0.04384	<.0001
Own lot			ref.		ref.	
Rented lot			-0.07361	<.0001	-0.08099	<.0001
Row house, no			ref.		ref.	
Row house, yes			0.145	<.0001	0.1514	<.0001
Condition, good			0.08356	<.0001	0.07644	<.0001
Contition, satisfactory			ref.		ref.	
Condition, poor			-0.07511	<.0001	-0.08514	<.0001
Condition, unknown			0.03121	<.0001	0.03139	<.0001
Rental status, free			-0.04524	<.0001	-0.04135	0.0021
Rental status, rented			ref.		ref.	
Rental status, unknown			-0.01852	0.0007	-0.01706	0.0328
Location 1. floor			ref.		ref.	
Location 2. floor			0.02291	<.0001	0.02125	0.0063
Location 3. floor			0.03219	<.0001	0.02936	0.0003
Location 4. floor			0.03786	<.0001	0.03003	0.0012
Location 5. floor			0.06373	<.0001	0.06764	<.0001
Location 6. floor			0.06657	<.0001	0.05643	<.0001
Location 7. floor			0.08795	<.0001	0.08862	<.0001
Location 8. floor or upper			0.08789	<.0001	0.09929	<.0001
Location unknown			0.03179	0.0104	0.03519	0.0122
Block of flats, number of floors 2			ref.		ref.	
Block of flats, number of floors 3			-0.05246	<.0001	-0.06287	<.0001
Block of flats, number of floors 4			-0.05206	<.0001	-0.06595	<.0001
Block of flats, number of floors 5			-0.05332	<.0001	-0.06783	<.0001
Block of flats, number of floors 6			-0.06252	<.0001	-0.08446	<.0001
Block of flats, number of floors 7			-0.06318	<.0001	-0.08224	<.0001
Block of flats, number of floors more than 7			-0.09362	<.0001	-0.1023	<.0001
Block of flats, number of floors unknown			-0.0529	<.0001	-0.06377	0.0004
Log distance to CBD						
Log distance to closest SBD						

Table 4.7 Mixed models *(cont.)*

	MODEL 4.15		MODEL 4.16		MODEL 4.17	
	EMPTY MODEL		LEVEL 1 FE		LEVEL 1 FE + RANDOM	
	Param.est.	**Pr > |t|**	**Param.est.**	**Pr > |t|**	**Param.est.**	**Pr > |t|**
Log distance to nearest metro or railway station						
Socioeconomic status index						
Log distance to coastline						
Log distance to nearest park or forest						
Log distance to nearest recreational area						
Log % of green space in 100 buffer						
Log % of green space in 101-300 buffer						
Log % of recreational areas in 100 buffer						
Log % of recreational areas in 101-300 buffer						
Maintenance charge, 0e/sqm/month			-0.01766	0.072	-0.01361	0.2288
Maintenance charge, 1e/sqm/month			ref.		ref.	
Maintenance charge, 2e/sqm/month			-0.01149	0.1668	-0.00002	0.9982
Maintenance charge, 3e/sqm/month			-0.02476	0.0039	-0.01391	0.1881
Maintenance charge, 4e/sqm/month			-0.02936	0.003	-0.01918	0.108
Maintenance charge, 5e/sqm/month			-0.05915	<.0001	-0.05939	0.0005
Maintenance charge, over 5e/sqm/month			-0.2905	<.0001	-0.2101	<.0001
-2 Res Log Likelihood	7,584.3		-7,540.1		-8,511.3	
AIC	7,590.3		-7,534.1		-8,505.3	
AICC	7,590.3		-7,534.1		-8,505.3	
BIC	7,598.2		-7,526.1		-8,497.4	
N	7,091		7,091		7,091	
Estimation method	PROC MIXED		PROC MIXED		PROC MIXED	

Table 4.7 Mixed models *(cont.)*

	MODEL 4.18		MODEL 4.19	
	LEVEL 1 FE + RANDOM + LEVEL 2 FE		FULL MODEL	
	Param.est.	Pr > |t|	Param.est.	Pr > |t|
Intercept	9.5118	<.0001	9.428	<.0001
Log floor area	0.8039	<.0001	0.8015	<.0001
Log age of dwelling	-0.0445	<.0001	-0.04798	<.0001
Own lot	ref.		ref.	
Rented lot	-0.07517	<.0001	-0.07002	<.0001
Row house, no	ref.		ref.	
Row house, yes	0.1438	<.0001	0.1469	<.0001
Condition, good	0.07831	<.0001	0.07918	<.0001
Contition, satisfactory	ref.		ref.	
Condition, poor	-0.08292	<.0001	-0.08246	<.0001
Condition, unknown	0.03309	<.0001	0.03229	<.0001
Rental status, free	-0.04004	0.0024	-0.0327	0.007
Rental status, rented	ref.		ref.	
Rental status, unknown	-0.01531	0.0489	-0.01547	0.0334
Location 1. floor	ref.		ref.	
Location 2. floor	0.02104	0.0055	0.02471	0.0005
Location 3. floor	0.02911	0.0003	0.03316	<.0001
Location 4. floor	0.02919	0.0013	0.0348	<.0001
Location 5. floor	0.06974	<.0001	0.07899	<.0001
Location 6. floor	0.05874	<.0001	0.06869	<.0001
Location 7. floor	0.0909	<.0001	0.09333	<.0001
Location 8. floor or upper	0.09487	<.0001	0.08924	<.0001
Location unknown	0.03619	0.009	0.03884	0.0034
Block of flats, number of floors 2	ref.		ref.	
Block of flats, number of floors 3	-0.0608	<.0001	-0.0539	<.0001
Block of flats, number of floors 4	-0.06405	<.0001	-0.05485	<.0001
Block of flats, number of floors 5	-0.064	<.0001	-0.04906	0.0005
Block of flats, number of floors 6	-0.0804	<.0001	-0.06519	<.0001
Block of flats, number of floors 7	-0.07894	<.0001	-0.06391	0.0002
Block of flats, number of floors more than 7	-0.1026	<.0001	-0.08296	<.0001
Block of flats, number of floors unknown	-0.06481	0.0003	-0.05218	0.0016
Log distance to CBD	-0.1013	<.0001	-0.1312	<.0001
Log distance to closest SBD	-0.03444	0.0051	0.000359	0.984

Table 4.7 Mixed models *(cont.)*

	MODEL 4.18		MODEL 4.19	
	LEVEL 1 FE + RANDOM + LEVEL 2 FE		FULL MODEL	
	Param.est.	**Pr > |t|**	**Param.est.**	**Pr > |t|**
Log distance to nearest metro or railway station	0.00711	0.1466	0.0105	0.2609
Socioeconomic status index	0.02796	0.1894	0.0868	0.147
Log distance to coastline	-0.02353	<.0001	-0.03191	0.0011
Log distance to nearest park or forest	-0.00313	0.1278	-0.00172	0.7585
Log distance to nearest recreational area	0.004199	0.1344	0.007899	0.27
Log % of green space in 100 buffer	0.02905	0.0002	0.02727	0.0107
Log % of green space in 101-300 buffer	0.05185	<.0001	0.06562	<.0001
Log % of recreational areas in 100 buffer	0.008904	<.0001	0.01136	0.0279
Log % of recreational areas in 101-300 buffer	0.004744	0.0298	0.007199	0.2642
Maintenance charge, 0e/sqm/month	-0.01427	0.199	-0.01354	0.2023
Maintenance charge, 1e/sqm/month	ref.		ref.	
Maintenance charge, 2e/sqm/month	0.000417	0.9665	0.000655	0.9449
Maintenance charge, 3e/sqm/month	-0.01429	0.1682	-0.01409	0.1545
Maintenance charge, 4e/sqm/month	-0.01915	0.1024	-0.02082	0.0654
Maintenance charge, 5e/sqm/month	-0.05686	0.0006	-0.05193	0.0011
Maintenance charge, over 5e/sqm/month	-0.2095	<.0001	-0.1954	<.0001
-2 Res Log Likelihood	-8,594		-9,206.5	
AIC	-8,588		-9,094.5	
AICC	-8,588		-9,093.6	
BIC	-8,580.1		-8,946.4	
N	7,091		7,091	
Estimation method	PROC MIXED		PROC MIXED	

It can be calculated on the basis of the empty model's (Table 4.7, Model 4.14) estimation results that 35.8 per cent of the variation in the explained variable, variation in housing prices, was caused by area level (sub-district-level) factors. Once variables indicating dwelling attributes are added (Model 4.15), the model's explanatory power increased substantially (AIC) 7590.30 -> -7534.1). Furthermore, once variables expressing dwelling attributes were added as random effects (Model 4.16), the model's explanatory power increased substantially (AIC: -7534.1 -> -8505.3). In the subsequent stage, additional fixed variables expressing a dwelling's location and residential environment in the model were added (Model 4.17). The explanatory power increased notably less as a result of these additional variables than in connection with the addition of the control variables. Finally, the random variables were added, varying on a district-specific basis, for the variables expressing dwelling location and residential environment (Model 4.18).

The coefficients of the variables expressing urban natural amenities and pertaining to land use are, almost without exception, statistically significant and they feature the expected prefix symbols (Models 4.17 and 4.18). An increased share of green space in the vicinity of a dwelling entail a distinct positive price effect, whether it be the 100-metre or 101–300 metre range surrounding the dwelling. Recreational areas also have a positive price effect, even though this is less significant than the effect of yard and green areas. The price effect of distance to a seashore is less significant than that found in the OLS model's results, but it is still in line with expectations and statistically significant. The price effects of distance to green areas and recreational areas were not statistically significant.

Moreover, Appendix D includes models estimated by means of the mixed models method, using a more specific level, i.e. small district as clustering level, and Appendix E a less specific level, i.e. district, instead of the sub-district as a clustering level.

4.6 Discussion

This chapter aims at quantifying the effects of urban natural amenities on property values by applying the hedonic pricing method on data from Helsinki. The city of Helsinki has a relatively diverse urban structure and an abundant supply of green areas compared many European cities. The average distance from a dwelling to a green area is 300 metres. In the suburban areas, this distance is under 200 metres. The share of unbuilt land is also quite large, so the supply of urban natural amenities (in the form of yards, parks and recreational areas) is plentiful. According to questionnaire surveys, urban natural amenities and the resulting services are held in high esteem (Tyrväinen et al. 2007). Of course, one might contend that, as urbanisation progresses, values will also change. Or that people who move to cities are more likely to value urban residential environments. However, in their 2007 study, Tyrväinen et al. (2007) came to the conclusion that the majority of people (in Helsinki) still find the natural element to be important.

Questionnaire surveys can be considered to be limited in that they are not based on people's real life choices. For this reason, analysis based on market information should also be conducted alongside questionnaire surveys. Urban natural amenities can be considered to represent local public goods. Typically, market-based solutions – solutions based on people's willingness to pay, revealed through consumer demand – are not optimal with regard to public goods. Because of the free-rider problem, incentives for revealing preferences do not exist and, therefore, the supply of public goods is sub-optimal in market-based solutions. However, the housing market provides one method for assessing the valuation of local public goods, in this case urban natural amenities. It can be considered that the value of urban natural amenities is capitalised into housing prices.

One of the main goals of the study was to create well-defined data concerning environmental variables and to identify well-functioning and cost-efficient variables for hedonic studies. Environmental variables were constructed from the remote sensor images and master plan documentations. Urban natural amenities were measured by means of two dimensions, distance and land use. Distance based variables measured distances from the seashore, parks and smaller green areas, and recreational areas. Land use variables measured the share of parks and smaller green areas, and recreational areas surrounding dwellings.

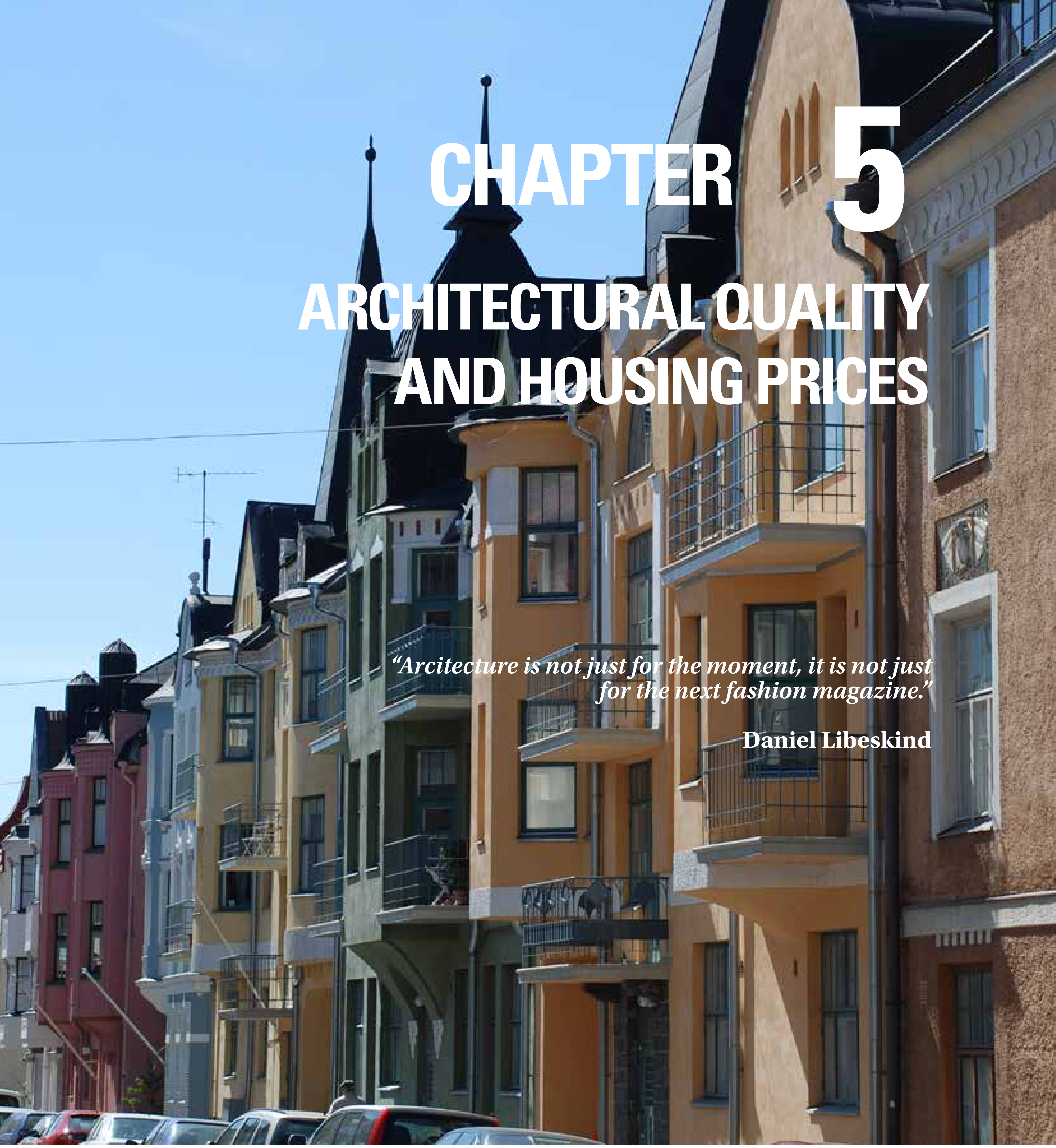
In many cases, when formally tested, sub-markets can be identified within a metropolitan area. Still, a single model is frequently estimated for an entire metropolitan area. Another salient feature in hedonic pricing model studies is the fact – and this study is no exception – that sub-market boundaries are drawn in an ad hoc manner. But even under these conditions, our model based on the pooled data set was rejected by the Chow test (OLS estimation). Another problem, which relates to sub-markets, is the estimation of regression models. The planning system and the simple logic of urban growth produces spatial autocorrelation in housing attributes. This correlation structure might be a problem when estimating models. Some strong pair-wise correlations were observed (over 0.7), but the variance inflation measures were within the acceptable limits for all our variables.

In order to improve the reliability of the results, alternative modelling methods were used. In addition to the OLS model covering the entire research area, separate models were estimated on the basis of district and type of building. Multilevel modelling was also applied. Models were built in stages on the basis of variable groups, progressing from the fixed effects model to a model that also included random effects.

The price effects of urban natural amenities in Helsinki have been examined in other studies (Laakso 1997, Laakso 2015) that applied an approach that is slightly different from this study – using district-specific measures of land use development. The results (related to land use) of the study authored by Laakso (1997) are similar to the results obtained in this study. For urban natural amenities, Tyrväinen (1999) and Tyrväinen & Miettinen (2000) offer closest reference point though both studies are based on data from other Finnish cities (see Section 4.2).

The price effects of urban natural amenities were largely in line with the expectations. As regards the distance variables, distance to a seashore was a strong factor impacting on housing prices, but the results regarding the price effects of the nearest park or recreational area were less clear and, in the case of the proximity of recreational areas, even partially unexpected. The share of unbuilt land – whether it was measured using one dimension (unbuilt land) or, in more specific terms, classified into two different land use categories (green space as well as recreational areas) – had a clear positive effect on housing prices. Alongside these findings, one must note the clear price premium, about 14%, that row houses have when compared with blocks of flats. This might have something to do with the utilities that private yards, even if they are often small, offer as compared to flats. One notable finding was, when examining land use based on less specific level of analysis, unbuilt land, the results in city centre showed that the positive effect of unbuilt land on housing prices is even stronger than in suburban parts of Helsinki. Altogether, though urban natural amenities are abundant in Helsinki, the positive price effects are still noticeable. In the future, when infill development densifies the city, these effects are most likely to be even stronger.

In order to have a more detailed picture of the price effects of natural amenities, several extensions could be made. First, the price effects of view should be studied (Tyrväinen & Miettinen 2000) though variables related to the view are harder to obtain. Modern 3D techniques might offer one way to construct these variables in a cost efficient way. Second, the price effects of different qualities of green space could be studied in more detail. Third, the trade-off between accessibility and abundance of natural amenities could be studied. This can be done for example by combining distance based variable and a land use variable.



CHAPTER 5

ARCHITECTURAL QUALITY AND HOUSING PRICES

“Arcitecture is not just for the moment, it is not just for the next fashion magazine.”

Daniel Libeskind

5 ARCHITECTURAL QUALITY AND HOUSING PRICES

5.1 Introduction

The urban environment is full of architecture. City residents live surrounded by architecture – good and bad. The building stock in cities is a compilation of styles and design decisions from various eras – the ideals and economic realities of their own times. As urbanisation has progressed, the role of aesthetic factors has been found to be important – not least because of the external effects generated by them. High-class residential environments can be considered a luxury commodity, the demand for which increases in line with income levels.

Finnish cities are relatively young. The temporal layers of architecture in Finnish cities are, in many places, relatively minor. In many instances, the oldest parts of the building stock have been replaced with new buildings, preventing the creation of temporal layers. The urban structure has also seen significant changes brought about by the rapid growth. Rather a large part of the building stock in Finnish cities is located in the suburbs, built after the Second World War. The prefabricated building stock from the 1960s and 1970s, in particular, was not originally built with an eye for aesthetic values and long lifespans. The zeitgeist was different at the time of their construction. Antti Tuuri (1998) writes about a way of thinking that was prevalent in the 1960s, based on which a volume of housing construction that was as high as possible was pursued through district development projects. One of the sources referenced by Tuuri (1998) in his book is the housing policy pamphlet Anna meidän asua ("Letting Us Live"), published by Lounela in 1964. According to the pamphlet, building quality was not a key criterion guiding construction, since "the apartments are not being built for future generations". According to Lounela, "our grandchildren will deem our housing as uncomfortable as we nowadays consider the old dwellings in Kruununhaka and Katajanokka."

As part of an extensive questionnaire survey of Helsinki residents conducted in 2012, people were asked about their satisfaction with different features of their residential areas. Typically, between 75 and 80 per cent of respondents were very or rather satisfied with the architectural quality and look of their residential area. Some 94 per cent of the respondents in Helsinki's southern central areas – i.e. the region in which the oldest building stock in the entire city, including the aforementioned Kruununhaka and Katajanokka districts, is located – were very or rather satisfied. Moreover, the majority of these respondents were very satisfied with the architectural quality and look of their residential area. (authors' calculations from survey data, see Appendix A) Housing prices in this area are the highest in the Helsinki metropolitan area and the whole of Finland.

This chapter analyses the effects of architecture on housing prices in Helsinki's southern central areas. The impact of a building's architectural style and its architect's age, experience and success in architectural competitions on the sales prices of housing will be analysed by applying the hedonic pricing method to housing price data. In addition, the impact of each building's architectural significance and potential success in architectural competitions on the sales prices of dwellings located in that building and the prices of housing in the neighbourhood will be analysed.

In addition to the price effects of architectural styles and the architect's education and experience, analysis presented in this chapter will attempt to answer the question of how architectural quality effects the sales price of a dwelling. However, one have to simultaneously acknowledge that architectural quality is a multidimensional property that is difficult to pin down and measure. Insofar as architectural quality is concerned, one have to settle for a few variables that might indirectly reveal which buildings are considered to represent high quality among the ranks of architects, based on matters such as architectural competition results. In other words, this study will be actually testing the extent to which the housing market – ultimately, consumers – values these properties.

The rest of this chapter organised as follows: After introduction (Section 5.1), the concept of architectural quality is analysed (Section 5.2). Section 5.3 reviews earlier literature related to architectural quality and housing prices and Section 5.4 introduces study area, research data and methods. In Section 5.5 results of estimated models are presented and in Section 5.6 conclusions are made.

5.2 Architectural quality and housing markets

What does architectural quality actually mean, and how does one determine whether architecture is good or bad? First of all, one should differentiate between construction quality and architectural quality, even though this distinction may be difficult to make in some cases. In terms of architecture, the question of quality can be approached from a variety of perspectives. The field of architecture has seen numerous attempts to define architectural quality. For instance, Gaivoronchi (2012) identifies the following as partial aspects of architectural quality: safety and health, ecological and economic efficiency, functionality, maintainability, aesthetic quality, and social and cultural dimensions. Several other definitions and classifications of architectural quality can be found in the field's literature. It should be apparent that the measurement of architectural quality is difficult, if not impossible. How does one measure the various aspects of architectural quality, and how does one weigh various quality factors in assessments? The utilisation of housing market information provides one way of assessing quality factors. In these cases, the focus is on consumer valuations (in relation to the supply of housing).

The capitalisation of a dwelling's various properties, including architectural quality, into housing prices is dependent on how scarce housing with these properties is on the market in proportion to demand for the properties. An attribute that is widely available or that is easy to produce in a simple and inexpensive manner affects a dwelling's price less than a scarcely available attribute that is considered to be in high demand and that is difficult if not impossible to produce. The demand for a dwelling's quality-related properties, including architectural quality, may depend on the properties of a household. The demand for some properties may increase along with income, while the demand for some attributes may be more closely tied to family structure or lifestyle.

The valuations of consumers may differ from those of the designers of housing – usually architects. In this event, the valuations of professional architects are not necessarily reflected in housing prices. Current legislation requires that a building's main designer has graduated with a degree in architecture (Ministry of Environment 2002). In other words, the designer does not have free rein. The developer places various restrictions on the design. A significant part of these restrictions is related to the demand for housing – i.e. the developer's estimate of what kinds of dwellings can be sold and at what prices. The commencement of new construction projects often requires a sufficient number of advance reservations on the project's dwellings. The evaluations of professional architects do not necessarily correspond with those of the market or consumers. The idea in this chapter is to test whether architectural quality has market value or not (Hough & Kratz 1983). The ability of the market to assess architectural quality is often held in doubt. Some believe that there is no market for some of the values represented by good architecture that could be used to measure the value of these properties. On the other hand, architects themselves often cite the economic, long-term benefits provided by architecture as reasons to focus resources on design. Accordingly, architects' contributions are often viewed in relation to their economic benefits (Schumacher 2012). Quality is expensive, but how much are people willing to pay for it?

In the context of new blocks of flats and row houses built in Finland, architects usually design buildings on behalf of construction firms that determine the preconditions for design on the basis of market information and, ultimately, make the decisions on the implementation of plans within the framework of the building code. When it comes to the construction of single-family homes, the developer is usually the future user of the house, and the relationship between architectural solutions and the residents is, therefore, more direct. Then again, type-planned house solutions are a rather common implementation method. Therefore, unique design plays a somewhat limited role in the production of single-family homes, too.

In addition to being able to assess the consumer's options in accordance with the construction year of the building stock, the longevity of the building stock should also be taken into account. The majority of sold dwellings are not new. Accordingly, it can be stated, in contradiction to the Lounela pamphlet (1964) cited above by Tuuri (1998), that housing is almost always designed or at least built for future generations too. Since the valuations related to housing can change over time, the design challenge is significant. An architect should be able to design buildings and dwellings that meet common needs and valuations decades after their construction. In addition, this is not just about the users of buildings, since buildings are also – especially in urban environments – commodities, the impact of which can be assumed to extend beyond their users.

There is no separate market for architectural quality. This makes it necessary to attempt to assess the value of architectural quality in an indirect manner. To this end, the hedonic pricing method is applied. The premise in this is that the sales prices of dwellings are formed on the basis of the various properties of the dwellings, and what is known as the shadow prices of these properties.

The various combinations of attributes existing in the housing market vary a great deal. When estimating the hedonic pricing method and, in particular, when interpreting its results, it should be noted that not all combinations of properties may be found in the dwellings on the market, or even the entire building stock. With respect to certain variables, suspicions that they are influenced by unseen factors must also be entertained. For instance, the architectural style of a building may represent matters other than just the aesthetic qualities of the building. Differences in such things as construction materials may exist between various architectural styles that may in turn affect the functional properties of buildings and their usage and repair costs. Room height may also vary significantly between various styles of construction. On the other hand, the architectural style of a building is closely related to the building's construction year, and thus its age. On a general level, then, the issue is that the model, in all likelihood, is missing attributes affecting the price of a dwelling, and these variables may correlate with variables included in the model. Moreover, the fact that the price effects of a certain attribute of a dwelling may be related to the existence of some other attribute of the dwelling must be taken into account.

5.3 Related literature

The price effects of the features of dwellings have been studied for a long time in economics. However, the number of studies accounting for architectural quality is rather low – and almost non-existent in terms of Finnish research. Suokko's (1972) study is one of the exceedingly rare Finnish empirical studies investigating the relationship between dwellings' design choices and market prices. In his study, Suokko used extensive data on dwellings located in blocks of flats sold between 1966 and 1967 in Helsinki to analyse the effect of the number of floors and dwellings as well as the capacity, width and height of a building on housing prices. According to his results, primarily those variables related to a building's frame depth and capacity had a statistically significant effect on housing prices. Increasing building size had a negative impact on housing prices. People were willing to pay more for dwellings located in smaller buildings. Increasing frame depth also reduced the price of a dwelling, according to Suokko's analysis. However, certain reservations regarding the results are in order. For instance, one could ask whether the small size (capacity) of a building is tied to uncontrolled factors in the model – such as the building's architectural style – i.e. whether the age variable is sufficient to account for the impact of architectural style on the price of a dwelling. Moreover, the frame depth and capacity of a building may be connected to the building's typology, which may in fact be a more decisive factor with regard to housing prices than frame depth alone.

International research on the relationship between housing prices and design or architectural quality is not abundant either. Asabere et al. (1989) used data on semi-detached houses sold in Newburyport, Massachusetts, to analyse the purchase prices of properties representing different architectural styles, and observed an obvious price premium placed on buildings representing "historical" architectural styles. Moorhouse and Smith (1994) studied the factors affecting the prices of Victorian row houses from the 1800s by means of data collected from Boston's South End district. What is extraordinary about this work is that the data on housing transactions covered dwellings sold between 1850 and 1872. Explanatory variables included dwelling and lot size, microlocation (located along a main street or side street, next to a park and whether the lot is a corner lot), architectural style classified into six different categories, and 15 architectural characteristics. According to their results, significant price differences existed between the different architectural styles, and location next to a park increased housing prices substantially.

In their study, Ahlfeldt and Mastro (2011) analysed the impact of proximity to buildings designed by architect Frank Lloyd Wright on housing prices, using housing transaction data collected from the municipality of Oak Park in the Chicago metropolitan area. A total of 24 detached houses designed by Wright, which were built between 1892 and 1914, are located in Oak Park. Comprising 3,334 transactions, the housing transaction data was collected between 2003 and 2009. In addition to dwelling and lot size and structural properties, the explanatory variables used by the authors in their model were variables expressing the level of local schooling and the transaction date as well as a variable depicting the sold dwelling's location in Oak Park's various districts, three of which are recognised as national historic districts. The buildings designed by Wright are all located in one of these districts. In addition, distance from the nearest Wright-designed house and the number of Wright houses in the vicinity was measured for each sold house. The researchers used models to estimate a number of different model specifications and estimation techniques. For instance, the spatial error model was used in addition to the usual OLS model.

According to the results, a distance of 50 metres from buildings designed by Frank Lloyd Wright created a price premium of around 8.5 per cent for the property in question, while a 250-metre distance created a five per cent premium. No effect on prices was detected at longer distances. In addition to analysing the effect of buildings designed by Wright on the prices of houses nearby, the researchers observed a premium of 41 per cent in the sale prices of buildings designed by Wright as compared with other houses, controlling for variables measuring the structural properties of these buildings. With regard to the last result, it should be noted that only five of the housing transactions involved houses designed by Wright.

Numerous studies on the effect of historic buildings, architectural heritage status and districts on housing prices have been drafted in the US. What is being studied is the effect of architectural heritage status on both the price of a dwelling or building and the housing prices in the neighbourhood in question. Noonan (2007) used data on 63,000 housing transactions collected from Chicago to study the effect of architectural heritage status by means of alternative model specifications and estimation techniques. Status as an architectural heritage site increased the price of a dwelling – more if the dwelling itself had this status as compared with buildings located in an architectural heritage area but themselves lacked architectural heritage status. However, the authors suspected that some part of the effect could be explained by unobserved factors correlating with architectural heritage status. Cebula (2009) analysed transaction data on detached houses from Savannah, Georgia covering the period between 2000 and 2005. According to the results, both architectural heritage sites themselves and properties located in historic architectural heritage areas were more expensive than other properties. Coulson and Lahr (2005) analysed data collected from Memphis, Tennessee and arrived at the conclusion that dwellings located in historic districts were 17.6 per cent more expensive than in other parts of the same city, controlling for various kinds of factors pertaining to dwelling structures.

Some parts of the research findings on the price effects of architectural heritage status contradict the aforementioned findings. This may be caused by the maintenance of architectural heritage sites possibly being more expensive than that of other properties due to stringent conservation regulations. Apparently, the price effect of architectural heritage status varies between areas based on the stringency of building conservation, the special characteristics of properties and the status of the housing market. For example: when analysing data collected from Sacramento, California, Clark and Herrin. (1997) arrived at the conclusion that the price effect of building conservation varies between areas. In their model, Winson-Geideman and Gao (2011) used, alongside traditional age-variable, a variable expressing effective age, which is based on evaluations on remaining economic life of the structure. They analysed data set from Savannah (Georgia, USA) and concluded that at least part of price differential between districts can be attributed to differences of investments which in turn had their effect on effective age of housing stock.

When analysing the price effect of architectural heritage status, it should also be noted that in many US states, the owners of historic buildings obtain various kinds of tax relief in exchange for the maintenance and renovation of these buildings. It can be assumed that some of these subsidies are capitalised into prices.

Historic architectural heritage districts are appointed to conserve architectural heritage, and enhancing the prestigiousness of these areas – including increased price levels – is seen to support this goal. However, success in this pursuit is dependent on many factors such as the building stock itself, the size of the area and whether it has distinct boundaries, the area's location relative to the main centre, and the general economic success of the urban region in question. In the right circumstances, architectural heritage status may create expectations for the conservation of the area, thus encouraging maintenance and investments, which may be witnessed in the form of increased property prices (Berry 1985, Asabere & Huffman 1994a, Asabere & Huffman 1994b, Coulson & Leichenko 2001).

As regards research conducted outside the US, Lazrak et al. (2011) should be mentioned. According to their analysis of housing transaction data collected from the city of Zaanstad in the Netherlands, houses with architectural heritage status are more than 25 per cent more expensive than other houses, and houses located in an architectural heritage conservation area are similarly 25 per cent more expensive than houses located in other areas. They also discovered that each architectural heritage site located within a 50-metre radius of a sold house increased its price by 0.28 per cent.

In some studies, the assessment of architectural quality is focused on the functional elements of urban spatial structure rather than the aesthetic qualities of individual buildings. One example of this is a study by Song and Knaap (2003), in which the authors used data on housing transactions collected from Portland, Oregon, to assess the effect of a set of urban planning principles collectively known as New Urbanism on the prices of detached houses. According to their results, houses located in areas constructed in compliance with the principles of New Urbanism are over 15 per cent more expensive than other houses.

In addition to residential buildings, the effect of architectural quality and architect on the prices and rental rates of dwellings has been studied in the business property market (e.g. Hough & Kratz 1983, Vandell & Lane 1989, Gat 1998). Pihlajaniemi (2014) provides a review of this literature.

5.4 Data and method

5.4.1 Study area

The southern parts of central Helsinki served as the research area (Figure 5.1).

Figure 5.1 Study area

This area forms the historic centre of Helsinki and, to a large extent, its functional core. In geographical terms, the area is a peninsula surrounded by the Baltic Sea. The oldest building stock in Helsinki and the entire region is located in this area, even though it is not that old when compared with stock in many other European cities. The building stock is almost entirely comprised of blocks of flats. The oldest buildings date from the mid-1800s, while the newest were built in the 2000s (Table 5.1). In terms of urban spatial structure, the area mostly comprises a grid plan structure and perimeter blocks. The building stock's maximum floor number is typically seven. There are very few opportunities for supplementary construction in the area. Excluding the recession of the early 1990s, housing prices in the area have been climbing steadily and rather intensely since the 1970s (Lönnqvist 2009). Housing prices in this area are the highest in Helsinki and Finland in terms of price per square metre. The socioeconomic status of the area is relatively high, clearly higher than the average level in Helsinki, for instance.

5.4.2 Data and variables

VTT Technical Research Centre of Finland Ltd's housing price data (for details, see Appendix A) was used as housing transaction data in this chapter. The analyses in this chapter are based on housing transactions that took place between 1980 and 2008. The total number of housing transactions included in this data is 13,074. Regular control variables expressing the structure of the building stock were used in the price model (Table 5.2). The effect of the neighbourhood on housing prices was controlled by using fixed-effects variables in most assessments. These were based on indicator variables based on the small areas determined in accordance with Helsinki's statistical area division system. The effect of the transaction time, year and quarter of housing transaction was also controlled by means of indicator variables. The point of comparison in all the models was the first quarter of the period being assessed.

The architectural quality of buildings was analysed via several different dimensions. Variables related to architectural quality are divided into two main categories. The first main category includes variables which are related directly building itself (Table 5.1). The first subcategory of variables is related to the planner of the building. Initial assumption is that an architect as the designer would increase the price of the building in question. Alongside education level, planner's experience and success as architecture was measured via three variables: number of buildings

Table 5.1 Variables representing architectural features of the building

Variable subcategory	Variables	Variable type	Data source
Planner of the building	Planner is an architect	0/1	Databases of Museum of Finnish Architecture
	Number of planned buildings	Continuous	Databases of Museum of Finnish Architecture
	Number of published buildings	Continuous	Finnish Architectural Review (ARK) 1903–2008
	Competition success	Continuous	Databases of Museum of Finnish Architecture
	Age of the planner in years (under 31, 31–40, 41–50, 51–60, over 60)	0/1	Databases of Museum of Finnish Architecture
Architectural status of the building	Building is an architectural landmark	0/1	Architectural Guide of Helsinki, Espoo, Vantaa, Kauniainen 2009
	Building has been published in the Finnish Architectural Review (ARK) 1903–2008	0/1	Finnish Architectural Review (ARK) 1903–2008
Architectural style of the building	Historic styles Finnish Art Nouveau Classicism Functionalism Reconstruction and rationalization period Structuralism Postmodernism	0/1 0/1 0/1 0/1 0/1 0/1 0/1	Korttelit.fi database

planned, number of buildings published in the Finnish Architectural Review (ARK) and competition success (first places in architectural competitions organised by Finnish Association of Architects). The information on architectural competitions was obtained from the databases of the Museum of Finnish Architecture. Also the planner's age was included as an explanatory variable. Presuppositions pertaining to this variable were more difficult to make. It would seem natural to presume that experience, which accumulates with age, would increase the quality of architecture and design. However, are inexperienced designers more open-minded and more in tune with the zeitgeist, or do they implement previously tested solutions due to their lack of experience?

Second sub-category of variables is related to a building's architectural status evaluated by architect profession. This category includes two variables (Table 5.1) – a variable which indicates whether or not the building in an architectural landmark or not, and a variable which indicates whether or not the building has been presented in the Finnish Architecture Review. The data of the architectural landmarks is based on the Architectural Guide of Helsinki (2009). The first edition was published in 1963, by the Museum of Finnish Architecture, and subsequent editions in 1990, 2000 and 2009. The Finnish Architectural Review was first published (in 1903) in Swedish. The magazine, the only one of its kind in Finland, is published by the Finnish Association of Architects (SAFA). The locations of architectural landmarks and buildings presented in the Finnish Architectural Review are represented in Figure 5.2.

Third sub-category in this study is related to the architectural style of the building (Table 5.1). Originally architectural style was divided into ten different styles, but after combining some groups only seven were included in the final models. Information on the architectural style of buildings was collected from sources such as the korttelit.fi database, which comprises information on buildings' designers and years of completion, in addition to image data. The share of architects among the designers of buildings has increased over time (Table 5.2). However, architects have only designed around half of the Finnish Art Nouveau building stock – or at least of those dwellings that were sold. Similarly, the average age of the designers of Finnish Art Nouveau buildings was clearly lower than in the other groups. Correspondingly, the average age of the designers of the newest buildings – built in the 1980s or later – was clearly higher than the average age of the designers of buildings representing other architectural styles.

The second main category includes variables related to externalities created by architecture. Externality effects of architecture are studied by including variables which describe view from the building in to price models (Table 5.3).

The first pair of these view-related variables indicates whether or not there is (direct or diagonal) a view to a building is an architectural landmark (Table 5.3 and Figure 5.4). The second pair of variables indicates whether there is (direct or diagonal) to a building that has been introduced in

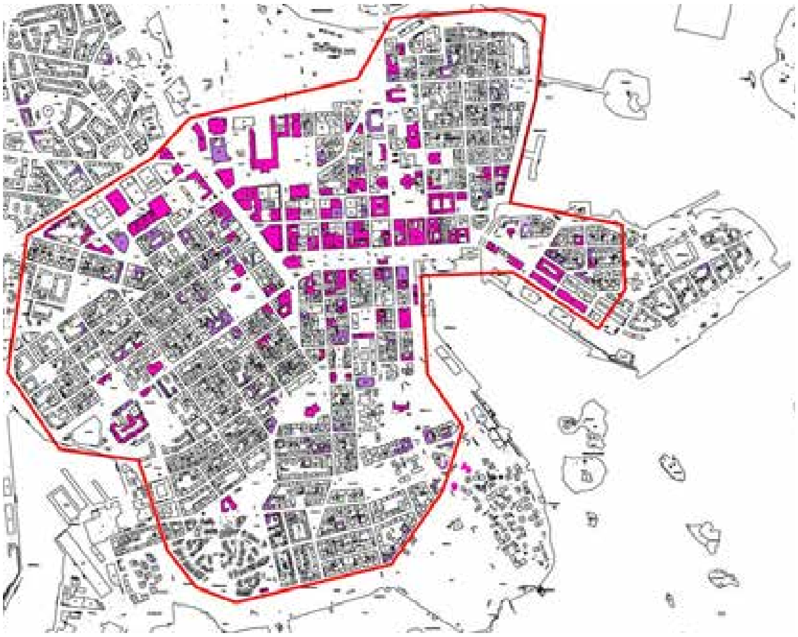
Table 5.2 Architectural styles and planner profiles

Style	% of transac-tions	Number of planners	Architect as a planner (%)	Average age of planner (years)	Competition success (median)	Buildings published ARK magazine
Historic styles	6.4	33	77.2	43.6	0	0
Finnish Art Nouveau	33.0	119	48.3	37.2	1	3
Classicism	26.5	72	84.4	43.2	1	3
Functionalism	12.4	42	94.9	43.1	2	9
Reconstruction and rationalization period	4.0	22	93.1	46.9	5	3
Structuralism	12.6	38	100	46.9	3	2
Postmodernism	2.7	13	100	61.1	19	6

Table 5.3 Variables representing architectural views from the building

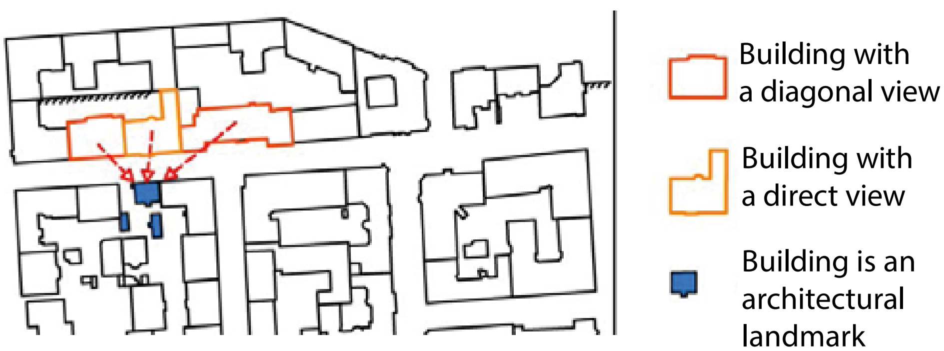
Variable	Variable type	Data source
Direct view to an architectural landmark	0/1	Architectural Guide of Helsinki, Espoo, Vantaa, Kauniainen 2009
Diagonal view to an architectural landmark	0/1	Architectural Guide of Helsinki, Espoo, Vantaa, Kauniainen 2009
Direct view to building which has been created as the result of an architecture competition	0/1	Databases of Museum of Finnish Architecture
Diagonal view to building which has been created as the result of an architecture competition	0/1	Databases of Museum of Finnish Architecture
Direct view to a building which has been published in the Finnish Architectural Review (ARK) 1903–2008	0/1	Finnish Architectural Review (ARK) 1903–2008
Diagonal view to a building which has been published in the Finnish Architectural Review (ARK) 1903–2008	0/1	Finnish Architectural Review (ARK) 1903–2008

Figure 5.2 Architectural landmarks and buildings presented in the ARK magazine



Finnish Architectural Review in 1903-2008 (Figure 5.5). The third pair of variables indicates whether the building was created as the result of an architecture competition (Figure 5.6). Figure 5.3 illustrates the measurement method for variables indicating view-related matters.

Figure 5.3 Construction of view-related variables

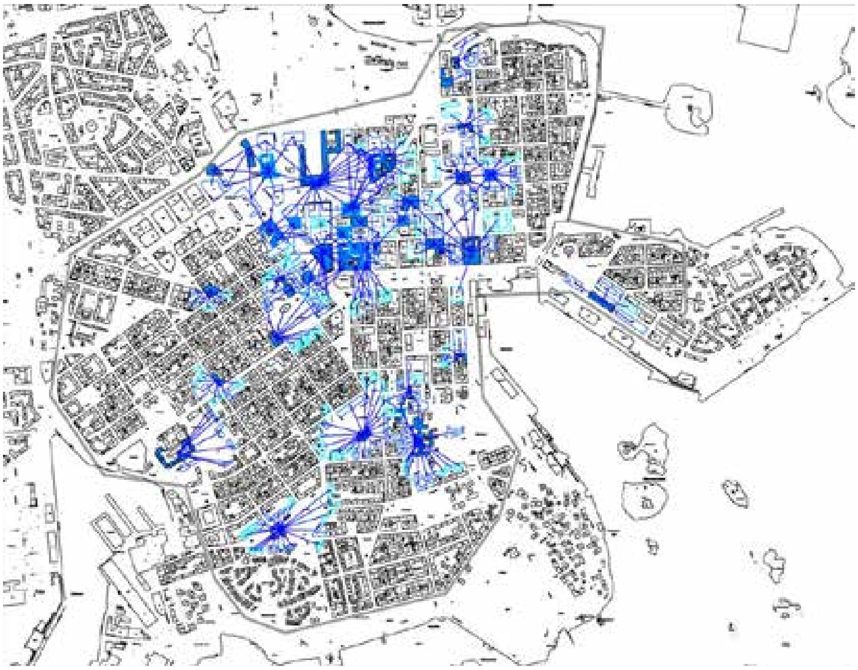


The initial assumption, with regard to all three of the aforementioned variables, is that these dimensions increase the price of a dwelling since they measure architectural quality.

Figure 5.4 View to architectural landmarks

Figure 5.5 View to buildings presented in the Finnish Architectural Review

Figure 5.6 View to buildings that were created as the result of an architecture competition



Finnish Art Nouveau. Luotsikatu 5 by Gesellius, Lindgren and Saarinen (1903).
An Architectural Landmark.

In addition to the architectural view variables, two control variables expressing whether a building has a park or sea view, were included in the models. Some 13.3 per cent of the buildings included in the data were located in a building with a park view, while 4.3 per cent were located in a building featuring a sea view.

5.4.3 Hedonic method and estimation issues

As stared earlier in this chapter, architectural quality has no direct markets. Its economic value can be detected only indirectly. The approach adopted here, the hedonic method, is based on the idea that the price of housing is a combination of implicit prices of different characteristics of housing unit. When compared to some other methods frequently applied, such as the contingent valuation method, one of the advantages of the hedonic method is that it is based on actual market information. As argued in Chapter 3, which presented a discussion on the fundamentals of the hedonic method, the method is based on assumption of continuous implicit price functions. Again, referring to Drhymes (1971), it is assumed that there might only a limited number of combinations of housing characteristics, and spatial clustering of similar units limits the models to cover only a small part of the equilibrium surface. Based on this assumption, there is probably no superior form that outperforms all others (Rothenberg et al. 1991). In price models, log-linear function (i.e. the semi-log function) is applied because it has several desirable features (Malpezzi 2002).

The model to be estimated in this chapter is

$$\text{(5.1)} \qquad \mathbf{P} = \boldsymbol{\alpha} + \mathbf{X}\boldsymbol{\beta}_1 + \mathbf{D}\boldsymbol{\beta}_2 + \mathbf{e} \ .$$

where **P** the (log) transaction price vector of dwellings, **X** is vector of (log) continuous variables (age and size of the dwelling) and **D** is a vector of dummy variables for other variables (including variables related to architecture, transaction time and location). $\boldsymbol{\beta}_1$ and $\boldsymbol{\beta}_2$ are the respective vectors of regression coefficients to be estimated and **e** is the vector of error terms.

The main tool for analysis is the OLS model. As an alternative to the OLS, median regression is also applied. Instead of minimising the sum of squares of residuals (OLS), median regression is linear regression which is based on minimising the sum of the absolute value of residuals. Median regression reduces the effect of outliers on regression coefficients, though the whole data is still used in analysis. Like the traditional OLS model, the median regression model also models the central location of the exogenous variable. In the OLS setting, the coefficients of exogenous variables give information on how much the mean of endogenous variable changes when the exogenous variable changes by one unit. In median regression the interpretation is the same, except that instead of the mean, it is the median (of the endogenous variable) that is modelled (Hao & Naiman 2007).

The main interest in hedonic regressions was to examine whether the previously presented variables concerning views of the buildings of architectural interest have statistical significance of dwelling prices. In order to ensure that these variables could be analysed as dependably as possible, variables describing the characteristics of buildings and the environment are used as control variables in the hedonic models. Besides these, variables related to architectural quality, which in our previous researches found to be statistically significant, are also included in model (Pihlajaniemi & Lönnqvist 2013). Moreover, additional two other variables – a view to the sea and a view to the park – are included to the hedonic model.

5.5 Results

5.5.1 Descriptive statistics

The average size of the building stock included in the research data is 60 square metres, which is rather close to the average value for the entire city (Table 5.4). In terms of eave height, the building stock in the area is rather balanced. Only around three per cent of the dwellings included in the data are located on the seventh floor or higher. A little more than one-third of the dwellings included in the data were classified as being in good condition, and some two-thirds of the dwellings were located in buildings equipped with a lift. Around one-third of the dwellings were rented at the moment of purchase, and in almost the same number of dwellings, it was unknown whether they were unoccupied or leased.

Historic Styles. Fredrikinkatu 14 by Kiseleff and Heikel (1890).

Table 5.4 Descriptive statistics

Variable	Continuous variables				Dictoto-mous vari-ables
	Mean	Standard deviation	Min.value	Max. value	Relative share, %
Log floorarea (sqm)	60.64	39.30	15.00	395.00	
Log age of the dwelling	66.75	24.43	1.00	138.00	
Own lot					87.70
Rented lot					12.30
Condition, other or unknown					73.90
Condtion, good					36.10
Rental status, free or unknown					91.00
Rental status, rented					9.00
Location 1. floor					17.30
Location 2. floor					22.40
Lcoation 3. floor					22.10
Location 4. floor					18.40
Location 5. floor					12.40
Location 6. floor					4.80
Location 7. floor					1.90
Location 8. floor					0.60
Location 9. floor or higher					0.10
Lift in the building, no					30.20
Lift in the building, yes					69.80
Planner is not an architect					33.90
Planner is an architect					76.10
Number of residential building planned	8.96	7.69	1.00	28.00	
Number of published buildings	9.96	12.98	0.00	54.00	
Competition success	4.37	6.87	0.00	64.00	
Age of the planner under 31 year					9.30
Age of the planner 31-40 years					40.10
Age of the planner 41-50 years					28.80
Age of the planner 51-60 years					16.50
Age of the planner over 60 years					3.60
Age of the planner unknown					1.70
Style, Historic styles					6.50
Style, Finnish Art Nouveau					32.50

Table 5.4 Descriptive statistics *(cont.)*

Variable	Continuous variables				Dictoto-mous vari-able
	Mean	Standard deviation	Min.value	Max. value	Relative share, %
Style, Classicim					26.30
Style, Functionalism					15.20
Style, Reconstruction and rationalization period					3.90
Style, Structuralism					13.00
Style, Postmodernism					2.60
Building is not an architectural landmark					99.70
Building is an architectural landmark					0.30
Building not in the ARK magazine					92.30
Building in the ARK magazine					6.70
Sea view, no					95.70
Sea view, yes					4.30
Park view, no					86.70
Park view, yes					13.30
Direct view to architectural landmark, no					96.70
Direct view to architectural landmark, yes					3.30
Diagonal view to architectural landmark, no					95.80
Diagonal view to architectural landmark, yes					4.20
Direct view to arch.comp. building, no					98.30
Direct view to arch.comp. building, yes					1.70
Diagonal view to arch.comp. building, no					97.40
Diagonal view to arch.comp. building, yes					2.60
Direct view to ARK mag. building, no					92.70
Direct view to ARK mag. building, yes					7.30
Diagonal view to ARK mag. building, no					93.50
Diagonal view to ARK mag. building, yes					6.50
Transaction time 1980–1993					44.17
Transaction time 1994–2008					55.83

Correlations between variables were analysed in pairs and by means of the variance inflation factor method. The key observation based on the assessments was that a distinct correlation existed between the variables indicating a dwelling's age and its architectural style. Obviously, this is no surprise since architectural styles are tightly connected to eras. Models including and missing a variable indicating a dwelling's age will be analysed in connection with price models in Subsection 5.5.2. The VIF values for the other variables were quite low, which, coupled with in-pair correlation assessments, indicate that no such strong correlation structure exists between the variables that could distort individual coefficient estimates.

5.5.2 Price models

The price model estimation was carried out in stages, adding variable groups to the model. Following this, the effect of missing information was assessed with regard to the full model. The models were separately estimated on the basis of data from which observations containing missing information had been excluded, data from which variables containing missing information had been excluded, and data in which values had been imputed to replace missing information. With the exception of the missing floor location of a dwelling, any missing information was replaced with the most typical value from the data during imputation. If the floor location was missing, the default floor used for dwellings was the first floor. Following these models, the robustness of the results was assessed by applying median regression to the full data set (values imputed to replace missing values), which generates results that are less sensitive to the effect of outliers when compared with the results generated by the traditional OLS model.

The architectural style of a building is closely tied to its age, since the buildings from each era represent their own architectural style. This is why the variable indicating a building's age is connected to its architectural style. This link is particularly strong where the data only covers a brief period of time. Because of this, the full model without an age variable was estimated, which allowed to evaluate what happens to the coefficients of variables representing architectural style when the effect of a building's age on the price of a dwelling is entirely transferred to variables indicating architectural style.

All of the aforementioned assessments were performed on data that covered the entire period under investigation, 1980–2008. Of course, it is not a given that the effect of all the variables impacting on the price of a dwelling would remain unchanged for almost 30 years. However, our basic premise was that valuations change rather slowly. In order to take this perspective into account, we have analysed the data in two parts: the first part covers the years between 1980 and 1993 and the latter part covers the years between 1994 and 2008.

Step-by-step model building by variable group can be used to assess the stability of the model (Table 5.5). Only the structural properties of a dwelling are included in the model during the first stage (Models 5.1 and 5.2). During the second stage, variables pertaining to the designer (Model 5.3) are added to the model, while variables related to architectural style are included during the third stage (Model 5.4). The view-related variables are added to the model in the final stage (Models 5.5 and 5.6).Small area-specific indicators are missing from Model 5.1 but are included in Models 5.2–5.5.

With the exception of the lift variable, the variables in Models 5.1 and 5.2 were as expected and, for the most part, were statistically significant. When variables indicating the designer's education, age and success are included in the model, the variables depicting the structural properties of a dwelling remain almost unchanged (Model 5.3). The variable indicating the number of the designer's published designs was prefixed by an unexpected symbol, as was the designer's education.

Once the variables indicating the building's architectural style are added to the model (model 5.4), the coefficient of the building's age variable may change so that the negative effect of the building's age increases more rapidly as the building ages. The prefix symbols of the architectural style coefficients complied with expectations and the variables were, for the most part, statistically significant. Some prefix symbols of the variables indicating the designer's age changed, while the coefficients primarily remained statistically insignificant. The coefficient for a building presented in Finnish Architectural Review proved to be statistically insignificant (and negative, defying expectations). The coefficient for architectural sites was positive, expected and statistically significant. With regard to the control variables, the prefix symbol of the lift variable changed into the expected one – meaning that a lift boosts the price of a dwelling.

The view-related variables were added to the model in the final stage (Models 5.5 and 5.6). Furthermore, the prefix symbols for the variable indicating the designer's published designs and the variable indicating a building's inclusion in Finnish Architectural Review remained negative, while the first was also statistically significant. These results did not comply with expectations. As far the designer's age was concerned, a statistically significant yet relatively small premium was observed in the age group between 41 and 50 when compared with the reference group (ages from 31 to 40). The architect coefficient was also statistically significant, and the price premium on architectural sites was shown to increase. The expected prefix symbols (positive) were found in connection with views, but only coefficients indicating a view of an architectural site were found to be statistically significant. The coefficients for sea and park views complied with expectations and were statistically significant.

Table 5.5 Step-by-step models

Variable	MODEL 5.1		MODEL 5.2		MODEL 5.3	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Intercept	6.5922	<.0001	6.7490	<.0001	6.7524	<.0001
Log floor area	0.9252	<.0001	0.9009	<.0001	0.9002	<.0001
Log age of dwelling	-0.0377	<.0001	-0.0609	<.0001	-0.0629	<.0001
Own lot	ref.		ref.		ref.	
Rented lot	-0.0339	0.1242	0.0134	0.5283	0.0049	0.8189
Condition, other or unknown	ref.		ref.		ref.	
Condition, good	0.1143	<.0001	0.1087	<.0001	0.1089	<.0001
Rental status, free or unknown	ref.		ref.		ref.	
Rental status, rented	-0.0266	<.0001	-0.0311	<.0001	-0.0312	<.0001
Location 1. floor	ref.		ref.		ref.	
Location 2. floor	0.0321	<.0001	0.0435	<.0001	0.0434	<.0001
Location 3. floor	0.0475	<.0001	0.0593	<.0001	0.0598	<.0001
Location 4. floor	0.0440	<.0001	0.0621	<.0001	0.0625	<.0001
Location 5. floor	0.0714	<.0001	0.0910	<.0001	0.0904	<.0001
Location 6. floor	0.1349	<.0001	0.1380	<.0001	0.1362	<.0001
Location 7. floor	0.1696	<.0001	0.1803	<.0001	0.1782	<.0001
Location 8. floor	0.2278	<.0001	0.2367	<.0001	0.2332	<.0001
Location 9. floor or upper	0.0862	0.1340	0.1479	0.0080	0.1467	0.0084
Lift in the building, no	ref.		ref.		ref.	
Lift in the building, yes	-0.0379	<.0001	-0.0236	<.0001	-0.0132	0.0029
Planner is not an architect					ref.	
Planner is an architect					-0.0080	0.0895
Number of residential buildings planned					0.0013	<.0001
Number of published buildings					-0.0009	<.0001
Competition success					0.0008	0.0031
Age of the planner, under 31 years					0.0041	0.4984
Age of the planner, 31-40 years					ref.	
Age of the planner, 41-50 years					-0.0013	0.7467
Age of the planner, 51-60 years					-0.0107	0.0317
Age of the planner, over 60 years					-0.0089	0.3705
Style, Historic styles						
Style, Finnish Art Nouveau						
Style, Classicism						
Style, Functionalism						
Style, Reconstruction and rationalization period						

Table 5.5 Step-by-step models *(cont.)*

Variable	MODEL 5.1		MODEL 5.2		MODEL 5.3	
	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Style, Structuralism						
Style, Postmodernism						
Building is not an architectural landmark						
Building is an architectural landmark						
Building not in the ARK magazine						
Building in the ARK magazine						
Sea view, no						
Sea view, yes						
Park view, no						
Park view, yes						
Direct view to architectural landmark, no						
Direct view to architectural landmark, yes						
Diagonal view to architectural landmark, no						
Diagonal view to architectural landmark, yes						
Direct view to arc.comp.bulding, no						
Direct view to arc.comp.bulding, yes						
Diagonal view to arc.comp.bulding, no						
Diagonal view to arc.comp.bulding, yes						
Direct view to ARK mag. building, no						
Direct view to ARK mag. building, yes						
Diagonal view to ARK mag. building, no						
Diagonal view to ARK mag. building, yes						
Neighborhood fixed effects	no		yes		yes	
Transaction time fixed effects	yes		yes		yes	
Adjusted R2	0.9358		0.9454		0.9457	
Time period	1980–2008		1980–2008		1980–2008	
Number of observations	13,074		13,074		13,074	
Missing data	imputed		imputed		imputed	
Outliers excluded	no		no		no	
Estimation method	OLS		OLS		OLS	
Estimation procedure (SAS)	PROC REG		PROC REG		PROC REG	

Table 5.5 Step-by-step models *(cont.)*

Variable	MODEL 5.4		MODEL 5.5		MODEL 5.6	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Intercept	6.9905	<.0001	6.9914	<.0001	6.8894	<.0001
Log floor area	0.8902	<.0001	0.8851	<.0001	0.8980	<.0001
Log age of dwelling	-0.1090	<.0001	-0.1061	<.0001	-0.0862	<.0001
Own lot	ref.		ref.		ref.	
Rented lot	-0.0208	0.3381	-0.0271	0.2108	-0.0798	0.0003
Condition, other or unknown	ref.		ref.		ref.	
Condition, good	0.1045	<.0001	0.1047	<.0001	0.1097	<.0001
Rental status, free or unknown	ref.		ref.		ref.	
Rental status, rented	-0.0325	<.0001	-0.0324	<.0001	-0.0285	<.0001
Location 1. floor	ref.		ref.		ref.	
Location 2. floor	0.0472	<.0001	0.0509	<.0001	0.0433	<.0001
Location 3. floor	0.0630	<.0001	0.0655	<.0001	0.0568	<.0001
Location 4. floor	0.0669	<.0001	0.0693	<.0001	0.0558	<.0001
Location 5. floor	0.0961	<.0001	0.0984	<.0001	0.0833	<.0001
Location 6. floor	0.1450	<.0001	0.1406	<.0001	0.1362	<.0001
Location 7. floor	0.1922	<.0001	0.1840	<.0001	0.1754	<.0001
Location 8. floor	0.2516	<.0001	0.2359	<.0001	0.2187	<.0001
Location 9. floor or upper	0.1639	0.0029	0.1448	0.0083	0.0566	0.3113
Lift in the building, no	ref.		ref.		ref.	
Lift in the building, yes	0.0291	<.0001	0.0248	<.0001	0.0116	0.0270
Planner is not an architect	ref.		ref.		ref.	
Planner is an architect	0.0062	0.1946	0.0107	0.0272	0.0300	<.0001
Number of residential buildings planned	0.0006	0.0213	0.0007	0.0024	0.0008	0.0012
Number of published buildings	-0.0004	0.0319	-0.0006	0.0013	-0.0006	0.0007
Competition success	0.0005	0.0739	0.0006	0.0277	0.0007	0.0224
Age of the planner, under 31 years	-0.0044	0.4669	-0.0045	0.4537	0.0053	0.4076
Age of the planner, 31-40 years	ref.		ref.		ref.	
Age of the planner, 41-50 years	0.0024	0.5538	0.0080	0.0462	0.0156	0.0002
Age of the planner, 51-60 years	-0.0083	0.0947	-0.0092	0.0646	-0.0081	0.1208
Age of the planner, over 60 years	-0.0106	0.3285	-0.0129	0.2356	-0.0015	0.8984
Style, Historic styles	-0.0038	0.6267	-0.0063	0.4164	-0.0482	<.0001
Style, Finnish Art Nouveau	ref.		ref.		ref.	
Style, Classicism	-0.0948	<.0001	-0.0925	<.0001	-0.1078	<.0001
Style, Functionalism	-0.1162	<.0001	-0.1104	<.0001	-0.1354	<.0001
Style, Reconstruction and rationalization period	-0.1595	<.0001	-0.1534	<.0001	-0.1878	<.0001

Table 5.5 Step-by-step models *(cont.)*

Variable	MODEL 5.4		MODEL 5.5		MODEL 5.6	
	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Style, Structuralism	-0.1265	<.0001	-0.1283	<.0001	-0.1347	<.0001
Style, Postmodernism	-0.1450	<.0001	-0.1373	<.0001	-0.1728	<.0001
Building is not an architectural landmark	ref.		ref.		ref.	
Building is an architectural landmark	0.0941	0.0033	0.1165	0.0003	0.1068	0.0016
Building not in the ARK magazine	ref.		ref.		ref.	
Building in the ARK magazine	-0.0084	0.2370	-0.0134	0.0626	-0.0066	0.3838
Sea view, no	ref.		ref.		ref.	
Sea view, yes			0.0664	<.0001	0.0678	<.0001
Park view, no			ref.		ref.	
Park view, yes			0.0290	<.0001	0.0595	<.0001
Direct view to architectural landmark, no			ref.		ref.	
Direct view to architectural landmark, yes			0.0557	0.0105	0.0673	<.0001
Diagonal view to architectural landmark, no			ref.		ref.	
Diagonal view to architectural landmark, yes			0.0296	0.0102	0.0210	0.0411
Direct view to arc.comp.bulding, no			ref.		ref.	
Direct view to arc.comp.bulding, yes			-0.0076	0.0142	-0.0162	0.2774
Diagonal view to arc.comp.bulding, no			ref.		ref.	
Diagonal view to arc.comp.bulding, yes			-0.0258	0.0125	-0.0045	0.7295
Direct view to ARK mag. building, no			ref.		ref.	
Direct view to ARK mag. building, yes			0.0130	0.0065	0.0164	0.0145
Diagonal view to ARK mag. building, no			ref.		ref.	
Diagonal view to ARK mag. building, yes			0.0105	0.0069	0.0015	0.8369
Neighborhood fixed effects	no		yes		yes	
Transaction time fixed effects	yes		yes		yes	
Adjusted R2	0.9472		0.9479		0.9401	
Time period	1980–2008		1980–2008		1980–2008	
Number of observations	13,074		13,074		13,074	
Missing data	imputed		imputed		imputed	
Outliers excluded	no		no		no	
Estimation method	OLS		OLS		OLS	
Estimation procedure (SAS)	PROC REG		PROC REG		PROC REG	

What follows is an assessment of the data with regard to missing information and outliers. Imputing was used to complete the data in cases of missing information. The performed imputations are described above. Two alternative estimations were carried out for the models in Table 5.6, in addition to the full model (Model 5.9), which includes all observations along with their imputations. Observations comprising missing information were excluded from Model 5.7, while all variables featuring missing information were excluded from Model 5.8. The results yielded by the models, as compared with the full model (Model 5.9) remained unchanged, in the sense that no substantial changes were seen in the variables' prefix symbols or the statistical significance of the coefficients. However, a certain systematic tendency in the magnitude of the coefficients was observable when comparing a model from which variables that featured missing information were excluded (Model 5.8) with a full model (Model 5.9). These changes were particularly observable with regard to the coefficients of the variables pertaining to the floor of a dwelling and the architectural style of a building.

The last model in Table 5.6 (Model 5.10) was estimated using the median regression method. This method was used to reveal whether a significant amount of effects resulting from outliers underpinned the full model's (Model 5.9) results. Unlike the OLS model, median regression is not very sensitive to the effects of outliers. The first observation pertaining to Model 5.10's results was that the effect of the architect variable decreases while the battery of variables indicating the architect's age increases. Similarly, it was discovered that the variable indicating a sea view decreases, while other view-related variables are bolstered. Of course, whether some observations can be considered soe extreme (outlier) that their effect should be in some way be dampened is a matter of interpretation.

This is also partially a question of the fulfilment of the assumptions related to estimation methods – i.e. whether a method is capable of generating unbiased results in the event that the data contains outlying observations (outliers). According to the limited model comparison performed here, the data does not seem to feature observations affecting the results in a significant manner. For instance: even though the variable indicating sea view yields a significantly lower coefficient in the median regression model than in the OLS model, the OLS model is rather credible in light of the research literature.

The most significant finding based on the assessment pertaining to the occurrence of multicollinearity in the data included in Section 5.5.1 was the correlation between a building's age and architectural style. In addition to the full model (Model 5.11), Table 5.7 displays a model from which the age variable has been excluded. The effects of this change on the other model variables are fairly insignificant, yet rather significant with regard to the factors pertaining to architectural style. First of all, the difference between the architectural style representing the oldest building stock (Historic styles) and the reference group (Finnish Art Nouveau) increased. Second, in the case of later architectural styles, the exclusion of the age variable from the model reduces the price difference between these architectural styles and the reference group. In the case of the latest architectural style, Postmodernism, the coefficient, previously clearly negative (Model 5.11), changed into a positive one. A building's age can therefore be considered an aspect of the building that is at least partially separated from architectural style. Age can be considered to affect a building's operating and repair costs. This makes it understandable as to why the omission of the age variable has such a significant effect on the variable indicating a dwelling's price in the case of the latest building stock.

On the basis of the previous assessments (Tables 5.3–5.4) we can draw several conclusions regarding the coefficients that affect housing prices. Firstly, the effects of a dwelling's structural properties on the price of the dwelling were, according to our data, more or less as expected. The age, size, floor number, condition and status (unoccupied or leased) of a dwelling had the expected effect on the price of the dwelling. Larger dwellings were more expensive than smaller ones, but the effect of a dwelling's increasing size was not linear; instead, it was diminishing, forced by the function form. The effect of a building's age on housing prices may seem somewhat difficult to accept. The oldest dwellings in the area are held in rather high esteem. Does that not make interpretation problematic if the increasing age of a dwelling seems to reduce its price in light of the results? This is not the case when variables indicating architectural style are included in the model. In this event, the age variable can be thought to express the dwelling's structural age, which can be considered to be related to maintenance and repair costs. On the other hand, variables indicating architectural style express the aesthetic and perhaps also the functional desirability of a dwelling. The oldest part of the building stock – Finnish Art Nouveau, especially representative of early 20th century styles – is the most prestigious part of the building stock under this type of analysis.

Table 5.6 Full models, different estimation techniques

Variable	MODEL 5.7		MODEL 5.8	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|
Intercept	7.0154	<.0001	7.0461	<.0001
Log floor area	0.8868	<.0001	0.8893	<.0001
Log age of dwelling	-0.1150	<.0001	-0.1205	<.0001
Own lot	ref.		ref.	
Rented lot	-0.0375	0.1015	-0.0069	0.7568
Condition, other or unknown	ref.			
Condition, good	0.1062	<.0001		
Rental status, free or unknown	ref.			
Rental status, rented	-0.0296	<.0001		
Location 1. floor	ref.		ref.	
Location 2. floor	0.0611	<.0001	0.0571	<.0001
Location 3. floor	0.0729	<.0001	0.0729	<.0001
Location 4. floor	0.0777	<.0001	0.0759	<.0001
Location 5. floor	0.1067	<.0001	0.1069	<.0001
Location 6. floor	0.1483	<.0001	0.1532	<.0001
Location 7. floor	0.1871	<.0001	0.1924	<.0001
Location 8. floor	0.2457	<.0001	0.2496	<.0001
Location 9. floor or upper	0.1543	0.0062	0.1617	0.0045
Lift in the building, no	ref.		ref.	
Lift in the building, yes	0.0141	0.0087	0.0222	<.0001
Planner is an architect	ref.		ref.	
Planner is not an architect	0.0177	0.0007	0.0113	0.0235
Number of residential buildings planned	0.0005	0.0653	0.0006	0.0224
Number of published buildings	-0.0005	0.0132	-0.0005	0.0053
Competition success	0.0007	0.0279	0.0004	0.1278
Age of the planner, under 31 years	-0.0015	0.8112		
Age of the planner, 31-40 years	ref.			
Age of the planner, 41-50 years	0.0150	0.0005		
Age of the planner, 51-60 years	-0.0035	0.5141		
Age of the planner, over 60 years	-0.0091	0.4301		
Style, Historic styles	-0.0113	0.1756	-0.0038	0.6296
Style, Finnish Art Nouveau	ref.		ref.	
Style, Classicism	-0.0912	<.0001	-0.0974	<.0001
Style, Functionalism	-0.1160	<.0001	-0.1233	<.0001
Style, Reconstruction and rationalization period	-0.1622	<.0001	-0.1759	<.0001

Table 5.6 Full models, different estimation techniques *(cont.)*

Variable	MODEL 5.7		MODEL 5.8	
	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Style, Structuralism	-0.1306	<.0001	-0.1497	<.0001
Style, Postmodernism	-0.1550	<.0001	-0.1518	<.0001
Building is not an architectural landmark	ref.		ref.	
Building is an architectural landmark	0.0704	0.0381	0.0959	0.0036
Building not in the ARK magazine	ref.		ref.	
Building in the ARK magazine	0.0067	0.3821	-0.0089	0.2292
Sea view, no	ref.		ref.	
Sea view, yes	0.0573	<.0001	0.0615	<.0001
Park view, no	ref.		ref.	
Park view, yes	0.0303	<.0001	0.0288	<.0001
Direct view to architectural landmark, no	ref.		ref.	
Direct view to architectural landmark, yes	0.0382	0.0005	0.0564	<.0001
Diagonal view to architectural landmark, no	ref.		ref.	
Diagonal view to architectural landmark, yes	0.0096	0.3771	0.0208	0.0496
Direct view to arc.comp.bulding, no	ref.		ref.	
Direct view to arc.comp.bulding, yes	-0.0026	0.8625	-0.0155	0.2935
Diagonal view to arc.comp.bulding, no	ref.		ref.	
Diagonal view to arc.comp.bulding, yes	0.0209	0.1166	0.0062	0.6349
Direct view to ARK mag.building, no	ref.		ref.	
Direct view to ARK mag.building, yes	0.0096	0.1668	0.0123	0.0681
Diagonal view to ARK mag.building, no	ref.		ref.	
Diagonal view to ARK mag.building, yes	0.0083	0.2569	0.0144	0.0441
Neighborhood fixed effects	yes		yes	
Transaction time fixed effects	yes		yes	
Adjusted R2	0.9520		0.9437	
Time period	1980-2008		1980-2008	
Number of observations	11,127		13,074	
Missing data	observations excluded		variables excluded	
Outliers excluded	no		no	
Estimation method	OLS		OLS	
Estimation procedure (SAS)	PROC REG		PROC REG	

Table 5.6 Full models, different estimation techniques *(cont.)*

Variable	MODEL 5.9		MODEL 5.10	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|
Intercept	6.9914	<.0001	7.0868	<.0001
Log floor area	0.8851	<.0001	0.8747	<.0001
Log age of dwelling	-0.1061	<.0001	-0.1078	<.0001
Own lot	ref.		ref.	
Rented lot	-0.0271	0.2108	-0.0213	0.1811
Condition, other or unknown	ref.		ref.	
Condition, good	0.1047	<.0001	0.1005	<.0001
Rental status, free or unknown	ref.		ref.	
Rental status, rented	-0.0324	<.0001	-0.0339	<.0001
Location 1. floor	ref.		ref.	
Location 2. floor	0.0509	<.0001	0.0379	<.0001
Location 3. floor	0.0655	<.0001	0.0491	<.0001
Location 4. floor	0.0693	<.0001	0.0529	<.0001
Location 5. floor	0.0984	<.0001	0.0803	<.0001
Location 6. floor	0.1406	<.0001	0.1095	<.0001
Location 7. floor	0.1840	<.0001	0.1523	<.0001
Location 8. floor	0.2359	<.0001	0.2077	<.0001
Location 9. floor or upper	0.1448	0.0083	0.1054	0.0640
Lift in the building, no	ref.		ref.	
Lift in the building, yes	0.0248	<.0001	0.0105	0.0038
Planner is an architect	ref.		ref.	
Planner is not an architect	0.0107	0.0272	-0.0026	0.4772
Number of residential buildings planned	0.0007	0.0024	0.0002	0.2418
Number of published buildings	-0.0006	0.0013	-0.0002	0.0938
Competition success	0.0006	0.0277	0.0007	0.0051
Age of the planner, under 31 years	-0.0045	0.4537	0.0009	0.8490
Age of the planner, 31-40 years	ref.		ref.	
Age of the planner, 41-50 years	0.0080	0.0462	0.0050	0.0784
Age of the planner, 51-60 years	-0.0092	0.0646	-0.0094	0.0128
Age of the planner, over 60 years	-0.0129	0.2356	-0.0226	0.0084
Style, Historic styles	-0.0063	0.4164	0.0032	0.6588
Style, Finnish Art Nouveau	ref.		ref.	
Style, Classicism	-0.0925	<.0001	-0.0718	<.0001
Style, Functionalism	-0.1104	<.0001	-0.0927	<.0001
Style, Reconstruction and rationalization period	-0.1534	<.0001	-0.1199	<.0001

Table 5.6 Full models, different estimation techniques *(cont.)*

Variable	MODEL 5.9		MODEL 5.10	
	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Style, Structuralism	-0.1283	<.0001	-0.1076	<.0001
Style, Postmodernism	-0.1373	<.0001	-0.1072	<.0001
Building is not an architectural landmark	ref.		ref.	
Building is an architectural landmark	0.1165	0.0003	0.0850	0.1168
Building not in the ARK magazine	ref.		ref.	
Building in the ARK magazine	-0.0134	0.0626	0.0010	0.8638
Sea view, no	ref.		ref.	
Sea view, yes	0.0664	<.0001	0.0278	0.0019
Park view, no	ref.		ref.	
Park view, yes	0.0290	<.0001	0.0254	<.0001
Direct view to architectural landmark, no	ref.		ref.	
Direct view to architectural landmark, yes	0.0557	0.0105	0.0397	<.0001
Diagonal view to architectural landmark, no	ref.		ref.	
Diagonal view to architectural landmark, yes	0.0296	0.0102	0.0139	0.1163
Direct view to arc.comp.bulding, no	ref.		ref.	
Direct view to arc.comp.bulding, yes	-0.0076	0.0142	0.0160	0.2504
Diagonal view to arc.comp.bulding, no	ref.		ref.	
Diagonal view to arc.comp.bulding, yes	-0.0258	0.0125	0.0272	0.0053
Direct view to ARK mag.building, no	ref.		ref.	
Direct view to ARK mag.building, yes	0.0130	0.0065	0.0088	0.1205
Diagonal view to ARK mag.building, no	ref.		ref.	
Diagonal view to ARK mag.building, yes	0.0105	0.0069	0.0133	0.0175
Neighborhood fixed effects	yes		yes	
Transaction time fixed effects	yes		yes	
Adjusted R2	0.9479			
Time period	1980–2008		1980–2008	
Number of observations	13,074		13,074	
Missing data	imputed		imputed	
Outliers excluded	no		1.17 % observations identified as outliers (cutoff value 4.5)	
Estimation method	OLS		Median regression	
Estimation procedure (SAS)	PROC REG		PROC QUANTREG	

Table 5.7 Full model with/without age variable

Variable	MODEL 5.11		MODEL 5.12	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|
Intercept	6.9914	<.0001	6.5480	<.0001
Log floor area	0.8851	<.0001	0.8862	<.0001
Log age of dwelling	-0.1061	<.0001		
Own lot	ref.		ref.	
Rented lot	-0.0271	0.2108	0.0257	0.2292
Condition, other or unknown	ref.		ref.	
Condition, good	0.1047	<.0001	0.1078	<.0001
Rental status, free or unknown	ref.		ref.	
Rental status, rented	-0.0324	<.0001	-0.0318	<.0001
Location 1. floor	ref.		ref.	
Location 2. floor	0.0509	<.0001	0.0499	<.0001
Location 3. floor	0.0655	<.0001	0.0647	<.0001
Location 4. floor	0.0693	<.0001	0.0680	<.0001
Location 5. floor	0.0984	<.0001	0.0981	<.0001
Location 6. floor	0.1406	<.0001	0.1407	<.0001
Location 7. floor	0.1840	<.0001	0.1793	<.0001
Location 8. floor	0.2359	<.0001	0.2287	<.0001
Location 9. floor or upper	0.1448	0.0083	0.1500	0.0065
Lift in the building, no	ref.		ref.	
Lift in the building, yes	0.0248	<.0001	0.0258	<.0001
Planner is not an architect	ref.		ref.	
Planner is an architect	0.0107	0.0272	0.0125	0.0101
Number of planned buildings	0.0007	0.0024	0.0004	0.1188
Number of residential buildings planned	-0.0006	0.0013	-0.0005	0.0037
Number of published buildings	0.0006	0.0277	0.0006	0.0339
Age of the planner, under 31 years	-0.0045	0.4537	-0.0052	0.3915
Age of the planner, 31-40 years	ref.		ref.	
Age of the planner, 41-50 years	0.0080	0.0462	0.0080	0.0480
Age of the planner, 51-60 years	-0.0092	0.0646	-0.0019	0.7093
Age of the planner, over 60 years	-0.0129	0.2356	-0.0106	0.3340
Style, Historic styles	-0.0063	0.4164	-0.0307	<.0001
Style, Finnish Art Nouveau	ref.		ref.	
Style, Classicism	-0.0925	<.0001	-0.0706	<.0001
Style, Functionalism	-0.1104	<.0001	-0.0732	<.0001
Style, Reconstruction and rationalization period	-0.1534	<.0001	-0.0748	<.0001

Table 5.7 Full model with/without age variable *(cont.)*

Variable	MODEL 5.11		MODEL 5.12	
	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Style, Structuralism	-0.1283	<.0001	-0.0203	0.0071
Style, Postmodernism	-0.1373	<.0001	0.1097	<.0001
Building is not an architectural landmark	ref.		ref.	
Building is an architectural landmark	0.1165	0.0003	0.1095	0.0007
Building not in the ARK magazine	ref.		ref.	
Building in the ARK magazine	-0.0134	0.0626	-0.0091	0.2058
Sea view, no	ref.		ref.	
Sea view, yes	0.0664	<.0001	0.0652	<.0001
Park view, no	ref.		ref.	
Park view, yes	0.0290	<.0001	0.0390	<.0001
Direct view to architectural landmark, no	ref.		ref.	
Direct view to architectural landmark, yes	0.0557	0.0105	0.0528	<.0001
Diagonal view to architectural landmark, no	ref.		ref.	
Diagonal view to architectural landmark, yes	0.0296	0.0102	0.0285	0.0056
Direct view to arc.comp.bulding, no	ref.		ref.	
Direct view to arc.comp.bulding, yes	-0.0076	0.0142	-0.0157	0.2722
Diagonal view to arc.comp.bulding, no	ref.		ref.	
Diagonal view to arc.comp.bulding, yes	-0.0258	0.0125	-0.0124	0.3252
Direct view to ARK mag.building, no	ref.		ref.	
Direct view to ARK mag.building, yes	0.0130	0.0065	0.0099	0.1302
Diagonal view to ARK mag.building, no	ref.		ref.	
Diagonal view to ARK mag.building, yes	0.0105	0.0069	0.0070	0.3122
Neighborhood fixed effects	yes		yes	
Transaction time fixed effects	yes		yes	
Adjusted R2	0.9479		0.9472	
Time period	1980–2008		1980–2008	
Number of observations	13,074		13,074	
Missing data	imputed		imputed	
Estimation method	OLS		OLS	
Estimation procedure (SAS)	PROC REG		PROC REG	

Table 5.8 Different time periods, 1980-1993 and 1994–2008

Variable	MODEL 5.13		MODEL 5.14	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|
Intercept	7.0444	<.0001	7.8998	<.0001
Log floor area	0.8511	<.0001	0.9130	<.0001
Log age of dwelling	-0.0869	<.0001	-0.0619	<.0001
Own lot	ref.		ref.	
Rented lot	-0.0413	0.255	0.0172	0.5025
Condition, other or unknown	ref.		ref.	
Condition, good	0.0977	<.0001	0.1095	<.0001
Rental status, free or unknown	ref.		ref.	
Rental status, rented	-0.0624	<.0001	-0.0098	0.1216
Location 1. floor	ref.		ref.	
Location 2. floor	0.0448	<.0001	0.0516	<.0001
Location 3. floor	0.0545	<.0001	0.0715	<.0001
Location 4. floor	0.0565	<.0001	0.0778	<.0001
Location 5. floor	0.0775	<.0001	0.1105	<.0001
Location 6. floor	0.1184	<.0001	0.1489	<.0001
Location 7. floor	0.1487	<.0001	0.2117	<.0001
Location 8. floor	0.1958	<.0001	0.2643	<.0001
Location 9. floor or upper	0.0410	0.6887	0.2294	0.0001
Lift in the building, no	ref.		ref.	
Lift in the building, yes	0.0254	0.0037	0.0249	<.0001
Planner is not an architect	ref.		ref.	
Planner is an architect	0.0062	0.4528	0.0124	0.0267
Number of planned buildings	0.0004	0.3771	0.0008	0.0033
Number of residential buildings planned	-0.0002	0.4533	-0.0009	<.0001
Number of published buildings	0.0014	0.0073	0.0003	0.3051
Age of the planner, under 31 years	-0.0174	0.09	0.0048	0.4966
Age of the planner, 31-40 years	ref.		ref.	
Age of the planner, 41-50 years	0.0241	0.0005	-0.0066	0.1556
Age of the planner, 51-60 years	0.0000	0.9959	-0.0152	0.0074
Age of the planner, over 60 years	-0.0087	0.6311	-0.0233	0.0697
Style, Historic styles	-0.0086	0.5333	-0.0214	0.0161
Style, Finnish Art Nouveau	ref.		ref.	
Style, Classicism	-0.0886	<.0001	-0.0818	<.0001
Style, Functionalism	-0.1233	<.0001	-0.0773	<.0001
Style, Reconstruction and rationalization period	-0.1088	<.0001	-0.1404	<.0001

Table 5.8 Different time periods, 1980-1993 and 1994–2008 (cont.)

Variable	MODEL 5.13		MODEL 5.14	
	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Style, Structuralism	-0.0554	0.0101	-0.1280	<.0001
Style, Postmodernism	-0.0715	0.1027	-0.0412	0.1711
Building is not an architectural landmark	ref.		ref.	
Building is an architectural landmark	0.1052	0.1002	0.1043	0.0018
Building not in the ARK magazine	ref.		ref.	
Building in the ARK magazine	0.0103	0.4162	-0.0278	0.0007
Sea view, no	ref.		ref.	
Sea view, yes	0.0598	0.0001	0.0686	<.0001
Park view, no	ref.		ref.	
Park view, yes	0.0243	0.0172	0.0374	<.0001
Direct view to architectural landmark, no	ref.		ref.	
Direct view to architectural landmark, yes	0.0662	0.0001	0.0401	0.0013
Diagonal view to architectural landmark, no	ref.		ref.	
Diagonal view to architectural landmark, yes	0.0258	0.1416	0.0296	0.0129
Direct view to arc.comp.bulding, no	ref.		ref.	
Direct view to arc.comp.bulding, yes	0.0199	0.3996	-0.0281	0.0933
Diagonal view to arc.comp.bulding, no	ref.		ref.	
Diagonal view to arc.comp.bulding, yes	0.0190	0.3804	-0.0225	0.1187
Direct view to ARK mag.building, no	ref.		ref.	
Direct view to ARK mag.building, yes	0.0162	0.1457	0.0099	0.1846
Diagonal view to ARK mag.building, no	ref.		ref.	
Diagonal view to ARK mag.building, yes	0.0154	0.198	0.0079	0.3134
Neighborhood fixed effects	yes		yes	
Transaction time fixed effects	yes		yes	
Adjusted R2	0.9103		0.9471	
Time period	1980–1993		1994–2008	
Number of observations	5,775		7,299	
Missing data	imputed		imputed	
Outliers excluded	no		no	
Estimation method	OLS		OLS	
Estimation procedure (SAS)	PROC REG		PROC REG	

Insofar as the control variables are concerned, the effects of a dwelling's floor number were as expected. The higher the floor, the better. A lift increases the value of a dwelling, as does the dwelling's good condition and is not being leased at the moment of purchase. No price effects pertaining to rented lots were identified. The expectation was that a rented lot would reduce the price of a dwelling. This should occur if the rent is at a reasonable level based on land prices, which is obviously something one cannot be entirely sure of. The price effect of a rented lot was partially identifiable in assessments covering a shorter period.

The previous assessments entailed the rather bold assumption that the factors impacting on housing prices had not changed over the course of the assessment period. However, the assessment period was quite long – almost 30 years. That is why this assumption of the unchangeability of the coefficients must be tested. In the following (Table 5.8), the data is divided into two parts. The first part of the data covers the period between 1980 and 1993, while the latter part covers the period between 1994 and 2008. The break-off point, therefore, was 1993 – the nadir of the great recession of the early 1990s. Models that are otherwise identical in terms of variables were estimated for these two data sets (Model 5.13 for the 1980-1993 data and Model 5.14 for the 1994-2008 data).

By comparing Models 5.13 and 5.14, it can be surmised that the negative effect of a dwelling's age (variable indicating age) has decreased while the prices of buildings representing the (postwar) rebuilding and rationalisation period and 1960s and 1970s structuralism have fallen. When it is simultaneously noted that the value of functionalist buildings from the rebuilding period has risen proportionally, it can at least suspected that this change in architectural styles also has to do with renovation needs imposed by the age of the buildings.

The negative coefficient of a building's age has dropped (i.e. moved closer to zero) since 1993, while the impact of the coefficients indicating the rebuilding period and structuralism has increased and the one for functionalism has decreased. Insofar as control variables are concerned, the effect of a rented lot on the price of a dwelling was decreasing prior to 1994 and was inconsequential after that. The status of a dwelling (unoccupied or leased) seems to have also lost some of its significance. On the other hand, the effect of the floor of a dwelling has increased since 1993.

This study particularly focused on variables related to architecture. In terms of architecture-related variables, it was discovered that the prices of dwellings located in architect-designed buildings have seen a slight increase. The same seems to apply to buildings designed by young architects. Architectural sites remain valued in terms of both a building's own features and view-related variables, including park and sea views. The positive price effect of a park view has grown over time.

5.6 Discussion

Due to rapid urbanisation, the quantitative sufficiency of housing supply is sometimes considered to be a more crucial question than aesthetic quality. Then again, building stock has a rather long lifespan, which offers an incentive to invest in the overall quality of buildings, including architecture. This is not merely a question of aesthetics. Understanding life-cycle costs as part of construction costs promotes investment in design. Expensive construction costs can also be considered a reason to invest in architectural design. Small living spaces must be well-designed in order to ensure the functionality of dwellings.

However, architectural quality is a concept that is difficult to pinpoint. In this work, the question is approached by using information provided by the housing market. Are the valuations of professional architects ones that the market also values? Do architectural competitions provide added value, do sites included in architectural guides increase the price of dwellings in these buildings or the neighbourhood, and are buildings designed by architects more valuable than buildings that are not?

In this chapter, data on housing prices in the southern parts of central Helsinki was used to analyse the effects of variables indicating architectural quality, the designer's experience and education, as well as a building's architectural style and views from the building on housing prices. The effects of architectural quality and style on housing prices was assessed by using research data collected from the southern parts of central Helsinki. This research data covered housing transactions between 1980 and 2008. Architectural variables of this study were constructed using various databases of the Museum of Finnish Architecture, the korttelit.fi database and the Architecture Guide of Helsinki, Espoo, Kauniainen and Vantaa (2009). Variables representing views from buildings were constructed using digital maps and CAD tool.

Literature on the effects of architectural quality on housing prices is scarce, especially those made from European perspective. Research done in North America, mainly in the United States, focuses mostly on price effects related to architectural heritage status. There is no well identified tradition of research that would give starting point for hypothesis formation.

The impact of the structural properties of a dwelling – serving as control variables – was, for the most part, as expected and compliant with existing research results. Some of the results pertaining to architecture-related results were as expected, while some were statistically insignificant and some defied expectations.

Depending on the model used, architect-designed buildings and dwellings located in these buildings proved to be 1–2 per cent more valuable than ones not designed by architects. The difference may not seem that great, but it is financially significant in proportion to the prices of dwellings. The designer's age – one of the indicators for the designer's experience – proved to be rather sensitive in relation to the other variables in step-by-step assessments.

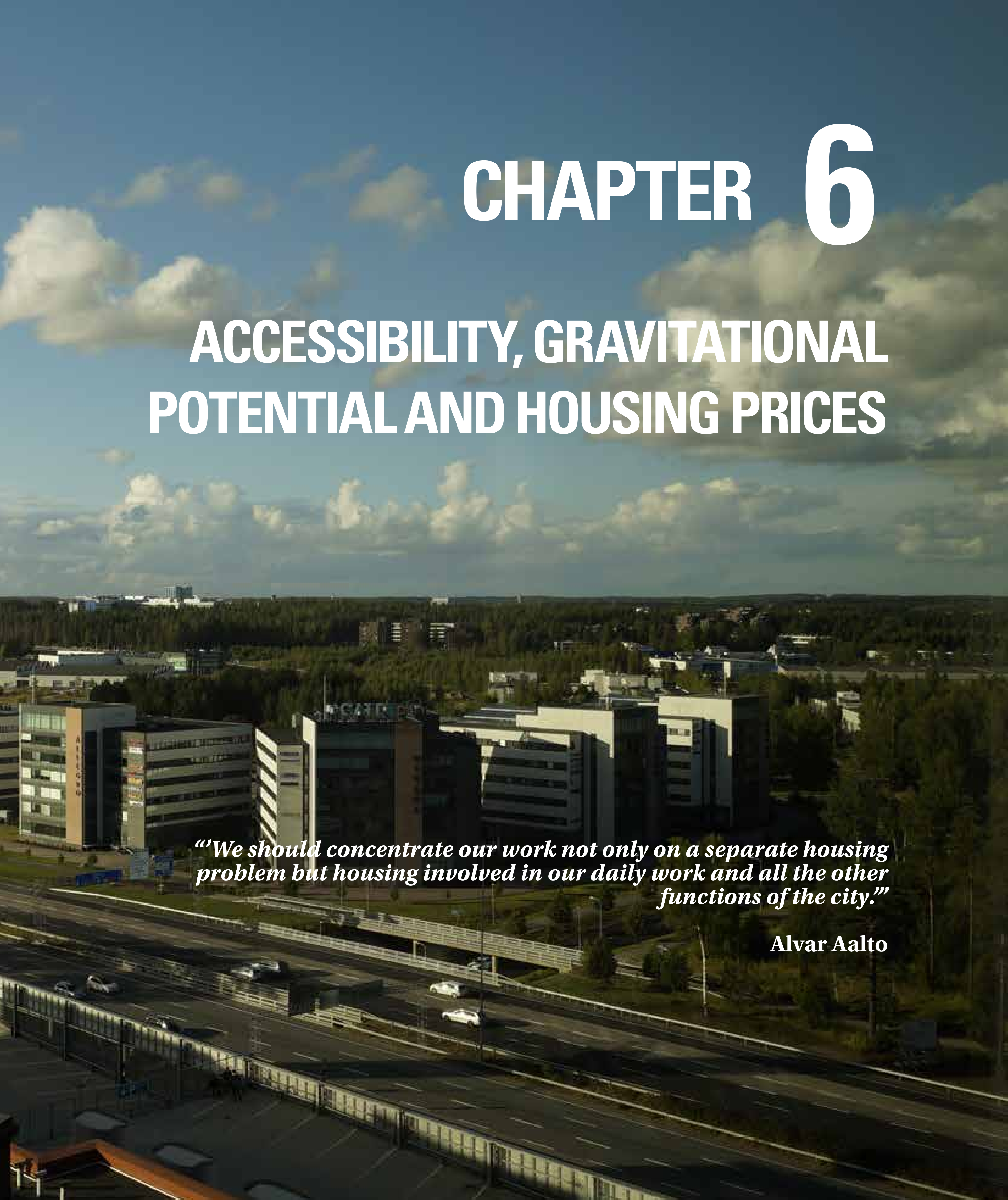
Ultimately, it can be stated, however, that the designer's age does not monotonically increase the prices of dwellings. Compared to the reference group (31-40-year-olds), only the group comprising people aged between 41 and 50 obtained a positive and statistically significant result. The designer's experience was also measured directly, on the basis of the number of designed buildings located in the area. The number of buildings designed varied from one to 28. In the full model, the variable obtained a positive and statistically significant coefficient. Therefore, the designer's experience increases the value of the dwelling. Due to limitations of the data, the variable representing the planners' experience (number of planned buildings) comprises only the buildings they have designed within the study area. Of course, a planner might have designed (even similar) buildings to other places. The designer's success in terms of architecture competitions generated a positive and statistically significant coefficient in the full model (Model 9). The values of the variable indicating success in competitions ranged from zero to 64. Then again, defying expectations, the number of buildings included in Finnish Architectural Review had a negative effect on housing prices. This result is difficult to parse.

As regards architectural style, Finnish Art Nouveau dwellings were more expensive than dwellings in other styles. The styles that were chronologically closest to Finnish Art Nouveau – the Historic Styles of the preceding period and the classicism of the subsequent period – were the architectural styles that were held in highest esteem after Finnish Art Nouveau. A tentative interpretation can be drawn concerning the correlation between a building's age and architectural style, according to which a distinction can be made between these two aspects. The age of a building can be considered to represent the building's maintenance and repair costs, which – via this distinction between variables related to age and architectural style – can be considered to be separable from the aesthetic and functional valuations expressed by variables related to architectural style. The period in which buildings representing the rebuilding period and structuralism went under renovation was concurrent with the latter assessment period (1994–2008). The log-specified age variable was not, therefore, necessarily adequate for controlling all age-related effects.

The results (negative coefficient) for buildings included in Finnish Architectural Review were contrary to expectations. On the other hand, architectural landmarks were held in high esteem, and this result was robust. The results pertaining to view-related variables were in line with expectations. Views of architectural landmarks as well as park and sea views increased the price of a dwelling. The coefficients related to buildings included in competitions and Finnish Architectural Review were in line with expectations but were statistically insignificant.

The evidence on match between values of the architecture profession and the values of consumers is somewhat mixed though the balance between results from different variables favours the interpretation that the values of the architecture profession are in line with the market's values. For example architectural landmarks have positive price premium. Based on view variables, architectural quality also seems to have positive external effects. Several of the architecture-related view variables have positive and statistically significant coefficients. However, these variables were formed based on building level information, not dwelling level information. When interpreting the results, it must be noted that the architectural style and age of a building are interrelated. For this reason, other factors besides aesthetic ones may affect the valuation of an architectural style, indicated by housing prices. The age of a building may be linked to maintenance and repair costs via building technology. Architectural style may also have to do with the functionality of a dwelling. For instance, in the oldest part of the building stock, room heights are clearly greater than in buildings built later. Through this prism, architectural style can be considered to be a part of the larger concept of architectural quality, which may comprise other desirable dwelling attributes in addition to aesthetic quality.

The study only covered a very limited area. Extending similar analyses to the entire urban region might be reasonable, since this would mean a more comprehensive inclusion in the research data of buildings representing different eras. On the other hand, remarkable homogeneity (style, planning solutions and even planner) of the housing stock of the suburban estates might produce problems for estimation and interpretation of these models.



CHAPTER 6

ACCESSIBILITY, GRAVITATIONAL POTENTIAL AND HOUSING PRICES

"'We should concentrate our work not only on a separate housing problem but housing involved in our daily work and all the other functions of the city.'"

Alvar Aalto

6 ACCESSIBILITY, GRAVITATIONAL POTENTIAL AND HOUSING PRICES

6.1 Introduction

The key research question in this chapter is how accessibility to workplaces affects housing prices. The usual method for measuring accessibility in housing price studies has been based on using the distance to the main urban centre and, to some extent, (commercial) subcentres as an indicator of accessibility. In monocentric cities, the effect of distance to the main centre is usually pronounced with regard to housing prices, whereas in polycentric cities it may be less so (Heikkilä et al. 1989). This chapter focuses on the price effects of general accessibility to workplaces (alongside distance to the main centre). Housing market transaction data and grid-level data on workplaces in the Helsinki Metropolitan Area (Helsinki, Espoo, Vantaa, Kauniainen) alongside travel time data are combined to create variables depicting accessibility to workplaces. This approach utilises the idea of gravitational potential (Hansen 1959).

According to the basic logic of urban economics, accessibility affects the desirability of a location and, therefore, its price. It guides the placement of the population – discrepancies in evaluations and budget limitations both guide the placement of the population on the basis of accessibility. Accessibility creates expectations for increases in the value of unbuilt land in good locations. It also guides the placement of jobs and services. Central locations are desirable since they maximise the size of the market area of businesses operating in local markets (Hotelling 1929), while also providing businesses with productivity benefits (Marshall 1920). Moreover, travel expenses constitute a sort of friction that provides businesses with local monopoly power and encourages them to position themselves closer to their customers.

The literature provides several definitions of accessibility. Within the framework of the basic model of urban economy – the monocentric urban model – accessibility was originally seen as accessibility to the city centre, which was assumed to be the location of all workplaces. What is termed the wasteful commuting debate also brought up other factors that may influence households' location decisions in a manner that may not directly correspond with the (simple) monocentric model's logic for minimising travel costs. Apparently, accessibility is a multifaceted and elusive quality.

Insofar as the urban structure is concerned, there are many complementary perspectives. The workplace structure is not necessarily monocentric; some workplaces are located outside the main centre in subcentres and dispersed all over the urban region. In addition to commuting, the location of services and recreational activities also affect placement decisions. The transport system plays an important part – in addition to the monetary and time-related costs of travel, reliability, comfort and service level are deemed important at all times. The qualitative attributes of residential areas and the building stock may vary greatly, which means that evaluations related to living and the living environment may play an important part when selecting a place of residence. Some of these perspectives were discussed above in Section 2.5. Accessibility is a multifaceted concept in and of itself – the accessibility of what, accessibility when and how, and whose accessibility?

This chapter is structured as follows: after the introductory Section 6.1, the content of the concept of accessibility and the various methods for operationalising it are discussed in Section 6.2. The characteristics typical of the urban structure in the study area are discussed in Section 6.3. Following this, Section 6.4 reviews the literature on hedonic pricing that focuses particularly on the aspect of accessibility. The data used and estimation methods are introduced in Section 6.5. The results of the data analysis are presented in Section 6.6, and discussion in Section 6.7.

6.2 What is accessibility?

6.2.1 Defining accessibility

In addition to the monocentric urban model, household location decisions have also been analysed using other economic models. Lowry's (1964) simulation model, based as it was on the gravitational model, highlighted the aspect of accessibility in the context of the urban economy. McFadden (1974, 1978) argued that households pick their dwelling from among the available options on the basis of various dwelling attributes, attempting to maximise the benefit level to the household in question. This approach has since been used for modelling household placement decisions, for instance. For example, Blijie (2005) used extensive survey data collected from the Netherlands to analyse the impact of such matters as commuting distance and accessibility to public transport on the location of households in the discrete choice matrix.

Whatever one's perspective on accessibility data, it is necessary to understand what is principally meant by accessibility and what kinds of different accessibility measures are used. The content of accessibility has been widely studied outside urban economics – within such fields as traffic research and city planning. The literature in the field draws rather specific lines between the different definitions and approximate concepts – their content and application – of accessibility. For instance, Bhat et al. (2002) differentiate between mobility and accessibility in the following manner:

"Traditionally, measures to evaluate the transportation system have focused on the concept of mobility. Mobility measures assess the potential for movement…On the other hand, accessibility measures assess the potential for interaction…Mobility is one element of accessibility."

On the other hand, Bertolini et al. (2005) define accessibility as follows:

"The amount and diversity of places that can be reached within a given travel time and/or cost."

When individual factors have been standardised, accessibility is in some way the result of both land use and the transport system – regardless of the measurement method. However you choose to measure accessibility, changes in one or both of these should be reflected in the variable (indicator) depicting accessibility. Moreover, accessibility comprises a dimension related to the time of travel (accessibility when) and one related to individual properties, needs. The various accessibility measurement methods presented later in this study take these factors into account to varying degrees (Geurs and van Wee, 2004).

6.2.2 Criteria for accessibility measures

The literature in the field provides numerous criteria for accessibility indicators. Here two of them are highlighted, since they are often quoted in the literature. As a rule, the assessment of accessibility is based on the assumption that the calculation of accessibility measures entails two components – distance and desirability. Distance simply indicates distance from the observation point (the accessibility to which is being calculated) to an activity being analysed. Distance should be primarily viewed through costs, i.e. travel time (and effort) and the resulting expenses. Desirability, on the other hand, depicts how much weight is placed on an activity in the calculation of accessibility. Workplace clusters are one example of this. Distance to workplace clusters can be measured directly, yet it is often calculated, or weighted, by means of some non-linear function. The desirability of a workplace cluster, on the other hand, can be depicted by means of the number of jobs at each workplace cluster.

Weibull (1976) developed an axiomatic foundation for accessibility indicators and announced several criteria that accessibility indicators should fulfil. For example, a shorter distance to a specific activity must be indicated as a higher accessibility index value than the accessibility index values of similar activities featuring a longer distance. The value of an activity featuring a null distance must be determined solely on the basis of its desirability (without a distance function calculating an accessibility value) and it must be finite. On the other hand, activities featuring an accessibility of null must not affect the accessibility index value. Furthermore, if the desirability of two different locations with the same accessibility index increases equally if measured in absolute terms, their accessibility index values must also be the same in the new circumstances.

Geurs and van Wee (2004) were of the opinion that a measure indicating accessibility should contain at least the five following attributes. First of all, accessibility measures should react to service level changes occurring in any mode of transport in the area – regardless of whether these changes are related to travel time or costs, or availability in the general sense of the word. Second, if the availability of a travel-destination activity (e.g. a specific service) changes, the measured accessibility value related to the said activity should change correspondingly. Third, if changes occur in the circumstantial factors restricting the demand for some activity, the accessibility measure related to the said activity should react correspondingly. The restriction of demand results in decreased accessibility. Fourth, if the accessibility of some activity changes at a certain location, this change should not affect the accessibility of this activity at locations that are, in terms of travel time, so far away from the activity in question as to render use of the activity impossible. Finally, improvements to the service level of some modes of transport or increased supply of some activities should not affect accessibility in the case of groups that do not use the mode of transport or activity in question due to various types of limitations (economic, etc.).

6.2.3 Different types of accessibility measures

General accessibility measures are based on micro-level aggregation of data. They depict accessibility in general terms, possibly accounting for individual factors on the micro-level but bypassing them on the indicator level. Bhat et al. (2002) and Geurs and van Wee (2004) have compiled a comprehensive summary of the various approaches to accessibility. Their categorisation is applied next, accessibility measures are divided into seven main methodological groups.

The spatial separation approach largely corresponds with urban economics' approach to accessibility. In this model, accessibility is viewed through the disutility – whether time- or money-related – caused by travel. Typical accessibility measurement methods include variables measuring distance, travel time and monetary costs. Distance measures can be construed as distances measured as the crow flies, or actual travel distances within the transport network, measured using route optimisation tools. Potential problems include the fact that the real routes available via different modes of transport may be difficult to trace and the question of how route selection is performed because of delays caused by such matters as congestion. Travel time measures are used increasingly often, since GIS tools provide better opportunities for this than they have in the past. Public transport journey planners enable the creation of travel time data sets based on the use of public transport. More advanced assessment methods also account for transport network congestion, parking, switching between modes of transport, and the time required to reach a stop or a station. Travel cost may also be calculated on the basis of measures based on the duration and distance of previous trips. Two of the challenges related to the calculation of travel cost are the valuation of travel time and the valuation of the discomfort caused by having to switch modes of transport.

The contour measures-based approach depicts accessibility by means of accessibility zones based on travel time or distance – i.e. travel cost in general. In this event, the value of the accessibility variable is obtained by adding up the number of workplaces located within such a zone. Good accessibility will be shown as a higher variable value. Several accessibility zones can be construed and used to test the distance at which explanatory variables can affect dependent variable, e.g. the price of a dwelling. Accessibility zones can and should be construed for various modes of transport since travel times to the same destination may vary a great deal between different modes of transport. One drawback of the method is that it ignores the effects of distance within any one zone and weighs all locations similarly with regard to distance.

In the gravity measures or potential measures approach, the value of an accessibility measure is dependent on both the desirability and distance of a location (Hansen 1959). Distance is believed to create friction that reduces the desirability of a desirable location (distance decay). The accessibility of a location is based on the general accessibility of desirable locations such as workplaces. The value of an accessibility variable is obtained by adding up the desirability of different locations. For instance, in the case of workplaces, this means that each location's contribution to the accessibility variable is obtained by multiplying the number of workplaces by the accessibility of the location. Insofar as the impact of distance is concerned, the function formulations ensure that an increase in distance reduces the desirability of a location (distance decay). The impact of the number of workplaces on the desirability of a location can also be rendered non-linear by using a suitable function formulation. One drawback of this method is that selecting one moment of accessibility is usually necessary for calculations, even though such things as congestion of the transport network and public transport service levels may vary a great deal depending on the time of day.

The competition measures approach includes the effects of competition in the previous approach. In this event, not only the available opportunities but also competition over the utilisation of these opportunities affects accessibility. There are several approaches. One example worth mentioning is the balancing factor approach (Wilson 1970). In this method, an additional factor – the balancing factor – is added to the accessibility index calculated by using the potential measures method in order to correct the influence of competition on accessibility. These calculations are based on the iterative method. This method has been used in research into housing prices (Osland et al. 2008) and it is briefly described in the Section 6.4 on related literature.

Time-space measures combine geographical accessibility with individual time constraints. This approach is rooted in the geographical models related to analysing time-space developed by Hägerstrand (1970). Time limitations constricting the option-space can be divided into three groups: These may be general (limited amount of time, capability constraint); they may be related to certain activities having to be performed at a certain time in a certain place (coupling constraint); or they may be related to restrictions set by such parties as the authorities for certain activities (authority constraints). As a rule, the indicators representing this approach operate on the individual level, depicting the geographical area within which individuals can move within their time constraints and determining the amount of activities available to these individuals.

The utility measures approach is based on microeconomics, and its premise is the benefit-maximising individual. Individual choices reveal valuations of various targets. The accessibility of the individual location i can be calculated as follows:

$$A_i = \frac{1}{\gamma} ln \frac{\sum_j \left(exp\left(\gamma d_{ij} \right) O_j \right)}{\sum_j O_j} \qquad (6.1)$$

where is the distance between locations, is the estimated parameter and is the benefit produced by location j – measured in monetary terms, for instance.

The network measures or space syntax approach is based on the idea that the constructed environment crucially influences one's social life. Hillier (1996) goes so far as to argue that the urban structure, street network and city block structure guide city traffic more than attractive individual locations. The network measures approach comprises several alternative methods for measuring the accessibility of various locations within the urban spatial structure. These methods were briefly discussed in Section 2.5.

6.3 Development of urban spatial structure in the Helsinki Region

One key, although not the sole, factor influencing accessibility is urban spatial structure. As a term it is often employed, and equally often defined in a very ambiguous manner. Urban spatial structure is a multidimensional concept, and to condense it into one dimension or indicator would be difficult. For instance, in the discussion on urban sprawl, what is meant by urban spatial structure and urban sprawl is often left undefined. In order to clarify this web of concepts, Galster et al. (2001) devised a set of indicators comprising eight dimensions that they used to illustrate and measure the development of urban spatial structure in 13 urban regions in the United States. These dimensions were population density, the cohesiveness of built-up urban areas, the concentration of the population in areas of high population density, the concentration of population within subareas, the population's orientation towards centres, hubs in the urban spatial structure measured by means of workplaces, the extent to which the population and workplaces are mixed, and the average distance between workplaces and housing.

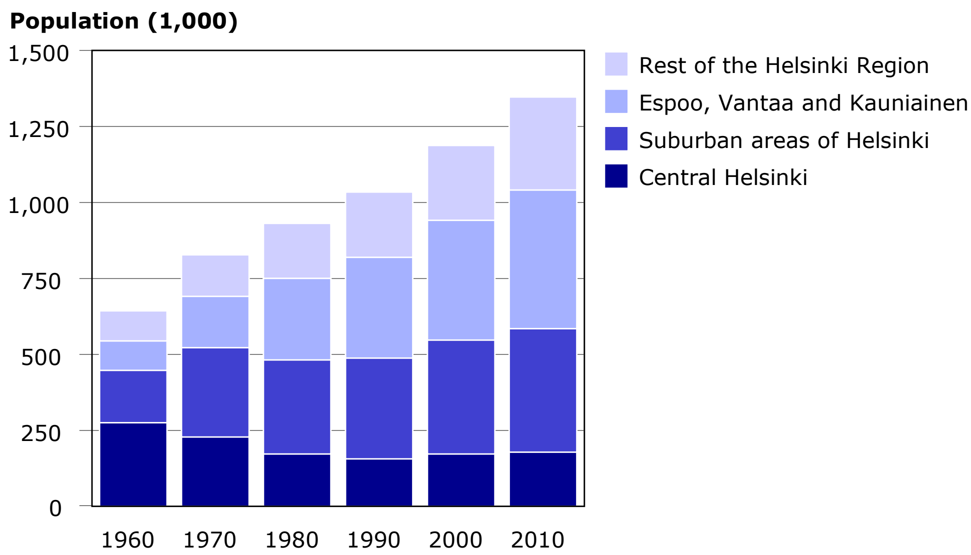
Jaakola and Lönnqvist (2009) applied the assessment framework of Galster et al. (2001) to Helsinki Region data concerning the period between 1980 and 2000. According to their results, population density in the Helsinki Metropolitan Area (the cities of Helsinki, Espoo, Vantaa and Kauniainen) saw a substantial increase, although there were no notable changes in population density in the entire region (Helsinki Region and the commuter belt of Helsinki). The cohesiveness of region's built-up area also increased a little. The share of densely populated areas (measurement based on 250m x 250m map grids) – particularly in the central parts of the region – has grown, while at the same time the population share of densely populated areas has decreased, since the population density of the most densely populated areas (map grids) has seen a marked decrease. Population within the subareas is distributed more evenly than before. On the other hand, population density in the most densely populated grid cells has decreased, while infill development has boosted population density in both central and fringe areas in the region. A downward trend was initially experienced with regard to the population's orientation towards the centre, followed by a slight upward tendency between 1995 and 2000. The share of the main centre – i.e. central Helsinki – of the region's workplaces decreased while the share of the subcentres increased. In this sense, the region's workplace structure did not disintegrate; instead, its structure became more flexible. No major changes were seen with regard to the mixedness of housing and workplaces since 1990. However, the calculatory average distance between housing and workplaces decreased. This occurred because a relatively large share of new workplaces were located outside central Helsinki.

The preceding description of changes in urban spatial structure is rather multifaceted and difficult to summarise. In many instances – for the purpose of decision-making, for instance – one has to be able to condense the developmental attributes of urban spatial structure into a relatively limited number of dimensions. In their extensive review article on urban spatial structure, Anas et al. (1998) paid attention to the concentration of urban structure. They differentiated between two dimensions of concentration. Looking at urban regions in their entirety, they characterised cities as centralised or decentralised depending on how heavily the population and workplaces are concentrated in the main centre and its surroundings. On the other hand, when looking at urban regions in terms of their areas, they characterised cities as either clustered or dispersed. Clustering most closely resembles the polycentric urban structure.

The subsequent characterisation of the Helsinki Region's urban spatial structure comes from Laakso and Lönnqvist (2012). The Helsinki Region is rather main centre-oriented. However, numerous long-term change-related trends can be discerned in the urban spatial structure. First of all, the urban area has expanded away from the original main centre, namely central Helsinki (see Appendix B for area definitions). The placement of the region's increased population and, consequently, the regional distribution of land use have undergone major changes in the last 50 years (Figure 6.1). In the 1950s, population growth began to veer away from the original main centre (central Helsinki) and towards suburbs of Helsinki, and even further to the cities of Espoo and Vantaa, and to other surrounding municipalities. This change began levelling out in the late 1980s, and this trend has continued in the 2000s: the population decline in central Helsinki came to an end, and even experienced a modest reversal. At the same time, the population of the entire city of Helsinki experienced a strong upturn. This trend has continued, excluding the period 2003-2005, until this day. However, looking at the entire Helsinki Region, the population's centre of gravity has been continuously moving further away from central Helsinki. Since the 1970s, the strongest area of growth comprised cities of Espoo and Vantaa, but the surrounding municipalities also saw rapid growth.

Over the last 50 years, Helsinki Region's population more than doubled between 1960 and 2010. The population in central Helsinki was almost halved by 1990, but has since slightly recovered. Population in Helsinki's suburban areas has doubled, while population in the rest of the Helsinki Region has quadrupled from 1960 to 2010.

Figure 6.1 Population development in the Helsinki Region between 1960 and 2010 (Laakso et al.2012, data from Statistics Finland and City of Helsinki Urban Facts)



The population's centre of gravity has moved further away from the urban structure, and the majority of population growth in the region has occurred in new subcentres and their fringe areas. However, this has also meant decreased population density in the most densely populated areas. This change is illustrated in Figure 6.2, which depicts 250m x 250m map grids, populated in 2010, on a horizontal axis ordered according to population size in order, and the population accumulation as a percentage of the entire population on the vertical axis. The figure also shows the curve becoming significantly less steep between 1980 and 2010, which is principally based on the fact that in 2010, the population was dispersed across a much larger number of map tiles than in 1980. One additional factor in this change is that the absolute population numbers of the most densely populated tiles had decreased by 2010, while those of the most sparsely populated map grids had increased.

Third, the growth of the number of workplaces in the region has taken place outside the original centre, i.e. central Helsinki (Figure 6.3). Since 1990, the number of workplaces in central Helsinki has remained more or less unchanged, while growing in all the other areas.

Figure 6.2 Cumulative population share, calculated for the Helsinki Region for 1980, 1995 and 2010 using grid data (Laakso et al. 2012, data from the Finnish Environmental Institute: monitoring data on urban spatial structure (YKR))

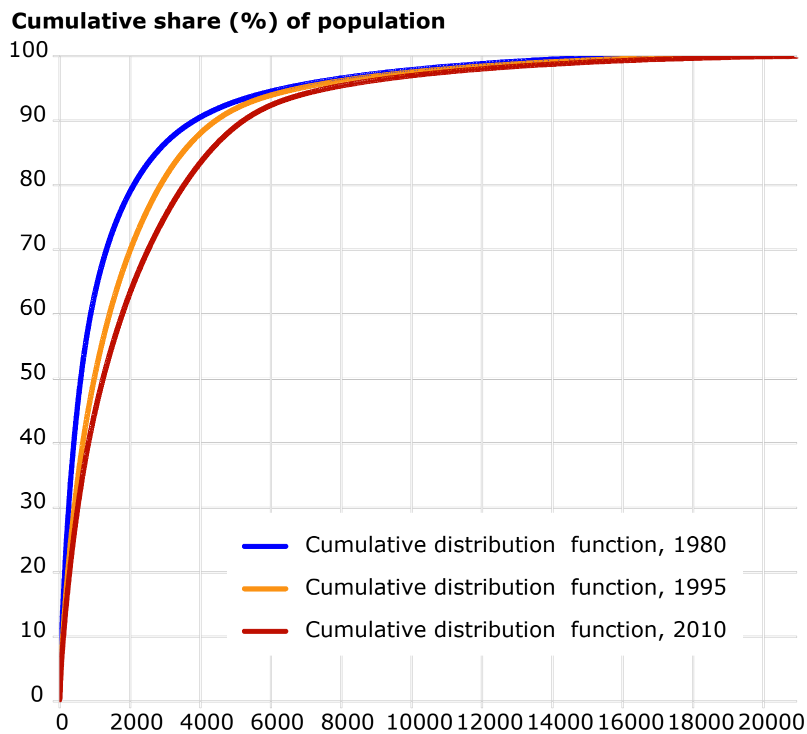


Figure 6.3 Workplace development by area in the Helsinki Region between 1960 and 2010 (Laakso et al. 2012, data from Statistics Finland).

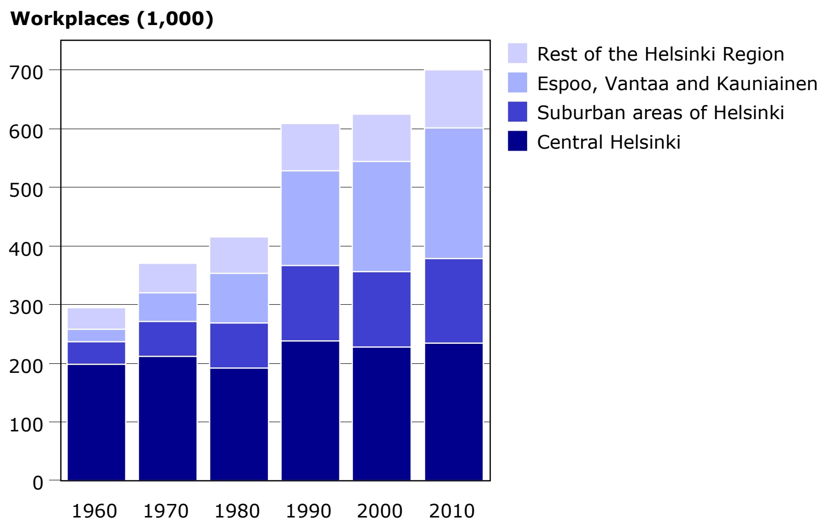
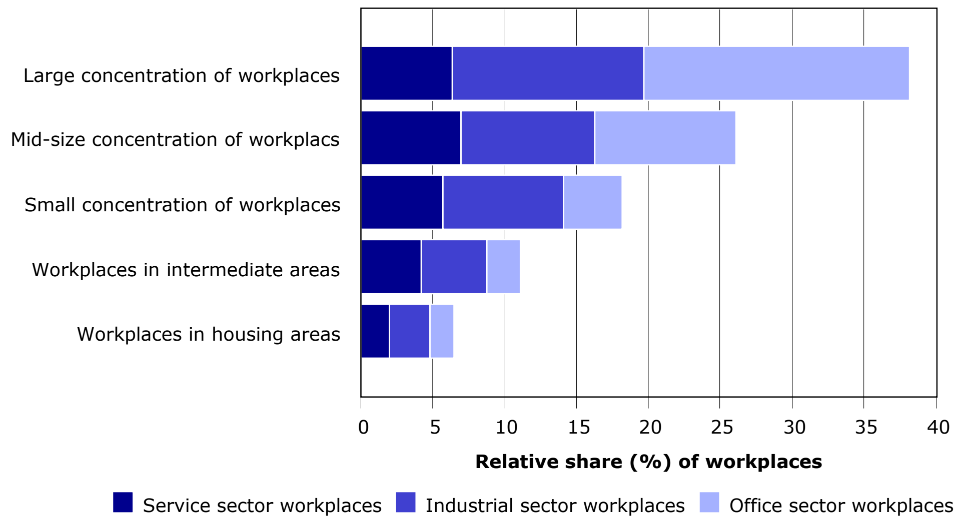


Figure 6.4 The placement of workplaces in variously sized workplace clusters and other areas in the Helsinki Region in 2008 (Laakso et al. 2012)



In the Helsinki Region, workplaces tend to be centralised much more than housing, positioned as they are around workplace clusters of varying sizes. The share of workplaces in the intermediate areas and fringe areas amounts to less than 20 per cent (Figure 6.4). Some 73 per cent of the region's workplaces are located within an area that only covers one per cent of the region's total area. On the other hand, only 33 per cent of the population lives in this area.

For the most part, the concentration of workplaces near other workplaces has remained unchanged. What has changed is that new workplace clusters have been created outside central Helsinki. Analysis of workplace clusters in terms of size reveals that office-sector workplaces are still heavily concentrated in larger centres and in the proximity of other office workplaces.

6.4 Related literature

A variable indicating the accessibility of a dwelling can be found in almost all hedonic housing price studies. In most cases, and previously almost without fail, this variable is the variable expressing a dwelling's distance from the centre. In many cases, a variable expressing a dwelling's distance from the nearest subcentre is also included. This is why a literature review concerning the price effects of accessibility should be a literature review of the entire research tradition. Of course, this is too broad a task. In this study, the discussion is limited to the type of modern-day research that has replaced the conventional accessibility approach with accessibility measures that provide an alternative to centre-distance.

Adair et al. (2000) used data for 2,648 residential sales, gathered from an urban area of Belfast, Northern Ireland in 1996, to study the effect of accessibility on housing prices. They divided this data into distinct sub-markets according to both house type and location, with a dedicated regression model estimated for each. They used a rather sparse set of variables characterising the structural attributes of the dwellings and the residential areas. Their somewhat complex accessibility index was based on the accessibility of workplaces (from the dwellings). The accessibility variable turned out to be a weak variable that was statistically meaningful with regard to a specific single house type and two regional price models. It should be noted that their model did not feature any other accessibility-related variables in addition to the accessibility index.

Srour et al. (2002) studied the effect of accessibility on housing prices using data covering a total of 374,642 addresses and 697,695 dwellings. This data was obtained from the authorities carrying out property evaluations in the Dallas-Fort Worth metroplex in Texas, United States. The database also included information on the structural characteristics of the dwellings. Typical accessibility variables were added to the data (distance to both cities' centres using the road network). In addition to these, three so-called cumulative opportunity variables, expressing the accessibility of commercial services, recreational services and workplaces, were also included in the model. They were measured using the number of retail workplaces (commercial services), areas dedicated to parks (recreational services) and the number of workplaces (accessibility of workplaces). Interaction variables were also included in the model between such items as lot size and accessibility variables. Strong multicollinearity was found to exist between centre-distance variables and the cumulative opportunities variable expressing employment. Workplace accessibility proved to be a statistically significant and strong variable, whereas the variables indicating the amount of recreational and commercial services did not have a notable impact.

Franklin and Waddell (2002) studied the impact of accessibility on sales prices using data on single-family houses sold between 1995 and 1998 in Kings County, Washington, United States. In addition to the structural attributes of dwellings, control variables were used to measure such matters as views from the dwellings and school districts. The Puget Sound Regional Council travel demand model was used to calculate the number of workplaces in each Transportation Analysis Zone and the rush-hour travel times between all zones (car traffic). An accessibility variable was used to calculate each Transportation Analysis Zone's average accessibility, weighted with the number of workplaces and travel time, from other workplace zones. Workplace accessibility was assessed on the basis of three different workplace groups – commercial (including retail, office and government employment), education (educational employment) and industrial employment (manufacturing, warehouse, communications, transportation and utilities). All of the accessibility variables proved to be statistically meaningful. Increasing distance had the greatest reducing effect on housing prices in the educational employment dimension. The industrial employment dimension also produced a negative variable. However, in the case of the commercial employment dimension, an increase in distance also increased housing prices.

Osland and Thorsen (2008) used data on 2,788 detached house transactions collected from 13 municipalities in Rogaland, Norway between 1997 and 2001 to study the effect of workplace accessibility on the prices of detached houses. In addition to the usual variables expressing the structural properties of detached houses (the age of the house, living area, lot size, etc.), various types of accessibility measures were used as explanatory variables in the model. The accessibility of the nearest city centre (Stavanger) in terms of travel time was calculated on the basis of travel time using a quadratic conversion,

$$(6.2) \quad h\left(d_{ij}\right) = d_{ij}^{\beta}\left(\left(d_{ij}\right)^{2}\right)^{\beta_q}$$

where d_{ij} indicates the distance between locations i and j, measured by travel time, $h(d_{ij})$ is the accessibility measure value and the terms β and β_q are estimable parameters. In addition to the accessibility measure referenced above, Osland and Thorsen et al. (2008) used a group of variables measuring workplace accessibility in more extensive terms. Of these four variables, the first was

$$(6.3) \quad S_j = \sum_{k=1}^{w} D_k \, exp\left(\sigma_e d_{jk}\right)$$

where the accessibility S_j of location j is calculated as the sum of all workplaces D, which is calculated by weighting them in accordance with accessibility – the term d_{jk} indicates the distance between locations j and k and σ_e is the estimable parameter under zero. Increasing distance reduces accessibility, and this decreasing effect is non-linear. The second complementary accessibility variable resembles the first one, with the minor addition that the number of workplaces D_k also entails the parameter γ_e, which enables the number of workplaces to have a non-linear effect on accessibility, i.e.

$$(6.4) \quad S_j^e = \sum_{k=1}^{w} D_k^{\gamma_e} \, exp(\sigma_e d_{jk}).$$

The third complementary accessibility measure in Osland and Thorsen et al. (2008) was the number of workplaces accessible within a certain time frame. They operationalised this variable as follows:

$$(6.5) \quad \bar{d_\iota} = \sum_k \frac{D_k}{D} d_{ik}$$

where the value of the area's accessibility measure $\bar{d_\iota}$ is the average accessibility of all workplaces, directly weighted with travel time. Osland and Thorsen's final accessibility measure was a model in which an estimable (exponent) parameter is connected to both the number of workplaces and accessibility, i.e.

$$(6.6) \quad S_j^p = \sum_{k=1}^{w} D_k^{\gamma_e} \, d_{jk}^{\sigma_p}$$

where γ_e and σ_p are estimable parameters. Moreover, in model estimations, Osland and Thorsen (2008) also tested the alternative accessibility measures S_j^e and S_j^p together with the variable $h(d_{ij})$, measuring distance to the main centre. According to their results, housing prices decreased as the distance to the main centre increases, even when accounting for workplace accessibility. Eliminating distance to the main centre from the model reduced its coefficient of determination, even if this variable was replaced with an alternative accessibility variable. From the perspective of the coefficient of determination, no major differences existed between the alternative accessibility measures.

EI-Geneidy and Levinson (2006) used data on more than 44,000 housing transactions collected from the Minneapolis-St Paul metropolitan area, located in the state of Minnesota in the US, to study the effects of various accessibility factors on housing prices. In addition to variables pertaining to the structural properties of housing and neighbourhood characteristics, they tested the functionality of four accessibility variables of different kinds. The first accessibility variable was distance to the nearest city centre. The second variable was the place rank variable, created by the authors themselves. This variable is regional (zone) in nature and it is calculated in an iterative manner

$$(6.7) \quad R_{j,t} = \sum_{i=1}^{I} E_{ij} P_{i,t-1}$$

$$P_{i,t-1} = \left[E_j\left[R_{j,t-1}/E_i\right]\right]$$

where $R_{j,t}$ refers to the placement of area j in iteration round t, E_{ij} refers to people in area i working in area j, E_j refers to the number of workplaces in area j and E_i refers to the number of residents in area i. The desirability or place rank of an area is, therefore, dependent on the number of workplaces in the area E_{ij} and the weighting factor of the labour force coming to the area, which is dependent on the proportional relationship of workplaces and the population in the area they come from. In El-Geneidy and Levinson (2006), the standardisation of the variable took 19 estimation rounds in the iterative process. Their third accessibility measure was a gravitational measure based on workplaces, modelled on Hansen's (1959) concept. It was calculated as follows:

$$A_i = \sum_j O_j C_{ij}^{-2} \qquad (6.8)$$

where Oj refers to the number of workplaces in location j and C_{ij}^{-2} refers to the friction generated by the distance between locations i and j, which reduces accessibility by weighting workplaces located at a greater distance than those that are nearer in accessibility index A_i. The fourth and fifth accessibility measures used by the authors were cumulative opportunities variables, which were calculated on the basis of workplaces located within a 20–30 minute travel time of each location. The housing price models were estimated in a manner that ensured that only one of the aforementioned accessibility variables was included in each model. The variables were all statistically meaningful and their factors complied with expectations. In interpreting the models, the authors arrived at the conclusion that differences between the models were rather insignificant when measured using the models' coefficients of determination.

Cerda and El-Geneidy (2009) studied data on 1,961 housing transactions collected from the city of Quebec in Canada in 2006. They calculated numerous coefficient of determination variables for this data set. Firstly, they included distance to the centre in the data. In addition, they included the availability of workplaces and certain services (grocery stores) in the data by employing the accessibility zone method. Thirty minutes was selected as the distance for workplaces. Gravitational measures were calculated for both workplaces and population. Moreover, the authors noted that the accessibility aspect should be further expanded by means of a new type of variable, where the workplace accessibility of each target area's population acts as a standardising factor. This is done to account for the fact that accessibility does not merely entail opportunities; instead, the competition over jobs affects one's chances of getting a job, for instance. Consequently, Cerda and El-Geneidy (2009) create a two-equation system where the accessibility variable is determined by means of an iterative process:

$$A_i = \sum_{j=1}^{n} \frac{1}{B_j} J_j f\left(C_{ij}\right) \qquad (6.9)$$

$$B_j = \sum_{i=1}^{n} \frac{1}{A_i} E_i f\left(C_{ij}\right)$$

where A_i is the accessibility of workplaces at location i, J_j is the number of workplaces at location j, and $f\left(C_{ij}\right)$ is a function indicating the friction (cost, detrimental effect) generated by the distance between locations i and j. Furthermore, B_j is the accessibility of workers at location j and E_i is the number of workers (looking for employment) at location i. However, Cerda and El-Geneidy (2009) only used distance to the centre, the number of grocery stores within a 10-minute distance and the accessibility measure specified in 6.8 in their final model. The distance to the centre has an independent and expected effect on housing prices: increasing distance to the city centre reduces housing prices. The effect of distance to the centre remains almost unchanged after the two aforementioned accessibility variables are included in this basic model. Both of the added variables – the number of grocery stores within a 10-minute distance and the accessibility variable specified in 6.8 – were also statistically meaningful and expected, supporting the positive price effects of accessibility.

Giuliano et al. (2010) assessed the effect of workplace accessibility on housing prices using data on more than 260,000 housing transactions collected from the Los Angeles metropolitan area in 2001. They used the multilevel model of the hedonic regression model in an attempt to control the effects of undetected neighbourhood-specific factors. They analysed the price effects of workplace accessibility by creating dedicated variables for the workplace accessibility of people in different business sectors. They named a total of eight business sectors. Travel times were calculated on the basis of rush-hour travel times for passenger cars. The accessibility variable used by the authors was calculated as follows:

$$A_{ik} = \sum_{j} S_{jk} \exp(-\beta C_{ij}) \quad (6.10)$$

where the accessibility of workplace sector k at location i, A_{ik} is based on the number of sector k workplaces S_{jk} at location j, weighted via the exponent function and estimable parameter β (>0) with the travel time C_{ij} between locations i and j. According to the results of Giuliano et al. (2010), major differences exist between the effects of the different workplace sectors. As expected, the proximity of industrial-sector workplaces, for instance, reduces housing prices, whereas workplaces in many other sectors, including retail and information, raise housing prices. In contrast to the researchers' expectations, public-administration and business-sector service workplaces had a negative impact on housing prices.

Iacono and Levinson(2011) analysed the effect of accessibility on housing prices on the basis of data on sold dwellings collected between 2001 and 2004 in Hennepin County, Minnesota (which includes the cities of Minneapolis and St Paul) in the United States. Their key variable expressing accessibility – a logarithm related to the number of workplaces reachable in under 30 minutes – complied with expectations and proved to be statistically strong.

In addition to the regular distance to the centre variable and the aforementioned gravitation potential variable, Law et al. (2012) applied a variable expressing spatial integration and this variable to the second power (see Subsection 2.5.5). They used data on housing transactions was collected in London. According to their results, the model comprising both gravitation potential and spatial integration is more expressive when compared with the model including distance to the centre as an accessibility variable. According to the authors' interpretation, the latter model is able to increase the expressiveness of the hedonic model by accounting for the effects of accessibility variables other than workplace accessibility – including negative ones – on housing prices.

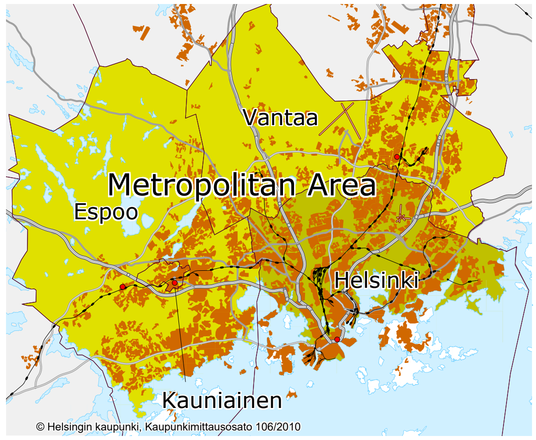
Xiao (2012) applied the space syntax method in a study that assessed the effect of workplace accessibility on housing prices in the UK and China. Xiao demonstrates that accounting for morphology by such means as variables depicting integration increases the expressiveness of the hedonic model. The problems caused by heteroskedasticity, spatial autocorrelation and multicollinearity were simultaneously reduced. Xiao's results also indicated that variables depicting spatial integration are useful for identifying urban area submarkets and price models.

6.5 Method and data

6.5.1 Study area and data

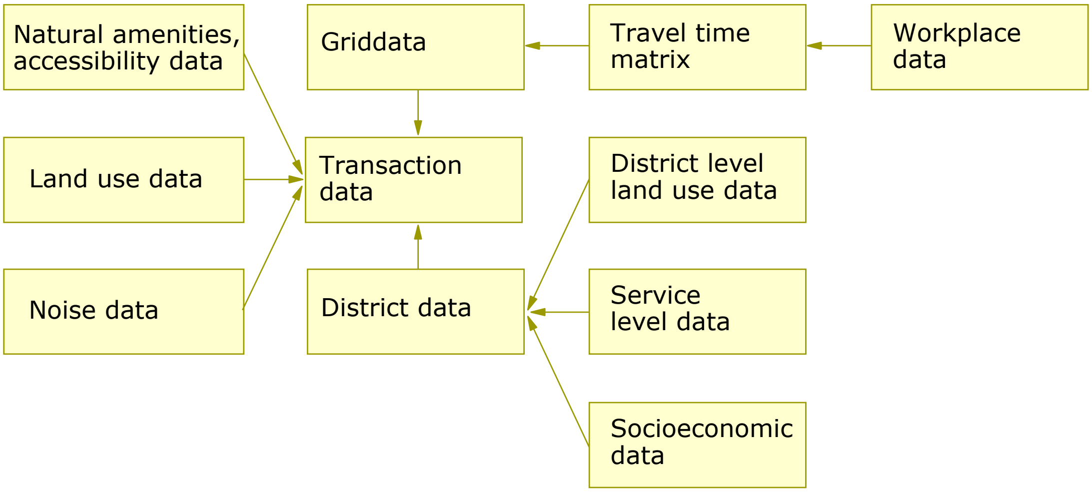
The study area covers Helsinki Metropolitan Area which consists of the cities of Helsinki, Espoo, Vantaa and Kauniainen (Figure 6.5). Only dwellings in blocks of flats and row houses were included. The data was collected by VTT Technical Research Centre of Finland Ltd. The data set comprised a total of 9,482 housing transactions. Of these 7,570 were dwellings in blocks of flats, and 1,912 were row house dwellings.

Figure 6.5 Study area.



Key information on the dwellings' structural properties was included in the data. Multiple other data sets were used to complement the transaction data sets (Figure 6.6). The databases of the City of Helsinki were used to supplement missing structural information. The address information in the housing transaction data and GIS software was used to locate the dwellings, which enabled the creation of variables pertaining to the environment and accessibility. For accessibility variables, the public transportation timetable data of the Helsinki Regional Transport Authority (HSL), road data from national road and street database (Digiroad) and route optimisation tool were applied (Salonen & Tovonen 2013). Land use variables are based on Corine 2006 Land Cover satellite data and SeutuCD map data. Noise data was obtained from databases of the Helsinki Region Environmental Services

Figure 6.6 Data set and formation of variables.



Authority's (HSY), socioeconomic data is based on the Helsinki Region Statistics Database (Aluesarjat). Service level variables are based on Statistics Finland's Register of Enterprises and Establishments.

6.5.2 Accessibility variables

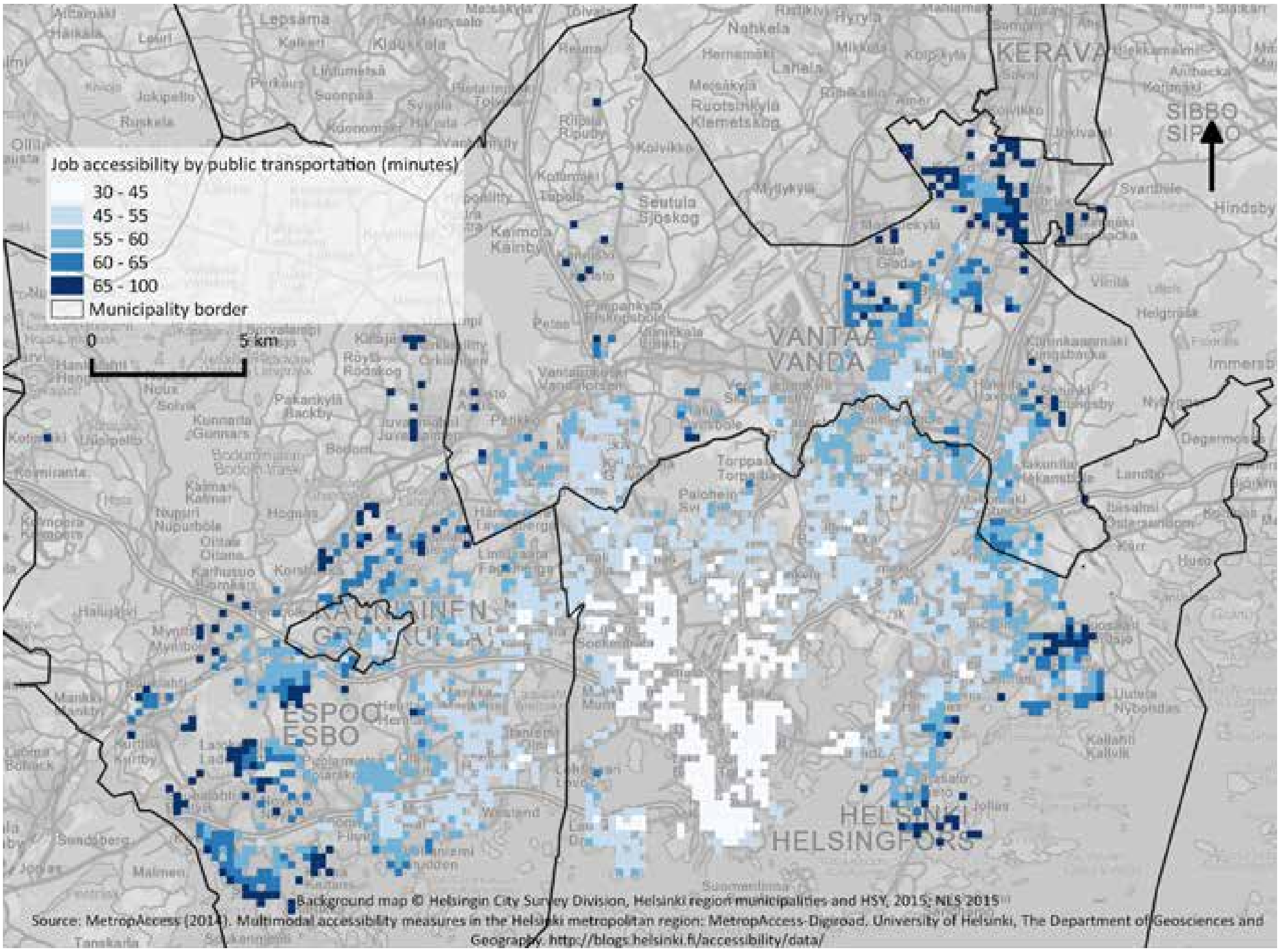
The key research question in this chapter is to assess the effect of accessibility to workplaces on housing prices. Traditionally, accessibility has been measured using distance to the main centre, sometimes also distance to a subcentre. In this chapter, we will compare the accessibility of the main centre, the Central Railway Station, with three alternative accessibility measures in housing price models. The first is based on the idea of gravitation potential, and it expresses the accessibility of each dwelling from all workplaces. The first accessibility measure is calculated as follows:

$$s = log \sum_{j=1}^{n} e_j \, d_{ij} \qquad (6.11)$$

where e_j is the number of workplaces at location j and d_{ij} is the distance between locations i and j. Therefore, the accessibility measure expresses the average accessibility of workplaces, weighted with their distance from each location. The second accessibility measure expresses how many workplaces are within a 30-minute travel time, respectively, from each location i. It is based on the idea of culturally invariant fixed travel time budget, so called Marchetti's constant (Zahavi 1976, Marchetti 1994). The third measure is a more conventional one – the (log) travel time to CBD.

Distance calculations were based on travel time by car and public transport between 250m x 250m grids (Figures 6.7 and 6.8). Travel times were calculated in accordance with traffic conditions on weekday mornings (9:00 am).

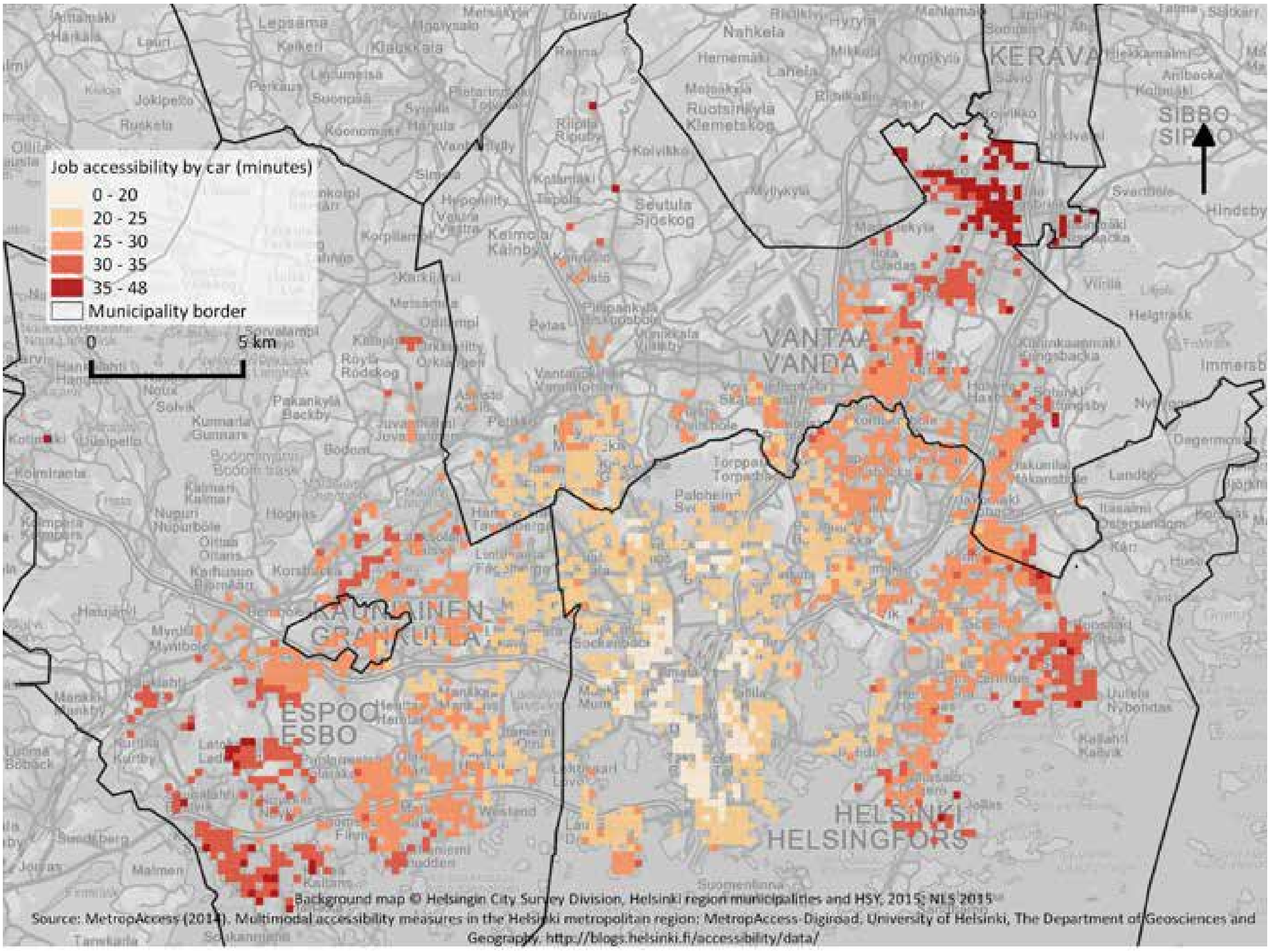
Figure 6.7 Workplace accessibility by public transportation



6.5.3 Control variables

The model includes information on the following structural properties of dwellings: living area, age of dwelling, type of building, ownership relation of lot (owned or rented), condition of dwelling (three-tier classification), rental status of dwelling (unoccupied or rented), lift (yes/no), number of floors, and which floor the dwelling is on. Some information regarding the condition of the dwelling, rental status and floor of dwelling was missing from the data. As regards this information, the data was supplemented by imputing values commensurate with typical values in place of the missing information. Insofar as the condition of dwellings was concerned, the most typical value was the middle one on the scale (satisfactory condition), while "free" was the most common rental status value (not rented upon pur-

Figure 6.8 Workplace accessibility by car



chase) and the third-floor location was the most common location.

The following variables related to the living environment were included in the model: an index variable depicting the socioeconomic structure of the area, district and lot-level building efficiency measures, variables expressing traffic noise, and local-distance variables expressing distances to a seashore and industrial areas. Local distance variables were calculated on the basis of distance by means of a route optimisation tool.

The variable expressing socioeconomic structure was constructed by means of main component analysis, where the unemployment rate and income and education levels in each area were used as the starting variables. In addition to the aforementioned variables, models with subarea-specific indicator variables were estimated. This was done in order to control the effects of area-specific variables missing from the model. However, area-specific indicator variables proved problematic in the model estimations, since their strong correlation structures largely stripped accessibility variables of their expressiveness, and accessibility variables are the key variables with regard to the research questions in this chapter.

6.6 Results

6.6.1 Descriptive statistics

The research data comprised 9,482 housing transactions, some 82 per cent of which pertained to blocks of flats, while 18 per cent pertained to row houses. Some 20 per cent of these dwellings were located in central areas of Helsinki. The average age of the dwellings included in the data was 42 years, while the average size was 65 square metres. In regression models, a variable in logarithmic form is used for the age and size of dwellings.

About 18 per cent of the dwellings included in our research data were located in properties built on rented lots. With regard to lot ownership, missing information was added from a City of Helsinki database. Some information regarding the condition of the dwelling, rental status and floor of the dwelling was missing from the data. In these instances, the missing information was replaced with an indication of the most typical value of the variable in question. For instance, some 13 per cent of observations were missing information related to the condition of dwellings. Over 60 per cent of the dwellings whose condition was known at the time of purchase were in good condition. For this reason, the missing information was replaced with the value "good". The results gained when separately testing a model in which missing information was expressed as a separate variable supported this choice. As a result of this analysis, a coefficient close to the variable's "condition of dwelling good" coefficient was obtained as the regression coefficient of the variable expressing the missing information. Correspondingly, the value 3 and, with regard to rental status, "free" were imputed for the missing information pertaining to the location floor.

The minimum distance to a coastline was 10 metres from a building, but the maximum distance was 18 kilometres, with the average amounting to some three kilometres. The average distance to an industrial estate was a little under 450 metres. Both of the aforementioned variables were included in logarithmic form in the models. Great differences existed between the districts with regard to services. The lowest number of business sectors within a district was four, while the highest number was 115. Around one third of the dwellings were located in a traffic noise zone, but only five per cent were located in a rail traffic noise zone.

Table 6.1 Descriptive statistics

Variable	Continuous variables				Dictotomous variables
	Mean	Standard deviation	Min.value	Max. value	Relative share, %
Log floor area	64.65	30.44	15.00	360.00	
Log age of dwelling	41.87	24.48	1.00	150.00	
Own lot					81.83
Rented lot					18.17
Condition, good					66.90
Condition, satisfactory					30.71
Condition, poor					2.49
Rental status, free					92.04
Rental status, rented					7.96
Location 1. floor					35.29
Location 2. floor					20.61
Location 3. floor					19.85
Location 4. floor					10.78
Location 5. floor					6.44
Location 6. floor					4.00
Location 7. floor					1.95
Location 8. floor					0.85
Location 9. floor or higher					0.22
Block of flats, number of floors 2					3.09
Block of flats, number of floors 3					18.68
Block of flats, number of floors 4					16.94
Block of flats, number of floors 5					10.96
Block of flats, number of floors 6					12.73
Block of flats, number of floors 7					8.11
Block of flats, number of floors 8					5.49
Block of flats, number of floors 9					1.12
Block of flats, number of floors 10					0.24
Block of flats, number of floors 11					0.61
Block of flats, number of floors 12 of more					0.88
Row house, number of floors 1					6.87
Row house, number of floors 2					11.32
Row house, number of floors 3					0.84

Table 6.1 Descriptive statistics *(cont.)*

Variable	Continuous variables				Dictotomous variable
	Mean	Standard deviation	Min.value	Max. value	Relative share, %
Lift in the building, no					54.62
Lift in the building, yes					45.38
Distance to coastline (m)	2,948.67	3,194.15	11.93	18,103.60	
Distance to industrial area (m)	643.81	444.79	0.00	2,734.55	
Socioeconomic status indes	0.28	0.96	-3.29	2.71	
District service level, number of industries	61.95	25.17	4.00	115.00	
Road noise area, no					66.28
Road noise area, yes					33.72
Rail noise area, no					94.81
Rail noise area, yes					5.19
District building efficiency	0.36	0.32	0.00	1.23	
Lot building efficiency	1.00	0.95	0.04	5.84	
Travel time distance to CBD by car	22.41	7.61	0.00	51.00	
Travel time distance to CBD by public transportation	38.12	12.52	0.00	95.00	
Workplace accessibility by car	24.90	4.83	0.07	47.97	
Workplace accessibility by public transportation	49.62	9.86	30.36	99.99	
Number of workplaces within 30 min by car	412,335.43	114,800.19	8,260.00	538,158.00	
Number of workplaces within 30 min by public transportation	80,267.47	78,957.87	0.00	278,057.00	
Maintenance charge, 0e/sqm/month					1.29
Maintenance charge, 1e/sqm/month					4.71
Maintenance charge, 2e/sqm/month					13.26
Maintenance charge, 3e/sqm/month					44.94
Maintenance charge, 4e/sqm/month					29.99
Maintenance charge, 5e/sqm/month					4.63
Maintenance charge, over 5e/sqm/month					1.18
Transaction time 4/2009					8.35
Transaction time 1/2010					29.87
Transaction time 2/2010					27.05
Transaction time 3/2010					23.23
Transaction time 4/2010					11.50

Separate variables for various means of transportation are included in the model for variables expressing accessibility. When comparing accessibility by public transport and car, it was observed that, in terms of travel time, accessibility by car was significantly better than accessibility by public transport with regard to central Helsinki and workplaces in general. The average travel time to central Helsinki by private car amounted to 22 minutes, while the average time by public transport amounted to 38 minutes. A similar relationship was also found with regard to the variables expressing general workplace accessibility. In spite of this, a significant majority of journeys to central Helsinki were made by public transport. Therefore, the differences in travel time cannot be directly translated into a distribution of transport methods. The variables indicating travel time were included in logarithmic form in the models. On the other hand, the number of workplaces within 30-minute distance zones is not based on variable transformations.

Table 6.2 Correlations between accessibility variables

	Travel time distance to CBD by car	Travel time distance to CBD by public transportation	Workplace accessibility by car
Travel time distance to CBD by car	1	0.91824	0.84816
Travel time distance to CBD by public transportation	0.91824	1	0.72961
Workplace accessibility by car	0.84816	0.72961	1
Workplace accessibility by public transportation	0.87295	0.93484	0.84678
Number of workplaces within 30 min by car	-0.70285	-0.62063	-0.90213
Number of workplaces within 30 min by public transportation	-0.89735	-0.93766	-0.75563

	Workplace accessibility by public transportation	Number of workplaces within 30 min by car	Number of workplaces within 30 min by public transportation
Travel time distance to CBD by car	0.87295	-0.70285	-0.89735
Travel time distance to CBD by public transportation	0.93484	-0.62063	-0.93766
Workplace accessibility by car	0.84678	-0.90213	-0.75563
Workplace accessibility by public transportation	1	-0.77753	-0.93208
Number of workplaces within 30 min by car	-0.77753	1	0.60751
Number of workplaces within 30 min by public transportation	-0.93208	0.60751	1

As expected, strong covariation was found between the various accessibility variables (Table 6.2). For instance, a 0.9-level correlation was found to exist between the variable measuring the accessibility of the city centre by car and the one expressing the accessibility of the city centre by public transport. The existence of such a high level of correlation results in some complications in the interpretation of the correlation coefficients of regression models that are related to these variables.

6.6.2 Price models

Models encompassing the entire research area were estimated in the first stage (Table 6.3). This estimation was performed in stages. The first model (Model 6.1) only comprises the structural properties of dwellings. In the second stage (Model 6.2), variables indicating the attributes of residential areas were added to the model. The addition of these variables significantly affects the regression coefficients related, for instance, to lot ownership, rental status and building type.

Variables indicating accessibility were added separately to the model (Models 6.3 – 6.5). Regardless of which accessibility variables are added to the model, the coefficients of the control variables (the structural attributes of dwellings, the variables related to the residential environment and the variables indicating transaction time) are, for the most part, relatively stable. However, in the case of the variables expressing building efficiency, relatively significant differences were seen between the various accessibility variables.

Accessibility variables were added to the model (Models 6.3 – 6.5) in pairs, with the variables expressing both accessibility by car and accessibility by public transport included. As proved above in Table 6.2, a strong correlation exists between these variable pairs. Instead of the absolute values of these coefficients, this assessment concentrated on their interdependent values.

In Model 6.3, accessibility is measured using the traditional method – travel time to the centre (CBD) by both car and public transport. Both of these coefficients were statistically significant and rather close to each other. On the other hand, in Model 6.4, accessibility is measured by means of variables expressing the general accessibility of workplaces. The coefficient of accessibility by car is significantly lower than the coefficient indicating accessibility by public transport. However, the coefficients of determination for Models 6.3 and 6.4 are relatively close to each other. In Model 6.5, accessibility is expressed by the number of workplaces within a travel time of 30 minutes. The coefficient of the number of workplaces accessible by public transport is one order of magnitude higher than the coefficient of the number of workplaces accessible by car. This result should be compared with the difference between accessibility by car and that by public transport highlighted in Table 6.1. Some 75 per cent of the workplaces in the area are located within a 30-minute car ride, whereas only 15 per cent of them are located within a 30-minute commute on public transport.

Table 6.3 OLS-models

Variable	MODEL 6.1		MODEL 6.2		MODEL 6.3	
	Parameter, Estimate	Pr > |t|)	Parameter, Estimate	Pr > |t|	Parameter, Estimate	Pr > |t|
Intercept	8.6716	<.0001	9.3465	<.0001	10.9658	<.0001
Log floor area	0.7523	<.0001	0.7533	<.0001	0.7609	<.0001
Log age of dwelling	0.0786	<.0001	-0.0348	<.0001	-0.0588	<.0001
Own lot	ref.		ref.		ref.	
Rented lot	-0.1214	<.0001	-0.0116	0.0331	-0.0590	<.0001
Condition, good	0.0972	<.0001	0.0719	<.0001	0.0770	<.0001
Condition, satisfactory	ref.		ref.		ref.	
Condition, poor	0.0094	0.6319	-0.0720	<.0001	-0.0753	<.0001
Rental status, free	ref.		ref.		ref.	
Rental status, rented	0.0736	<.0001	-0.0115	0.1130	-0.0301	<.0001
Location 1. floor	ref.		ref.		ref.	
Location 2. floor	0.0252	0.0108	0.0028	0.6582	0.0031	0.5885
Location 3. floor	0.0322	0.0013	0.0080	0.2035	0.0071	0.2249
Location 4. floor	0.0425	0.0005	0.0264	0.0006	0.0248	0.0005
Location 5. floor	0.0449	0.0021	0.0239	0.0091	0.0182	0.0328
Location 6. floor	0.0769	<.0001	0.0413	0.0002	0.0397	0.0001
Location 7. floor	0.0472	0.0439	0.0322	0.0280	0.0378	0.0055
Location 8. floor	0.0540	0.1136	0.0660	0.0021	0.0713	0.0003
Location 9. floor or higher	0.0080	0.9042	0.0583	0.1634	0.0538	0.1652
Block of flats, number of floors 2-3	ref.		ref.		ref.	
Block of flats, number of floors 4-5	0.1202	<.0001	-0.0005	0.9391	-0.0112	0.0538
Block of flats, number of floors 6-8	0.1329	<.0001	-0.0376	<.0001	-0.0544	<.0001
Block of flats, number of floors 9-11	0.0467	0.0649	-0.0089	0.5761	-0.0341	0.0213
Block of flats, number of floors 12 or more	0.1180	0.0005	-0.0396	0.0676	-0.0543	0.0069
Row house, number of floors 1	0.1515	<.0001	0.1723	<.0001	0.2151	<.0001
Row house, number of floors 2	0.1886	<.0001	0.1252	<.0001	0.1579	<.0001
Row house, number of floors 3	0.2955	<.0001	0.1579	<.0001	0.1813	<.0001
Lift in the building, no	ref.		ref.		ref.	
Lift in the building, yes	0.0497	<.0001	0.0155	0.0129	0.0162	0.0050
Log distance to coastline			-0.0657	<.0001	-0.0379	<.0001
Log distance to industrial area			0.0077	0.0001	0.0040	0.0344
Socioeconomic status indes			0.1224	<.0001	0.0985	<.0001
District service level, number of industries			0.0016	<.0001	0.0017	<.0001

Table 6.3 OLS-models *(cont.)*

Variable	MODEL 6.1		MODEL 6.2		MODEL 6.3	
	Parameter, Estimate	Pr > |t|	Parameter, Estimate	Pr > |t|	Parameter, Estimate	Pr > |t|
Road noise area, no			ref.		ref.	
Road noise area, yes			0.0190	<.0001	-0.0113	0.0079
Rail noise area, no			ref.		ref.	
Rail noise area, yes			0.0654	<.0001	0.0554	<.0001
District building efficiency			0.0961	<.0001	-0.1330	<.0001
Lot building efficiency			0.1026	<.0001	0.0446	<.0001
Travel time distance to CBD by car					-0.2508	<.0001
Travel time distance to CBD by public transportation					-0.2387	<.0001
Workplace accessibility by car						
Workplace accessibility by public transportation						
Number of workplaces within 30 min by car						
Number of workplaces within 30 min by public transportation						
Maintenance charge, 0e/sqm/month	-0.0496	0.0951	-0.0538	0.0042	-0.0377	0.0310
Maintenance charge, 1e/sqm/month	ref.		ref.		ref.	
Maintenance charge, 2e/sqm/month	-0.0160	0.3313	-0.0374	0.0003	-0.0274	0.0046
Maintenance charge, 3e/sqm/month	-0.1428	<.0001	-0.0809	<.0001	-0.0564	<.0001
Maintenance charge, 4e/sqm/month	-0.1442	<.0001	-0.0963	<.0001	-0.0698	<.0001
Maintenance charge, 5e/sqm/month	-0.0963	<.0001	-0.0925	<.0001	-0.0628	<.0001
Maintenance charge, over 5e/sqm/month	-0.1747	<.0001	-0.1822	<.0001	-0.1772	<.0001
Transaction time fixed effects	yes		yes		yes	
Adjusted R2	0.6168		0.8502		0.8701	
N	9,482		9,482		9,482	
Estimation procedure (SAS)	PROC REG		PROC REG		PROC REG	

Table 6.3 OLS-models *(cont.)*

Variable	MODEL 6.4		MODEL 6.5	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|
Intercept	11.5669	<.0001	9.2211	<.0001
Log floor area	0.7641	<.0001	0.7668	<.0001
Log age of dwelling	-0.0519	<.0001	-0.0521	<.0001
Own lot	ref.		ref.	
Rented lot	-0.0512	<.0001	-0.0436	<.0001
Condition, good	0.0778	<.0001	0.0756	<.0001
Condition, satisfactory	ref.		ref.	
Condition, poor	-0.0726	<.0001	-0.0754	<.0001
Rental status, free	ref.		ref.	
Rental status, rented	-0.0224	0.0010	-0.0264	0.0001
Location 1. floor	ref.		ref.	
Location 2. floor	0.0029	0.6180	0.0025	0.6656
Location 3. floor	0.0065	0.2690	0.0069	0.2445
Location 4. floor	0.0225	0.0018	0.0226	0.0018
Location 5. floor	0.0195	0.0235	0.0192	0.0259
Location 6. floor	0.0378	0.0003	0.0373	0.0004
Location 7. floor	0.0355	0.0102	0.0343	0.0129
Location 8. floor	0.0742	0.0002	0.0730	0.0003
Location 9. floor or higher	0.0583	0.1378	0.0638	0.1048
Block of flats, number of floors 2-3	ref.		ref.	
Block of flats, number of floors 4-5	-0.0093	0.1149	-0.0097	0.0992
Block of flats, number of floors 6-8	-0.0574	<.0001	-0.0629	<.0001
Block of flats, number of floors 9-11	-0.0329	0.0285	-0.0333	0.0268
Block of flats, number of floors 12 or more	-0.0497	0.0147	-0.0497	0.0148
Row house, number of floors 1	0.2233	<.0001	0.2051	<.0001
Row house, number of floors 2	0.1620	<.0001	0.1465	<.0001
Row house, number of floors 3	0.1779	<.0001	0.1673	<.0001
Lift in the building, no	ref.		ref.	
Lift in the building, yes	0.0199	0.0007	0.0188	0.0013
Log distance to coastline	-0.0665	<.0001	-0.0614	<.0001
Log distance to industrial area	0.0063	0.0009	0.0048	0.0130
Socioeconomic status indes	0.0990	<.0001	0.0948	<.0001
District service level, number of industries	0.0016	<.0001	0.0019	<.0001

Table 6.3 OLS-models *(cont.)*

Variable	MODEL 6.4		MODEL 6.5	
	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Road noise area, no	ref.		ref.	
Road noise area, yes	-0.0154	0.0004	-0.0025	0.5700
Rail noise area, no	ref.		ref.	
Rail noise area, yes	0.0467	<.0001	0.0597	<.0001
District building efficiency	-0.0709	<.0001	-0.1006	<.0001
Lot building efficiency	0.0819	<.0001	0.0738	<.0001
Travel time distance to CBD by car				
Travel time distance to CBD by public transportation				
Workplace accessibility by car	-0.0998	<.0001		
Workplace accessibility by public transportation	-0.4587	<.0001		
Number of workplaces within 30 min by car			0.00000024	<.0001
Number of workplaces within 30 min by public transportation			0.00000132	<.0001
Maintenance charge, 0e/sqm/month	-0.0345	0.0517	-0.0355	0.0454
Maintenance charge, 1e/sqm/month	ref.		ref.	
Maintenance charge, 2e/sqm/month	-0.0358	0.0003	-0.0383	<.0001
Maintenance charge, 3e/sqm/month	-0.0717	<.0001	-0.0708	<.0001
Maintenance charge, 4e/sqm/month	-0.0870	<.0001	-0.0864	<.0001
Maintenance charge, 5e/sqm/month	-0.0845	<.0001	-0.0845	<.0001
Maintenance charge, over 5e/sqm/month	-0.1958	<.0001	-0.2010	<.0001
Transaction time fixed effects	yes		yes	
Adjusted R2	0.8672		0.8671	
N	9,482		9,482	
Estimation procedure (SAS)	PROC REG		PROC REG	

When this assessment (Table 6.3) is performed separately for central Helsinki and the rest of the Helsinki Metropolitan Area (suburbs in Table 6.4), the primacy of accessibility by public transport with regard to the formation of housing prices is observed (Models 6.6 – 6.8). No major differences were found between the expressiveness of models using different accessibility variable pairs. The result is quite understandable, since both car ownership and using a car for commuting are rarer in central Helsinki than in the rest of the region.

With regard to suburban areas, the coefficients of both means of transport – car and public transport – were statistically significant, while their prefix symbols were in line with expectations. However, the price effects of accessibility by public transport were distinctly higher than accessibility by car.

Table 6.4 OLS-models, separate models for CBD and suburbs

Variable	CBD					
	MODEL 6.6		MODEL 6.7		MODEL 6.8	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Intercept	9.3220	<.0001	8.7481	<.0001	8.9874	<.0001
Log floor area	0.8833	<.0001	0.8865	<.0001	0.8873	<.0001
Log age of dwelling	0.0337	<.0001	0.0332	<.0001	0.0332	<.0001
Own lot	ref.		ref.		ref.	
Rented lot	-0.1635	<.0001	-0.1745	<.0001	-0.1759	<.0001
Condition, good	0.0764	<.0001	0.0754	<.0001	0.0755	<.0001
Condition, satisfactory	ref.		ref.		ref.	
Condition, poor	-0.0805	<.0001	-0.8106	<.0001	-0.0805	<.0001
Rental status, free	ref.		ref.		ref.	
Rental status, rented	-0.0175	0.0921	-0.0152	0.1444	-0.0149	0.1502
Location 1. floor	ref.		ref.		ref.	
Location 2. floor	0.0088	0.5142	0.0095	0.4830	0.0095	0.4805
Location 3. floor	0.0300	0.0218	0.0305	0.0198	0.0308	0.0186
Location 4. floor	0.0412	0.0033	0.0421	0.0028	0.0423	0.0026
Location 5. floor	0.0641	<.0001	0.0636	<.0001	0.0640	<.0001
Location 6. floor	0.0766	<.0001	0.0772	<.0001	0.0776	<.0001
Location 7. floor	0.0720	0.0008	0.0701	0.0011	0.0695	0.0012
Location 8. floor	0.1381	<.0001	0.1338	<.0001	0.1343	<.0001
Location 9. floor or higher	0.0564	0.3278	0.0536	0.3543	0.0532	0.3578
Block of flats, number of floors 2-3	ref.		ref.		ref.	
Block of flats, number of floors 4-5	-0.0732	0.0001	-0.0753	<.0001	-0.0761	<.0001
Block of flats, number of floors 6-8	-0.1161	<.0001	-0.1189	<.0001	-0.1190	<.0001
Block of flats, number of floors 9-11	-0.0322	0.2968	-0.0250	0.4175	-0.0209	0.4989
Block of flats, number of floors 12 or more	-0.0937	0.0053	-0.1004	0.0029	-0.0960	0.0045
Row house, number of floors 1						
Row house, number of floors 2	0.3470	0.0003	0.3599	0.0002	0.3633	0.0001
Row house, number of floors 3						
Lift in the building, no	ref.		ref.		ref.	
Lift in the building, yes	-0.0027	0.8089	-0.0027	0.8114	-0.0027	0.8101
Log distance to coastline	-0.0406	<.0001	-0.0495	<.0001	-0.0434	<.0001
Log distance to industrial area	0.0243	<.0001	0.0305	<.0001	0.0309	<.0001
Socioeconomic status indes	0.0338	0.0007	0.0356	0.0004	0.0347	0.0006
District service level, number of industries	0.0035	<.0001	0.0038	<.0001	0.0035	<.0001

Table 6.4 OLS-models, separate models for CBD and suburbs *(cont.)*

Variable	CBD					
	MODEL 6.6		MODEL 6.7		MODEL 6.8	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Road noise area, no	ref.		ref.		ref.	
Road noise area, yes	-0.0731	0.0151	-0.0900	0.0025	-0.0867	0.0038
Rail noise area, no	ref.		ref.		ref.	
Rail noise area, yes	0.0577	0.1143	0.0542	0.1418	0.0517	0.1586
District building efficiency	-0.3003	<.0001	-0.2750	<.0001	-0.2447	<.0001
Lot building efficiency	0.0077	0.2122	0.0133	0.0304	0.0162	0.0080
Travel time distance to CBD by car	-0.0691	0.2024				
Travel time distance to CBD by public transportation	-0.1123	0.0011				
Workplace accessibility by car			0.2117	0.0428		
Workplace accessibility by public transportation			-0.1696	0.0366		
Number of workplaces within 30 min by car					-0.00000063	0.0254
Number of workplaces within 30 min by public transportation					0.00000024	0.2094
Maintenance charge, 0e/sqm/month	-0.0365	0.4985	-0.0330	0.5415	-0.0316	0.5592
Maintenance charge, 1e/sqm/month	ref.		ref.		ref.	
Maintenance charge, 2e/sqm/month	-0.0007	0.9822	-0.0107	0.7417	-0.0109	0.7372
Maintenance charge, 3e/sqm/month	-0.0133	0.6712	-0.0225	0.4724	-0.0235	0.4525
Maintenance charge, 4e/sqm/month	-0.0332	0.2927	-0.0432	0.1710	-0.0444	0.1591
Maintenance charge, 5e/sqm/month	0.0245	0.4687	0.0140	0.6792	0.0131	0.6985
Maintenance charge, over 5e/sqm/month	-0.1023	0.0122	-0.1106	0.0069	-0.1111	0.0066
Transaction time fixed effects	yes		yes		yes	
Adjusted R2	0.9142		0.9137		0.9136	
N	1,912		1,912		1,912	
Estimation procedure (SAS)	PROC REG		PROC REG		PROC REG	

Table 6.4 OLS-models, separate models for CBD and suburbs *(cont.)*

Variable	SUBURBS					
	MODEL 6.9		MODEL 6.10		MODEL 6.11	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Intercept	10.9670	<.0001	11.8517	<.0001	9.5631	<.0001
Log floor area	0.7079	<.0001	0.7061	<.0001	0.7096	<.0001
Log age of dwelling	-0.0724	<.0001	-0.0722	<.0001	-0.0746	<.0001
Own lot	ref.		ref.		ref.	
Rented lot	-0.0480	<.0001	-0.0458	<.0001	-0.0388	<.0001
Condition, good	0.0718	<.0001	0.0729	<.0001	0.0707	<.0001
Condition, satisfactory	ref.		ref.		ref.	
Condition, poor	-0.0832	<.0001	-0.0828	<.0001	-0.0858	<.0001
Rental status, free	ref.		ref.		ref.	
Rental status, rented	-0.0423	<.0001	-0.0398	<.0001	-0.0449	<.0001
Location 1. floor	ref.		ref.		ref.	
Location 2. floor	0.0040	0.5128	0.0043	0.4841	0.0041	0.5060
Location 3. floor	0.0035	0.5808	0.0026	0.6754	0.0032	0.6127
Location 4. floor	0.0191	0.0189	0.0173	0.0321	0.0183	0.0234
Location 5. floor	-0.0001	0.9935	0.0010	0.9188	0.0001	0.9918
Location 6. floor	0.0301	0.0217	0.0277	0.0336	0.0280	0.0311
Location 7. floor	0.0293	0.0887	0.0304	0.0759	0.0291	0.0888
Location 8. floor	0.0510	0.0343	0.0545	0.0230	0.0512	0.0324
Location 9. floor or higher	0.0357	0.4747	0.0291	0.5575	0.0382	0.4412
Block of flats, number of floors 2-3	ref.		ref.		ref.	
Block of flats, number of floors 4-5	-0.0219	0.0005	-0.0245	<.0001	-0.0248	<.0001
Block of flats, number of floors 6-8	-0.0475	<.0001	-0.0480	<.0001	-0.0530	<.0001
Block of flats, number of floors 9-11	-0.0873	<.0001	-0.0909	<.0001	-0.0819	<.0001
Block of flats, number of floors 12 or more	0.0107	0.7007	0.0004	0.9874	0.0063	0.8200
Row house, number of floors 1	0.2441	<.0001	0.2570	<.0001	0.2403	<.0001
Row house, number of floors 2	0.1931	<.0001	0.2022	<.0001	0.1874	<.0001
Row house, number of floors 3	0.2314	<.0001	0.2382	<.0001	0.2280	<.0001
Lift in the building, no	ref.		ref.		ref.	
Lift in the building, yes	0.0252	0.0001	0.0278	<.0001	0.0266	<.0001
Log distance to coastline	-0.0523	<.0001	-0.0752	<.0001	-0.0707	<.0001
Log distance to industrial area	0.0098	<.0001	0.0110	<.0001	0.0099	<.0001
Socioeconomic status indes	0.0886	<.0001	0.0796	<.0001	0.0727	<.0001
District service level, number of industries	0.0008	<.0001	0.0003	0.0050	0.0006	<.0001

Table 6.4 OLS-models, separate models for CBD and suburbs *(cont.)*

Variable	SUBURBS					
	MODEL 6.9		MODEL 6.10		MODEL 6.11	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Road noise area, no	ref.		ref.		ref.	
Road noise area, yes	-0.0068	0.1150	-0.0163	0.0002	-0.0078	0.0770
Rail noise area, no	ref.		ref.		ref.	
Rail noise area, yes	0.0410	<.0001	0.0372	<.0001	0.0522	<.0001
District building efficiency	0.1999	<.0001	0.2227	<.0001	0.2159	<.0001
Lot building efficiency	0.0428	<.0001	0.0587	<.0001	0.0422	<.0001
Travel time distance to CBD by car	-0.1372	<.0001				
Travel time distance to CBD by public transportation	-0.2552	<.0001				
Workplace accessibility by car			-0.0607	0.0008		
Workplace accessibility by public transportation			-0.4782	<.0001		
Number of workplaces within 30 min by car					0.00000025	<.0001
Number of workplaces within 30 min by public transportation					0.00000132	<.0001
Maintenance charge, 0e/sqm/month	-0.0411	0.0225	-0.0354	0.0482	-0.0354	0.0480
Maintenance charge, 1e/sqm/month	ref.		ref.		ref.	
Maintenance charge, 2e/sqm/month	-0.0287	0.0039	-0.0334	0.0007	-0.0355	0.0003
Maintenance charge, 3e/sqm/month	-0.0575	<.0001	-0.0654	<.0001	-0.0636	<.0001
Maintenance charge, 4e/sqm/month	-0.0783	<.0001	-0.0864	<.0001	-0.0846	<.0001
Maintenance charge, 5e/sqm/month	-0.0956	<.0001	-0.1091	<.0001	-0.1043	<.0001
Maintenance charge, over 5e/sqm/month	-0.1971	<.0001	-0.2137	<.0001	-0.2192	<.0001
Transaction time fixed effects	yes		yes		yes	
Adjusted R2	0.8620		0.8635		0.8649	
N	7,570		7,570		7,570	
Estimation procedure (SAS)	PROC REG		PROC REG		PROC REG	

Table 6.5 Separate models for different house types

Variable	BLOCK OF FLATS					
	MODEL 6.12		MODEL 6.13		MODEL 6.14	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Intercept	11.0582	<.0001	11.6818	<.0001	9.2542	<.0001
Log floor area	0.7614	<.0001	0.7669	<.0001	0.7669	<.0001
Log age of dwelling	-0.0718	<.0001	-0.0625	<.0001	-0.0633	<.0001
Own lot	ref.		ref.		ref.	
Rented lot	-0.0515	<.0001	-0.0455	<.0001	-0.0334	<.0001
Condition, good	0.0755	<.0001	0.0766	<.0001	0.0750	<.0001
Condition, satisfactory	ref.		ref.		ref.	
Condition, poor	-0.0764	<.0001	-0.0735	<.0001	-0.0760	<.0001
Rental status, free	ref.		ref.		ref.	
Rental status, rented	-0.0303	<.0001	-0.0221	0.0018	-0.0246	0.0006
Location 1. floor	ref.		ref.		ref.	
Location 2. floor	0.0018	0.7573	0.0015	0.8029	0.0011	0.8573
Location 3. floor	0.0067	0.2509	0.0059	0.3199	0.0064	0.2814
Location 4. floor	0.0247	0.0005	0.0220	0.0025	0.0223	0.0022
Location 5. floor	0.0180	0.0350	0.0195	0.0250	0.0193	0.0265
Location 6. floor	0.0388	0.0002	0.0366	0.0005	0.0364	0.0006
Location 7. floor	0.0381	0.0052	0.0352	0.0112	0.0340	0.0144
Location 8. floor	0.0706	0.0004	0.0730	0.0003	0.0719	0.0004
Location 9. floor or higher	0.0561	0.1484	0.0603	0.1272	0.0662	0.0944
Block of flats, number of floors 2-3	ref.		ref.		ref.	
Block of flats, number of floors 4-5	-0.0133	0.0234	-0.0119	0.0450	-0.0107	0.0720
Block of flats, number of floors 6-8	-0.0551	<.0001	-0.0590	<.0001	-0.0623	<.0001
Block of flats, number of floors 9-11	-0.0315	0.0343	-0.0328	0.0305	-0.0300	0.0481
Block of flats, number of floors 12 or more	-0.0567	0.0050	-0.0530	0.0101	-0.0511	0.0131
Row house, number of floors 1						
Row house, number of floors 2						
Row house, number of floors 3						
Lift in the building, no	ref.		ref.		ref.	
Lift in the building, yes	0.0146	0.0129	0.0192	0.0013	0.0170	0.0044
Log distance to coastline	-0.0343	<.0001	-0.0659	<.0001	-0.0577	<.0001
Log distance to industrial area	0.0075	0.0004	0.0102	<.0001	0.0085	<.0001
Socioeconomic status indes	0.1051	<.0001	0.1063	<.0001	0.1040	<.0001
District service level, number of industries	0.0018	<.0001	0.0018	<.0001	0.0022	<.0001

Table 6.5 Separate models for different house types *(cont.)*

Variable	BLOCK OF FLATS					
	MODEL 6.12		MODEL 6.13		MODEL 6.14	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Road noise area, no	ref.		ref.		ref.	
Road noise area, yes	-0.0094	0.0525	-0.0142	0.0044	-0.0012	0.8122
Rail noise area, no	ref.		ref.		ref.	
Rail noise area, yes	0.0583	<.0001	0.0487	<.0001	0.0630	<.0001
District building efficiency	-0.1389	<.0001	-0.0752	<.0001	-0.0965	<.0001
Lot building efficiency	0.0438	<.0001	0.0795	<.0001	0.0737	<.0001
Travel time distance to CBD by car	-0.2619	<.0001				
Travel time distance to CBD by public transportation	-0.2475	<.0001				
Workplace accessibility by car			-0.0838	<.0001		
Workplace accessibility by public transportation			-0.4919	<.0001		
Number of workplaces within 30 min by car					0.00000020	<.0001
Number of workplaces within 30 min by public transportation					0.00000134	<.0001
Maintenance charge, 0e/sqm/month	-0.0436	0.3282	-0.0503	0.2675	-0.0474	0.2966
Maintenance charge, 1e/sqm/month	ref.		ref.		ref.	
Maintenance charge, 2e/sqm/month	-0.0562	0.0312	-0.0798	0.0027	-0.0779	0.0034
Maintenance charge, 3e/sqm/month	-0.0897	0.0004	-0.1186	<.0001	-0.1133	<.0001
Maintenance charge, 4e/sqm/month	-0.0966	0.0002	-0.1281	<.0001	-0.1232	<.0001
Maintenance charge, 5e/sqm/month	-0.0917	0.0006	-0.1280	<.0001	-0.1244	<.0001
Maintenance charge, over 5e/sqm/month	-0.2102	<.0001	-0.2419	<.0001	-0.2427	<.0001
Transaction time fixed effects	yes		yes		yes	
Adjusted R2	0.8567		0.8513		0.8509	
N	7,678		7,678		7,678	
Estimation procedure (SAS)	PROC REG		PROC REG		PROC REG	

Table 6.5 Separate models for different house types

Variable	ROW HOUSES					
	MODEL 6.15		MODEL 6.16		MODEL 6.15	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Intercept	10.7358	<.0001	11.5198	<.0001	9.5526	<.0001
Log floor area	0.7538	<.0001	0.7481	<.0001	0.7498	<.0001
Log age of dwelling	-0.0237	<.0001	-0.0240	<.0001	-0.0242	<.0001
Own lot	ref.		ref.		ref.	
Rented lot	-0.0883	<.0001	-0.0815	<.0001	-0.0798	<.0001
Condition, good	0.0710	<.0001	0.0725	<.0001	0.0710	<.0001
Condition, satisfactory	ref.		ref.		ref.	
Condition, poor	-0.0490	0.4917	-0.0611	0.3852	-0.0509	0.4678
Rental status, free	ref.		ref.		ref.	
Rental status, rented	-0.0304	0.2231	-0.0271	0.2717	-0.0365	0.1376
Location 1. floor						
Location 2. floor						
Location 3. floor						
Location 4. floor						
Location 5. floor						
Location 6. floor						
Location 7. floor						
Location 8. floor						
Location 9. floor or higher						
Block of flats, number of floors 2-3						
Block of flats, number of floors 4-5						
Block of flats, number of floors 6-8						
Block of flats, number of floors 9-11						
Block of flats, number of floors 12 or more						
Row house, number of floors 1	ref		ref		ref	
Row house, number of floors 2	-0.0338	0.0001	-0.0342	<.0001	-0.0337	0.0001
Row house, number of floors 3	0.0006	0.9759	0.0035	0.8606	-0.0038	0.8480
Lift in the building, no						
Lift in the building, yes						
Log distance to coastline	-0.0498	<.0001	-0.0675	<.0001	-0.0667	<.0001
Log distance to industrial area	-0.0068	0.1045	-0.0060	0.1440	-0.0031	0.4534
Socioeconomic status indes	0.0626	<.0001	0.0558	<.0001	0.0514	<.0001
District service level, number of industries	0.0006	0.0085	0.0004	0.1107	0.0004	0.0745

Table 6.5 Separate models for different house types *(cont.)*

Variable	ROW HOUSES					
	MODEL 6.15		MODEL 6.16		MODEL 6.17	
	Parameter estimate	Pr > |t|)	Parameter estimate	Pr > |t|	Parameter estimate	Pr > |t|
Road noise area, no	ref.		ref.		ref.	
Road noise area, yes	-0.0268	0.0031	-0.0390	<.0001	-0.0341	0.0002
Rail noise area, no	ref.		ref.		ref.	
Rail noise area, yes	0.0291	0.0808	0.0284	0.0798	0.0311	0.0532
District building efficiency	0.1949	0.0054	0.1689	0.0128	0.1629	0.0154
Lot building efficiency	-0.0768	0.0007	-0.0724	0.0011	-0.0955	<.0001
Travel time distance to CBD by car	-0.1908	<.0001				
Travel time distance to CBD by public transportation	-0.1441	<.0001				
Workplace accessibility by car			-0.1808	<.0001		
Workplace accessibility by public transportation			-0.2941	<.0001		
Number of workplaces within 30 min by car					0.00000033	<.0001
Number of workplaces within 30 min by public transportation					0.00000150	<.0001
Maintenance charge, 0e/sqm/month	-0.0485	0.0074	-0.0435	0.0150	-0.0438	0.0141
Maintenance charge, 1e/sqm/month	ref.		ref.		ref.	
Maintenance charge, 2e/sqm/month	-0.0353	0.0007	-0.0366	0.0003	-0.0403	<.0001
Maintenance charge, 3e/sqm/month	-0.0433	0.0001	-0.0474	<.0001	-0.0502	<.0001
Maintenance charge, 4e/sqm/month	-0.0849	<.0001	-0.0906	<.0001	-0.0933	<.0001
Maintenance charge, 5e/sqm/month	-0.0547	0.1730	-0.0649	0.1019	-0.0805	0.0430
Maintenance charge, over 5e/sqm/month	-0.1309	0.1591	-0.1537	0.0937	-0.1414	0.1220
Transaction time fixed effects	yes		yes		yes	
Adjusted R2	0.7973		0.8025		0.8035	
N	1,804		1,804		1,804	
Estimation procedure (SAS)	PROC REG		PROC REG		PROC REG	

With regard to building type (dwellings in blocks of flats and row houses), a significant difference was found in the estimated models' (Table 6.5) ability to explain variation in housing prices. In the models for blocks of flats, the coefficient for determination was around five per cent higher than in the models for row houses.

The differences in the coefficients measuring average distance to the centre were relatively insignificant in the model for blocks of flats (Model 6.12). Then again, the coefficient of public transport six times higher than the coefficient of accessibility by car in the model measuring workplace accessibility (Model 6.13).

On the other hand, the coefficients of accessibility by car were significantly higher as compared to the models estimated for blocks of flats (Table 6.5, Models 6.15–6.17). In terms of distance to the centre, the coefficient of accessibility by car (Model 6.15) was higher than the coefficient of accessibility by public transport. In the model based on general workplace accessibility (Model 6.16), the coefficients of accessibility by car and public transport were substantially closer to each other than in Model 6.13, estimated on the basis of data on blocks of flats, for instance.

6.7 Discussion

The key research question in this chapter was to assess the effect of accessibility on housing prices. Market price of otherwise similar dwellings may vary significantly as a result of different location those units. The view that distance to centre holding an essential role behind housing prices is at least partially based on the idea of the city centre's role as workplace cluster. This common assumption is not entirely in line with the developments that have occurred in urban structures. In many cities, workplace structures have become less main centre-oriented over time. New workplace clusters have sprung up alongside main centres. Helsinki is another city in which a significant portion of new workplaces has been created outside the main centre, central Helsinki, over the last few decades.

In this study, accessibility was measured from three different perspectives. In addition to the traditional accessibility measure, distance to the main centre (CBD), the second approach based on the measurement of accessibility to all workplaces in the region. The third approach based on measuring the number of workplaces within a 30-minute travel time. 30-minute travel time was chosen because it is compatible with idea of fixed travel time budget. Accessibility measures were calculated separately for two different modes of transportation, for cars and for public transportation. The study area was the Helsinki Metropolitan Area and the data covers 15 months, from the last quarter of 2009 to the end of 2010. The initial hypothesis was that general accessibility measure and accessibility measure based on the idea of fixed time budget should outperform the traditional accessibility measure (travel time to CBD).

According to the results, all of the different approaches produced models with no significant differences related to coefficients of determination, i.e. the ability of the models to explain variation in housing prices. On the basis of the models encompassing the entire research area, there is a distinct difference between accessibility based on gravitational potential and accessibility based on regular distance to the centre. On the basis of the regular accessibility measurement, distance to the centre, accessibility by car and public transport would be in the same order of magnitude as factors explaining housing prices. However, from the perspective of general accessibility, the role of accessibility by public transport was clearly more significant. In terms of workplaces accessible within a 30-minute travel time, the effect of accessibility by public transport on housing prices was also higher than accessibility by car.

From the perspective of house prices in central Helsinki, the role of accessibility by car was relatively insignificant. The effects of accessibility by public transport were also proportionally lower as compared to models encompassing the entire region. On the other hand, the role of accessibility by public transport in suburban areas was pronounced as compared to assessments covering the entire region. However, it must be noted that, assessed in terms of building type, the significance of accessibility by car was relatively high with regard to row houses.

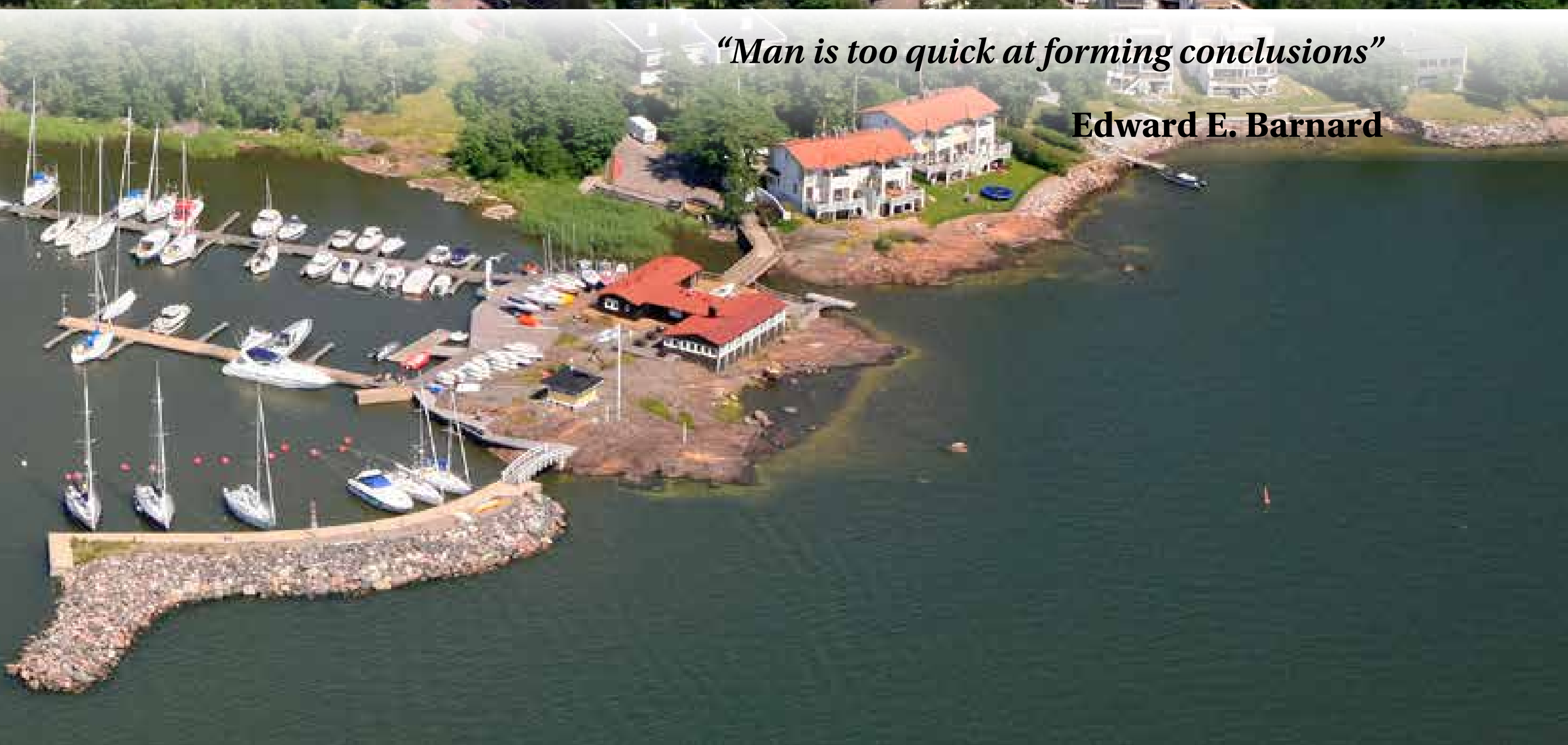
This work concentrated on expanding the assessment of accessibility related to commuting. The results reveal that, while a development where the number of workplaces in the main centre has not grown significantly can be observed with regard to the workplace structure, the role of the main centre as a major factor behind housing prices still remains. This result can be interpreted in a number of ways. We might consider that the main centre still occupies a crucial role as a service hub. Traffic congestion and low service levels in public transport between the east and the west outside central Helsinki may also serve to make central locations more attractive. The increased number of households with two working parents and the similar increase in the number of households with no children may also ramp up the attractiveness of central locations. The location of central Helsinki on a peninsula surrounded by the sea may also contribute to a scenario in which the next wave of pressure for the city centre's expansion has no outlet, which will only emphasise the accessibility benefits of central locations.

Accessibility measures in this study were mostly based on workplace accessibility. As was pointed out earlier, about one quarter of all trips are work related. In order to have a more accurate picture on accessibility, more versatile data on mobility and destination of trips would be needed. The acquisition of this type of data is more difficult compared to data on accessibility to CBD or to workplaces. The price effects of accessibility to different types of workplaces might also differ. For example in the case of industrial workplaces, the impact of accessibility might be mixed with some negative side effects of those workplaces.

More extensive data would be useful in other ways as well. For example, the transportation service level might differ (even when the value accessibility measure based on travel time is identical), based on the quality level and capacity utilisation level of public transportation vehicles, and this should be taken into account when accessibility measures are compared. Hybrid index, combining service level information with travel time information might also enhance the explanatory power of the model. Also monetary factors related to transportation could offer new insights for the analysis.

CHAPTER 7

CONCLUSIONS



"Man is too quick at forming conclusions"

Edward E. Barnard

7 CONCLUSIONS

7.1 Results of this study

This study focused on three groups of factors affecting housing prices in the Helsinki Region. These three groups of factors were urban natural amenities, architecture and accessibility. The motivation for this study and selection of these three groups of factors rose from those pressures on land use that the Helsinki Region faces when the region grows rapidly.

In what follows, the results of this study are discussed research question by research question. The first research question (RQ1) is related to the price effects of natural amenities, especially those concerning green space and recreational areas, unbuilt areas and coastline. The results confirm the positive price effects of green space (yards and parks) and recreational areas. Alternative land use variables, unbuilt land in 100m and 101-300m buffers, confirm results obtained from the models where land use is modelled in more detail. For flats, unbuilt land has stronger positive effect on housing prices in central Helsinki than in the suburban areas of Helsinki. On the other hand, distance variables related to urban natural amenities, except coastline distance, were mainly statistically insignificant.

The second research question (RQ2) is related to the price effects of architectural quality and architectural style. Architectural quality is a rare topic in housing price studies. The data set covers southern part of central Helsinki and years 1980-2008. Only flats are included in the data set. Analysis in this study utilises several architecture-related data sources in an innovative way. The results offer some support for the argument that architect as planner (nowadays a norm) affects positively the prices of dwellings. The results also confirm that status of architectural landmark has a positive effect on the price of a dwelling. A rank-order, based on housing prices, of different architectural styles is also established. Based of variables describing view from the building, architectural quality (for example architectural landmarks) also seems to have positive externality effects.

The third research question (RQ3) is related to the effects of accessibility to workplaces on housing prices. The data set covers the Helsinki Metropolitan Area. Only flats and row houses are included in the data set. Alongside the traditional accessibility measure, the CBD distance, two alternative measures are tested: average accessibility to workplaces and work places inside 30 minute buffer from the dwelling. Although these different approaches offer roughly similar level coefficients of determination, some interesting conclusions can be drawn from the models. When alternative measures of accessibility are used as accessibility measures, public transportation seems to have much stronger impact on housing prices compared to car accessibility.

7.2 Contributions of the study

This study contributes to the field of urban economics by applying a variety of hedonic modelling techniques to analyse the price effects of urban natural amenities, architectural quality and accessibility on housing prices in Helsinki and Helsinki Metropolitan Area.

Scientific contributions of this study can be divided into two groups. First of all, several innovative methods were used for processing original data sets. Detailed data on urban land use (RQ1) is constructed by using remote sensor images and digital planning documents. Several architectural databases are utilised to form variables representing architectural features of a building (RQ2). In addition, CAD modelling is used to construct view-related variables. Advanced route optimisation tools and a public transportation database are used to construct accessibility variables (RQ3).

Another group of scientific contributions of this study relates to the empirical analysis of data sets. Our analysis of the effects of urban natural amenities on housing prices (RQ1) is one of the few studies in Finland (and the first one from Helsinki) which utilises detailed data on urban natural amenities. The results reveal that though there is a plenty of supply of natural amenities in Helsinki, they still have a clear positive price effect on housing prices. Our analysis of the effects of architectural quality on housing prices (RQ2) is, to our knowledge, a pioneer work of its kind in Finland and equivalent studies are rare even by international standards. The results indicate that architectural quality has both positive internal and external effects on housing prices. Our analysis of the effects of accessibility on housing prices (RQ3) is among the first studies that utilises detailed public transportation data sets in housing markets studies. The results indicate that the price effects of accessibility differ significantly when flats and row houses are compared. Also the magnitude of price effects of different modes of transport are quite different.

On the basis of the results of this study several policy implications can be drawn. Firstly, although Helsinki has plenty of green space – parks, forests, recreational areas and coastline – the price effects of urban natural amenities on housing prices can still found (RQ1). In particular closeness to coastline and land use variables proved to be important. These factors have expected effects on housing prices. Except the aforementioned coastline distance, other distance variables were less important or statistically insignificant. These price effects of urban natural amenities must be interpreted in right manner taking into account the logic behind the hedonic model. In the hedonic model, the price of dwelling is an outcome of the qualities and the shadow prices of that dwelling. Housing prices in the densely build central city area, where natural amenities are scarce, are the highest in the region. For example, the price effects of unbuilt land are in real terms (in euros) much higher in central Helsinki than in the suburbs. Scarcity of unbuilt land leads to a situation where the relative marginal price effects are quite strong. Though central locations with a good service level are valued highly, the price effect of (scarce) unbuilt land is also quite strong. So, even in an urban context nature is valued and should be taken into account when planning decision are made.

Results of this study also support the idea that architectural quality has positive price effects (RQ2). Especially dwellings in buildings which are architectural landmarks are more valuable than other dwellings, and architectural landmarks also have external effects on housing prices. The price of dwelling in a building produced as an outcome of an architectural competitions and in buildings presented in the Finnish Architectural Review, on the other hand, do not a have price premium over other dwellings. Planners' experience and competition success both have positive effect on housing prices. When different architectonic styles are compared, the results indicate that the oldest styles are the most valuable. This result is in accordance with everyday experience. It should be remembered that architectonic styles represent not just the aesthetical features of a building. Architectural styles also differ with respect to structural and functional features, for example with respect to construction materials and room height. To summarise, this study supports the argument that the quality of planning has an effect on housing prices. The external effects of architectural quality also raise the question whether market solution can internalise all effects that design of a single building has?

Earlier literature on housing prices has shown that location is an essential factor behind housing prices. Most of the earlier studies have used quite rudimentary measures of location. Latest research utilises more detailed data on location. In this study, the focus is on job accessibility (RQ3). When job accessibility is measured as an average workplace accessibility or with the buffer method, and separately for different transportation modes (car and public transportation), new insights emerge. Job accessibility by public transportation appears to be a much stronger driver of housing prices, compared to car accessibility. When different dwelling types (flats and row houses) are analysed separately, accessibility by public transportation has much stronger effects on prices of flats (compared to the effects on the prices of row houses). Partly this outcome might have something to do with the fact that in areas dominated by detached housing (where the bulk of row houses are located) car is more common as a transportation mode than it is in areas where blocks of flats are the dominant form of housing. Car accessibility varies much less compared to accessibility by public transportation. The results give support to a planning policy which aims to direct major building activities into areas where the service level of public transportation is or will be high.

Combining good accessibility, good service level and natural amenities is not an easy task for urban planning. Naturally preferences for different housing characteristics are likely to differ. One obvious solution is to offer a variety of different types of living environments which enables sorting according to housing preferences.

7.3 Evaluation of the study

Each empirical part of this study (Chapters 4-6) contains detailed discussion of the quality of the research. This section evaluates the overall quality of the study, focusing on method, data and external validity of the results.

7.3.1 Method and data

Methodologically this study is based on econometric analysis of housing market transaction data sets. Methodologically, the analysis in all empirical topics is quite similar. The core method applied is the hedonic method. As described earlier, the hedonic method is based on the assumption that dwellings are so called composite commodities and the shadow price of each attribute can be estimated by using the regression model. The hedonic model has been applied for quite a long time and it is standard workhorse in housing market studies. Though dominant, the hedonic method is not the only method used.

Alternatives for the hedonic method were described in Section 3.1. Compared to the hedonic method, these alternative methods have more shortcomings than advantages. For example, the repeated sales method is useful when the focus of study is the overall development of housing prices but not applicable to analysis of shadow prices of different housing characteristics. Contingent choice and contingent valuation methods are also quite commonly applied. One of the main weaknesses of these methods is that they are not based on actual transactions in the housing market.

The hedonic method has several advantages. Firstly, it is based on actual market transactions, actual choices. Secondly, housing markets are often seen as relatively efficient with respect to information, though there is also a quite extensive literature which is critical to the efficiency hypothesis (Maier & Herath 2009). Thirdly, housing market data sets (on transactions) are available in most areas and the data is generally reliable. The housing market data set used in this study is collected by association of real estate agents and organised by Finnish Technical Research Centre (VTT). The data set is widely used for real estate evaluation and research purposes. Supplementary data sets are also available, and they enable many different topics to be analysed in the housing market context. In this study, supplementary data sets come manly from data bases maintained by regional and national statistical offices, and the Museum of Finnish Architecture.

Though the hedonic method is itself a well-developed tool, some critical remarks must be made, first on the estimation of the hedonic model. The reliability of results, based on the commonly used OLS-technique, is founded on several assumptions which are commonly referred as Gauss-Markov conditions (Greene 2003). These assumptions were discussed in detail in Subsection 3.4.1. In order to diminish the possibility of biased estimates and false statistical inference, several measures were taken. To avoid problems related to omitted variables, spatial indicator variables were added to models. Standard errors and related statistical probabilities were calculated in most cases by using so called White method (which takes into account possible heteroskedasticity) and in some cases, by using the cluster-robust method. A robust estimation technique, median regression, was also applied (RQ2). Additionally multilevel technique was used alongside the traditional single-level OLS model (RQ1). Multilevel technique takes explicitly into account the hierarchical structure of the data and it is not based on the assumption of uncorrelated errors. All models were estimated in a step-by-step manner to evaluate the stability of the models. The selection of functional form was based on literature review on earlier studies (discussion in Subsection 3.4.1). Furthermore, geographically weighted regression was tested (RQ1). After numerous estimations, this approach was abandoned because variables representing prices of natural amenities were quite unstable between model specifications. This lead to suspicion, that some omitted spatial variables caused this instability. In OLS models, these factors were controlled, at least to some extent, by adding spatial indicator variables into models.

Secondly, some critical remarks on the data must also be made. It is not self-evident that housing market data used in this study represents the whole housing stock. This problem has been extensively studied in the literature related to estimation of housing price indexes (Haurin & Hendershott 1991, Jud & Seaks 1994, Case & Wachter 2005). The possibility of the selection bias cannot be ruled out. In this study, single- family houses were categorically omitted from the analysis. This choice was based on the fact that single family houses are very heterogeneous. In order to model the prices of single-family houses properly, the data should contain very detailed description of each house sold. Also, single family houses represent less than 8 % of the housing stock in Helsinki and the number of houses sold in each area is very limited which would cause additional uncertainties on results.

Thirdly, the hedonic model is based on the assumption that buyer can choose, within his or her budget constraint, from all possible combinations of housing characteristics. It is obvious that housing markets do not offer all these combinations. This might distort the results though it is difficult to evaluate the magnitude of this distortion.

7.3.2 External validity

Housing markets information is always local. This follows from the fact that local supply and demand conditions vary, and housing prices are an outcome of the balance between supply and demand. On the demand side, consumer preferences and income level can differ remarkably between different areas. On the supply side, there are significant differences in geographical features, institutional and financial conditions, existing housing stock and structure of the construction sector. This makes comparison of housing market information between different cities and areas to some extent problematic. For example, the Helsinki Metropolitan Area is in its own scale among city regions in Finland. It is quite likely that values and preferences of the population in the Helsinki Metropolitan Area differ to some extent from the rest of the country.

Despite the fact that all local housing markets exhibit their own peculiarities, the results of this study also have a wider significance. Although Helsinki is, in internationally comparison, a sparsely built city, with relative young housing stock, the results obtained in this work can, however, be considered to be indicative also more broadly, because the urbanization trend is generally similar in most of the countries. Thus, quality factors of urban environments are very likely to become more important. If general living standards keep on rising, housing demand is directed to high-quality environments. Continuing urbanisation alongside growing living standards makes scarce green areas more valuable. In a dense urban environment, the aesthetic values are also emphasised. And, as cities grow, accessibility becomes an even more important factor behind housing prices.

7.4 Methodological development and future research

As stated previously, the hedonic pricing method holds a rather dominant position in housing price research, and the number of studies using this method is considerable. The hedonic method provides tools for assessing the market prices of a dwelling's various attributes, the opportunity for making quality adjustments in the housing price index, and a foundation for housing and real estate price assessment information systems. Also rental housing markets and commercial real estate markets can be modelled using the hedonic pricing method.

The empirical methods which are used to implement the hedonic pricing method have developed over time. Some of this has resulted from the general development of statistical methods and some of it has been caused by improved technical capacity for compiling and processing research data. Various kinds of approaches based on natural test arrangements have become more common in the field of econometrics, which has opened up new avenues for housing price research based on the hedonic pricing method. The extent to which the correlations implicated by the regression model can be interpreted as causal relations in line with the expectations should be studied further. When controlled experiments are not possible to arrange, and this is usually the case, instrument variable estimation would be a suitable tool for this task (Angrist & Pischke 2015). However, finding suitable instrument variables may not necessarily be simple.

In terms of the heterogeneity of the factors affecting the price of a dwelling, an understanding of the spatial structure of variation – in addition to the modelling of variation – would provide significant additional information for purposes of urban planning, for instance. As stated earlier, GWR estimation (see Section 3.3 for details) based on local models was tested in connection with this work. However, the sensitivity of these results to model specification resulted in the omission of these models from the final version of the study. So, the applicability of the method should be tested more comprehensively. Interaction between the factors affecting housing prices should also be analysed more thoroughly.

The majority of the applications of the hedonic pricing method in the housing market, including this study, concentrate on the estimation of the shadow prices of dwelling attributes. This, in accordance with the terminology of the aforementioned Rosen article (1974), is the first stage of the hedonic pricing model, which yields information on the extent and direction of changes in the price of a dwelling when one or more of the dwelling's attributes change. In the second-stage model estimation, the (observed) demand for a certain dwelling attribute is explained by the shadow price of this attribute (which was estimated during the first stage of the hedonic pricing model) and other factors affecting demand such as the buyer's income. These demand curves express household preferences with regard to dwelling attributes. Unfortunately second-stage modelling is rarely seen in research. This situation is partially caused by the problems of endogeneity in second-stage estimation, described by Bartik (1987) and Epple (1987). However, estimation of demand models would be important since the first-stage models of hedonic pricing only assess the price effects of marginal changes, while not, for instance, enabling comparisons of economic well-being experienced by consumers related to the effects of various kinds of policy measures. Recent research literature indicates that identification of demand functions might be possible by using modern econometric methods based on quasi experimental set up and instrument estimation (Kuminoff & Pope 2012, Klaiber & Smith 2013, Zhang et al. 2015).

ABSTRACT

Urbanisation will bring substantial pressure on housing production in the Helsinki Metropolitan Area over the next few decades. City growth logic has also changed towards densification of the urban structure. The densification of the urban structure affects in many ways the existing residential areas. One of the main issues related to urban growth is how to maintain or improve quality factors while building new housing in different areas. Information provided by the housing market can be utilised in the assessment of various policy options.

Contribution of the various features of the apartment housing prices can be examined empirically using the so-called hedonic price method. The method allows the total price of the dwelling to be dismantled into parts representing the impact of the various characteristics of the dwelling on its price. The price of dwelling is generally considered to be a sum of the three main group of factors. These are the dwelling's location, structural characteristics and the quality of the neighborhood. This dissertation studies three factors affecting housing prices: urban natural amenities, architectural quality and accessibility.

The first empirical part of this study focused on the price effects of urban natural amenities. The study area was the City of Helsinki. Variables measuring urban natural amenities were related to distances and land use. Distance based variables measured distances to coast line, green space and recreational areas. Land use variables measured the share of green space, recreational areas and unbuilt areas in the vicinity of a dwelling. According to the results of this study, factors related to land use (land use based variables measuring urban natural amenities) have a positive effect on housing prices. The closeness of coastline has also a clear positive price effect on housing prices.

The second topic was the architectural quality of the building. The study area was the southern part of central Helsinki. The study approached the topic from several perspectives. The planner's experience and competition success as well as education (architect vs. non-architect) have all positive impact on the price of dwelling. Dwellings in buildings designated as architectural landmarks are more expensive than dwellings with similar characteristics but in buildings without the status of architectural landmark. Architectural quality also has externality effects. For example, dwellings in buildings with a view over an architectural landmark have a price premium.

The third topic was accessibility and different approaches to measuring accessibility. Though the development of employment centres in the Helsinki Metropolitan Area has changed over the decades the main centre, central Helsinki, is still the dominant employment centre in the region. The traditional accessibility measure, the accessibility to city centre, still has equal explanatory power when compared to more general accessibility measures based on accessibility to all workplaces. Accessibility by public transportation has a stronger impact on housing prices compared to accessibility by car.

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APPENDICES A-E

APPENDIX A

Research data sets

Housing transaction data set, 1980–2010 (Chapters 4-6)

Data was obtained from VTT Technical Research Centre of Finland Ltd. The purchase of the data set was funded by the Housing economics- research project (prof. Heikki A. Loikkanen, 2005-2007, funded by the Academy of Finland) and the Housing economics II –research project (prof. Heikki A. Loikkanen, 2010-2012, funded by the Academy of Finland) and City of Helsinki Urban Facts.

These data are voluntarily collected by a consortium of Finnish real estate brokers and the dataset is refined and maintained by the VTT Technical Research Centre of Finland Ltd. As not all real estate agencies participate, the dataset represents a sample (albeit rather large) of the total volume of transactions.

Variables included in the data set were:

1. Address
2. Postal code
3. Transaction price
4. Date of transaction
5. Old/new dwelling
6. House type
7. Size of the dwelling (sqm)
8. Number of rooms in the dwelling
9. Construction year of the building
10. Rental status of dwelling
11. Lift yes/no
12. Lot ownership
13. Lot size (sqm)
14. Building right (lot, sqm)
15. Construction material of the building
16. Condition of the dwelling (evaluation by the real estate broker)
17. Location (floor)
18. Number of floors in the building
19. Maintenance charge (per sqm)
20. Sales starting date
21. Share of housing company's debt
22. Municipality

Basic data set was supplemented with other data sets. These additions are described in detail in each chapter.

Survey data set on welfare, housing conditions and social relations, 2012 (Chapter 5)

Survey data on welfare, housing conditions and social relations in the Helsinki region, Lahti and Lohja (prof. Matti Kortteinen and prof. Mari Vaattovaara, University of Helsinki). Survey was funded by the Helsinki Metropolitan Region Urban Research Program. For more detailed description of the data set, see Kemppainen (2014) and Laaksonen et al. (2015).

APPENDIX B

Area defintions

Southern part central Helsinki. See figure 5.1.

Central Helsinki (in Finnish *kantakaupunki*) is defined as the area which includes Major districts 1 (excluding district 105) and 3, district 201 and sub-district 190 (see digital map of the City of Helsinki http://kartta.hel.fi/?setlanguage=en&e=25502627.72&n=6673136.68&r=32&w=*&l=Karttasarja%2Cosaalueet&o=100%2C100, visited 10.8.2015).

Suburbs of Helsinki (in Finnish *Helsingin esikaupunkialueet*) is defined as the areas in Helsinki outside the central Helsinki.

The Helsinki Metropolitan Area (HMA) (in Finnish *pääkaupunkiseutu*) covers four municipalities (Helsinki, Espoo, Vantaa and Kauniainen)

The Helsinki region (in Finnish *Helsingin seutu*) covers HMA and 10 other municipalities around HMA (Kirkkonummi, Vihti, Nurmijärvi, Hyvinkää, Tuusula, Kerava, Järvenpää, Sipoo, Pornainen and Mäntsälä).

Commuter belt of Helsinki (in Finnish *Helsingin työssäkäyntialue*) covers Helsinki region and 11 other municipalities (Inkoo, Siuntio, Lohja, Karkkila, Loppi, Riihimäki, Hausjärvi, Pukkila, Myrskylä, Askola and Porvoo).

APPENDIX C

Bootstrap estimation

	FULL MODEL, BOOTSTRAP	
	Param.est	t value
Intercept	9.5969	53.8827
Log floor area	0.8340	206.2835
Log age of dwelling	-0.0354	-9.1567
Own lot	ref.	
Rented lot	-0.0678	-11.6126
Row house, no	ref.	
Row house, yes	0.1410	12.4382
Condition, good	0.0840	21.0376
Contition, satisfactory	ref.	
Condition, poor	-0.0753	-8.2117
Condition, unknown	0.0318	7.2366
Rental status, free	ref.	
Rental status, rented	-0.0438	-4.7345
Rental status, unknown	-0.0162	-3.0186
Location 1. floor	ref.	
Location 2. floor	0.0221	4.3556
Location 3. floor	0.0319	6.0884
Location 4. floor	0.0361	5.8492
Location 5. floor	0.0635	8.2555
Location 6. floor	0.0658	7.5110
Location 7. floor	0.0876	7.1578
Location 8. floor or upper	0.0799	4.8124
Location unknown	0.0306	2.5008
Block of flats, number of floors 2	ref.	
Block of flats, number of floors 3	-0.0511	-5.1781
Block of flats, number of floors 4	-0.0479	-4.8440
Block of flats, number of floors 5	-0.0518	-4.7832
Block of flats, number of floors 6	-0.0600	-5.4917
Block of flats, number of floors 7	-0.0585	-5.0710
Block of flats, number of floors more than 7	-0.0928	-7.9274
Block of flats, number of floors unknown	-0.0544	-4.1425
Log distance to CBD	-0.1359	-6.7184
Log distance to closest SBD	-0.0235	-1.7897

Bootstrap estimation *(cont.)*

	FULL MODEL, BOOTSTRAP	
	Param.est	t value
Log distance to nearest metro or railway station (m)	0.0133	2.6651
Socioeconomic status index	0.1576	2.4022
Log distance to coastline	-0.0277	-5.5583
Log distance to nearest park or forest	-0.0028	-1.3178
Log distance to nearest recreational area	0.0079	2.7421
Log % of green space in 100 buffer	0.0162	2.0865
Log % of green space in 101-300 buffer	0.0335	3.3736
Log % of recreational areas in 100 buffer	0.0095	5.3601
Log % of recreational areas in 101-300 buffer	0.0027	1.1992
Maintenance charge, 0e/sqm/month	-0.0185	-1.9105
Maintenance charge, 1e/sqm/month	ref.	
Maintenance charge, 2e/sqm/month	-0.0122	-1.4924
Maintenance charge, 3e/sqm/month	-0.0252	-2.9829
Maintenance charge, 4e/sqm/month	-0.0313	-3.2062
Maintenance charge, 5e/sqm/month	-0.0611	-4.5457
Maintenance charge, over 5e/sqm/month	-0.2885	-22.4503
Sub-district level fixed effects	yes	
Transaction time fixed effects	yes	
R2	0.9272	
N	7,091	
Estimation method	OLS	
Estimation procedure (SAS)	PROC SURVEYREG	

APPENDIX D

Mixed model, clustering at small district level

	MODEL A1		MODEL A2		MODEL A3	
	EMPTY MODEL		LEVEL 1 FE		LEVEL 1 FE + RANDOM	
	Param.est.	**Pr > |t|**	**Param.est.**	**Pr > |t|**	**Param.est.**	**Pr > |t|**
Intercept	11.8335	<.0001	8.4933	<.0001	8.6656	<.0001
Log floor area			0.8301	<.0001	0.7974	<.0001
Log age of dwelling			-0.0337	<.0001	-0.0446	<.0001
Own lot			ref.		ref.	
Rented lot			-0.0711	<.0001	-0.0745	<.0001
Row house, no			ref.		ref.	
Row house, yes			0.1319	<.0001	0.1388	<.0001
Condition, good			0.0838	<.0001	0.0781	<.0001
Contition, satisfactory			ref.		ref.	
Condition, poor			-0.0732	<.0001	-0.0785	<.0001
Condition, unknown			0.0318	<.0001	0.0328	<.0001
Rental status, free			-0.0534	<.0001	-0.0413	0.0011
Rental status, rented			ref.		ref.	
Rental status, unknown			0.0017	0.7547	0.0046	0.5123
Location 1. floor			ref.		ref.	
Location 2. floor			0.0281	<.0001	0.0261	0.0001
Location 3. floor			0.0369	<.0001	0.0381	<.0001
Location 4. floor			0.0381	<.0001	0.0369	<.0001
Location 5. floor			0.0745	<.0001	0.0787	<.0001
Location 6. floor			0.0676	<.0001	0.0744	<.0001
Location 7. floor			0.0917	<.0001	0.0965	<.0001
Location 8. floor or upper			0.0796	<.0001	0.0852	0.0004
Location unknown			0.0346	0.0057	0.0352	0.0108
Block of flats, number of floors 2			ref.		ref.	
Block of flats, number of floors 3			-0.0344	0.0022	-0.0455	0.0007
Block of flats, number of floors 4			-0.0265	0.0183	-0.0434	0.0017
Block of flats, number of floors 5			-0.0333	0.0065	-0.0529	0.0006
Block of flats, number of floors 6			-0.0460	0.0002	-0.0649	<.0001
Block of flats, number of floors 7			-0.0405	0.0018	-0.0504	0.0035
Block of flats, number of floors more than 7			-0.0638	<.0001	-0.0678	0.0003
Block of flats, number of floors unknown			-0.0333	0.0201	-0.0501	0.0062
Log distance to CBD						

Mixed model, clustering at small district level *(cont.)*

	MODEL A1		MODEL A2		MODEL A3	
	EMPTY MODEL		LEVEL 1 FE		LEVEL 1 FE + RANDOM	
	Param.est.	**Pr > |t|**	**Param.est.**	**Pr > |t|**	**Param.est.**	**Pr > |t|**
Log distance to closest SBD						
Log distance to nearest metro or railway station						
Socioeconomic status index						
Log distance to coastline						
Log distance to nearest park or forest						
Log distance to nearest recreational area						
Log % of green space in 100 buffer						
Log % of green space in 101-300 buffer						
Log % of recreational areas in 100 buffer						
Log % of recreational areas in 101-300 buffer						
Maintenance charge, 0e/sqm/month			-0.0602	<.0001	-0.0507	<.0001
Maintenance charge, 1e/sqm/month			ref.		ref.	
Maintenance charge, 2e/sqm/month			-0.0123	0.1524	-0.0040	0.6785
Maintenance charge, 3e/sqm/month			-0.0127	0.1541	0.0004	0.9721
Maintenance charge, 4e/sqm/month			-0.0188	0.0643	-0.0108	0.3509
Maintenance charge, 5e/sqm/month			-0.0445	0.0014	-0.0408	0.0124
Maintenance charge, over 5e/sqm/month			-0.2548	<.0001	-0.1823	<.0001
-2 Res Log Likelihood	6,916.7		-7,125.5		-7,995.4	
AIC	6,916.7		-7,119.5		-7,989.4	
AICC	6,916.7		-7,119.5		-7,989.4	
BIC	6,927.3		-7,108.9		-7,978.8	
N	7,091		7,091		7,091	
Estimation method	PROC MIXED		PROC MIXED		PROC MIXED	

Mixed model, clustering at small district level *(cont.)*

	MODEL A4		MODEL A5	
	LEVEL 1 FE + RANDOM + LEVEL 2 FE		FULL MODEL	
	Param.est.	**Pr > |t|**	**Param.est.**	**Pr > |t|**
Intercept	9.5906	<.0001	10.0464	<.0001
Log floor area	0.8028	<.0001	0.8152	<.0001
Log age of dwelling	-0.0447	<.0001	-0.0478	<.0001
Own lot	ref.		ref.	
Rented lot	-0.0716	<.0001	-0.0637	<.0001
Row house, no	ref.		ref.	
Row house, yes	0.1373	<.0001	0.1269	<.0001
Condition, good	0.0801	<.0001	0.0801	<.0001
Contition, satisfactory	ref.		ref.	
Condition, poor	-0.0763	<.0001	-0.0772	<.0001
Condition, unknown	0.0343	<.0001	0.0300	<.0001
Rental status, free	-0.0389	0.0014	-0.0306	0.0021
Rental status, rented	ref.		ref.	
Rental status, unknown	0.0055	0.4096	-0.0149	0.0072
Location 1. floor	ref.		ref.	
Location 2. floor	0.0275	<.0001	0.0253	<.0001
Location 3. floor	0.0385	<.0001	0.0349	<.0001
Location 4. floor	0.0374	<.0001	0.0366	<.0001
Location 5. floor	0.0800	<.0001	0.0734	<.0001
Location 6. floor	0.0756	<.0001	0.0709	<.0001
Location 7. floor	0.0987	<.0001	0.0977	<.0001
Location 8. floor or upper	0.0844	0.0003	0.0825	<.0001
Location unknown	0.0390	0.0041	0.0435	0.0003
Block of flats, number of floors 2	ref.		ref.	
Block of flats, number of floors 3	-0.0440	0.0007	-0.0370	0.0011
Block of flats, number of floors 4	-0.0403	0.0025	-0.0304	0.0087
Block of flats, number of floors 5	-0.0518	0.0005	-0.0370	0.0038
Block of flats, number of floors 6	-0.0633	<.0001	-0.0467	0.0006
Block of flats, number of floors 7	-0.0518	0.0020	-0.0426	0.0031
Block of flats, number of floors more than 7	-0.0712	0.0001	-0.0680	<.0001
Block of flats, number of floors unknown	-0.0541	0.0028	-0.0428	0.0060
Log distance to CBD	-0.0957	<.0001	-0.1679	<.0001
Log distance to closest SBD	-0.0137	0.3230	-0.0066	0.6978

Mixed model, clustering at small district level *(cont.)*

	MODEL A4		MODEL A5	
	LEVEL 1 FE + RANDOM + LEVEL 2 FE		FULL MODEL	
	Param.est.	Pr > |t|	Param.est.	Pr > |t|
Log distance to nearest metro or railway station	0.0148	0.0141	0.0223	0.0081
Socioeconomic status index	0.0272	0.0042	0.0267	0.0157
Log distance to coastline	-0.0424	<.0001	-0.0568	<.0001
Log distance to nearest park or forest	0.0012	0.6186	-0.0031	0.3930
Log distance to nearest recreational area	-0.0018	0.5944	0.0086	0.1338
Log % of green space in 100 buffer	0.0099	0.2610	0.0111	0.2527
Log % of green space in 101-300 buffer	0.0345	0.0035	0.0285	0.0426
Log % of recreational areas in 100 buffer	0.0080	<.0001	0.0087	0.0068
Log % of recreational areas in 101-300 buffer	0.0052	0.0385	0.0051	0.2975
Maintenance charge, 0e/sqm/month	-0.0540	<.0001	-0.0184	0.0547
Maintenance charge, 1e/sqm/month	ref.		ref.	
Maintenance charge, 2e/sqm/month	-0.0072	0.4406	-0.0072	0.3775
Maintenance charge, 3e/sqm/month	-0.0036	0.7135	-0.0177	0.0416
Maintenance charge, 4e/sqm/month	-0.0135	0.2276	-0.0301	0.0032
Maintenance charge, 5e/sqm/month	-0.0452	0.0050	-0.0541	0.0003
Maintenance charge, over 5e/sqm/month	-0.1869	<.0001	-0.2060	<.0001
-2 Res Log Likelihood	-8,056.0		-9,109.6	
AIC	-8,050.0		-8,997.6	
AICC	-8,050.0		-8,996.7	
BIC	-8,039.4		-8,800.4	
N	7,091		7,091	
Estimation method	PROC MIXED		PROC MIXED	

APPENDIX E

Mixed model, clustering district level

	MODEL A6		MODEL A7		MODEL A8	
	EMPTY MODEL		LEVEL 1 FE		LEVEL 1 FE + RANDOM	
	Estimate	**Pr > |t|**	**Estimate**	**Pr > |t|**	**Estimate**	**Pr > |t|**
Intercept	11.7413	<.0001	8.3948	<.0001	8.6513	<.0001
Log floor area			0.8476	<.0001	0.7943	<.0001
Log age of dwelling			-0.0181	<.0001	-0.0349	0.0009
Own lot			ref		ref	
Rented lot			-0.0860	<.0001	-0.0826	<.0001
Row house, no						
Row house, yes			0.1492	<.0001	0.1748	<.0001
Condition, good			0.0907	<.0001	0.0812	<.0001
Contition, satisfactory			ref		ref	
Condition, poor			-0.0686	<.0001	-0.0717	<.0001
Condition, unknown			0.0375	<.0001	0.0450	<.0001
Rental status, free			-0.0483	<.0001	-0.0432	0.0087
Rental status, rented			ref		ref	
Rental status, unknown			-0.0037	0.5448	0.0077	0.5042
Location 1. floor			ref		ref	
Location 2. floor			0.0296	<.0001	0.0268	0.0179
Location 3. floor			0.0346	<.0001	0.0272	0.0178
Location 4. floor			0.0378	<.0001	0.0289	0.0215
Location 5. floor			0.0754	<.0001	0.0698	<.0001
Location 6. floor			0.0708	<.0001	0.0575	0.0007
Location 7. floor			0.0923	<.0001	0.0864	<.0001
Location 8. floor or upper			0.0773	<.0001	0.0897	0.0001
Location unknown			0.0363	0.0097	0.0380	0.0274
Block of flats, number of floors 2			ref		ref	
Block of flats, number of floors 3			-0.0724	<.0001	-0.0687	<.0001
Block of flats, number of floors 4			-0.0628	<.0001	-0.0606	<.0001
Block of flats, number of floors 5			-0.0719	<.0001	-0.0743	<.0001
Block of flats, number of floors 6			-0.0771	<.0001	-0.0990	<.0001
Block of flats, number of floors 7			-0.0798	<.0001	-0.0831	<.0001
Block of flats, number of floors more than 7			-0.1055	<.0001	-0.1112	<.0001
Block of flats, number of floors unknown			-0.0722	<.0001	-0.0698	0.0002

Mixed model, clustering district level *(cont.)*

	MODEL A6		MODEL A7		MODEL A8	
	EMPTY MODEL		LEVEL 1 FE		LEVEL 1 FE + RANDOM	
	Estimate	**Pr > |t|**	**Estimate**	**Pr > |t|**	**Estimate**	**Pr > |t|**
Log distance to CBD						
Log distance to closest SBD						
Log distance to nearest metro or railway station						
Socioeconomic status index						
Log distance to coastline						
Log distance to nearest park or forest						
Log distance to nearest recreational area						
Log % of green space in 100 buffer						
Log % of green space in 101-300 buffer						
Log % of recreational areas in 100 buffer						
Log % of recreational areas in 101-300 buffer						
Maintenance charge, 0e/sqm/month			-0.0671	<.0001	-0.0622	<.0001
Maintenance charge, 1e/sqm/month			ref		ref	
Maintenance charge, 2e/sqm/month			-0.0235	0.0114	-0.0225	0.0936
Maintenance charge, 3e/sqm/month			-0.0269	0.0049	-0.0243	0.0788
Maintenance charge, 4e/sqm/month			-0.0299	0.0068	-0.0244	0.1060
Maintenance charge, 5e/sqm/month			-0.0582	0.0001	-0.0741	<.0001
Maintenance charge, over 5e/sqm/month			-0.3081	<.0001	-0.2687	<.0001
-2 Res Log Likelihood	8,302.0		-6,049.2		-7,014.3	
AIC	8,308.0		-6,043.2		-7,008.3	
AICC	8,308.0		-6,043.2		-7,008.3	
BIC	8,312.4		-6,038.0		-7,003.9	
N	7,091				7,091	
Estimation method	PROC MIXED		PROC MIXED		PROC MIXED	

Mixed model, clustering district level *(cont.)*

	MODEL A9		MODEL A10	
	LEVEL 1 FE + RANDOM + LEVEL 2 FE		FULL MODEL	
	Estimate	**Pr > |t|**	**Estimate**	**Pr > |t|**
Intercept	9.1814	<.0001	9.1313	<.0001
Log floor area	0.8103	<.0001	0.7915	<.0001
Log age of dwelling	-0.0295	0.0023	-0.0397	<.0001
Own lot	ref		ref	
Rented lot	-0.0692	<.0001	-0.0653	<.0001
Row house, no				
Row house, yes	0.1590	<.0001	0.1512	<.0001
Condition, good	0.0840	<.0001	0.0784	<.0001
Contition, satisfactory	ref		ref	
Condition, poor	-0.0719	<.0001	-0.0748	<.0001
Condition, unknown	0.0429	<.0001	0.0372	0.0002
Rental status, free	-0.0465	0.0025	-0.0377	0.0113
Rental status, rented	ref		ref	
Rental status, unknown	0.0078	0.4638	-0.0113	0.2391
Location 1. floor	ref		ref	
Location 2. floor	0.0256	0.0147	0.0198	0.0389
Location 3. floor	0.0260	0.0143	0.0240	0.0147
Location 4. floor	0.0298	0.0107	0.0265	0.0153
Location 5. floor	0.0736	<.0001	0.0658	<.0001
Location 6. floor	0.0596	0.0002	0.0571	0.0005
Location 7. floor	0.0884	<.0001	0.0844	<.0001
Location 8. floor or upper	0.0866	0.0001	0.0867	0.0006
Location unknown	0.0327	0.0458	0.0324	0.0352
Block of flats, number of floors 2	ref		ref	
Block of flats, number of floors 3	-0.0596	<.0001	-0.0601	<.0001
Block of flats, number of floors 4	-0.0447	0.0021	-0.0471	0.0014
Block of flats, number of floors 5	-0.0643	<.0001	-0.0581	0.0005
Block of flats, number of floors 6	-0.0782	<.0001	-0.0740	<.0001
Block of flats, number of floors 7	-0.0666	0.0002	-0.0593	0.0019
Block of flats, number of floors more than 7	-0.0864	<.0001	-0.0864	<.0001
Block of flats, number of floors unknown	-0.0564	0.0016	-0.0495	0.0061
Log distance to CBD	-0.0392	0.0121	-0.0910	0.0021
Log distance to closest SBD	-0.0192	0.0466	0.0183	0.2889

Mixed model, clustering district level *(cont.)*

	MODEL A9		MODEL A10	
	LEVEL 1 FE + RANDOM + LEVEL 2 FE		FULL MODEL	
	Estimate	**Pr > |t|**	**Estimate**	**Pr > |t|**
Log distance to nearest metro or railway station	-0.0014	0.7617	0.0007	0.9503
Socioeconomic status index	0.0462	<.0001	0.0368	<.0001
Log distance to coastline	-0.0470	<.0001	-0.0445	0.0003
Log distance to nearest park or forest	-0.0046	0.0312	-0.0041	0.6030
Log distance to nearest recreational area	0.0048	0.0727	0.0152	0.0970
Log % of green space in 100 buffer	0.0144	0.0759	0.0189	0.1155
Log % of green space in 101-300 buffer	0.0387	0.0001	0.0444	0.0034
Log % of recreational areas in 100 buffer	0.0073	<.0001	0.0070	0.3569
Log % of recreational areas in 101-300 buffer	0.0035	0.0820	0.0119	0.1610
Maintenance charge, 0e/sqm/month	-0.0590	<.0001	-0.0241	0.0583
Maintenance charge, 1e/sqm/month	ref		ref	
Maintenance charge, 2e/sqm/month	-0.0183	0.1469	-0.0156	0.1772
Maintenance charge, 3e/sqm/month	-0.0188	0.1468	-0.0269	0.0272
Maintenance charge, 4e/sqm/month	-0.0201	0.1584	-0.0339	0.0132
Maintenance charge, 5e/sqm/month	-0.0590	0.0011	-0.0685	0.0004
Maintenance charge, over 5e/sqm/month	-0.2557	<.0001	-0.2620	<.0001
-2 Res Log Likelihood	-7,230.9		-8,623.6	
AIC	-7,224.9		-8,511.6	
AICC	-7,224.9		-8,510.7	
BIC	-7,220.4		-8,427.8	
N	7,091		7,091	
Estimation method	PROC MIXED		PROC MIXED	

HELSINGIN KAUPUNKI
TIETOKESKUS
PL 5500
00099 HELSINGIN KAUPUNKI

KUVAILULEHTI

Tekijä(t)

Lönnqvist, Henrik

Nimike

ON THE EFFECTS OF URBAN NATURAL AMENITIES, ARCHITECTURAL QUALITY AND ACCESSIBILITY TO WORKPLACES ON HOUSING PRICES
An empirical study on the Helsinki Metropolitan Area

Julkaisija (virasto tai laitos)	Julkaisuaika	Sivumäärä, liitteet
Helsingin kaupungin tietokeskus	2015	237

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Tiivistelmä

Kaupungistuminen tuottaa mittavia paineita asuntojen tuotannolle Helsingin seudulle lähivuosikymmenten aikana. Kaupungin kasvun logiikka on myös muuttunut kohti tiivistyvää kaupunkirakennetta. Kaupunkirakenteen tiivistäminen vaikuttaa monin tavoin nykyisiin asuinalueisiin. Keskeinen täydennysrakentamiseen liittyvä kysymys onkin, miten asuinalueiden laatutekijät voidaan säilyttää tai miten niitä voidaan parantaa samalla kun uusia asuntoja rakennetaan eri alueille.

Asuntojen markkinahintoihin katsotaan yleensä keskeisimmin vaikuttavan asunnon sijainnin, asunnon rakenteellisten ominaisuuksien ja asuinympäristön laadun. Niin sanottua hedonista hintojen menetelmää hyödyntämällä voidaan arvioida eri tekijöiden vaikutuksia asuntojen hintoihin. Tässä tutkimuksessa menetelmään sovelletaan Helsingistä ja Helsingin seudulta kerättyyn asuntohinta-aineistoon. Tutkimuskohteena ovat kaupunkiluonnon, arkkitehtonisen laadun ja työpaikkojen saavutettavuuden vaikutuksia asuntojen hintoihin.

Kaupunkiluonnon osalta tutkimuskohteena ovat viheralueet ja ulkoilualueet sekä rakentamattomat maa-alueet yleensä. Maankäyttöä kuvaavien muuttujien ohella tarkastellaan kaupunkiluonnon hintavaikutuksia etäisyysmuuttujien kautta. Helsingin runsaasta viheraluetarjonnasta huolimatta, kaupunkiluonnolla voidaan havaita olevan selviä positiivisia vaikutuksia asuntojen hintoihin. Arkkitehtonisen laadun osalta tulokset osoittavat, että esimerkiksi arkkitehtoniset maamerkit vaikuttavat positiivisesti asuntojen hintoihin lähiympäristössään. Jugendtyylin arvostus nousee myös esille tuloksista. Työpaikkojen saavutettavuuden osalta tavanomaiselle keskustaetäisyydelle rinnakkaiset mitat, kaikkien työpaikkojen saavutettavuus ja työpaikkojen määrä 30 minuutin matka-aikavyöhykkeellä, tuottavat likimain selitysasteeltaan likimain samankaltaisia tuloksia. Merkittävä on kuitenkin havainto siitä, että työpaikkojen saavutettavuus joukkoliikenteellä on huomattavasti autosaavutettavuutta voimakkaampi asuntohintoihin vaikuttava tekijä.

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Abstract

Urbanization brings substantial pressure on housing production in the Helsinki metropolitan area over the next few decades. City growth logic has also changed towards densification urban structure. The densification of the urban structure affects in many ways the existing residential areas. One of the main issues of the urban growth is how the quality factors can be maintained or how they can be improved, while new housing will be built in different areas.

The price of dwelling is generally considered to be a sum of the three main group of factors - location, structural characteristics and quality of neighborhood of the dwelling. This dissertation studies three factors affecting housing prices: urban natural amenities, architectural quality and accessibility. Contribution of the various features of the apartment housing prices can be examined empirically using the so-called hedonic price method.

As regards urban natural amenities, the research focuses on green space and recreational areas as well as unbuilt areas in general. In addition to land use variables, the price effects of urban natural amenities are analysed through distance-based variables. Despite the abundance of green space in Helsinki, urban nature can be identified to have a clear positive effect on housing prices. Concerning architectonic quality, the results indicate that architectonic landmarks, for example, have a positive effect on prices of dwellings in their vicinity. The appreciation of the Art Nouveau style (Jugendstil) is also confirmed by the results. With regard to the accessibility of workplaces, the two alternative measures to the conventional CBD distance – accessibility to all workplaces and the number of workplaces within a 30-minute travel time range – each produce results that have approximately the same explanatory power. A significant finding is that accessibility to workplaces by public transport has a considerably stronger impact on housing prices compared to accessibility by car.

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An empirical study on the Helsinki Metropolitan Area

Urbanisation will bring substantial pressure on housing production in the Helsinki Region over the next few decades. City growth logic has also changed towards densification of the urban structure. The densification of the urban structure affects in many ways the existing residential areas. One of the main issues related to urban growth is how to maintain or improve quality factors while building new housing in different areas. Information provided by the housing market can be utilised in the assessment of various policy options. In this study, housing market information is used to analyse the effects of urban natural amenities, architectural quality and accessibility to workplaces on housing prices in Helsinki and Helsinki Metropolitan Area.

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