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Antti Kurvinen

Real Estate Development Externalities

Impacts on Housing Prices and Socio-Economic Segregation

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Abstract

This doctoral contribution is a quantitative study based on positivist philosophy. Relying on the theory of externalities, the objective is to extend understanding on impacts of externalities deriving from real estate development. To contribute to the existing research-based knowledge, four relevant research questions were selected to be addressed. Those include the following themes: (i) price impact from proportion of rental housing, (ii) development impact from senior houses, (iii) development impact from multi-story apartment buildings, and (iv) relationship between development of building stock and socio-economic status in the neighborhood. To address the targeted knowledge, comprehensive quantitative data was analyzed combining advanced econometric methods and GIS techniques. Based on the findings, the following presents main contributions and recommendations:

(i) Only minor depreciation was estimated to be attributable to higher proportion of rental housing. First, this should alleviate prejudices against rental housing. Second, the results contribute to policy debate of whether home-ownership should be subsidized. Based on the findings from the externalities point of view, heavy subsidization of homeownership may not be justified and this should be brought into discussion.

(ii) Senior houses were estimated to be built in areas where housing prices are appreciated relatively higher. Also in the post-development period, flat prices in close proximity to senior house developments remained higher, albeit no statistically significant difference between pre- and post-development prices was detected. However, when also other types of developments were simultaneously allowed in the surroundings, post-development prices were found to be positive and statistically different from pre-development prices. These findings encourage adopting more integrated and systemic approaches to neighborhood development and including senior houses as a part of such development strategies.

(iii) Development of new residential multi-story apartment buildings was estimated to have no statistically significant impact on the prices of nearby flats from 1960s and 1970s. Thus, no evidence of any harmful effect in such cases was found. While these findings should alleviate concerns of the impacts of land use change, they do not, however, provide a clear incentive to initiate infill projects.

(iv) From the spatial perspective, socio-economic segregation seems to be a relatively permanent phenomenon. The analyzed indicators suggest that spatial segregation has increased in major Finnish cities in the 21st century but, however, the pace has remained relatively low. Real estate development may provide tools to revitalize neighborhoods and prevent adverse effects of segregation at neighborhood level. However, the analysis at grid cell level does not provide adequate evidence for long-term decision-making. Therefore, more research on different scales, such as neighborhood level, is needed to properly understand the bounds of possibilities.

Tiivistelmä

Tämä väitöstutkimus perustuu kvantitatiivisiin menetelmiin ja positivistiseen tieteen filosofiaan. Tavoitteena on ollut lisätä ymmärrystä kiinteistökehityshankkeista syntyvistä ulkoisvaikutuksista. Tutkimuksen kohteeksi valittiin seuraavat neljä keskeistä teemaa: (i) vuokra-asumisen ulkoisvaikutukset, (ii) senioritalojen rakentamisen ulkoisvaikutukset, (iii) asuinkerrostalojen rakentamisen ulkoisvaikutukset ja (iv) rakennuskannan kehitys ja alueellinen sosioekonominen eriytyminen. Edellä mainittuihin teemoihin liittyvän tiedon tuottamiseksi analysoitiin laajaa kvantitatiivista aineistoa sekä ekonometristen että paikkatietomenetelmien avulla. Seuraavassa on esitetty päätutkimustulokset ja niiden perusteella annettavat suositukset:

(i) Tämän tutkimuksen perusteella vuokra-asumisen osuuteen yhdistettävissä oleva asuntojen hintoja laskeva vaikutus on varsin pieni. Tämän pitäisi vähentää vuokra-asumiseen liittyviä ennakkoluuloja. Lisäksi tulos liittyy keskeisesti omistusasumisen tukipolitiikasta käytävään keskusteluun viittaamalla siihen, että omistusasumisen voimakas tukeminen ei välttämättä ole ulkoisvaikutusten näkökulmasta perusteltua. Tämä havainto pitäisi ottaa huomioon asumisen tukipolitiikasta keskusteltaessa.

(ii) Tämän tutkimuksen tulosten perusteella senioritaloja rakennetaan yleensä alueille, joissa on keskimääräistä korkeampi hintataso. Myös uuden senioritalon valmistuttua sen lähellä sijaitsevien kerrostaloasuntojen hinnat pysyivät keskimääräistä korkeampina. Niiden ei kuitenkaan havaittu nousevan tilastollisesti merkitsevästi lähtötilanteeseen verrattuna. Hintaero lähtötilanteeseen verrattuna muuttui kuitenkin tilastollisesti merkitsevästi positiiviseksi, jos lähialueella sallittiin samanaikaisesti myös muita rakennushankkeita. Tulosten perusteella voidaan suositella, että alueiden kehittämisen lähtökohdaksi otettaisiin systeeminen lähestymistapa, joka huomioi koko alueen kokonaisuutena, ja että senioritalot otettaisiin osaksi tällaista kehitysstrategiaa.

(iii) Uusien kerrostalojen rakentamisella ei haivattu olevan tilastollisesti merkitsevää vaikutusta 1960- ja 1970-luvulla rakennettujen kerrostaloasuntojen hintoihin. Näin ollen ei löydetty mitään merkkejä siitä, että tällaiset hankkeet laskisivat vanhojen kerrostaloasuntojen hintoja. Tulosten pitäisi vähentää täydennysrakentamisen vaikutuksiin liittyviä huolia, mutta toisaalta ne eivät tarjoa selkeitä kannusteita täydennysrakennushankkeiden käynnistämiselle.

(iv) Spatiaalisesta näkökulmasta katsottuna sosioekonominen segregaatio näyttäisi olevan suhteellisen pysyvä ilmiö. Analysoidut indikaattorit viittaavat siihen, että sosioekonominen segregaatio olisi lisääntynyt Suomen suurimmissa kaupungeissa 2000-luvulla eriytymisen ollessa kuitenkin verrattain hidasta. Kiinteistökehittäminen saattaa tarjota keinoja asuinalueiden elvyttämiseen ja segregaation haitallisten vaikutusten ehkäisyyn asuinaluetasolla. Tilastoruututasolla toteutettu analyysi ei kuitenkaan anna riittävästi pitkän aikavälin päätöksentekoa tukevaa näyttöä. Näin ollen tarvitaan lisää tutkimusta eri mittakaavoissa, kuten asuinaluetaso, jotta kiinteistökehittämisen tarjoamat mahdollisuudet ja rajoitteet sosioekonomisen eriytymisen ehkäisemisessä voidaan kunnolla ymmärtää.

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After graduating from master's program, the idea of dissertation and doctoral studies felt very distant. At that time, my intention was to complete the two research projects I had got involved in while still working on my master's and then jump from academia to industry. However, my interest in the world of research grew little by little and, being a person who likes to challenge himself, I soon found myself seriously considering the rocky path of doctoral studies. This journey towards doctorate has definitely been an extensive learning experience with both up and down hills. After passing through this demanding process, it is good to look back on all the wonderful people who have helped me to achieve my driver's license to do science.

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List of appended publications

Paper 1

Kurvinen, A., Vihola, J. & Sorri, J. (2015), "Alentaako vuokra-asuntojen yleisyys omistusasuntojen hintoja? [Does a high proportion of rented accommodation adversely impact residential property values?]", *Yhteiskuntapolitiikka*, Vol. 80 No. 6, pp. 575–586.

Paper 2

Kurvinen, A. & Tyvimaa, T. (2016), "The Impact of Senior House Developments on Surrounding Residential Property Values", *Property Management*, Vol. 34 No. 5, pp. 415–433.

Paper 3

Kurvinen, A. & Vihola, J. (2016), "The Impact of Residential Development on Nearby Housing Prices", *International Journal of Housing Markets and Analysis*, Vol. 9 No. 4, pp. 671–690.

Paper 4

Kurvinen, A. & Sorri, J. (2016), "Rakennuskannan kehitys ja alueellinen sosioekonominen eriytyminen. [Development of Building Stock and Socio-economic Segregation in Finnish Neighborhoods]", *Janus*, Vol. 24 No. 4, pp. 109–134.

Author's contribution

Paper 1

The author is responsible for initiating this paper, planning the research design and performing the analysis. Writing the paper was done in collaboration with the co-authors.

Paper 2

The author is responsible for initiating this paper, planning the research design and performing the analysis. Writing the paper was done in collaboration with the co-author. The co-author also contributed to data collection.

Paper 3

The author is responsible for initiating this paper, planning the research design and performing the analysis. Writing the paper was done in collaboration with the co-author.

Paper 4

The author is responsible for initiating this paper, planning the research design and performing the analysis. Writing the paper was done in collaboration with the co-author.

Contents

1. Introduction

1.1 Purpose of the study

In urban areas, real estate development projects inevitably have an impact on their surroundings, meaning that they do not only affect people directly involved in the project, but also some third parties that did not choose the project to be initiated or completed. Consequently, costs and benefits of real estate developments also spill over to these external third parties, making it logical that such spillovers are called *externalities* (McConnell & al., 2009).

Housing prices provide an appropriate proxy for neighborhood externality impacts, as based on the economic theory of externalities, neighborhood externalities capitalize into housing prices (e.g. Pope & Pope, 2015). Also, socio-economic status can be regarded as a direct measure or a proxy of neighborhood externalities (Orford, 2017). Three of the four articles included in this dissertation, approach the externality impacts from the angle of housing prices, contributing to the existing body of literature and providing relevant evidence on the impacts of (i) local proportion of rental housing, (ii) development impact of senior houses, and (iii) development impact of regular multi-story apartment blocks. While, the fourth article approaches externality impacts from the perspective of socio-economic status in the neighborhood (iv).

As externalities are an inherent component of real estate development, better understanding of what kind of externalities different development projects impose on their local communities is needed. A real estate development proposal is likely to induce uncertainty surrounding the future impact the land use change would cause for the neighborhood, being often met with controversy and opinionated debate. Since, the debate is often fueled more by feelings than research-based evidence; the need for targeted evidence is obvious. Providing such evidence is the primary goal for this dissertation, and thus, the results should be of interest to a wide range of policymakers and community stakeholders.

1.2 Research problem and questions

The objective of this study is to extend understanding on impacts of externalities deriving from real estate development. Given the complex nature of real estate development, an all-embracing approach is not possible within the limits of one doctoral thesis. Consequently, to add on the existing body of literature, four specific themes were selected to be addressed, including *proportion of rental housing*, *development of senior houses*,

development of multistory apartment houses, and *socio-economic segregation*. The selected themes and related research questions are shortly motivated below, and the underlying theoretical background is presented in Section 2.

Proportion of rental housing

The cost of housing is a relevant question in modern communities, taking a notable proportion of average people's income. Regularly, claims of negative externalities from rental housing and their negative impact on surrounding housing prices arise in the public debate. Despite the importance of the question, there is very little reliable empirical evidence on the actual impacts. Under uncertainty, public debate has remained opinionated and feeling-based. In an attempt to take the discussion towards knowledge-based, this void in knowledge has been addressed in the first article.

> **RQ 1:** *What impact does the proportion of rented flats have on residential property values within the neighborhood?*

Development of senior houses

Even as many countries, including Finland, are facing changes in demographic profile as population is getting progressively older, and new types of senior housing development are becoming more and more important, there are very few empirical studies investigating the development impact of a senior house on surrounding residential property values. Previous studies that include age-restricted housing have focused only on US Government subsidized housing developments and their effects on single-family house prices. Subsidized developments imply that residents will be low income in addition to age qualified; making disentangling of the two effects difficult. In addition, most studies do not identify or consider the implications of the type of senior housing (independent living, assisted living, or nursing homes) examined in their studies. As a result, previous studies have produced mixed results, creating uncertainty as to whether age-restricted housing developments exert any measurable effect on surrounding housing prices and if that effect is positive or negative. No research specifically addresses the potential externality effect of market-rate age-restricted multi-family housing units. In addition, no research has isolated the influence of multi-family age-restricted buildings on the value of similar multi-family buildings without age restrictions. This void in knowledge has been addressed in the second article.

> **RQ 2:** *Do market-rate age-restricted multi-family housing developments exert any measurable effect on the value of similar multi-family buildings without age restrictions?*

Development of multistory apartment houses

Even as multi-story apartment building development proposals in existing residential areas represent a substantial component of policy debate at local planning boards, there is limited evidence for the impact of residential development on the prices of surrounding

flats. The majority of most closely related previous literature focuses on the price impact from low-income, affordable or supportive housing, whereas studies also including non-subsidized residential multi-story apartment developments are very few. Furthermore, the majority of the previous literature concentrates on studying the impact on single-family houses and there is very little literature focusing on the impact on flat prices. This void in knowledge has been addressed in the third article.

> **RQ 3:** *Do multi-story apartment building developments have a measurable impact on the prices of flats in existing multi-story apartment blocks from 1960s and 1970s?*

Socio-economic segregation

In general, means of preventing socio-economic segregation are of wide interest, and policy makers widely seek for tools to prevent socio-economic differentiation of residents. Many suburban development projects have been established to target socio-economic segregation, and in Finland, also entire development programs have been implemented to prevent segregation (e.g. Ministry of Environment, 2008). Despite socio-economic segregation has been widely examined, studies that would attempt to recognize how real estate development and socio-economic segregation are connected, based on analysis of extensive quantitative data, seem to be virtually non-existent. This gap has been addressed in the fourth article.

> **RQ 4:** *Has socio-economic segregation increased in major Finnish cities in the 21st century, and is there a link between building stock and socio-economic segregation?*

1.3 Data, methodology and hypotheses

The research onion framework was adopted from Saunders & al. (2012) to select an appropriate methodological approach for this doctoral thesis. The layers of research onion depict the decisions which the researcher must make when formulating a proper research design. These layers, from the outer to the inner, include research philosophy, approach, strategy, choices of methods, time horizons, and applied techniques and procedures. Next, choices made on each layer of the research onion are shortly motivated, as applicable.

Attempting to work with an observable reality, and seeking to adopt the philosophical value-free stance of a natural scientist, the research philosophy of this doctoral thesis is positivist. The positivist path and relating principles as also addressed by Robson (2011) have widely been applied in closely relating research (e.g. Rabiega & al., 1984; Wang & al., 1991; Simons & al., 1998; Ellen & al., 2001; Ooi & Le, 2013; Zahirovich-Herbert & Gibler, 2014; Kortelainen & Saarimaa, 2015). Furthermore, the data available for this study allowed addressing the research questions relying on evidence-based

quantitative approach. Given the above, adopting positivism as the philosophical stance was well-founded and considered as a most appropriate option.

This dissertation comprises a number of empirical analyses to test hypotheses deduced from the theory of externalities, meaning that the adopted research approach was deductive. The meaning of performed analyses was to study causal links, denoting that experimental research strategy was employed. The analyzed data was pooled cross-sectional data collected from multiple secondary sources, and analyses were restricted within quantitative world view. The analyses are based on advanced econometric techniques, which are applied on various comprehensive data sets from major Finnish cities. Due to the spatial nature of the data, a geographic information system (GIS) is utilized to allow innovative combination of different data sources. What follows is a further description of data, techniques and procedures utilized in an attempt to answer the previously defined research questions, as summarized in Figure 1.

Proportion of rental housing

Research question 1 (RQ1) aims at providing information on if the negative externalities from rental housing outweigh the positive, exerting a negative impact on housing prices. The analysis is performed by combining three different data sources covering Helsinki Metropolitan Area: (i) residential property transactions spanning from 1999 to 2014, (ii) property registry data, and (iii) dwelling data from the urban structure monitoring system (YKR). Geocoding and geographical location coordinates are utilized to merge the data sets, and to compute the distances between structures of interest. Price impact is estimated in two alternative ways. In the first phase, a hedonic regression model (Rosen, 1974) is specified and estimated using ordinary least squares (OLS) estimation method for the full sample. The hedonic model potentially suffers from omitted variable bias which is primarily addressed by including neighborhood fixed effects in the hedonic model. In the second phase, instead of estimating the full sample, three matched samples from propensity score matching (Rosenbaum & Rubin, 1983) are estimated by a similar hedonic regression to control for differences in housing stock. This kind of matching approach provides a better ground for comparing "apples-to-apples" than the classical hedonic approach alone, and according to McMillen (2012) also reduces issues from omitted variable bias. The null hypothesis to be tested is:

> **Null hypothesis 1:** *The proportion of rented flats has no impact on residential property values within the neighborhood.*

In literature, it has been suggested that home-ownership should be an incentive to take proper care of the building and its surroundings. If this is the case, higher homeownership rates should create positive externalities relative to higher rates of rental housing, and these externalities should capitalize into housing prices. Moreover, potentially lower socio-economic status of renters may have a negative impact on housing prices. Given

these assumptions, it would be expected that the estimated impact of higher proportion of rented flats is negative.

Development of senior houses

Research question 2 (RQ2) seeks to extend understanding on the price impact from senior house developments. The analyzed quantitative data combines three different data sources covering the City of Tampere, Finland: (i) housing sales transactions from 1999 to 2014, (ii) a complete property registry, and (iii) a spatial data set on senior house developments. Geocoding and geographical location coordinates are utilized to merge the data sets, and to compute the distances between senior house developments and housing transactions. To specify valuation effects of proximate senior house development projects, an advanced research design combining propensity score matching procedure and hedonic pricing model is used.

The implemented research approach attempts to address three notable challenges associated with empirical tests for the impact of real estate development, including (i) the need to compare effects in a consistent impact area before and after completion, (ii) potential endogeneity in site selection, and (iii) unobserved impacts from other developments. The classical hedonic approach is known to be sensitive to omitted variable bias. A repeat sales approach is sometimes used to overcome such omitted variable bias. However, repeat sales technique suffers from small sample sizes, selection bias in properties that are sold repetitiously, and changes in asset quality for the same dwelling if any improvements are made over the sample period. According to McMillen (2012) a matching methodology reduces issues with omitted variable bias and produces similar indices as repeat sales, while it allows larger sample sizes. Potential endogeneity in site selection occurs as a result of land availability constraints and because developers prefer sites located in areas where housing prices are stable and all units can be expected to be sold profitably. Matching should also reduce this bias. Finally, a complete property registry allows controlling for potential confounding effects from other new real estate developments that could have been completed either recently before or recently after the subject site. The null hypothesis to be tested is:

> **Null hypothesis 2:** *Market-rate age-restricted multi-family housing developments have no impact on the value of similar multi-family buildings without age restrictions.*

Based on the economic theories of externalities, the fixed nature of real property implies that the value of individual properties is partially determined by the characteristics of the surrounding neighborhood and the characteristics of nearby buildings. Whether real estate development is followed by an increase in property values depends on both positive and negative externalities. Placing age restrictions on the residents of a building does not necessarily mean that the property will possess specific physical characteristics that will influence surrounding property values; however, it does mean that the resident

characteristics are known, reducing uncertainty and the riskiness of future externality effects (Hughes and Turnbull, 1996). Thus, in the case of senior houses it could be assumed that most of the residents live a relatively peaceful life and take good care of their investment. Second, provided amenities (such as a diner, or a café) should also benefit the surrounding neighborhood. Third, delivery of a senior house does not directly increase the supply of regular housing in the neighborhood, while it still contributes to renewal of the neighborhood. Given the above, it would be expected that the net effect of externalities induced by senior houses is positive, and the positive price impact is greater in magnitude in comparison to delivery of regular housing.

Development of multistory apartment houses

Research question 3 (RQ3) targets at understanding the development impact from multi-story apartment buildings, focusing on the price impact on flats built in 1960s and 1970s – which is, in Finland, considered the era of industrialized serial production of uniform precast apartment buildings. The analyzed quantitative data combines four different data sources, comprising (i) housing sales transactions from 1999 to 2014, (ii) a complete property registry, and two spatial data sets, including (iii) residential high-rise areas and (iv) city and district centers in Helsinki Metropolitan Area. To specify valuation effects of proximate development projects, an advanced research design combining matched sample methodology and hedonic-based difference-in-difference approach, consistent with the methodology applied by Ellen & al. (2001), is used. In the applied matching process, the subject properties are clustered by submarket, property type, property age, and transaction calendar quarter. To be included in the matched control group, observations must be in the same submarket and of the same property type. Moreover, the properties should have age within five years of subject property. Lastly, control transactions must have occurred within the same calendar quarter as the transaction of subject property. Similar matching approach has been applied by Eichholtz & al. (2010), Wiley (2012), and Wiley (2013). The null hypothesis to be tested is:

> **Null hypothesis 3:** *Multi-story apartment building developments do not have a measurable impact on the prices of flats in existing multi-story apartment blocks from 1960s and 1970s.*

Whether new residential development is followed by an increase in nearby flat prices largely depends on both positive and negative externalities; if the positive outweigh the negative, prices should increase and vice versa. On the positive, a new well-designed residential development contributes to renewal of the neighborhood, thereby making the neighborhood more attractive. While, in case of age-restricted housing, the resident characteristics are rather well-known, there is a much greater uncertainty about the resident characteristics and the future externality effects when considering regular multifamily housing production; if the land use change introduces the neighborhood to unwanted types of residents, the net price impact might be negative. Another important

aspect is that regular housing production not only contributes to renewal of neighborhood, but also potentially increases the supply of similar housing units, which should dampen the prices. Yet, another perspective is that the developer initiating the project must expect that all the built units can be sold profitably. Consequently, new developments are likely to be built in areas where the prices are at least stable or even rising. Given the above, there is much room for speculation of what should be expected and to which magnitude.

Socio-economic segregation

Research question 4 (RQ4) aims at extending knowledge on the development of socio-economic segregation in major cities in Finland, and also, investigating if real estate development has had any impact on the process. The empirical analysis is performed in three separate phases, including (i) spatial analysis, (ii) maximum likelihood estimations (ML) of logit models (Wooldridge, 2013; Verbeek, 2012), and finally, (iii) ordinary least squares (OLS) estimations of regression models (Wooldridge, 2013; Verbeek, 2012). The data is collected from grid-based monitoring system for spatial structure and urban form (YKR), spanning from 2000 to 2012. For further analysis, the grid data is merged with a dataset containing locations and basic information on housing developments subsidized by the Housing Finance and Development Center of Finland (ARA). The null hypotheses to be tested are:

> **Null hypothesis 4a:** *Socio-economic segregation has not increased in major Finnish cities in the 21st century.*
>
> **Null hypothesis 4b:** *There is no statistically significant link between building stock and socio-economic segregation.*

Based on previous studies it is expected that the number of socio-economically segregated grid cells has increased at least in Helsinki Metropolitan Area in the 21st century. The expectation is that the development has been similar also in two other major cities, albeit assumable slower. It is likely that there is a statistically significant relationship between building stock and socio-economic segregation. When measured at 250 m x 250 m grid level, the expected mechanism with the analyzed criteria for segregation is rather straightforward, and directly based on what kind of residents the new developments in the grid cell attract; if new single-family houses are delivered it is expected that the level of socio-economic segregation decreases, but if new rental multi-story apartment blocks are built the expected impact is opposite. Impact of other than residential buildings is harder to predict, but again it is linked to what kind of housing these activities attract and what kind of people will move in.

If either the favorable or detrimental outcomes associated with any of the research questions are offset by the other, then the related null hypothesis will be rejected in favor of the alternative that a significant impact exists. Beyond hypothesis rejection, a specific goal of this research is also to estimate the direction and magnitude of the interactions.

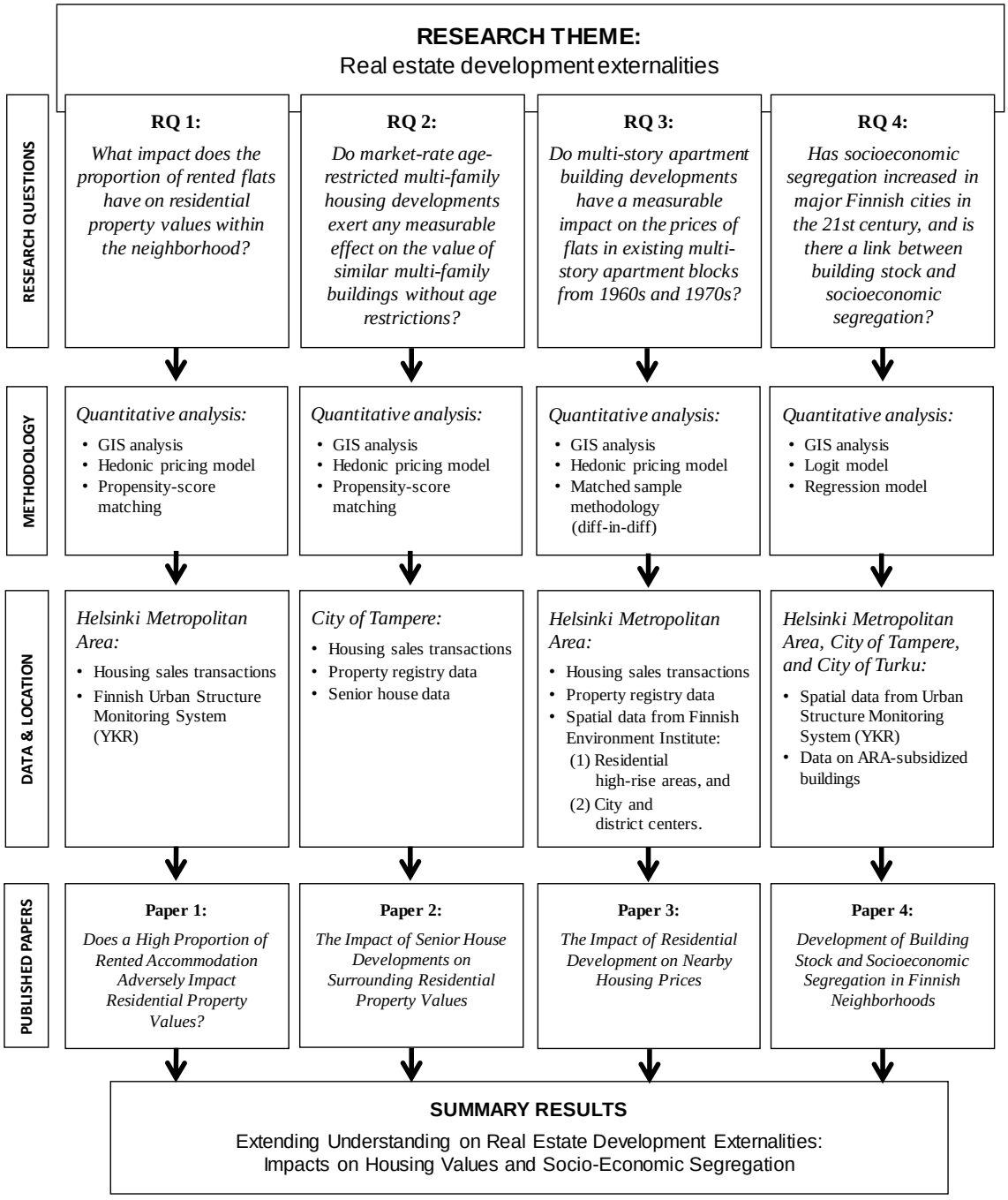

Figure 1. Research questions, methodology, analyzed data, and published papers.

1.4 Structure of the dissertation

This dissertation consists of a summary and four research papers. Each of the papers have been peer-reviewed and published in a scientific periodical. The author of this doctoral thesis has significantly contributed to all of the research papers, being fully responsible for the research designs and conducted empirical analyses. Writing the papers was performed in collaboration with the co-authors.

Paper 1 answers RQ 1, investigating what impact the proportion of rented flats has on residential property values within the neighborhood. The results provide information on how the proportion of rented accommodation impacts the neighborhood, and may help to dispel prejudices related to rental housing. The results are also of high importance when considering future land use and housing policies.

Paper 2 addresses RQ2, investigating the impact of senior house developments on apartment prices. The results help to understand the impact that new senior house developments impose on local communities, and may also encourage investors and developers to build senior houses. Furthermore, the results are of high importance when considering future land use and housing policies.

Paper 3 targets RQ 3, analyzing the impact of multi-story apartment building developments on flat prices in residential high-rise areas located outside city and district centers in Helsinki Metropolitan Area, Finland. The results provide evidence on the impact of new residential multi-story apartment building developments on the prices of existing apartments built in 1960s and 1970s – the era of industrialized serial production of uniform precast apartment buildings. This may help to dispel prejudices related to multi-story apartment building development in Finnish residential high-rise areas. The results are also of high importance when considering future land use and housing policies.

Paper 4 addresses RQ 4, discussing the status of socio-economic segregation in Helsinki Metropolitan Area, City of Tampere, and City of Turku. Furthermore, it is examined if statistically significant relationships between changes in housing and building stock and development of socio-economic segregation exist. The results illustrate recent changes in the status of socio-economic segregation in major Finnish cities, also paying attention to the role of real estate development. The results are of high importance when considering future policy measures to prevent segregation.

Figure 1 illustrates the structure of this dissertation. Each of the appended papers addresses one specific research question, contributing to the current knowledge. This dissertation summary comprises three chapters. The first chapter is an introduction, presenting the background, research problem and objectives, applied data and methodology, and structure of the thesis. The next chapter provides a summary of the most central findings reported in the individual research papers. Finally, in the third chapter, contribution, validity, reliability and relevance of this dissertation are discussed, and suggestions for future research are presented.

2. Theoretical background

In this section, the theoretical background for this doctoral research is shortly presented. First, the concept of externalities is introduced. Second, the principles of measuring externality impacts based on proxies are discussed. Third, the most closely related existing literature to the themes of this dissertation is reviewed.

2.1 The concept of externalities

According to Clark (1998), two Cambridge economists originated the concept of externalities. Henry Sidgwick (1838–1900) is known to be first one who articulated the idea of spillover costs and benefits (i.e. externalities), stating, the market would fail to provide lighthouses as a private owner could not charge ships for the benefits a lighthouse provides. However, Arthur C. Pigou (1877–1959) has received most of the credit, generalizing Sidgwick's findings and introducing the concept of externalities in *The Economics of Welfare* which was originally published in 1920. Today, neighborhood externalities are an important issue in real estate research, providing an appropriate theoretical framework for this dissertation.

Externalities can be either negative or positive, and there are numerous studies reporting negative as well as positive externalities from different types of land use. Some of the most often mentioned negative externalities include noise, associated with such developments as airports (Espey & Lopez, 2000; McMillen, 2004) or highways (Palmquist, 1992), traffic volume (Larsen & Blair, 2014), crime (Linden & Rockoff, 2008; Pope, 2008), and environmental hazards, for example, regarding landfills (Reichert & al., 1992), brownfields (Kaufman & Cloutier, 2006), Superfund sites (Kiel & Williams, 2007), livestock facilities (Herriges & al., 2005), and oil and gas facilities (Boxall & al., 2005). Often reported positive externalities are related to proximity to greenbelts and open spaces (Correll & al., 1978; Bolitzer & Netusil, 2000; Irwin & Bockstael, 2001; Irwin, 2002; Anderson & West, 2006; Voicu & Been, 2008; Conway & al., 2010), wetlands (Mahan & al., 2000), water views (Filippova, 2008), school quality (Gibson, 2011), building refurbishments (Yau & al., 2008) and accessibility, such as proximity to rail transit stations (Dewees, 1976; Grass, 1992; Gatzlaff & Smith, 1993; Bowes & Ihlanfeldt, 2001; Gibbons & Machin, 2005; Debrezion & al., 2007). Despite the decent amount of literature on externalities, there are still voids in knowledge, including externality impacts from proportion of rental housing, development of senior houses, development of multistory apartment buildings, and externalities for socio-economic status. The most closely related existing literature to the themes of this study is reviewed below.

2.2 Measuring externality impacts

Housing prices provide an appropriate proxy for neighborhood externality impacts, as based on the economic theory of externalities, neighborhood externalities capitalize into housing prices (e.g. Pope & Pope, 2015). For example, if the perceived benefits from the new development outweigh the costs imposed by any negative externalities that it imposes on the local community, housing values will increase. As for negative, if negative externalities from the development outweigh the positive, housing prices will decrease. Three of the four articles included in this dissertation, approach the externality impact from this angle, contributing to the existing body of literature and providing relevant evidence on the impacts of (i) local proportion of rental housing, (ii) development impact of senior houses, and (iii) development impact of regular multi-story apartment blocks.

Typically, measures of socio-economic status are constructed from census variables (Orford, 2017). Also in this study, socio-economic segregation is measured relying on Finnish census data, more specifically, by criteria that is analogous to Kortteinen & Vaattovaara (2015). The selected criteria is based on three variables, including *median income*, *proportion of employed in the workforce*, and *proportion of highly educated in the employed workforce*. Provided that built environment and real estate development affect the socio-economic status in the neighborhood, the selected indicators may also be considered as a proxy for externality impacts. Orford (2017) suggests that either socio-economic status can be regarded as a direct measure of neighborhood quality, or if neighborhood quality is considered income elastic, socio-economic status rather represents a proxy for other attributes of neighborhood quality. The reality is likely to fall somewhere between these two categories. This view is also supported by Knox & Pinch (2010), who divide the externalities arising from the behavior of private individuals into "public behavior" externalities and "status" externalities, and suggest that neighborhood quality is closely linked to patterns and processes of investment, disinvestment, and social segregation. Considering all the above, it is well-founded to assume that real estate development and development of socio-economic status in the neighborhood may have a statistically significant relation, which is studied in the fourth article (iv).

Based on the above, Figure 2 summarizes and illustrates how measuring externality impacts is approached in this study. The underlying idea is that real estate development induces different kinds of externalities which can be measured by proxy variables depicting housing values and socio-economic status in the neighborhood. First, housing transaction prices are selected as a proxy depicting housing values. Second, three variables including median income, proportion of employed in the workforce, and proportion of highly educated in the employed workforce are selected as proxies indicating socio-economic status.

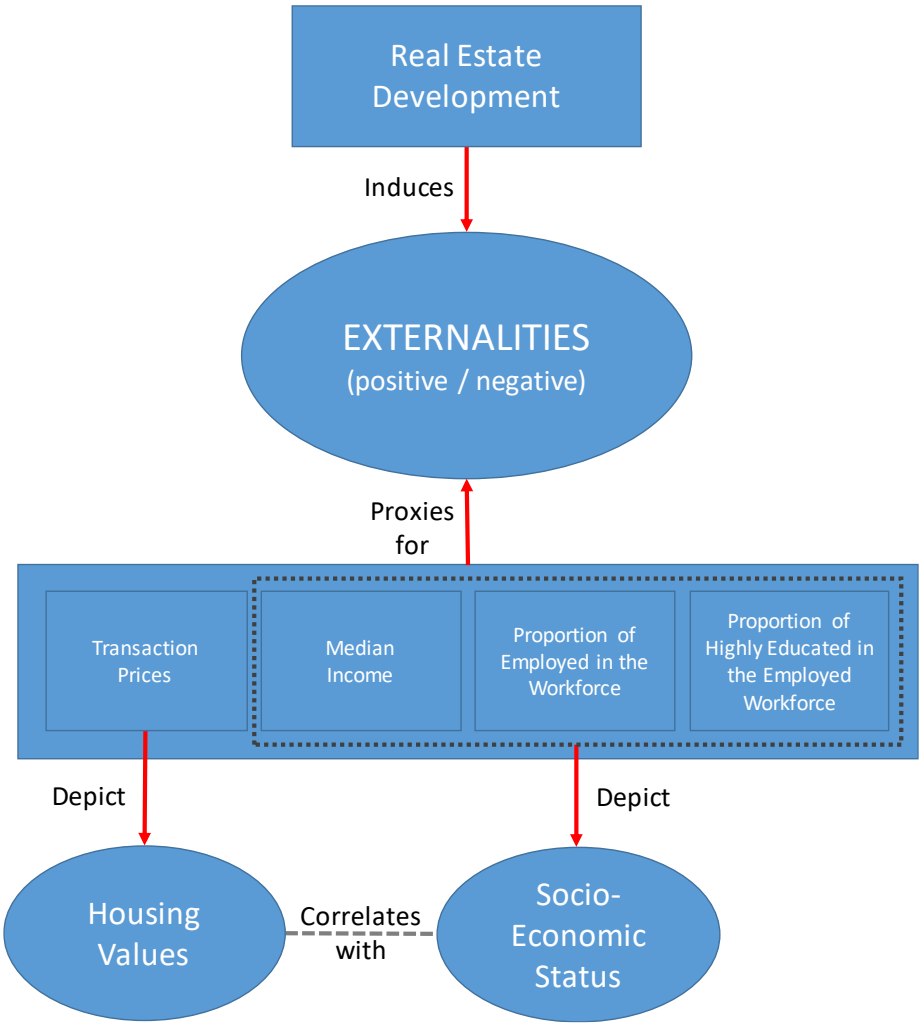

Figure 2. The approach to measure externality impacts from real estate development.

2.3 Rental housing externalities for housing prices

The impact of housing tenure distribution on neighborhood characteristics has been discussed in the previous literature. The neighborhood characteristics under scrutiny have been, for example, crime rate, voting activity, and children's success at school (e.g. Dipasquale, 1999; McNulty & Holloway, 2000). It has also been reported that people living in owner-occupied homes have a higher trust on other residents in the neighborhood, but also, a more negative attitude towards local governments than such people who are not homeowners (Roskruge & al., 2013). The impact of homeownership on neighborhood housing prices has also been under scrutiny. It has been suggested that renters do not have equal incentives to strive for maintaining and increasing the value of the neighborhood as homeowners do because renters do not directly benefit from the value increase. In some studies, it has been reported that homebuyers are willing to pay a premium for a neighborhood with a lower proportion of rented accommodation (Coulson & al., 2003; Coulson & Li, 2013). However, there are also studies where statistically

significant relationship between different proportions of housing tenures and housing prices was not found (Gatzlaff & al., 1998; Kortelainen & Saarimaa, 2015).

If the reported differences are a result of externalities from proportion of tenures or rather derive from the different characteristics of people living in different tenures, has been under debate. For example, it has been reported that there is a positive relationship between learning outcomes and neighborhoods with high homeownership rates. However, differences in learning outcomes may have turned out to be almost non-existent, or at the most very small, when backgrounds of students and schools have been controlled for in the analysis (Chellman & al., 2011). Other results on externalities have been on a stronger basis. One often reported result is that owner-occupiers tend to be less mobile than renters (Haelermans & De Witte, 2015). Some researchers have interpreted residential immobility as spatial lock-in of residents, and thus, to be a disadvantage of a high rate of homeownership. While, some others have considered immobility to be positive, for example, allowing deeper social relationships between residents in the neighborhood, or higher commitment of employees to their jobs (Coulson & Fisher, 2009). From the perspective of national economy, the negative side of residential immobility appears when there is a job available in another location, but a potential employee does not accept the job due to the lock-in effect of homeownership. On the other hand, moving to another location may affect the learning outcomes and the risk of dropping out of school (Haelermans & De Witte, 2015). Willingness to move may depend not only on housing tenure, but also on the employment situation and the characteristics of the rented home (Battu & al., 2008).

According to the Oswald hypothesis, homeowners have greater incentives to stay in their place of residence, resulting in spatial lock-in effect and increased unemployment in the society (Oswald, 1997). Many studies have found evidence supporting the part of the Oswald hypothesis that claims home-ownership to decrease people's willingness to switch locations. However, results on unemployment impact have been conflicting, particularly when considering unemployment rate in the society (Coulson & Fisher, 2009; Munch & al., 2006).

Multiple factors affect the location and price that a homebuyer is willing to accept. The decisions are influenced by not only home and neighborhood characteristics but also buyer's own preferences. Subsidization of homeownership is a global phenomenon, and a notable incentive to buy a home. This has inspired researchers to investigate if such subsidization is economically justified. The main idea is that to justify public subsidization of homeownership, it must also benefit other people than homeowners. Researchers have suggested that if positive externalities derive from homeownership, such externalities should also accumulate into housing prices (Coulson & al., 2003; Kortelainen & Saarimaa, 2015).

Coulson & al. (2003) and Coulson & Li (2013) have studied willingness to pay for owner-occupied single-family houses based on survey data. In both studies, homeownership was reported to have a positive impact on housing prices. However, survey responses may differ from how people act in the real life, and therefore studies using transacted sales prices are needed. Thus far there is only a limited number of studies on this topic using sales transaction data.

Wang & al. (1991) have previously studied if rental housing has a negative impact on nearby single-family house prices. Their research was inspired by a class-action suit filed in Texas, USA. In the lawsuit, thousands of homeowners claimed that rental properties built by a development company had an adverse impact on their home values. Wang & al. (1991) analyzed a dataset of 1,162 single-family houses, finding that rental properties have a negative impact on single-family house prices. Their research particularly focused on single-family house like rental houses that are fully rented to one family. Kortelainen & Saarimaa (2015) have studied if externalities from rental housing capitalize into flat prices, analyzing a dataset of 7,472 housing transactions spanning from 2006 to 2007. According to them a higher proportion of homeownership does not result in significant positive or negative externalities.

The most related data to this study has been analyzed in the study from Kortelainen & Saarimaa (2015), while the most similar research question has been in the study from Wang & al. (1991). In relation to the study from Kortelainen & Saarimaa (2015), the approach of this research is reverse, asking if rental housing induces negative externalities. Many phenomena impose both positive and negative externalities on surrounding communities and the price effect results from the total impact: if negative externalities outweigh the positive also price impact is negative, and vice versa.

2.4 Residential real estate development externalities for housing prices

Impacts to surrounding residential property prices have been considered for a variety of alternative land uses and developments including non-residential land-use (Grether & Mieszkowski, 1980; Li & Brown, 1980), announcement effect for a proposed shopping center (Colwell & al., 1985), size of an existing shopping center (Des Rosiers & al., 1996; Sirpal, 1994), development of a mixed-use shopping center (Yu & al., 2012), Walmart store openings (Pope & Pope, 2015), high-rise office buildings (Thibodeau, 1990), new urbanism (Song & Knaap, 2003), mixed land uses (Song & Knaap, 2004), sub-urban transit oriented development (Mathur & Ferrell, 2013), and single-family rental properties (Wang & al., 1991).

The existing literature studying the impact from non-subsidized infill-like development is relatively limited. Ryan & Weber (2007) focus on the value impacts of design and use hedonic regression to estimate the assessed values of new housing units in distressed Chicago neighbourhoods. They find that scattered infill developments command a higher

property value premium than clusters of residential buildings built in completely new neighbourhoods. The researchers interpret the results to be an indication of preferences for greater integration into the surrounding neighbourhood. Ooi & Le (2013) investigate the spillover impacts of infill development on vacant or under-used parcels within existing urban areas. Utilizing a difference-in-difference approach and studying the impact from 275 new private residential developments within the main residential areas in Singapore they find that infill developments have a positive impact on surrounding home values. Infill on a teardown site is found to have a particularly strong impact. Zahirovic-Herbert & Gibler (2014) used a hedonic model to estimate the premium paid for new houses and the impact of new single-family house development on existing houses in the neighbourhood. They found that building new average size homes hardly had any impact on surrounding home values whereas a concentration of relatively larger size houses induces a small positive impact, which is greatest within a quarter mile radius.

There are three studies investigating the impact from development of subsidized market-priced residential properties, focusing on Cleveland housing market. Simons & al. (1998) investigate the impact of new residential development and neighbourhood disinvestment on the market price of surrounding residential properties. They find new construction to have significant and positive effect on property values and neighbourhood disinvestment, as proxied by property tax delinquency to have a significant and negative effect on property prices. They also find indication of that the degree of concentration may have an impact on the magnitude of price effect. Ding & al. (2000) complement the shortcomings of the earlier study by Simons & al. (1998) using hedonic regression with spatially lagged variables to analyse the effect of both new and rehabilitation residential investment on surrounding single-family home values. They find that that both new investment and rehabilitation have a positive impact on price of single-family homes located within 150-foot radius. They find the impact from new development to be greater than from rehabilitation. However, small-scale investments are found to have no impact on nearby property values, and also the impact from larger projects is found to completely vanish beyond 300 feet radius. The results also suggest the influence of racial and income factors on the housing market as the impact of new construction is much greater in low-income areas and areas predominantly inhabited by white as compared to upper-income or non-white dominant areas. Interestingly, rehabilitation is found to have a greater impact in wealthier neighbourhoods. However, the impact is limited to two to three blocks away from the site. Ding & Knaap (2003) also focus on Cleveland, Ohio and study the impact of investment in new houses on surrounding residential property values, finding a positive impact, which is especially strong for houses close to the new construction.

Studies have examined the effect of the construction of different types of “specialized” housing that restricts occupancy to limited groups within the population on surrounding single-family house prices in the US. Colwell & al. (2000) find that single-family house prices within 200 feet (within sight) of group homes for mentally handicapped tenants

suffer from a negative announcement effect. They examine just over 600 sales of houses located in seven neighbourhoods where a planned group home was announced. Galster & al. (2004) examine the price effects of 11 Colorado special care homes for residents with physical, mental, or behavioural problems on surrounding single-family houses. One of the special care homes in their study is a senior special care home with eight beds and a second is a personal care boarding home with four beds. The homes were located in vacant, sometimes deteriorated property in lower value or declining neighbourhoods. Overall, they find a positive price effect within 1,001–2,000 foot rings around the sites, but they do not separately study the effects of the age-targeted homes.

Research on the external effects of government subsidized housing restricted to lower income residents of all ages indicates that the influence of such developments on surrounding properties may be negative, but dependent on quality, design, and concentration within the neighbourhood (Nguyen, 2005). Ellen & al. (2001) find that large-scale subsidized owner-occupied house developments on blighted or vacant lots in New York City have a positive influence on surrounding residential property prices using a sample containing sales of single-family attached and detached houses as well as rental and owner-occupied multi-family units in mixed use and single use developments. Larger subsidized developments in terms of number of units exert significantly larger effects on the immediate surroundings than infill projects consisting of fewer units. The subsidized developments consisted primarily of single-family houses, but also included some apartment units. Similarly, examining the sales in New York City, Schwartz & al. (2006) determine that housing units that were newly constructed or the result of gut rehabilitation of vacant, uninhabitable buildings exert a positive spillover effect on surrounding residential property prices. The price effects are larger if the projects are located in close proximity and contain more units, but the effects decrease with the proportion of new units in multi-family rental buildings. Ellen & Voicu (2006) compare the spillover effects from city subsidized development of rental housing by non-profit and for-profit developers in New York City by estimating surrounding property values. They employ a difference-in-difference specification of a hedonic model finding that both non-profit and for-profit developments generate positive spillover effects.

Deng (2011) observes a positive influence of new and rehabilitated affordable rental multi-family housing developments financed by the Low Income Housing Tax Credit on single-family house values within 1,000 feet. He does not separate out the effects of the 21 projects targeted to elderly tenants from the rest of the developments in his California study that employs a log-linear model estimated using OLS. Lyons & Loveridge (1993) observe a weak and inconsistent effect of subsidized rental projects units designed for the elderly on the prices of nearby houses in Minnesota. A study of single-family house sales in California near age-restricted subsidized rental multi-family projects ranging in size from 49 to 167 units finds a positive influence within one-eighth mile of one project and one-half mile of another; however the other two developments do not appear to exert any

influence on surrounding prices (Cummings & Landis, 1993). Rabiega & al. (1984) employ a simple regression that reveals little price effect on 208 single-family house transactions from new elderly subsidized multifamily rental apartments constructed in Portland, Oregon, except a small increase in values three blocks away. More recently, Funderburg & MacDonald (2010) find a short lived increase in appreciation rates of houses within one-half mile of one newly constructed subsidized multifamily rental elderly housing project in Iowa and a slower appreciation rate close to another. The difference is attributed to neighbourhood compatibility and the authors suggest such projects should be constructed with a buffer from the neighbouring single-family houses to mitigate negative effects of nearby multi-family structures.

2.5 Externalities for socio-economic status

Spatial segregation is a global phenomenon that occurs in cities around the world. In some places the public debate focuses on socio-economic issues, while in other areas, racial or ethnic disparities are under scrutiny (Greenstein & al., 2000). According to Knox & Pinch (2010) one of the key debates in urban studies is if modern cities are becoming increasingly polarized. Relying on scientific evidence, the European Commission (2010) has adopted the view of "polarization thesis" stating that economic modernization and labor market deregulation have resulted in increased polarization and inequalities in the EU. Also, Piketty (2013) argues that wealth inequality is on the rise in many countries, and this kind of unequal distribution of wealth can be considered detrimental to social and economic stability.

However, Tammaru & al. (2016) remark that despite the claims of increasing socio-economic segregation within the EU, no comprehensive research studying the changing levels of this type of segregation exists. Musterd & al. (2017) have addressed this void in the knowledge in their recent research studying socio-economic segregation in 12 European capitals. Their study is based on a multifactor analysis, confirming that socio-economic segregation has increased in Europe. Yet, Finland is not among the studied countries.

If socio-economic segregation is defined as socio-spatial inequality, income inequality is a relevant measure to be taken into consideration. In Finland, Statistics Finland annually produces income distribution statistics that describe the income of households and income differentials between different groups. The Gini coefficient is used as a measure for income inequality. Based on the Finnish statistics, income differentials even seem to have narrowed in the period of 2000–2012 (Statistics Finland, 2013). Furthermore, only a slight increase in income differentials (the Gini coefficient 0.3 percentage points higher than in the year before) was reported in 2015, when the coefficient was still at a notably lower level than in 2000 (Statistics Finland, 2016). However, this kind of statistics depict the situation only in a large scale and does not describe the micro-level dynamics.

There is also a decent amount of scholarly literature focusing on segregation in the Finnish context. Particularly, research on socio-economic segregation in Helsinki Metropolitan Area has been published in recent years (e.g. Kortteinen & Vaattovaara, 2015; Vilkama & al., 2014). While, studies focusing on other parts of Finland have been few in numbers. However, there are some studies investigating other urban areas as well, for example, the City of Turku (see Rasinkangas, 2013).

In Helsinki Metropolitan Area housing policy that aims at social mixing has been implemented for relatively long: according to the estimates of Vaattovaara & Kortteinen (2012) such policies have been applied in Helsinki already since 1960s. However, perceptions of what kind of segregation should be addressed have varied over time. For example, housing policies aiming at social mixing have been implemented to prevent socio-economic segregation of residents. These policies have involved, for instance, aspects of land-use planning, cession of land, and resident selection criteria for rental housing. Many suburban development projects have been targeted to prevent socio-economic segregation, and even entire development programs have been implemented to address segregation (e.g. Ympäristöministeriö, 2008).

However, it is important to notice that there are several underlying reasons for spatial segregation, and the reality is a mix of coercive and voluntary segregation (Greenstein & al., 2000). Consequently, despite its bad reputation, segregation does not always result in only negative impacts, but also positive ones, such as strengthened social and cultural identity. In certain cases, even implemented housing policies can – at least indirectly – be considered to have increased segregation in single buildings or within larger areas comprising several buildings. For example, to accommodate the needs of student housing, both single blocks of flats for students and entire student villages comprising several apartment buildings solely for students have purposely been built in many countries (Smith & Hubbard, 2014). Also in Finland, a notable proportion of students as well as a part of other young adults live in apartment buildings that have particularly been targeted for their groups. However, Kanniainen (2011) has criticized categorization in which students are considered to fall in the economic group of poor, stating that from the perspective of life cycle income students are in “investment phase”. Thus, socio-economic segregation of students is likely to have its own special characteristics compared to other low-income groups.

In housing developments that have received production subsidy from the Housing Finance and Development Center of Finland (ARA), the selection of residents is considered based on applicant’s assets, income, and need for housing. ARA also supports housing supply for special groups, and in some cases these special housing units have clustered in specific areas. Considering housing investment subsidies, special groups include e.g. long-term homeless, mentally disabled, people recovering from mental disorders, and elderly suffering from memory loss disease (Ympäristöministeriö, 2012).

A rising trend in Finland in the 21st century has been age-restricted housing developments for elderly people (Tyvimaa, 2010).

People have various preferences for where they wish to live and what kind of expectations they have for their homes (Gibler & Tyvimaa, 2014). Also other people's views on the reputation of a neighborhood may among one's own experiences affect not only the perceptions of a desirable neighborhood, but also, where one does not want to be located (Permentier & al., 2009; 2011). From the perspective of people living in the neighborhood, negative outside perceptions of the neighborhood reputation may not have a significant impact on their comfort and well-being as long-term residents tend to be attached to their neighborhood, and are often even ready to stand up for its reputation if necessary (Vilkama & Vaattovaara, 2015).

When considering a place of residence, in addition to its physical characteristics, also social aspects may be significant. For example, in Netherlands, it has been reported that one's distance to the average social status of other residents in the neighborhood is associated with the probability to strive for moving out from the neighborhood (Musterd & al. 2016). Zwiers & al. (2016) suggest that, even from the perspective of decades, the city locations where the lowest-income people in western cities live may be very path-dependent and rather slowly changing. Thus, one predictor for socio-economic segregation should be the original quality of dwellings that were first built in the neighborhood. Furthermore, for example, Tunstall (2016) has raised a question of the slow change of residents in existing residential neighborhoods, and how it should be addressed when deciding on housing policies.

Variety and quality of housing supply have been reported to have an influence on the social atmosphere of a residential neighborhood (Kleinhans, 2004). Owner-occupied housing is notably more common among people with higher income than within lower income classes (Statistics Finland, 2015). When choosing their place of residence, some people may also emphasize the role of other people living in the neighborhood (e.g. Vilkama & al., 2013; Vilkama & Vaattovaara, 2015).

Difficulties in finding a desirable home, high living costs, poor location in terms of work or studies and lack of services are – at least in Helsinki Metropolitan Area – often mentioned to be motivating factors for why people move out from their current neighborhood (Vilkama & al., 2013). In the same study, it was also observed that moving out from neighborhoods with relatively high proportion of immigrants was often explained by social problems, lack of tidiness, inadequate architecture, and feelings of insecurity. Furthermore, proportion of immigrants in the neighborhood or its schools was often perceived excessively high among people who decided to leave the neighborhood (Vilkama & al., 2013). Observations of the quality of architecture may suggest that in Helsinki Metropolitan Area immigrants have been clustered into architecturally less appreciated locations. The finding that architecture has been recognized to make a

difference when people are choosing their place of residence, supports assumptions suggesting that developing existing building stock could improve neighborhood status as a place of residence. Furthermore, such development might also be useful in attempts to prevent socio-economic segregation.

3. Summary of the findings

3.1 The impact of rental housing on nearby flat prices (Paper 1)

The first paper investigated what impact the proportion of rented flats has on residential property values within the neighborhood in Helsinki Metropolitan Area, Finland. The null hypothesis to be tested was that *the proportion of rental housing has no impact on residential property values within the neighborhood*. Price impact was estimated using hedonic regression models (Rosen, 1974), and the analysis was performed in two separate phases. In the first phase, the full sample was estimated to capture the price impact. In the second phase, the matched samples from the propensity score matching procedure (Rosenbaum & Rubin, 1983) were estimated with a similar hedonic model as in the first phase. Both analyses suggest rejecting the null hypothesis as it appears that a higher proportion of rented flats commands lower housing prices within the neighborhood. Thus, results from both empirical strategies are in line with each other, suggesting that negative externalities resulting from a larger relative share of rented flats appear to more than offset possible positive externalities. It is also found that the negative effect increases with the percentage of rented flats.

Magnitude of the estimated price impact slightly differs between the two analyses, however, being moderate in both cases. The least square estimation of full sample suggests relatively small negative price impact: between neighborhoods with 0–25% and neighborhoods with more than 75% of rented flats, the price difference is estimated to be less than 2%. While, estimations of propensity score matched samples reveal price difference of less than 4%. Propensity score matching and estimation of matched samples aimed at reducing potential selection and omitted variable bias, and thus, the results from the second analysis may be considered to be closer to the actual price impact. The results from the first phase are reported in Table 1 and from the second phase in Table 2.

Table 1. Estimated impact of the proportion of rented flats on housing values in the neighborhood: results from the estimation of full sample.

Dependent variable: ln(*Sale price*)

Variable	*Coefficient*	*(t-stat)*
Intercept	9.688 ***	(919.1)
ln(Property age)	-0.071 ***	(-52.8)
ln(Unit size)	0.785 ***	(582.2)
ln(Building size)	-0.019 ***	(-22.2)
ln(Weeks on market)	-0.043 ***	(-84.5)
Community loan: LTV	0.215 ***	(33.8)
ln(Maintenance fee)	-0.007 ***	(-11.8)
Floor	0.010 ***	(37.7)
I{New construction}	0.120 ***	(33.8)
I{Sauna}	0.119 ***	(73.7)
I{Property condition: Acceptable}	-0.084 ***	(-81.9)
I{Property condition: Poor}	-0.167 ***	(-75.9)
I{Property condition: Unavailable}	-0.047 ***	(-26.2)
I{Land lease}	-0.056 ***	(-32.4)
I{Proportion of rented flats: 0-25 %}	0.005 ***	(3.9)
I{Proportion of rented flats: >50-75 %}	-0.011 ***	(-7.9)
I{Proportion of rented flats: >75 %}	-0.013 ***	(-4.3)
Year indicators:	Included (14 variables)	
Sub-market indicators:	Included (147 variables)	
Adjusted R^2:	90.87 %	
Observations:	105,502	

**** = 1 % significance level, ** = 5 % significance level, * = 10 % significance level*

Table 2. Estimated impact of the proportion of rented flats on housing values in the neighborhood: results from the estimations of matched samples.

Dependent variable: ln(*Sale price*)

Proportion of rented flats:	0-25 %		>50-75 %		>75 %	
Estimated matched sample:	(1)		(2)		(3)	
Variable	*Coefficient*	*(t-stat)*	*Coefficient*	*(t-stat)*	*Coefficient*	*(t-stat)*
Intercept	10.282 ***	(485.7)	9.769 ***	(463.6)	10.407 ***	(129.6)
ln(Property age)	-0.124 ***	(-64.3)	-0.061 ***	(-27.9)	-0.090 ***	(-20.8)
ln(Unit size)	0.680 ***	(135.9)	0.745 ***	(162.1)	0.640 ***	(42.2)
ln(Building size)	-0.013 ***	(-11.9)	-0.016 ***	(-11.2)	-0.026 ***	(-7.0)
ln(Weeks on market)	-0.041 ***	(-59.1)	-0.043 ***	(-49.2)	-0.038 ***	(-17.5)
ln(Number of rooms)	0.031 ***	(7.6)	0.003	(0.9)	0.037 ***	(3.0)
Community loan: LTV	0.120 ***	(14.3)	0.243 ***	(25.3)	0.253 ***	(12.7)
ln(Maintenance fee)	-0.007 ***	(-9.6)	-0.007 ***	(-6.5)	-0.005 **	(-2.1)
Floor	0.008 ***	(22.3)	0.011 ***	(24.9)	0.012 ***	(10.5)
I{New construction}	0.061 ***	(13.1)	0.133 ***	(23.8)	0.097 ***	(9.1)
I{Sauna}	0.110 ***	(54.9)	0.118 ***	(43.9)	0.093 ***	(15.1)
I{Property condition: Acceptable}	-0.076 ***	(-56.4)	-0.087 ***	(-49.8)	-0.087 ***	(-19.1)
I{Property condition: Poor}	-0.166 ***	(-48.0)	-0.173 ***	(-46.1)	-0.190 ***	(-16.4)
I{Property condition: Unavailable}	-0.041 ***	(-18.2)	-0.052 ***	(-17.5)	-0.020 **	(-2.6)
I{Land lease}	-0.044 ***	(-19.9)	-0.057 ***	(-21.8)	-0.044 ***	(-6.5)
I{Proportion of rented flats: 0-25 %}	0.010 ***	(8.1)	-		-	
I{Proportion of rented flats: >50-75 %}	-		-0.014 ***	(-9.0)	-	
I{Proportion of rented flats: >75 %}	-		-		-0.029 ***	(-7.3)
Year indicators:	Included (14 variables)		Included (14 variables)		Included (14 variables)	
Sub-market indicators:	Included (142 variables)		Included (137 variables)		Included (133 variables)	
Adjusted R2:	89.77 %		89.42 %		88.27 %	
Observations:	49,556		36,376		5,996	

**** = 1 % significance level, ** = 5 % significance level, * = 10 % significance level*

This study is an important contribution to the existing body of literature, providing empirical evidence on the spillover effects from rental housing. Regularly, claims of negative externalities from rental housing and their negative impact on surrounding housing prices arise in the public debate, but still, the topic has remained largely unaddressed in the real estate literature. Some closely related studies exist, but their research design and data notably differs from this study. The main differences to the previous literature are: i) the data covers three major cities in Helsinki Metropolitan Area in Finland (Helsinki, Espoo and Vantaa), ii) the focus is on the price impact on residential multistory apartment buildings, iii) housing transactions data is the most comprehensive to date spanning from 1999 to 2014 and including 105,502 transactions, and iv) propensity-score matching has not been applied in this context before. The reported results confirm that a significant negative impact exists, but also, suggest that the negative spillover effects from rental housing are relatively small. While, public opinion tends to exaggerate the negative impact. The results may help to dispel prejudices against rental housing, and take the discussion towards knowledge-based.

3.2 The impact of senior house developments on surrounding residential property values (Paper 2)

The second paper evaluated the impact of senior house developments on surrounding residential property values in the City of Tampere, Finland. The null hypothesis to be tested was that *market-rate age-restricted multi-family housing developments have no impact on the value of similar multi-family buildings without age restrictions*. Price impact from the developments was analyzed estimating matched samples from propensity score matching procedure using hedonic regressions (Rosen, 1974; Rosenbaum & Rubin, 1983). The approach in this study addresses a number of empirical issues lacking from much of the previous literature including (i) considering residential property values before and after development completion, (ii) propensity-score matching to control for differences in housing stock close to development sites, and (iii) comprehensive registry of all residential and retail developments to avoid confounding effects. The carefully chosen empirical strategy also attempts to address the common problem of omitted variables bias by using fixed effects approach.

The results suggest rejecting the null hypothesis, showing that a senior house development has a significant positive impact on proximate apartment values within a 500-meter radius. The total impact is the highest when development is located in underdeveloped neighborhoods – with property values lower than average – where simultaneously also other types of real estate developments occur. Nevertheless, in neighborhoods where property values and demand for housing units are higher and senior house developments fall into the criteria of infill development, a premium is lower, but still statistically significant and notable in magnitude. Thus, despite the negative arguments against residential infill in the public debate, this study does not provide any

kind of evidence on negative interaction – on the contrary there is evidence on positive outcomes. The results from least squares estimations of the hedonic model for different data samples are presented in Table 3.

Table 3. Apartment price effect: close to senior house development.

	(1)		(2)		(3)	
Variable	*Coefficient*	*(t-stat)*	*Coefficient*	*(t-stat)*	*Coefficient*	*(t-stat)*
Intercept	8.961 ***	(160.0)	8.967 ***	(150.0)	9.001 ***	(138.4)
ln(Property age)	-0.055 ***	(-13.0)	-0.052 ***	(-11.4)	-0.067 ***	(-11.4)
ln(Unit size)	0.713 ***	(52.0)	0.703 ***	(47.8)	0.689 ***	(41.2)
ln(Building size)	0.024 ***	(6.2)	0.025 ***	(6.2)	0.040 ***	(9.1)
ln(Weeks on market)	-0.025 ***	(-11.0)	-0.026 ***	(-10.6)	-0.026 ***	(-9.6)
ln(Number of rooms)	0.033 ***	(3.1)	0.038 ***	(3.3)	0.042 ***	(3.3)
Floor number	0.010 ***	(8.4)	0.010 ***	(8.1)	0.009 ***	(6.3)
I{New construction}	0.094 ***	(10.6)	0.085 ***	(8.7)	0.200 ***	(11.6)
I{Sauna}	0.193 ***	(33.6)	0.202 ***	(32.0)	0.200 ***	(28.0)
I{Elevator}	0.064 ***	(9.0)	0.058 ***	(7.5)	0.021 **	(2.4)
I{Condition: Acceptable}	-0.091 ***	(-18.1)	-0.099 ***	(-18.1)	-0.091 ***	(-16.5)
I{Condition: Poor}	-0.167 ***	(-9.8)	-0.180 ***	(-9.8)	-0.183 ***	(-10.4)
I{Condition: Unavailable}	-0.023 ***	(-3.4)	-0.039 ***	(-5.2)	-0.056 ***	(-7.1)
I{Land lease}	-0.014 ***	(-2.6)	-0.014 **	(-2.5)	-0.046 ***	(-6.6)
Proximate*Period$_{t-2}$	-0.006	(-0.8)	-0.005	(-0.6)	0.028 ***	(3.2)
Proximate*Period$_{t-1}$	0.002	(0.3)	0.004	(0.4)	0.005	(0.5)
Proximate*Period$_{t}$	0.016 **	(2.5)	0.015 **	(2.2)	0.019 ***	(2.6)
Proximate*Period$_{t+1}$	0.021 **	(2.5)	0.025 ***	(2.8)	0.039 ***	(3.8)
Proximate*Period$_{t+2}$	0.041 ***	(6.2)	0.045 ***	(6.1)	0.046 ***	(5.3)
Year indicators:	Included (14 variables)					
Sub-market indicators:	Included (34 variables)					
Adjusted R^2:	87.19%		88.06%		91.82%	
Observations:	7,366		6,258		3,312	

Notes: This table presents results from the least squares estimation of the hedonic model for the 0.5 km radius. In specification (1), potential confounding effects only from other senior house developments haven been eliminated; in specification (2), also confusing effects from retail development projects have been eliminated, and finally in specification (3), confounding effects from all residential and retail developments have been eliminated. The dependent variable is Sale price, logged. The I{Close} indicator variable for proximity to senior house development is partitioned into five subsets in order to specify the pricing externality measured in transaction timing relative to the date of development completion. The subsets are t-2: 24 to 12 months before, t-1: 12 to 6 months before, t:6 months before to 6 months after, t+1: 6 months after to 12 months after, and t+2: 12 months after to 24 months after the senior house development is completed. ***, **, and * designate statistical significance for the estimated coefficients at the 1%, 5%, and 10% levels, respectively.

Even as many countries, including Finland, are facing changes in demographic profile as population is getting progressively older, and new types of senior housing development are becoming more and more important, there are very few empirical studies investigating the development impact of a senior house on surrounding residential property values. There are some closely related studies, but numerous shortcomings remain to be addressed (reported in more detail in Chapter 1.2). This study contributes to the previous literature by addressing these reported shortcomings using a unified framework and consistent methodology to explore the impact from new senior house developments, the only independent living option for seniors in Finland. The distinct advantage using the

Finnish data is the possibility to identify all new residential and retail developments in the studied city. In contrast to the prior literature, outside-radius control groups are carefully constructed using a propensity score matching procedure. Consequently, this study represents the most comprehensive approach to evaluate the impact of senior house development on surrounding residential property values undertaken to date. The findings of this study may generate positive associations for senior house developments, and also encourage investors and developers to build senior houses, indicating that a senior house development can give a boost to both lower and higher demand neighborhoods.

3.3 The impact of residential development on nearby housing prices (Paper 3)

The third paper investigated the impact of multi-story apartment building developments on flat prices in residential high-rise areas located outside city and district centers in Helsinki Metropolitan Area, Finland. The null hypothesis to be tested was that *new multi-story apartment building developments have no impact on the prices of surrounding multi-story apartment building units from 1960s and 1970s.* This study differentiates from the previous literature in many ways: (i) the price impact is studied on apartment units built in the era of industrialized mass production of precast concrete buildings in 1960s and 1970s, (ii) the focus is on the impact from both subsidized and non-subsidized development of residential multi-story apartment buildings in Northern Europe, (iii) the study areas are mapped based on the residential high-rise area delineation and the city and district center delineation of Finnish Environment Institute (SYKE), and (iv) every new residential and retail development in the study area can be identified, and thus, potential confounding effects from other development projects can be eliminated – for both treatment and control groups.

The studied multi-story apartment building developments occur in city blocks with declining housing price trend relative to nearby blocks outside the development impact radius but within the same zip code area. The completion of an apartment building seems to have a positive and statistically significant immediate impact on the surrounding flat prices. While, no significant impact on price trend is found, indicating that in declining city blocks, the prices of surrounding flats continue depreciating post-development. Despite the negative arguments against residential infill in the public debate, this study does not provide any kind of evidence on negative interaction – on the contrary evidence on positive outcomes is found. Depending on the estimation method, the immediate price impact from a new multi-story apartment building development is estimated to be 2.3–2.6 percent. Considering an average apartment unit in the subsample, this means price increase of 2,710–3,060 euros. The results from the least squares estimations of base model and spline regression model are presented in Table 4.

Table 4. Price effect of proximity to multi-story apartment building development.

	Equation (1): Base model			Equation (2): Spline regression		
Variable	*Coefficient*		*(t-stat)*	*Coefficient*		*(t-stat)*
Intercept	9.920	***	(77.9)	9.863	***	(77.2)
ln(Property age)	-0.141	***	(-6.1)	-0.134	***	(-5.8)
ln(Unit size)	0.578	***	(59.2)	0.577	***	(59.3)
ln(Building size)	-0.022	***	(-7.0)	-0.017	***	(-5.3)
ln(Weeks on market)	-0.018	***	(-14.0)	-0.017	***	(-13.5)
Community loan: LTV	0.349	***	(13.4)	0.357	***	(13.8)
ln(Maintenance dues)	-0.001		(-0.7)	-0.001		(-0.5)
Floor number	0.006	***	(9.7)	0.006	***	(9.7)
I{Sauna}	0.031	***	(3.3)	0.031	***	(3.3)
I{Condition: Acceptable}	-0.077	***	(-32.9)	-0.079	***	(-33.3)
I{Condition: Poor}	-0.165	***	(-29.5)	-0.166	***	(-29.7)
I{Condition: Unavailable}	-0.053	***	(-13.0)	-0.050	***	(-12.3)
I{Land lease}	0.010	**	(2.4)	0.008	*	(1.8)
I{1 Room}	-0.036	***	(-6.3)	-0.036	***	(-6.4)
I{3 Rooms}	0.043	***	(9.3)	0.043	***	(9.4)
I{4 Rooms}	0.147	***	(19.1)	0.148	***	(19.1)
Close	-0.014	***	(-3.5)	-0.022	***	(-2.7)
Close*After	0.023	***	(3.5)	0.031	***	(3.2)
Close*After*Trend	0.001		(1.2)	-0.008		(-1.4)
Spline 1				-0.005	***	(-3.2)
Spline 2				0.008		(1.6)
Zip-quarter indicators:	Included (977 variables)					
R^2:	93.85%			93.88%		
Adjusted R^2:	93.02%			93.05%		
Observations:	8,363			8,363		

Notes: This table presents the results from the least squares estimations of base model and spline regression model. The dependent variable is *Sale Price*, logged. *Close* is an indicator variable for apartment unit sales transactions that occur within the specified 300 meter radius of any new multi-story apartment building development during the sample period. Results for base model and spline regression model are presented in separate estimations, including the estimated coefficient and corresponding t-statistic in parentheses. The interaction term *Close*After* is an indicator variable for residential transactions that occur within the specified 300 meter radius after the development project is completed. The interaction term *Close*After*Trend* reveals the annual price change of apartment units located in close proximity to new multi-story apartment building developments. The price change is measured relative to apartment transactions located outside the impact radius but within the same zip code. *Spline 1* measures the overall price trend for all observations inside the radius, whereas *Spline 2* measures if the overall trend inside the radius has changed recently before the completion (beginning 3 years before completion). The following variables are omitted from the model to avoid perfect multicollinearity: *I{Condition: Good}* and *I{2 Rooms}*. ***, **, and * designate statistical significance for the estimated coefficients at the 1%, 5% and 10% levels, respectively.

Even as multi-story apartment building development proposals in existing residential areas represent a substantial component of policy debate at local planning boards, there is limited evidence for the impact of residential development on surrounding flat prices. The majority of most closely related previous literature focuses on the price impact from low-income, affordable or supportive housing, whereas studies also including non-subsidized residential multi-story apartment developments are very few. Furthermore, the majority of the previous literature concentrates on studying the impact on single-family houses, and there is very little literature focusing on the impact on flat prices.

This research study evaluates the impact of multi-story apartment building developments for the HMA – the major Finnish real estate market. The impact is investigated on the prices of apartment units built in 1960s and 1970s – the era which has been of great importance in the development of Finnish building stock and is characterized by simplified grid layouts and industrialized serial production of almost identical precast concrete buildings. The study specification is the first of its kind and contributes to heated public discussion on the impacts from residential infill. The estimated value impact for an individual apartment owner is relatively moderate. However, the results of this study may help to dispel prejudices against residential multi-story apartment building developments as no evidence of negative outcomes was found.

3.4 Development of building stock and socio-economic segregation in Finnish neighborhoods (Paper 4)

The fourth paper focused on development of socio-economic segregation in Helsinki Metropolitan Area, City of Tampere and City of Turku. Furthermore, potential statistically significant relationships between development of building stock and socio-economic segregation were under scrutiny. The analysis comprised three empirical sections, utilizing datasets collected from the monitoring system for spatial structure and urban form (YKR) and spanning from 2000 to 2012. The data allowed analysis at the accuracy level of 250 x 250 meters sized grid cells.

The socio-economic status of each grid cell was defined based on three variables: median income, proportion of employed in the workforce, and proportion of highly educated in the employed workforce. In the first and second empirical sections, the criteria for a socio-economically segregated grid cell was that all the three variables must take on a value that is within the lowest value quantile. In the third empirical section, instead, a continuous composite variable was constructed to describe the socio-economic status of each grid cell. The composite variable was constructed by multiplying the same three variables that were used for the criteria in the first and second empirical sections.

1st Empirical Section: Socio-economic segregation in Finnish neighborhoods

Despite that implemented housing policies have been targeted to prevent socio-economic segregation in residential areas, results from the first empirical section provide evidence for that socio-economic segregation has occurred in subject regions during the study period – at least when scrutinized at the level of 250 x 250 meters sized grid cells. The first section includes a GIS based analysis on the development of socio-economic segregation in residential areas. Location coordinates and numbers of segregated grid cells in different cross section years were scrutinized in each study

region. Moreover, development of socio-economic segregation was examined both from temporal and locational aspects.

Kortteinen & Vaattovaara (2015) have observed that the number of segregated grid cells and the population living within them have increased in Helsinki Metropolitan Area in the period of 2000–2010. They also found that socio-economic segregation is relatively permanent in nature, and segregated clusters tend to spread out through their surroundings. Previous Finnish segregation studies have mainly focused on Helsinki Metropolitan Area, but Rasinkangas (2013) has discovered similar findings also in the City of Turku, finding that the development trend of socio-economic segregation is akin to the development in the Helsinki Metropolitan Area. The first empirical section of this study also mainly confirms the conclusions of these previous Finnish studies, simultaneously suggesting that the development trend of socio-economic segregation in the City of Tampere also follows similar patterns that were discovered in two other major Finnish urban areas (see Figure 3, Figure 4, and Figure 5). This finding supports the conclusion of Rasinkangas (2013), suggesting that there is a linkage between the general social development of Finnish society and regional differentiation. Based on the selected indicators, findings from this study show that socio-economic segregation and proportion of population living in segregated grid cells have increased in major Finnish urban areas during the study period (Table 6). However, the findings do not refer to alarmingly rapid development, since the pace of socio-economic segregation has been moderate during the study period. Particularly, it is important to notice that the threshold values of the upper and lower quintiles for the selected variables, indicating the socio-economic status, differentiated only slightly during the study period (Table 5).

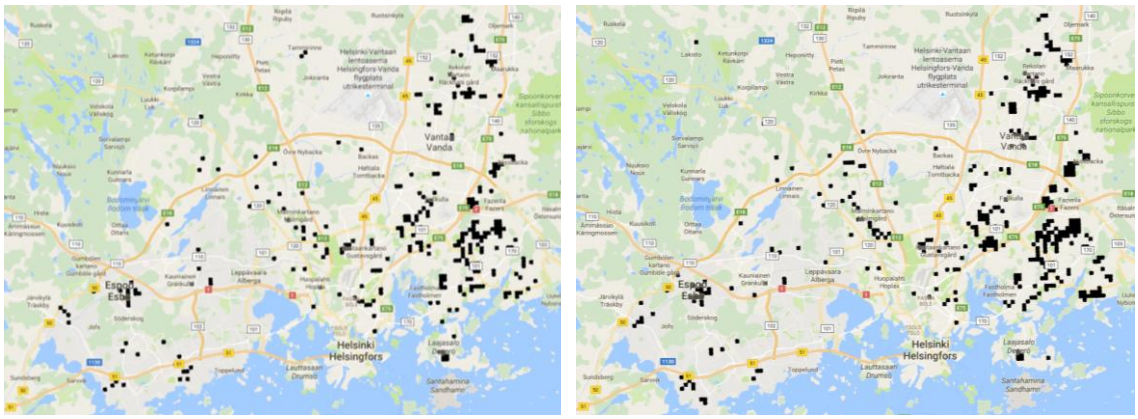

Figure 3. Socio-economic segregation in Helsinki Metropolitan Area in cross-section years 2000 and 2010 (Base map: Google Road Map).

Figure 4. Socio-economic segregation in the City of Tampere in cross-section years 2000 and 2010 (Base map: Google Road Map).

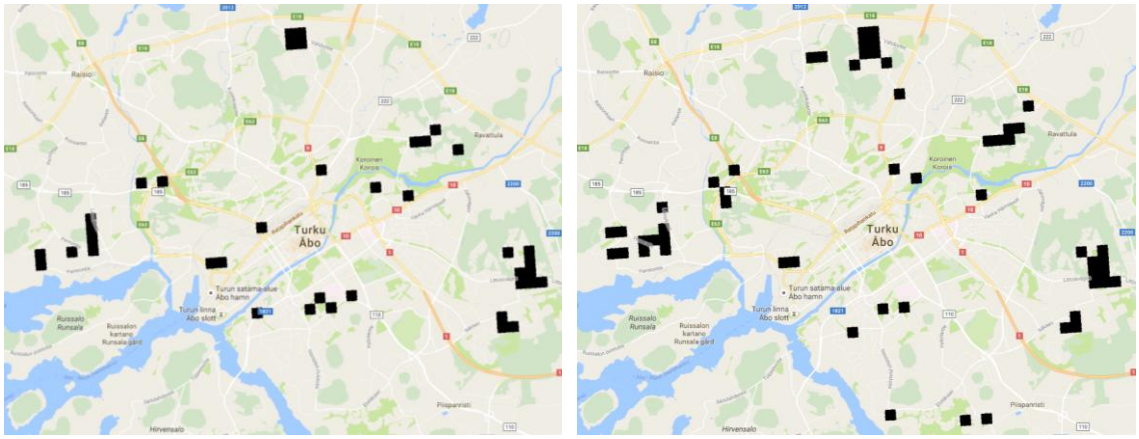

Figure 5. Socio-economic segregation in the City of Turku in cross-section years 2000 and 2010 (Base map: Google Road Map).

Table 5. Threshold values for lower and upper quintiles, and ratio between the values in different cross-section years.

A. Helsinki Metropolitan Area

Variable:	Median income [€]			Proportion of employed in the workforce			Proportion of higher educated in the employed workforce		
Year	Lower	Upper	Ratio	Lower	Upper	Ratio	Lower	Upper	Ratio
2000	26,406	59,446	0.44	0.91	0.98	0.93	0.29	0.60	0.49
2002	27,756	63,233	0.44	0.90	0.98	0.92	0.30	0.61	0.50
2005	28,669	68,373	0.42	0.90	0.98	0.92	0.32	0.64	0.51
2007	31,159	74,956	0.42	0.93	1.00	0.93	0.32	0.64	0.50
2010	33,679	80,783	0.42	0.91	0.98	0.93	0.34	0.67	0.51
2012	35,842	84,974	0.42	0.90	0.98	0.92	0.34	0.67	0.51

B. City of Tampere

Variable:	Median income [€]			Proportion of employed in the workforce			Proportion of higher educated in the employed workforce		
Year	Lower	Upper	Ratio	Lower	Upper	Ratio	Lower	Upper	Ratio
2000	20,351	44,845	0.45	0.83	0.95	0.88	0.30	0.54	0.55
2002	21,605	48,113	0.45	0.83	0.94	0.88	0.31	0.56	0.55
2005	23,153	52,088	0.44	0.85	0.95	0.89	0.34	0.58	0.58
2007	24,784	58,450	0.42	0.87	0.97	0.90	0.33	0.59	0.56
2010	26,105	59,752	0.44	0.83	0.95	0.87	0.36	0.63	0.58
2012	27,991	64,424	0.43	0.83	0.95	0.88	0.36	0.63	0.57

C. City of Turku

Variable:	Median income [€]			Proportion of employed in the workforce			Proportion of higher educated in the employed workforce		
Year	Lower	Upper	Ratio	Lower	Upper	Ratio	Lower	Upper	Ratio
2000	18,737	40,701	0.46	0.83	0.95	0.88	0.24	0.51	0.47
2002	19,901	44,186	0.45	0.85	0.95	0.89	0.25	0.53	0.47
2005	21,310	48,107	0.44	0.86	0.96	0.89	0.26	0.54	0.49
2007	23,292	52,664	0.44	0.88	0.97	0.91	0.25	0.55	0.45
2010	24,723	57,447	0.43	0.83	0.95	0.87	0.29	0.58	0.50
2012	26,098	59,504	0.44	0.83	0.95	0.88	0.29	0.59	0.48

Table 6. Socio-economically segregated grid cells in the study period of 2000–2012.

A. Helsinki Metropolitan Area

Number of grid cells that were segregated through the entire study period: 175

Year	Number of segregated grid cells	Population in segregated grid cells	Total population in the urban area	Proportion of population living in segregated grid cells
2000	303	115,345	929,298	12.4 %
2002	315	121,435	946,612	12.8 %
2005	370	142,659	964,974	14.8 %
2007	355	141,169	982,942	14.4 %
2010	380	151,307	1,016,199	14.9 %
2012	392	159,495	1,044,720	15.3 %

B. City of Tampere

Number of grid cells that were segregated through the entire study period: 33

Year	Number of segregated grid cells	Population in segregated grid cells	Total population in the urban area	Proportion of population living in segregated grid cells
2000	63	22,420	192,015	11.7 %
2002	65	23,670	196,588	12.0 %
2005	81	27,054	201,126	13.5 %
2007	73	25,120	204,762	12.3 %
2010	78	30,404	209,888	14.5 %
2012	81	30,630	214,200	14.3 %

C. City of Turku

Number of grid cells that were segregated through the entire study period: 24

Year	Number of segregated grid cells	Population in segregated grid cells	Total population in the urban area	Proportion of population living in segregated grid cells
2000	44	14,178	167,832	8.4 %
2002	54	17,602	169,953	10.4 %
2005	58	20,042	169,990	11.8 %
2007	61	19,567	170,496	11.5 %
2010	59	20,948	172,511	12.1 %
2012	63	21,542	175,213	12.3 %

2nd Empirical Section: Development of housing and building stock and socio-economic segregation

Results from the second empirical section suggest that construction production control, for example, through urban planning allows influencing on the socio-economic development in neighborhoods. In this section, relationships between development of housing and building stock and status of socio-economic segregation in grid cells were investigated using four logit model specifications. Statistical dependencies were examined both when a) status of a contemporarily segregated grid cell switches from

segregated to not segregated, and when b) status of a contemporarily not segregated grid cell switches from not segregated to segregated. As building stock changes in such grid cells are relatively few, observations from all three subject areas were combined into one panel data. It appears from the analysis that there is a favorable relationship between new small-scale housing developments (single-family houses, duplexes and townhouses) and socio-economic development in the neighborhood. Also, increase in the number of multistory apartment blocks is associated with the increased probability of a contemporarily segregated grid cell to switch its status from segregated to not segregated. However, at the same time increase in the number of multistory apartment blocks also increases the probability of a contemporarily not segregated grid cell to switch its status from not segregated to segregated.

The conflicting relationship between changes in the number of multistory apartment blocks and socio-economic segregation is comprehensible when different probability impacts from rental and owner-occupied housing are taken into account. New rental housing was estimated to decrease the probability of a grid cell to switch from segregated to not segregated, and increase the probability of a segregated grid cell to switch from not segregated to segregated. The findings were also similar when the number of ARA-subsidized housing increased. Thus, it may be concluded that increase in the number of multi-story apartment blocks with relatively high proportion of owner-occupied apartments decreases the probability for concentration of residents with low socio-economic status, and that impact of multi-story apartment blocks with relatively high proportion of rental housing on the socio-economic status of a grid cell is the opposite. Regarding residential buildings, the estimation results appear logical, since development of housing stock has through new residents a direct impact on the population living in a grid cell, which directly affects its socio-economic status. In paper 1, it is also reported that higher proportion of rented flats has a slightly adverse impact on housing prices in the neighborhood.

The impact of commercial development on socio-economic status in a grid cell was estimated negative. This result, however, is not quite obvious as better services linked to new commercial buildings could be considered to increase the attraction of the area, and thus, increase the probability for improved socio-economic status. For example, Vilkama & al. (2013) have reported the lack of services to be one often mentioned reason for moving out from a residential area. Positively, new commercial buildings also add to the local employment base, but on the other hand, jobs in the service sector tend to provide below average wages which may be reflected on the socio-economic status. In this study, commercial buildings include wholesale and retail buildings, hotel buildings, residential buildings for communities, and restaurants. Different types of commercial buildings are likely to impose different externalities on their surrounding communities. Furthermore, the vacancy rate of commercial real estate should affect the outcomes. However, the data available for this study did not allow further analysis to investigate the reasons for the

estimation results on commercial buildings. The full results from the maximum likelihood estimations of logit models are reported in Panels A and B of Table 7.

Table 7. Results from the estimations of logit models.

Panel A: Dependent variable I{from segregated to not segregated}

	Dependent variable:	I{from segregated **to not segregated**}			
	Estimated model:	Logit 1	Logit 2	Logit 3	Logit 4
Indicators for increasing number of apartments/buildings	ARA-subsidized apartments		-0.055		-0.051
	Rental apartments	-0.037		-0.055 ***	
	Single-family houses / Duplexes	0.161 ***	0.161 ***	0.148 ***	0.153 ***
	Townhouses	0.196 ***	0.200 ***	0.193 ***	0.199 ***
	Multistory apartment blocks	0.075 **	0.056	0.082 **	0.065 *
	Commercial buildings	-0.024	-0.020	-0.016	-0.009
	All other property types	0.098 ***	0.101 ***	0.101 ***	0.107 ***
Logit 1/2: Decreasing number of apartments/buildings	ARA-subsidized apartments				-0.083
	Rental apartments	0.042 *		-0.019	
	Single-family houses / Duplexes	-0.009	-0.010	0.042	0.039
Logit 3/4: Increasing number of apartments/ buildings (in the previous time window)	Townhouses	0.505 **	0.496 **	0.059	0.075
	Multistory apartment blocks	-0.042	-0.019	0.001	0.002
	Commercial buildings	0.045	0.047	0.009	0.015
	All other property types	0.089 **	0.085 **	0.109 ***	0.111 ***
	Observations	2,098			
	Pseudo-R^2	3.61 %	3.07 %	3.26 %	2.98 %

Panel B: Dependent variable I{from not segregated to segregated}

	Dependent variable:	I{Cell switches into segregation}			
	Estimated model:	Logit 1	Logit 2	Logit 3	Logit 4
Indicators for increasing number of apartments/buildings	ARA-subsidized apartments		0.018 **		0.017 **
	Rental apartments	0.008 ***		0.005 ***	
	Single-family houses / Duplexes	-0.018 ***	-0.019 ***	-0.017 ***	-0.017 ***
	Townhouses	-0.007 *	-0.008 *	-0.008 **	-0.008 **
	Multistory apartment blocks	0.009 ***	0.011 ***	0.006 *	0.007 **
	Commercial buildings	0.021 ***	0.021 ***	0.015 ***	0.017 ***
	All other property types	0.001	0.001	0.000	0.000
Logit 1/2: Decreasing number of apartments/buildings	ARA-subsidized apartments				0.019 **
	Rental apartments	0.005 ***		0.005 ***	
	Single-family houses / Duplexes	-0.008 ***	-0.009 ***	-0.013 ***	-0.014 ***
Logit 3/4: Increasing number of apartments/ buildings (in the previous time window)	Townhouses	-0.016	-0.017	-0.004	-0.004
	Multistory apartment blocks	0.005	0.007	-0.003	-0.002
	Commercial buildings	0.003	0.004	-0.002	-0.002
	All other property types	-0.004 *	-0.004 *	0.004	0.004
	Observations	25,778			
	Pseudo-R^2	4.62 %	4.34 %	5.14 %	4.93 %

Notes: Variable values in the table depict marginal effects. Positive values may be interpreted as a percentage increase in the probability of a contemporarily not segregated grid cell to switch its status to segregated. While, negative values may be interpreted as a percentage decrease in the probability. ***, ** and * designate statistical significance at the 1 %, 5 % and 10 % levels, respectively.

3rd Empirical Section: Housing and building stock and contemporary socio-economic status

Based on the results from the third empirical section, it was concluded that there is a statistically significant relationship between the existing building stock and the contemporary socio-economic status within a grid cell. In this section, the relation between the housing and building stock and socio-economic status in a grid cell at different cross-sections in time was examined. However, at this time a contemporarily prevailing status was under scrutiny rather than changes in the status between cross-section times, which were under scrutiny in the second empirical section.

The analysis supports the results from the second empirical analysis, confirming that housing and building stock are associated with the socio-economic status of the grid cell. Again, the higher number of rental and ARA-subsidized housing was associated with a negative impact on socio-economic status and owner-occupied housing was associated with a positive impact. Single-family houses, duplexes and townhouses were associated with a positive impact, and multistory apartment blocks with a negative impact. When interpreting the results, it is also important to pay attention to that rental apartments are most often located in multistory apartment blocks, and rental housing was observed to have a negative impact on socio-economic status. The negative impact of multistory apartment buildings was estimated the lowest in the Helsinki Metropolitan Area (HMA) and the highest in the City of Turku. This may be due to higher proportion of denser urban structure, and higher number of prestigious multistory apartment buildings in the HMA.

Ordinary least squares (OLS) estimations revealed a negative association between the number of commercial buildings and the contemporary socio-economic status in a grid cell, confirming the results from maximum likelihood estimations of logit models. Unfortunately, estimations of logit models did not allow studying differences between subject areas as the data available was insufficient for that purpose. OLS results suggest that negative relationship between commercial buildings and socio-economic status is particularly strong in the HMA. However, further studies would be needed to reveal the reasons for differences between urban areas.

Educational buildings were estimated to have a statistically significant negative impact on socio-economic status in the City of Turku, while in the HMA and the City of Tampere statistically significant relations were not observed. Interestingly, in Turku, the number of educational buildings relative the number of grid cells was higher than in other investigated urban areas. Estimating a data sample combining data from all the three investigated urban areas resulted in a relatively small negative impact of 1.7 percent. This may be linked to that students and low-income families with children are located in close proximity to educational buildings. However, the data available for this study did not allow further investigations on this. The full results from least squares estimations are presented in Table 8.

Table 8. Results from the least squares estimations.

Sample:	Full sample		Helsinki Metropolitan Area		City of Tampere		City of Turku	
Variable	*Coefficient*	*(t-stat)*	*Coefficient*	*(t-stat)*	*Coefficient*	*(t-stat)*	*Coefficient*	*(t-stat)*
Intercept	8.760 ***	(23.3)	9.905 ***	(99.9)	8.816 ***	(22.7)	9.136 ***	(121.1)
Owner-occupied apartmnets	0.003 ***	(44.7)	0.002 ***	(36.9)	0.003 ***	(16.5)	0.004 ***	(21.1)
Rental apartments	-0.004 ***	(-73.6)	-0.004 ***	(-66.7)	-0.004 ***	(-28.0)	-0.003 ***	(-15.5)
Single-family houses / Duplexes	0.017 ***	(61.3)	0.017 ***	(55.1)	0.014 ***	(21.6)	0.017 ***	(20.3)
Townhouses	0.008 ***	(9.9)	0.008 ***	(9.1)	0.010 ***	(4.9)	-0.001	(-0.3)
Multistory apartment blocks	-0.032 ***	(-28.8)	-0.022 ***	(-17.9)	-0.055 ***	(-20.2)	-0.085 ***	(-17.5)
Commercial buildings	-0.054 ***	(-15.5)	-0.094 ***	(-17.7)	-0.022 ***	(-3.7)	-0.047 ***	(-5.8)
Office buildings	-0.011 ***	(-2.7)	-0.017 ***	(-3.7)	-0.030 **	(-2.5)	0.041 ***	(3.2)
Traffic related buildings	0.010 ***	(3.0)	0.012 ***	(3.1)	-0.027 ***	(-2.6)	0.039 ***	(4.6)
Healthcare buildings	-0.061 ***	(-10.2)	-0.044 ***	(-6.6)	-0.097 ***	(-5.1)	-0.107 ***	(-6.4)
Buildings for assembly	-0.002	(-0.5)	-0.039 ***	(-4.6)	-0.058 ***	(-3.4)	0.025 ***	(4.2)
Educational buildings	-0.017 ***	(-2.9)	0.004	(0.5)	-0.020	(-1.1)	-0.062 ***	(-4.5)
Industrial buildings	-0.043 ***	(-9.6)	-0.043 ***	(-8.1)	-0.059 ***	(-5.2)	-0.038 ***	(-3.3)
Warehouses	-0.002	(-0.2)	0.021 **	(2.1)	0.025	(1.0)	-0.064 ***	(-3.6)
Other buildings	-0.035 ***	(-4.1)	-0.017 *	(-1.8)	-0.070 ***	(-2.6)	-0.090 ***	(-3.9)
Time window indicator:	(5 variables)		(5 variables)		(5 variables)		(5 variables)	
Zipcode indicator:	(227 variables)		(165 variables)		(34 variables)		(26 variables)	
R^2:	64.36 %		65.44 %		55.03 %		56.68 %	
Observations:	33,774		23,432		5,617		4,725	

Notes: The dependent variable is a composite variable that describes the socio-economic status of a grid cell, logged. Given the log-linear model specification, the parameter estimates may be interpreted as a percentage change in the value of dependent variable as the explanatory variable increases by one unit, ceteris paribus. ***, ** and * designate statistical significance at the 1 %, 5 % and 10 % levels, respectively.

This study provides an important contribution to understanding the state of socio-economic segregation in major Finnish cities. The previous studies have focused on the Helsinki Metropolitan Area, but this study also examines two other urban areas, confirming similar characteristics in the development of socio-economic segregation. At the same time, the study is one of the first attempts to statistically investigate the relationship between real estate development and socio-economic status of the neighborhood based on comprehensive quantitative data sets. The results suggest that socio-economic segregation has increased in Finland in the 21st century, but the pace has still not been particularly rapid. It was also found that, at the same time, the differences between the extremes of socio-economic status have been differentiating relatively little. On the one hand, the findings refer to that the attempts to prevent socio-economic segregation have mitigated negative outcomes, but on the other, implemented actions have not been enough to entirely stop the process. As socio-economic segregation seems to continue expanding, new measures and even harder preventative attempts are needed. Finding significant relationships between development of building stock and changes in the socio-economic status, this study provides an insight of how real estate development could be used in the fight against expanding socio-economic segregation.

4. Discussion

In this section, the results of this doctoral research are discussed. First, the results are critically reviewed with respect to the previous literature. Second, the limitations regarding these results are presented.

4.1 The results in relation to previous research

(i) Only minor depreciation may be linked to higher proportion of rental housing

The first research question asks: *What impact does the proportion of rented flats have on residential property values within the neighborhood?* Consequently, the null hypothesis to be tested was: *The proportion of rented flats has no impact on residential property values within the neighborhood.* Based on empirical analysis the null hypothesis was rejected, suggesting that the higher proportion of rental housing has a negative impact on residential property values within the neighborhood. Previous research from the U.S. (Coulson & al., 2003; Coulson & Li, 2013; Wang & al., 1991) suggest that owner-occupied and rental housing impose different externalities on their surroundings and that these externalities capitalize into housing prices. The results of this study are in line with those previous findings, but with the difference that in this study multi-story apartment building units were under scrutiny, while the earlier studies focused on the impacts on single-family houses. It is also important to notice that both Coulson & al. (2003) and Coulson & Li (2013) base their findings on survey data, while this study is based on housing transactions. As survey respondents' answers may differ from their real behavior, using transacted housing prices gives a more profound basis for the analysis. However, the results differ from the findings of Kortelainen & Saarimaa (2015) who did not find evidence of positive externalities from homeownership. Their research was the first to examine the relationship between externalities from owner-occupied housing and prices of multi-story apartment building units using Finnish data. Possible reasons for their different results are a notably smaller sample size, and differences in analysis methods and model specifications.

Before drawing final conclusions, the estimation results should be critically reviewed one more time based on the results presented in appended Table 9 and Table 10. These tables extend Table 1 and Table 2, presenting statistical inference also based on heteroscedasticity robust and within zip codes clustered standard errors. Such inference diminishes concerns relating to heteroscedasticity and spatial autocorrelation, which are discussed in more detail in Chapter 4.2. Also variance inflation factors are reported in order to evaluate presence of multicollinearity. The reported VIFs do not provide any indication of multicollinearity in any of the model specifications as none of the values is critically close to the threshold of 10, which is reported as a standard rule of thumb by

Verbeek (2012) and Wooldridge (2013). Particularly, the VIFs for variables of interest are notably lower than the threshold. Also, more detailed discussion on multicollinearity is presented in the next chapter.

As interpreting the extended tables, robust standard errors seem to have hardly any impact on statistical inference of the results, while within zip codes clustered standard errors have a greater impact, decreasing statistical significance of the variables of interest. As a result, only coefficients for categories 0–25% and >50–75% remain significant and only at 10% significance level. It is also important to notice that statistical significance of variables does not directly mean that the difference between two dummy variables is statistically significant, but this has to be confirmed by a statistical test. When considering results from the estimation of full sample reported in Table 9, a statistical test based on clustered standard errors reveals that there is no statistically significant difference between the regression coefficients for categories with the rental flat proportion of >50–75% and >75%. While, between other category coefficients of interests such statistical significance exists.

Taking results in Table 10 under scrutiny, it is noticed that statistical inference based on heteroscedasticity robust standard errors does not change much, but inference by clustered standard errors has again more tangible impact. However, this time the coefficient of interest remains statistically significant in all model specifications. Now, it is important to pay attention to that estimated coefficients from different regressions cannot directly be compared. To investigate whether differences between estimates from different regressions are statistically significant, method suggested by Clogg & al. (1995) is used. The statistical tests based on clustered standard errors reveal again that, the difference between categories of >50–75% and >75% is not statistically significant.

These above presented notifications should be taken into account when interpreting the results. When considering housing prices, it is well-founded to assume that error terms are spatially clustered. Thus, the interpretation of results should be based on clustered standard errors. After this critical review of the estimation results, it can be stated that high proportion of rental housing still seems to impose more negative than positive externalities when measured in neighborhood housing prices. However, only minor negative impact is detected; the average price difference between neighborhoods with the proportion of 0–25 percent and neighborhoods with the proportion of greater than 50 percent of rented flats was estimated to be 1.6–2.4 percent.

Understanding the impact of the proportion of rented flats on residential property values within the neighborhood should be of interest to a wide range of policymakers and community stakeholders. The results suggesting that only minor depreciation is linked to the higher proportion of rented flats may help to dispel prejudices related to rental housing. Most importantly, the results contribute to an important policy question about if subsidization of home-ownership is justified. As a prerequisite homeownership should

induce positive externalities that outweigh the costs of subsidization, such positive externalities should accumulate into housing prices. However, in this study, the detected price differences were only minor, which may not be enough to justify the heavy subsidization of homeownership in Finland. As this study, and also Kortelainen & Saarimaa (2015), focused only on flat prices, more research on other types of home-ownership is needed before the final conclusions on the justifiability of subsidization can be drawn.

(ii) The net impact of a senior house development is rather positive than negative

The second research question asks: *Do market-rate age-restricted multi-family housing developments exert any measurable effect on the value of similar multi-family buildings without age restrictions?* Consequently, the null hypothesis to be tested was: *Market-rate age-restricted multi-family housing developments have no impact on the value of similar multi-family buildings without age restrictions.* Based on empirical analysis the null hypothesis was rejected, suggesting that senior house developments have a positive impact on the prices of surrounding multi-family buildings.

The previous research on externality effects of group homes and subsidized housing on surrounding values has often examined the effect of multi-family housing developments on single-family houses (e.g. Colwell & al., 2000; Galster & al., 2004), which can make separating the impact of the scale of the development from the impact of the residents for which it is intended difficult. The importance of neighborhood fit, buffering, and screening have repeatedly been mentioned in these studies, but the data do not allow the researchers to disentangle these effects. Similarly, many studies (e.g. Deng, 2011; Schwartz & al., 2006) examine the effect of specialized housing constructed as part of rehabilitation schemes, confounding the influence of the type of housing with the age of the buildings. Previous studies that include age-restricted housing (e.g. Cummings & Landis, 1993; Funderburg & MacDonald, 2010; Lyons & Loveridge, 1993; Rabiega & al., 1984) have focused only on US government subsidized housing developments and their effects on single-family house prices. Subsidized developments imply that residents will be low-income in addition to age qualified; once again making disentangling of the two effects difficult. In addition, most studies do not identify or consider the implications of the type of senior housing (independent living, assisted living or nursing homes) examined in their studies. Due to these shortcomings, previous studies have produced mixed results, creating uncertainty as to whether age-restricted housing developments exert any measurable effect on surrounding housing prices and if that effect is positive or negative. No research has previously specifically addresses the potential externality effect of market-rate age-restricted multi-family housing units. In addition, no research has isolated the influence of multi-family age-restricted buildings on the value of similar multi-family buildings without age restrictions.

Recognizing the potential risk for presence of heteroscedasticity and multicollinearity, which are discussed in more detail in Chapter 4.2, the estimation results should be critically reviewed one more time before the final conclusions are drawn. The interpretation should be done leaning on the results presented in appended Table 11. This table extends Table 3, adding also statistical inference based on heteroscedasticity robust and within zip codes clustered standard errors. In doing so, concerns on heteroscedasticity and spatial autocorrelation can be dampened. Also variance inflation factors can be found in the extended table, but the reported VIFs do not provide any signs of multicollinearity when 10 is considered a cutoff value as e.g. Verbeek (2012) and Wooldridge (2013) suggest. Most importantly, the VIFs for variables of interest are at low level.

Looking at Table 11, statistical inference based on heteroscedasticity robust standard errors hardly has any impact on statistical significance of the estimated coefficients. While, inference based on clustered standard errors indisputably affects the statistical significance of estimated coefficients. As it is well-founded to assume that standard errors are in this case spatially clustered, the interpretation of results should be based on clustered standard errors. Another issue that should be taken into consideration is that the statistical significance of coefficient estimates does not automatically mean that the difference between two indicator variables is statistically significant too. A statistical test based on clustered standard errors reveals that, in Specification (3), the difference between coefficients for Proximate*$Period_{t-2}$ and Proximate*$Period_{t+2}$ is not statistically significant.

After this critical review of the results, it may be interpreted that a senior house development was estimated to have a significant positive impact on proximate apartment values within a 500 meter radius. 12–24 months after the development units nearby a senior house development were estimated to sell at a premium of 4.1–4.5 percent, relative to comparables. Compared to the estimated price level at 24–12 months before the development, this means price increase of 4.1–4.5 percentage points, relative to comparables. Interestingly, the statistically significant price difference between before and after the senior house development was only found when also other housing developments were allowed in the area. Consequently, it is not plausible to state that the entire estimated price impact would be attributable to a single senior house development project, but also to other development in the neighbourhood. After the development price level was estimated positive and significant relative to matched comparables also when only senior house developments were allowed. In that case the difference between before and after, however, is not statistically significant. Thus, the findings of this study fill a gap in knowledge, indicating that a senior house development has rather a positive than negative impact on its surroundings. The results should encourage investors and developers to build senior houses and help to mitigate prejudices that may potentially be linked to senior house developments.

Before generalizing the results of this study to a broader audience some limitations should be taken into account. First, the paper studies apartment values only in Tampere, Finland. Tampere represents a mid-size metro area in Finland, and market conditions may differ from smaller cities or larger metropolitan areas. Second, it is important to notice that local regulations can have a notable impact on the outcomes from senior house developments as there are no specific, national construction regulations for senior houses. The developments must meet the National Building Code, and possibly also some local senior house regulations. However, senior house regulations are imposed by local authorities and may differ between the cities. Third, no industry or government organization is gathering data on the senior house market in Finland. The senior house data used in this study is surveyed by the city of Tampere and the authors.

While population is getting older and a need for accessible apartment units increases, a senior house appears to be a good option as an infill development. As a lack of accessible apartments for senior citizens is already a public policy issue not only in Finland, but also in many other countries with ageing demographic structure, infill senior house developments could be one solution to vitalize neighborhoods and add a number of accessible apartments in existing residential areas. Senior house developments have many positive features compared to regular residential properties. Senior houses provide amenities and services, such as a gym, diner or café that can encourage neighbors to meet and socialize more. Moreover, senior residents are social, maintain their properties and do not vandalize, leading to a better community spirit. Thus, understanding the influence of new senior house developments on surrounding residential property values should be of interest to a wide range of policymakers and community stakeholders.

(iii) No indication of negative housing price impact from residential infill

The third research question asks: *Do multi-story apartment building developments have a measurable impact on the prices of flats in existing multi-story apartment blocks from 1960s and 1970s?* Consequently, the null hypothesis to be tested was: *Multi-story apartment building developments do not have a measurable impact on the prices of flats in existing multi-story apartment blocks from 1960s and 1970s*. Based on empirical analysis the null hypothesis was rejected, suggesting that multi-story apartment building developments have a positive impact on the prices of surrounding multi-family buildings. However, this baseline is re-evaluated below based on a critical review of Table 12.

In the previous literature, there are several studies focusing on the impact of low-income, affordable and supportive housing developments on surrounding residential property values (e.g. Ellen & al., 2001; Ellen & Voicu, 2006; Galster & al., 2004; Rabiega & al., 1984). There are also three studies investigating the impact from development of subsidized market-priced residential housing, focusing on Cleveland housing market (Ding & al., 2000; Ding & Knaap, 2003; Simons & al., 1998). Most of these studies, with the exceptions of Ellen & al. (2001) and Ellen & Voicu (2006), measure the impact only

on single-family house values, using either assed values or transacted prices. Furthermore, there is a limited amount of literature considering the impacts from non-subsidized infill development, including scattered infill developments in distressed Chicago neighborhoods (Ryan & Weber, 2007), new single-family house developments in existing neighborhoods in Baton Rouge, LA (Zahirovich-Herbert & Gibler, 2014), and infill development on vacant or under-used parcels within existing urban areas in Singapore (Ooi & Le, 2013). Given the above, the majority of the previous literature examines U.S. housing market, and no research has previously specifically addresses the potential externality effect of multi-story apartment buildings in existing neighborhoods from 1960s and 1970s which – in Finland – is the era of industrialized serial production of uniform precast apartment buildings. This period of time has been of great importance in the development of Finnish building stock, and is characterized by simplified grid layouts and industrialized serial production of almost identical precast concrete buildings. Thus, the study specification is the first of its kind and contributes to heated public discussion on the impacts from residential infill.

Knowing the potential risk for presence of heteroscedasticity and multicollinearity (a more detailed discussion in Chapter 4.2), the estimation results should be critically reviewed one more time before the final conclusions are drawn. The interpretation should be based on the results presented in appended Table 12. This table is an extension of Table 4, presenting also statistical inference based on heteroscedasticity robust and within zip codes clustered standard errors. Such inference decreases concerns on heteroscedasticity and spatial autocorrelation. To evaluate presence of multicollinearity, also variance inflation factors have been reported in the extended table. VIFs for the variables of interest in base model are still in a tolerable level even though VIF value for Close*After exceeds the standard threshold of 10 (Verbeek, 2012; Wooldridge, 2013). While, in the Spline regression specification, multicollinearity seems to be a more critical problem as VIFs indicate the variances of coefficients for variables of interest to be seriously inflated.

Based on Table 12, heteroscedasticity robust standard errors do not seem to have much impact on statistical significance of the estimated coefficients. While, inference based on clustered standard errors, notably decreases the statistical significance of estimated coefficients. This results in a situation where none of the variables of interest is statistically significant, and thus, the null hypothesis cannot be rejected. In this case, the standard errors are expected to be spatially clustered, and accordingly, interpretation of results should be based on clustered standard errors.

Taking the critical notifications above into account, it may be interpreted that, after clustering the standard errors, neither of the estimated model specifications provides statistically significant evidence on any kind of price impact on nearby flat prices after a new residential multi-story apartment building is built. Most importantly, no indication of negative price impact was found. The results are based on estimations of data from

Finnish residential areas with residential multi-story apartment buildings from 1960s and 1970s. It is important to notice that analyzed new developments may be somewhat heterogeneous and a more fine-grained analysis studying interactions of different development types might produce different results. Changing the confines for the analysis might also affect the results.

The results have the potential to be generalized to a broader audience in the context of neighborhoods which have been developed according to the principles of industrialized serial precast building production. Nevertheless, some limiting factors should be noted. First, this study utilizes a matched sample methodology which leads to smaller sample sizes instead of including the maximum number of observations available. On the other hand, matched samples increase the precision of the comparison between treatment and control group, but it is important to note that the results are noticeably sensitive to choice of radius and matching criteria. Second, this study considers a major Finnish housing market, which is characterized by positive net migration. Future research may consider markets that suffer from negative net migration and compare the long-horizon impacts. Third, it is important to understand the context in which the studied residential development takes place and the relative degree of development concentration. Results may substantially differ if the study area specification is changed or the value impact is studied on other property types, such as single-family homes. Fourth, although the carefully constructed research design attempts to address the potential issue of endogeneity in site selection, it is inevitable that developers are likely to prefer sites and areas with potentially rising prices. This could result in a positive bias in the results.

Understanding the influence of multi-story apartment building development on surrounding housing values should be of interest to a wide range of policymakers and community stakeholders. Residential infill is an important component of land use policy, and it should be considered as one measure to revitalize declining neighborhoods. In this study, no negative price impact on nearby flat prices was detected.

(iv) Proactive measures needed to prevent spatial segregation: real estate development is needed, but it does not resolve the root causes

The fourth research question asks: Has socio-economic segregation increased in major Finnish cities in the 21st century, and is there a link between building stock and socio-economic segregation? To answer the research question two null hypothesis were tested: 1) Socio-economic segregation has not increased in major Finnish cities in the 21st century, and 2) There is no statistically significant link between building stock and socio-economic segregation. Based on empirical analysis the both null hypothesis were rejected, suggesting that socio-economic segregation has increased in major Finnish urban areas in the 21st century, and there are statistically significant relationships between building stock and the level of socio-economic segregation.

Socio-economic segregation, its consequences and underlying forces have been widely studied around the world. Many recent studies have drawn attention to that socio-economic inequalities have notably increased in the world, which is also recognized by the European Commission (2010). These concerns were confirmed in 12 European capitals by a recent study from Musterd & al. (2017). However, Finland was not included in their study, meaning that the state of affairs in major Finnish cities was not directly investigated. In the Finnish context, particularly research on socio-economic segregation in Helsinki Metropolitan Area has been published in recent years (e.g. Kortteinen & Vaattovaara, 2015; Vilkama & al., 2014). While, studies focusing on other parts of Finland have been few in numbers. However, there are some studies investigating other urban areas as well, for example, the City of Turku (see Rasinkangas, 2013). Furthermore, most of the previous studies (excluding Kortteinen & Vaattovaara, 2015) are performed in larger scales than the micro-level approach that was adopted in this doctoral research. The results of this study are in line with previous research confirming that socio-economic segregation has increased also in major Finnish cities.

Specifically, the number of segregated grid cells has increased in all major urban areas during the study period by 29–43 percent. While, 52–58 percent of the grid cells which were segregated in the beginning remained segregated through the entire study period. At the same time, the proportion of population living in segregated grid cells increased 2.9–3.9 percentage points. However, the ratios between lower and upper quintile thresholds of selected indicators decreased 0.02 units at maximum, depicting relatively moderate differentiation in the study period. The observations on the development of income differentials from Statistics Finland (2013) also support this view.

In addition to confirming the increased segregation in major Finnish cities, this study provides a novel approach of investigating the links between real estate development and socio-economic segregation. Addition of detached houses (single-family houses and duplexes) was estimated to increase the probability of a grid cell to switch from segregated to not segregated by 14.8–16.1 percent. While, the probability of not segregated grid cells to switch to segregated decreased by 1.7–1.9 percent. Addition of townhouses was estimated to increase the probability to switch from segregated to not segregated by 19.3–20.0 percent, and to decrease the probability to switch from not segregated to segregated by 0.7–0.8 percent. Addition of multi-story apartment buildings was estimated to increase the probability of a grid cell to switch from segregated to not segregated by 6.5–8.2 percent, but at the same time, also to increase the probability to switch from not segregated to segregated by 0.6–1.1 percent. To understand the conflicting results for multi-story apartment buildings, the housing tenure must be taken into consideration as it seems to be crucial in relation to development of segregation. The probability of a grid cell to switch from segregated to not segregated decreased by 5.5 percent when addition of rental apartments occurred in a grid cell. At the same time the probability to switch from not segregated to segregated increased by 0.5–0.8 percent.

ARA-subsidized production increased the probability to switch from not segregated to segregated by 1.7–1.8 percent. Addition of retail buildings was estimated to increase the probability of a grid cell to switch from not segregated to segregated by 1.5–2.1 percent. While, statistically significant probability impact from segregated to not segregated was not found. The last building type category included all other building types. It appeared from the analysis that addition of all other buildings increases the probability of a grid cell to switch from segregated to not segregated by 8.5–11.1 percent. Whereas, the probability to switch from not segregated to segregated decreases by 0.4 percent.

It was also found that addition of rental and ARA-subsidized apartments in the previous time window increases the probability of a grid cell to switch from not segregated to segregated by 0.5–1.9 percent. While, addition of single-family houses or duplexes was estimated to decrease the probability by 1.3–1.4 percent. Instead, it appeared from the analysis that the changes in residential building stock had no statistically significant impact on the probability of a grid cell to switch from segregated to not segregated. Whereas, addition in the category of other buildings increased the probability by 10.9–11.1 percent. Statistically significant relationships were also estimated when the number of buildings in a grid cell decreased.

In summary, the results from logit estimations suggest that single-family houses and duplexes have a positive impact on socio-economic status in a neighborhood. While, regarding multi-story apartment buildings, the impact seems to be related to the proportion of rental and owner-occupied housing. More surprisingly, socio-economic impact from addition of retail buildings was estimated negative. However, it is also important to pay attention to that the sample size of grid cells with changes in the number of retail buildings is notably lower than the number of grid cells with changes in the number of residential units. However, the underlying reason to the negative estimate is likely to be that the analysis is performed at 250 m x 250 m grid level. Thereby, one large retail development may fill an entire grid cell or at least a major proportion of it. At the same time, an old multi-story apartment block may be torn down to give place to the new development, resulting in a negative estimate

As the relationship between the numbers of different types of buildings and contemporary socio-economic status of a grid cell were studied using OLS estimations of linear models, findings were in line with what could be expected based on the results from logit estimations described above. However, at the same time, the different approach allowed breaking down the category of other buildings into eight sub-groups and also investigating differences between the three studied urban areas. Heterogeneity tests revealed some differences between the urban areas. The differences were mainly estimated regarding the eight new sub-groups and one underlying reason for differences may be that the samples per each urban area are not fully representative in terms of all new sub-groups. Of course, also real differences between different urban areas may exist,

but better understanding of the underlying reasons would require further research using larger statistical grids.

Like e.g. Vilkama (2011, 76) has highlighted, there are multiple ways to study socio-economic segregation. As these different approaches measure various factors, they may also result in different conclusions. In this study, socio-economic segregation was examined particularly leaning on criteria analogous to Kortteinen & Vaattovaara (2015). The criteria was based on three variables, including median income, proportion of employed in the workforce, and proportion of highly educated in the employed workforce. It is important to notice that similar analysis could be performed using totally or partially different criteria. For example, in this study, one criterion was based on proportion of employed in the workforce which could be replaced, for instance, with a variable measuring proportion of employed in entire population. In that case, in addition to unemployed, also proportion of residents who are not placed in the workforce would have a greater importance when measuring socio-economic status of a neighborhood. Analyzing development of socio-economic segregation using different grid layouts of larger sizes could also help to better understand its dynamics.

Regarding possible sources of error for this research, it is important to notice that neighborhoods with lower socio-economic status may not be the most attractive locations particularly when deciding on more costly real estate developments. Thus, the characteristics of development projects in lower status neighborhoods may be crucially different to developments occurring in higher status areas. There is also potential endogeneity in site selection, likely resulting in that new constructions mostly occur in areas which are particularly considered potential for investments. Such selection bias may affect the results of this study.

It is also important to keep in mind that the median income data is based on information on taxable income collected by the Statistics Finland, and thus, does not include non-taxable income. For instance, some social subsidies, child support, non-taxable share of income from dividends, such interest income on which tax has been withheld at source, tax-exempt grants and scholarships are not included in median income statistics. However, the median income data from grid-based monitoring system for spatial structure and urban form (YKR) was the most comprehensive income data at grid cell level that was available for the researchers at the time of this study. If possible, future research should strive for using such income data that covers all types of income, and thus, giving even more comprehensive understanding of the total income of residents – regardless if their income is taxable or not.

Improving development of building stock provides some measures to address socio-economic segregation in neighborhoods. For example, through land use planning and zoning, vacant land may be allocated to different property types so that it creates optimal conditions for desired social mix. As for housing policies, political choices and decisions

allow, for instance, targeting a certain proportion of conveyed land for only rental housing. Thus, supply of different kinds of homes and their locations can be affected, and this also reflects to the geography of services. However, real estate development occurs in the large scale only if the business environment is right and market-based requirements for profitable projects are met. Furthermore, at the individual level, selection of place of residence is also affected by many other factors than supply of housing.

Because of the permanent and expanding nature of segregation development, proactive measures to prevent adverse effects should be considered at least in all three subject areas, but also in wider perspective, including all notable urban areas in Finland. Given that socio-economic segregation has continued expanding despite the preventative attempts implemented in housing policies, new potential preventative measures to address undesired development should be considered. For example, one potentially feasible policy instrument could be formed of models allowing a combination of both ARA-subsidized and market-based residential development in the same multi-story apartment building. However, it is important to keep in mind that social mix policies and redistributing wealth and poverty between neighborhoods does not address the underlying causes of socio-economic segregation, but will revitalize neighborhoods and prevent related adverse effects.

4.2 Limitations

The approach of this doctoral thesis is empirical and relies on quantitative analysis of comprehensive data sets, including housing transactions data, property registry data, and various grid-based spatial data from the monitoring system for spatial structure and urban form (YKR). When evaluating the trustworthiness of such quantitative research, the two most central aspects that arise to be discussed are validity and reliability. According to Robson (2011) validity refers to whether results of a research are truly what they appear to be, meaning that researchers have actually measured what is intended. While, reliability is concerned with the consistency of a measure over time and with different observers, asking can the results be plausibly repeated. It is important to notice that the measure cannot be valid, unless it is reliable. Still, reliability alone does not guarantee validity of the results.

Robson (2011) further divides validity into internal validity and external validity, as introduced by Campbell & Stanley (1963). External validity refers to generalizability of the results, and internal validity is concerned with if a study can plausibly demonstrate a causal relationship between treatment and outcome. There are a number of extraneous variables that may threaten the internal validity, potentially making the researchers mistakenly conclude that the treatment caused the outcome, or alternatively, confuse the causal relationship between them. For example, there could be such changing characteristics in the study area that cannot be accounted for (omitted variable bias). To establish internal validity, these threats must not only be taken seriously, but also, be

properly addressed. Similarly, relevant threats should also be taken into account when considering generalizability (i.e. external validity) of the study. Next, validity and reliability of this doctoral thesis is evaluated.

Finnish data is comprehensive, yet not all-inclusive

This doctoral research relies on quantitative analysis of a combination of extensive Finnish datasets. Finnish property data is more comprehensive in nature than data available in other countries, such as the United States. Specifically, Finnish cities maintain property registries that include detailed information for every completed structure. Particularly, the completeness of the property records benefits the development impact analysis as every new retail development occurring during the sample period can be recognized. This allows the potential confounding effects from other developments to be controlled, which has remained largely unaddressed in the relevant literature to date.

Despite all the benefits, Finnish property registry data also has its shortcomings. Next, most central defects from the perspective of this doctoral research have been listed, ignoring aspects that might still be relevant for other studies. First, property registries do not retain comprehensive information on renovations. This would relevant given that the current status of a property, say, built in 1970s would be very different if it was either recently fully renovated or still in its original condition. This kind of information remains unknown for the researchers, leaving undesired room for omitted variables. Second, year of construction remains unknown for numerous buildings. However, this problem is related to older buildings and should not affect recognition of new developments. Third, the intended purpose of use coding for residential buildings does not differentiate between homeownership and rental housing. This would be relevant as externalities from owner-occupied and rental housing seem to differ, and more precise data would allow further analysis on this matter. Moreover, differentiating between production subsidized and market-based rental house production would be needed. Fourth, some useful variables are sparsely populated, and thus, cannot be included in the analyses. A good example of such variable would be façade material which may affect property values. Fifth, contents of property registries in different cities are not completely uniform. Even though there are no major differences, a standardized format would decrease the risk for human errors when merging data from different registries. Sixth, usage of property registries requires careful cleaning of duplicates, which may increase the risk for human errors as a source of error.

At the time of this research, Logica Oy was the largest residential transaction data source in Finland, representing a notably high proportion of all housing transactions (according to some estimations 90 percent of all transacted sales). The utilized data sample included all housing transactions where a major real estate broker was involved. While, non-brokered transactions and those from small brokerage firms were excluded. Using transacted prices gives a distinct advantage compared to survey data as it demonstrates

actual behavior instead of anticipated behavior. As data input of housing transactions is on the responsibility of individual brokers, the risk for human errors is obvious. For example, individual brokers may understand the intended contents of requested input fields in various ways, which potentially leads to erroneous inputs. Observations with obviously erroneous values of relevant variables must be excluded from the analysis, decreasing the valid sample size. While, observations with faulty values that are not obvious to the researchers remain and may bias the results. Another problem is that individual brokers do not necessarily type in all the requested information, resulting in that some variables are sparsely populated, and thus, may not be included in the analysis. As location coordinates are not included in the housing transaction data, the locations must be geocoded based on street address. Since an unambiguous address is not reported for all observations, the geocoding also decreases the sample size.

Grid-based spatial data from the monitoring system for spatial structure and urban form (YKR) provides various regularly updated datasets in a 250 m x 250 m grid. The majority of the YKR datasets is provided by Statistics Finland who collects the data from multiple sources and processes it before delivering the data to the monitoring system. Thus, same limitations that apply to source data also apply to processed data, including e.g. that income data covers only taxable income excluding non-taxable income such as non-taxable dividends. Another limitation of YKR data is that due to privacy protection information in sparsely populated grid cells is hidden which may in some cases bias the results. Furthermore, data aggregation into 250 m x 250 m grid level loses some richness of the data, potentially, resulting in compromises in research design. As an example, due to aggregated data, proportion of rental housing could not be recognized at building level, thus compromising the analysis at grid level. Another shortage of YKR data is that some datasets are not updated on yearly bases which may in some cases force the researcher to use data from another cross-section year than for other included variables, potentially, biasing the results. Despite the above mentioned shortages, YKR data has several distinct advantages, such as that the data is already cleansed and comparable through different cross-section years.

Challenges in estimating housing prices

Three of four research topics in this dissertation attempt to isolate externality impact from either proportion of rental housing or development of multi-story residential buildings, measuring changes in housing prices. There is a well-established literature on the measurement of spillover effects, providing an appropriate baseline for this dissertation. In relevant literature, hedonic regressions are typically used to estimate the marginal contribution of individual characteristics to housing prices (Sirmans & al., 2005), serving as a solid base for the research design of this doctoral thesis. To isolate development impact hedonic regressions are typically combined with difference-in-difference approach (e.g. Ellen & al., 2001). The applied research designs have addressed several empirical issues: two of the research papers estimating housing prices rely on fixed-

effects hedonic models and propensity score matching, while, the third paper leans on fixed-effects hedonic models and matched samples methodology. As McMillen (2012) describes, use of matching techniques provides distinct advantages compared to an alternative repeat sales approach or leaning on classical hedonic approach alone. However, it is important to pay attention to that matched samples are sensitive to matching criteria, and such criteria is eventually the determinant of the quality of matched samples. A more precise description of the research designs and empirical issues addressed can be found in previous sections of this summary. Despite the well-developed research designs, there are still some particular assumptions and concerns that should be discussed when evaluating this research.

Ordinary least squares (OLS) method is used for the estimation of hedonic pricing models in this research. In order to justify the use of OLS, it is important to discuss its underlying assumptions. The following discussion on the key assumptions refers to Verbeek (2012). The Gauss-Markov theorem and related assumptions have a central role in characterizing a standard case where OLS estimator has several desirable properties. These assumptions are:

- Assumption (A1): The expected value of the error term is zero.
- Assumption (A2): The error term and regressors are independent, meaning that the matrix of regressor values does not provide any information about the expected values of the error terms or their (co)variances.
- Assumption (A3): Homoskedasticity; all error terms have the same variance.
- Assumption (A4): No autocorrelation; zero correlation between different error terms.

Under the Gauss-Markov assumptions A1–A4 the OLS estimator is best linear unbiased estimator (BLUE) which means that we can assume it to be on average equal to the true value in repeated sampling. However, it can be proved based on assumptions A1–A2 that the OLS estimator is unbiased even if assumptions A3–A4 are violated and there is heteroscedasticity or autocorrelation present. The Gauss-Markov conditions present a simple case where small sample properties are easy to derive, and are not strictly needed to justify OLS. Considering asymptotic properties of the OLS estimator, many of the assumptions can be relaxed. Asymptotic properties refer to a case when sample size grows infinitely. Econometric estimators have asymptotically desirable properties, including normality. Importantly, these asymptotic properties can be used to approximate the properties in large finite samples.

As Verbeek (2012) states, in many cases it is hard to prove that an estimator is unbiased or an unbiased estimator may not even exist. However, according to Wooldridge (2013), there is a wide consensus among economists that consistency is a minimum requirement for an estimator for it to be useful. Thus, it is now more important to focus on the consistency than the unbiasness of the estimator. The OLS estimator can be shown to be

consistent under much weaker assumptions than the Gauss-Markov conditions A1–A4. These relaxed conditions for the consistent OLS estimator are the following:

- No perfect multicollinearity; there is no exact linear relationships among the regressors.
- Finity; variances of regressors are finite.
- The error term is mean zero and uncorrelated with any of the regressors.

Satisfying the assumptions for the consistent OLS estimator has been a primary guideline for specifying the models in this doctoral research. As Xiao (2017) states, neither economic theory nor original research papers on hedonic models provide direct instructions for specifying hedonic function. Consequently, several alternative functional forms and specifications should be examined before deciding on the final analysis model. As a result, specifications may often seem to be tailored for case-by-case purposes, and in addition to problematic selection of functional form, it is not clear what variables should be included in the model. According to Sirmans & al. (2005) semi-logarithmic functional form has historically been the most typical choice. This is understandable due to its distinct advantages compared to conventional linear functional form, but on the other hand surprising, since the presence of non-linear relationships should be rather widely recognized.

In this doctoral study, several different model specifications were tested before deciding on the final functional form and specification for each analysis. In all final model specifications, the independent variable was log transformed. In doing so, the estimated coefficients have a convenient percentage change interpretation. According to Wooldridge (2013), a model with logged dependent variable has also other distinct advantages; (i) being more likely linear, (ii) having lower probability for presence of heteroscedasticity, and (iii) having a higher propensity for normality. In other words, logged dependent variable creates better opportunities for satisfying OLS assumptions. Also, most of the positive continuous regressors were log transformed as it effectively reduces variation, making OLS estimates less sensitive to outliers.

It is good to pay attention to that researchers of two recent studies on Finnish data (Fuerst & al., 2016; Tyvimaa & al., 2015) have found it necessary to also include quadratic variables in their hedonic models. Specifically, adding quadratic variables allows capturing non-linear relationships, including increasing or decreasing effect of the variable (Wooldridge, 2013). For variables such as property age and unit size non-linear relationships are likely to occur, and thus including powered variables in the model would be well-founded. Model specifications including quadratic variables for age and unit size were also tested in this study. Since the estimated regression coefficients, and most importantly variables of interest, were in all cases robust to such changes in the functional form, the log-linear specifications were eventually selected as the final models. Even if model specifications with powered variables might be considered more sophisticated

options in this case, the selected model specifications seem to perform well and no indication of that the selected functional form would bias the results could be detected. However, some other concerns relating to the consistency of OLS estimator and statistical inference of the regression estimates will be discussed below.

First, an underlying assumption in ordinary least squares (OLS) estimation of a hedonic regression model is that all independent variables are exogenous. However, there is a potential risk that the variables of interest may be correlated with the error term, meaning they would be endogenous and violate this assumption. Usually, endogeneity arises as a result of omitted variables or simultaneous causality. Simultaneity refers to a situation in which there is a causal loop between the independent and a dependent variable, meaning that changes in the dependent variable cause changes in the independent variable, but simultaneously, also changes in an independent variable cause changes in the dependent variable. Addressing endogeneity is of great importance, as its presence adversely affects the validity of a causal inference. In this study, endogeneity issue is addressed in multiple ways, including a rich set of control variables, fixed-effects approach and matching techniques.

However, it is important to notice that the research design implicitly assumes that real estate developments are randomly assigned to their locations. However, there is a concern that new developments may not be randomly allocated, but rather respond to population and economic growth, avoiding economically struggling areas to locate in areas that are prospering. To mitigate such potential endogeneity concerns, yet another option to improve the research design could be introducing an instrumental variable (IV) strategy. A prerequisite for implementing IV strategy is finding an instrument that strongly correlates with the endogenous independent variable, but neither correlates with dependent variable nor the error term. After all, finding a good instrument may be a true challenge, while relying on a weak instrument could result in even greater bias of results. Thus, applicability of a selected instrument is often heavily disputed, and IV strategy was not applied to this doctoral thesis.

Second, heteroscedasticity is a common issue when estimating housing prices using a hedonic model. Heteroskedasticity means that error terms are mutually uncorrelated and variance may vary over the observations (Verbeek 2012). Thus, it violates the homoscedasticity assumption of Gauss-Markov theorem (A3). However, it is also important to recall that heteroskedasticity does not affect unbiasness or consistency of the OLS estimator. Instead, it results in inefficient estimator and biased standard errors. Bias in standard errors usually leads in excessively high statistical significance. To address this bias, heteroscedasticity consistent standard errors should be used for statistical inference instead of default standard errors. Usually, such treatment of error terms results in decreased statistical significance. To evaluate the impact of heteroskedasticity in the models of this doctoral research, tables 9–12, including statistical inference based on heteroscedasticity robust standard errors, have been appended to the end of this thesis.

Third, the spatial nature of the data used in this research arises a potential risk of spatial autocorrelation. Autocorrelation arises when error terms are correlated; considering housing prices, it would be expected that error terms are correlated within the neighborhood. Recalling the Gauss-Markov assumptions presented above, presence of autocorrelation violates assumption (A4). Again, it is important to remember that autocorrelation is not fatal to unbiasness or consistency of the OLS estimator, but it makes the estimator inefficient and results in biased standard errors, thereby directly affecting statistical inference. In terms of housing prices, spatial autocorrelation means that the price of a housing unit is simultaneously determined by prices of the surrounding units (Kim & al., 2003; Anselin & Lozano-Gracia, 2008; Cohen & Coughlin, 2008; Yu & al., 2012). According to Basu & Thibodeau (1998) there are two reasons for housing prices to be spatially autocorrelated: (i) neighborhoods are developed at the same time, thus, having similar structural characteristics, and (ii) housing units in the neighborhood share the same amenities, such as public schools. As the standard tests for statistical significance assume uncorrelated residuals, spatial autocorrelation in hedonic residuals violates this assumption, potentially resulting in inaccurate conclusions. If hedonic residuals are positively spatially autocorrelated, the resulting t-statistics will be biased upwards (Basu & Thibodeau, 1998), meaning that coefficient estimates that actually are not statistically significant may be interpreted as statistically significant. To address this, it is highly recommendable to test if the results hold after spatial clustering of standard errors; therefore, tables 9–12, including statistical inference based on within zip codes clustered standard errors, have been appended to the end of this thesis.

The applied research design attempts to address spatial autocorrelation by including locational fixed-effects in the hedonic model and clustering standard errors within zip codes. The neighborhood fixed-effects were selected to be controlled at zip code level as it is widely used method in the previous literature. However, instead of using zip codes as neighborhood controls, the analyses may have benefitted from controls at a more fine-grained level, such as a statistical grid. Furthermore, given the development of spatial econometrics, incorporating more advanced spatial econometric techniques in the analysis could potentially improve credibility of the results.

Fourth, presence of multicollinearity should be evaluated when considering the reliability of estimation results. Multicollinearity refers to a problem when an approximate linear relationship among regressors results in unreliable estimates (Verbeek 2012). However, it is good to notice that only perfect collinearity violates underlying assupmtions of OLS. As milder forms of multicollinearity do not directly violate any of the assumptions, the definition for the problem of multicollinearity is not quite clear (Wooldridge 2013). Variance inflation factor (VIF) is a widely used statistics to evaluate the presence of multicollinearity. Both Verbeek (2012) and Wooldridge (2013) state that VIF value 10 is often suggested as a rule of thumb cutoff value for multicollinearity. At the same time, they both emphasize that VIF value cannot directly affect the decision on whether a

variable of interest is dropped from the model. As Verbeek (2012) suggests evaluation of VIF values may be useful if results seem inconsistent and are potentially biased by multicollinearity. It is also important to understand that multicollinearity might only affect some coefficient estimates, and there is no need to be particularly worried if the VIFs are high for other than variables of particular interest. To evaluate the presence of multicollinearity in the models of this doctoral research, tables 9–12, including VIFs for the estimated variables, have been appended to the end of this thesis.

Estimating development impact requires underlying assumptions

Two of the articles included in this dissertation compare changes in property values close to a newly developed site relative to changes in property values farther away from the site. The first of them is focusing on senior house developments, and the second examines the impact from regular multi-story apartment building developments. The research strategy of both development impact papers relies on a combination of a sample matching technique and least squares estimation of a hedonic regression model.

The adopted approach aims at isolating the effect of new development activity as far as it is practically possible. It is important to notice that supporting infrastructure investments (such as roads, schools, retail etc.) often occur simultaneously with new housing development activity. To isolate new housing development impact from such confounding effects, complete property registries have been used to constrain the analysis to consider only such treatment observations that occur close to one new housing development at a time. Furthermore, no new housing developments at all are allowed close to treatment observations. These constraints notably decrease the risk of confounding effects. However, given that the recognition of potential confounding effects is fully based on property registries which do not contain information on all types of infrastructure provision, there is still a possibility that some confounding externalities may affect the estimation results.

Furthermore, the validity of the selected approach depends on certain assumptions, which are important to understand when interpreting the results:

i. It is assumed that neighborhood characteristics do not differ between neighborhoods close to the developed site and neighborhoods farther away (if they are located within the same zipcode).

ii. To allow comparison to counterfactual situation, it is assumed that changes in property values farther away from the site represent what the changes in property value would have been for the properties closer to the site before and after the development of the site.

iii. If the two previous assumptions are valid, it is possible to measure the effect of real estate development on surrounding residential property values using a hedonic-based difference-in-differences model.

There is a risk that the above mentioned underlying assumptions may not be fully valid in all cases. The main concern is that same zipcodes may sometimes include highly different environments, particularly after the gradual zipcode reforms have enlarged the code areas. Furthermore, there is no guarantee that, in all cases, the counterfactual situation of treatment observations would have followed the same trend as housing transactions outside the impact radius. However, to allow the analysis, these carefully chosen assumptions were necessary in lack of any better data. Thus, the assumptions are based on the best available data available at the time of the analysis, and the reported results can be considered reliable, provided that the reader understands the above described limitations.

Estimating relationship between development of building stock and socio-economic segregation

This study has been one of the first attempts to directly evaluate the relationship between development of building stock and socio-economic segregation. The reported results contribute to the knowledge of development of socio-economic segregation in major Finnish cities, and have the potential to be generalized to wider audience. However, being the first attempt for such analysis, there are several shortcomings and limitations that should be discussed before drawing any wider inferences. First, the definition for socio-economic segregation is not universal, and a different criteria for socio-economic segregation could affect the findings. Second, socio-economic segregation was studied in 250 m x 250 m grid layout, which is a problematic choice for many reasons. Such grid cells are relatively small units when considering real estate development, and consequently a development project could cover an entire cell or large proportion of it. In such cases, the impact of real estate development on socio-economic status derives from that people are moving in new buildings or moving out from old ones if they are torn down. Furthermore, developments often happen in clusters, and thereby impact that manifests in a single grid cell may actually be sum of many events in the surrounding cells. Therefore, proper understanding of the relationship between real estate development and socio-economic segregation requires analysis at larger scales.. Third, model specification leaves room for a serious risk of endogeneity and reverse causality. The people moving in and out, and thus also the development of socio-economic status, is directly dependent on the type of new developments. For example, if new single-family houses are delivered, the residents moving in will not be unemployed or among the lowest income groups. On the contrary, if social housing with income limits is developed the median income level is not likely to rise. Fourth, planning practices and public provision result in sluggishness which is not controlled for in the estimated model. Fifth, there should be more precise controls included for the characteristics of the development site as it is likely that impacts vary between different areas. Sixth, the variable of interest is defined as an indicator variable, getting value of one if the number of buildings of the specific type has changed. However, the real estate developments are of very different

sizes (e.g. single-family house vs. multi-story apartment block), and thus, they are not directly comparable. Another issue is that the variable does not capture replacement effects, but only if the number of buildings has changed. Seventh, multicollinearity may cause inflation of variance for the estimated coefficients. Eighth, there is also a phenomenonal challenge of managing segregation through real estate development. Revitalization of neighborhoods usually results in higher price and rent levels. Such price increase may sometimes force the poorest population groups to cheaper areas. However, this kind of gentrification and displacement would appear as a decrease in socio-economic segregation when studied at 250 m x 250 m grid level. Bearing these limitations in mind, one should be cautious about making any causal interpretations based on the estimated results.

Generalizability

Considering generalizability of the results, it is important to bear in mind the limitations discussed previously in this chapter. Furthermore, it is important to notice that, globally, there are notable differences between urban environments. For example, comparing Finland to the US reminds that the tools and institutions for both real estate development and generating public spaces differ drastically between these two countries. As a result, the challenges and outright problems that are sought to be alleviated with the urban development projects also differ to some extent. Bearing in mind that local regulations and market conditions may have a notable impact on the outcomes from real estate development, the results have the potential to be generalized to a broader audience. However, it is necessary that the above mentioned limitations are taken into consideration. In terms of generalizability, it is also noteworthy that the pattern of socio-economic segregation in major Finnish cities is still relatively moderate compared to many international locations. Thus, on one hand, Finland is a good example of a country that has managed to control undesired development of socio-economic segregation. However, on the other hand, at the current stage it would be reasonable to evaluate the sufficiency of implemented measures to prevent segregation as it will be a whole new ball game since the severity of spatial segregation has reached the next level as is the case, for example, in the neighboring country, Sweden.

5. Conclusions

In this section, the concluding remarks of this doctoral research are presented. First, the contribution to the real estate research is discussed, which is followed by practical implications of each individual research strand. Third, the quality and validity of this research is evaluated, and finally, some suggestions for the future research are presented.

5.1 Contributions to the real estate research

This research contributes to the current knowledge of impacts from real estate development, presenting findings and evidence on four relevant topics: (i) price impact from proportion of rental housing, (ii) development impact from senior houses, (iii) development impact from multi-story apartment buildings, and (iv) relationship between development of building stock and socio-economic segregation.

At present, there is a decent amount of literature on externalities, but still many relevant issues have not been properly addressed, including the topics selected for this dissertation. Providing such evidence is of great importance as real estate developments are substantial investments, and their impacts spill over to their surroundings affecting external third parties. Land use regulations and policies endeavor to control such spillovers (already Pigou (1920) stated that markets are ineffective whenever externalities are present) and steer development towards better built environment. Thus, it is important that policymakers and community stakeholders rather base their understanding on studied evidence than speculation. To address these needs, comprehensive quantitative data from major cities in Finland was analyzed, combining GIS techniques and advanced econometric methods. Relevant evidence that should be of wide interest of not only real estate academics but also policymakers and community stakeholders appeared from the analysis.

(i) The cost of housing is a relevant question in modern communities, taking a notable proportion of average people's income. Regularly, claims of negative externalities from rental housing and their negative impact on surrounding housing prices arise in the public debate. Despite the importance of the question, there has been very little reliable empirical evidence on the actual impacts. Under uncertainty, public debate has remained opinionated and feeling-based. In an attempt to take the discussion towards knowledge-based, the results of this thesis have shown that rental housing has imposed more negative than positive externalities on their surroundings, but at the same time, the magnitude of negative price impact has been relatively low and only minor depreciation may be linked to higher proportion of rental housing. Understanding this should dispel the prejudices against rental housing and help policymakers and land use planners to make better

decisions. Most importantly, however, the results contribute to a debate on an important policy question about if subsidization of home-ownership is justified.

(ii) Even as many countries, including Finland, are facing changes in demographic profile as population is getting progressively older and new types of senior house development are becoming more and more important, there has been very few empirical studies investigating the development impact of a senior house on surrounding residential property values. In lack of proper research design and data, previous studies have produced mixed results, creating uncertainty as to whether age-restricted housing developments exert any measurable effect on surrounding housing prices and if that effect is positive or negative. No research has specifically addressed the potential externality effect of market-rate age-restricted multi-family housing units. In addition, no research has isolated the influence of multi-family age-restricted buildings on the value of similar multi-family buildings without age restrictions. This doctoral thesis has addressed these shortcomings, suggesting that new senior houses are built in areas where housing prices are appreciated relatively higher. Also after the development, the prices of flats located close to new senior house developments remain higher than their comparables outside the impact radius. When also other types of developments are simultaneously allowed in the neighborhood, the price difference before and after development is estimated positive and statistically significant. The results should encourage urban planners and developers to include senior houses in their development strategies and help to mitigate prejudices that may potentially be linked to senior house developments.

(iii) Even as multi-story apartment building development proposals in existing residential areas represent a substantial component of policy debate at local planning boards, there has been limited evidence for the impact of residential development on surrounding flat prices. The majority of most closely related previous literature focuses on the value impact from low-income, affordable or supportive housing, whereas studies also including non-subsidized residential multi-story apartment developments are very few. Furthermore, the majority of the previous literature concentrates on studying the impact on single-family houses and there is very little literature focusing on the impact on owner-occupied apartment values. In this study, the focus is particularly on multi-story apartment building units that were built in 1960s and 1970s. This specific era has been of great importance in the development of Finnish building stock and, at present, revitalization and infill development of such neighborhoods is a political hot potato. Intuitively, one might consider that an increase in the supply of flats would result in depreciation of surrounding multi-story apartment units from earlier eras. However, no empirical evidence on any negative price impact is detected. This should mitigate prejudices against residential infill and, hopefully, shift the focus of the heated public debate from speculation to empirical evidence.

(iv) Means of preventing socio-economic segregation are of wide interest, and policy makers are desperately seeking for preventative policy tools to be implemented. Many

suburban development projects have been established to target socio-economic segregation, and at least in Finland, also entire development programs have been implemented to prevent segregation (e.g. Ministry of Environment, 2008). Despite socio-economic segregation has been widely examined, there seems to be lack of previous studies that would attempt to recognize how real estate development and socio-economic segregation are connected, and would base their findings on comprehensive quantitative data. This doctoral thesis has taken the first steps to this direction, in an attempt to recognize if there is a statistically significant relationship between development of building stock and socio-economic segregation. However, in the end, the choice of performing the analysis at 250 m x 250 m grid cell level proved to be problematic; thus, understanding the shortcomings of this first attempt and also recognizing the potential of real estate development to facilitate revitalized neighborhoods, more research on this topic is needed to properly understand the role of real estate development in addressing undesired outcomes at the neighborhood level.

5.2 Practical implications

This dissertation presents findings and evidence from four different strands of research. These strands address the impacts from proportion of rental housing, senior house development and delivery of multi-story apartment buildings in existing neighborhoods, and furthermore, relationships between real estate development and socio-economic segregation. In this chapter, these findings are positioned to existing policy frameworks and urban development strategies, paying also attention to wider demographic and economic trends that are influencing future development activity, such as urbanization and aging population. The aim is to effectively communicate the individual outcomes from the four stands of research and, specifically, detail how each component of the research impacts on policy and future urban development planning. Based on this doctoral contribution, the following practical implications are suggested:

(i) Usually, higher proportion of rental housing is linked to negative impact on housing prices. However, only minor depreciation was detected in this study. The results contribute to policy debate of whether home-ownership should be subsidized. The findings that only minor price difference is attributable to the higher proportion of rented accommodation, suggests that positive externalities from home-ownership may not outweigh the costs of subsidization – which is often considered fundamental to its justification. The results apply to multi-story apartment blocks, and consequently, to confirm this also for other housing types, future research is needed. Addressing subsidization of home-ownership may also affect other policy issues that are linked to homeownership, including distorted capital allocation, allegedly impeded mobility of home-owners (potentially resulting in higher unemployment rates), and that such subsidy is arguably mainly allocated to wealthier instead of lowest income groups. Considering the results of

this study, the externality perspective on subsidization of homeownership should be brought into discussion.

(ii) Urbanization is one of the recognized megatrends, pushing more and more people into the cities. To address this in a sustainable manner, infill development and denser urban structure have been adopted as a national strategy in Finland. At the same time, ageing population creates new challenges in many fields, making new types of senior house developments more and more important. In this study, senior houses were estimated to be built in areas where housing prices are appreciated relatively higher. Also, in the post-development period, flat prices in close proximity to senior house developments remained higher, albeit no statistically significant difference between pre- and post-development prices was detected. However, when also other types of developments were simultaneously allowed in the surroundings, post-development prices were found to be positive and statistically different from pre-development prices. These findings encourage adopting more integrated and systemic approaches to neighborhood development. Moreover, it may be suggested that urban planners and developers should include senior houses in their systemic development strategies. This could potentially result in win-win benefits, such as less opposition among senior residents as they will be provided with a chance to move into a new accessible home in their own neighborhood. At the same time, senior-tailored housing provides aging people a suitable environment to stay in their own home for longer, which may be considered great both from social perspective and also economically.

(iii) At present, many Finnish suburban neighborhoods are in need of renovation and facelift. Nationally adopted goal of infill development has been sought as a remedy in an attempt to find ways to finance the renovation of declining housing stock from 1960s and 1970s. Considering the impact of new residential multi-story apartment buildings on the prices of nearby flats is an essential part of the profitability equation; in this study, no evidence of any harmful effect in such cases was found. While these findings should alleviate concerns of the impacts of land use change, they do not, however, provide a clear incentive to initiate infill projects. In central areas, where market price of land is appreciated higher, a natural market-based incentive to sell unnecessary share of land and use income to finance necessary renovations may exist. However, in lower demand areas, like most of Finnish suburbs, such market-based incentives do not exist. Therefore, new powerful incentives may need to be introduced if the intention is that the national goal of large scale infill is also implemented in Finnish suburbs.

(iv) The Finnish national policies aim at mitigating inequality. From the spatial perspective, socio-economic segregation has been recognized to be a relatively permanent phenomenon. Thereby, implementing proactive measures may be considered more recommendable than challenging mitigation attempts when the

problems have already turned into critical. The analyzed indicators suggest that spatial segregation has increased in major Finnish cities in the 21st century but, however, the pace has remained relatively low. This may be interpreted so that attempts to control detrimental impacts of spatial segregation seem to have worked relatively well. At the same time, it is important to notice that immigration of low-income groups from abroad to Finland has been very modest compared to many other countries. However, considering yet lower birth rates and original population's reluctance to low-income jobs, Finnish economy is likely to need boost from higher amount of immigrants in the coming years. Such development is likely to increase risk for spatial segregation. Given this and knowing that integrating notably large amount of immigrants in the society is increasingly challenging, a clear strategy should be prepared and implemented.

In this study, it is recognized that mechanisms through which real estate development affects indicators of socio-economic segregation at grid cell level are mainly linked to what kind of people move in and out because of the new development. Real estate development may also provide noteworthy larger scale opportunities to revitalize neighborhoods and prevent adverse effects of segregation at neighborhood level but, at the same time, potentially resulting in gentrification. However, at this point, it is important to notice that the analysis at grid cell level does not address such larger-scale impacts and, therefore, does not provide adequate evidence to support long-term decision-making. Consequently, more research on different scales (e.g. neighborhood level), is needed to properly understand the bounds of possibilities. In any case, it is important to understand that real estate development does not directly provide means to address the underlying root causes of socio-economic segregation.

In general level, this research has through the practical examples above shown that by combining and analyzing data by innovative ways, useful knowledge can be brought forward to decision making. Nevertheless, how to better understand and create such processes that facilitate the desired development of spatial structure and urban form, remains as a challenge for future urban development. To address this challenge, development should be based on a systemic analysis-based approach, taking full advantage of the opportunities provided by constantly increasing availability of data.

5.3 Evaluation of the research

The objective of this doctoral research is to extend understanding on impacts of externalities deriving from real estate development. In order to do so, four central gaps in the knowledge were selected to be addressed, including externality impacts deriving from (i) proportion of rental housing, (ii) senior house development and (iii) multi-story apartment building development, and (iv) relationship between development of building stock and socio-economic status in the neighborhood. The selected themes were

addressed through four blind peer-reviewed journal articles, and each of the papers attempted to answer to a specific research question.

The first question asked: *What impact does the proportion of rented flats have on residential property values within the neighborhood?* The research paper addressing this question was validated through scientific double-blind review and provided empirical evidence of the direction and magnitude of the impact that proportion of rental housing has on its surroundings when measured by neighborhood housing prices.

The second question asked: *Do market-rate age-restricted multi-family housing developments exert any measurable effect on the value of similar multi-family buildings without age restrictions?* The research paper addressing this question was validated through scientific double-blind review and provided empirical evidence of the direction and magnitude of the impact that development of new senior houses has on its surroundings when measured by nearby housing prices.

The third question asked: *Do multi-story apartment building developments have a measurable impact on the prices of flats in existing multi-story apartment blocks from 1960s and 1970s?* The research paper addressing this question was validated through scientific double-blind review and provided empirical evidence of the direction and magnitude of the impact that development of new multi-story apartment blocks has on its surroundings when measured by nearby flat prices.

The fourth question asked: *Has socio-economic segregation increased in major Finnish cities in the 21st century, and is there a link between building stock and socio-economic segregation?* The research paper addressing this question was validated through scientific triple-blind review and provided empirical evidence of (i) development of socio-economic segregation in major Finnish cities, and (ii) relationship between building stock and socio-economic status in the neighborhood.

Given the above, the contribution of this doctoral thesis can be considered scientifically valid. Furthermore, the results from each appended research paper fill a relevant gap in the knowledge, and should be of interest of not only academics but also a wide range of policy makers and stakeholders. Thus, the goal of providing valid and reliable information to serve the needs of urban real estate development was achieved.

5.4 Suggestions for future research

This doctoral research has contributed to knowledge of externalities from real estate development, specifically focusing on impacts on housing values and socio-economic segregation. Only a very limited number of research questions may be properly addressed in a single doctoral thesis. While, the scope of impacts arising from real estate development is wide. Thus, the topic provides many future research ideas of which the most topical ones are shortly presented below.

First, only major Finnish cities with positive net migration have been under scrutiny in this research. However, dynamics of real estate development, and consequently, also the findings may differ in cities with negative migration. Thus, also studies on such cities are needed to establish a proper understanding of impacts under different circumstances.

Second, in this thesis, the housing value impact has only been studied from residential real estate developments. However, impact of other property types, such as retail or health care may impose even more complex externalities on their surroundings, and the outcomes should be studied also in the Finnish context. Furthermore, there would be need for a study that focuses on the development impact of ARA-subsidized housing and compares if the outcomes differ from what would be expected based on the results from estimations of proportion of rental housing. There is also need to study the impact of proportion of rental housing on the prices of other residential property types than multi-story apartment blocks.

Third, in an attempt to isolate the impacts from single real estate development projects, the shortcoming of this study is that it does not take a stand on neighborhoods where several simultaneous development projects have occurred. On the one hand, such neighborhoods may experience greater positive effects, but on the other, establishing causal links based on numerical analysis, and providing reliable empirical evidence may be challenging. As causal relationships pertaining to real estate development are complex, and research data rarely (if ever) allows controlling for all significant neighborhood characteristics, it is likely that some essential factors escape the numerical analysis. Thus, triangulation using qualitative approach and specific case studies selected based on purposive sampling might be useful in the future.

Fourth, in terms of policy making, also the latest data on socio-economic variables should be studied, to find out if the pattern has recently changed. Also, alternative criteria to define socio-economic segregation, and different scales of the grid layout should be analyzed to better understand the dynamics of socio-economic segregation. As there has been relatively little research on the relationship between real estate development and development of socio-economic segregation, there is a need to further develop the research design to overcome potential endogeneity issues.

Fifth, due to the spatial nature of research data, methodically, incorporating more fine-grained spatial econometric techniques in the analysis could improve the reliability of the results. Thus, it is advisable that future research would pay more attention to addressing the potential biases deriving from spatial autocorrelation.

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Appendices

Appendix 1: *Table 9. Statistical inference based on heteroscedasticity robust (HC) and within zip code clustered standard errors for Table 1. Variance inflation factors (VIF) are reported for the evaluation of presence of multicollinearity.*

Dependent variable: ln(*Sale price*)

Variable	*Coefficient*	*(t-stat)*	*(HC t-stat)*	*(Clustered t-stat)*	*VIF*
Intercept	9.688	*** (919.1)	*** (919.1)	*** (80.2)	0.00
ln(Property age)	-0.071	*** (-52.8)	*** (-52.8)	*** (-4.4)	3.71
ln(Unit size)	0.785	*** (582.2)	*** (582.2)	*** (42.1)	1.49
ln(Building size)	-0.019	*** (-22.2)	*** (-22.2)	*** (-4.2)	1.47
ln(Weeks on market)	-0.043	*** (-84.5)	*** (-84.5)	*** (-17.5)	1.87
Community loan: LTV	0.215	*** (33.8)	*** (33.8)	*** (7.5)	2.07
ln(Maintenance fee)	-0.007	*** (-11.8)	*** (-11.8)	*** (-4.3)	1.28
Floor	0.010	*** (37.7)	*** (37.7)	*** (9.1)	1.16
I{New construction}	0.120	*** (33.8)	*** (33.8)	*** (5.5)	2.75
I{Sauna}	0.119	*** (73.7)	*** (73.7)	*** (10.4)	1.82
I{Property condition: Acceptable}	-0.084	*** (-81.9)	*** (-81.9)	*** (-40.1)	1.18
I{Property condition: Poor}	-0.167	*** (-75.9)	*** (-75.9)	*** (-41.9)	1.08
I{Property condition: Unavailable}	-0.047	*** (-26.2)	*** (-26.2)	*** (-9.3)	1.13
I{Land lease}	-0.056	*** (-32.4)	*** (-32.4)	*** (-7.3)	2.32
I{Proportion of rented flats: 0-25 %}	0.005	*** (3.9)	*** (3.9)	* (1.9)	1.48
I{Proportion of rented flats: >50-75 %}	-0.011	*** (-7.9)	*** (-7.9)	* (-1.8)	1.26
I{Proportion of rented flats: >75 %}	-0.013	*** (-4.3)	*** (-4.3)	(-0.6)	1.14
Year indicators:	Included (14 variables)				
Sub-market indicators:	Included (147 variables)				
Adjusted R^2:	90.87 %				
Observations:	105,502				

Appendix 2: *Table 10. Statistical inference based on heteroscedasticity robust (HC) and within zip code clustered standard errors for Table 2. Variance inflation factors (VIF) are reported for the evaluation of presence of multicollinearity.*

Dependent variable: ln(*Sale price*)

Proportion of rented flats:	0-25 %					>50-75 %					>75 %				
Estimated matched sample:	(1)					(2)					(3)				
Variable	*Coefficient*	*(t-stat)*	*HC*	*Clustered*	*VIF*	*Coefficient*	*(t-stat)*	*HC*	*Clustered*	*VIF*	*Coefficient*	*(t-stat)*	*HC*	*Clustered*	*VIF*
Intercept	10.282 ***	(485.7) ***	(335.4) ***	(63.9)	0.00	9.769 ***	(463.6) ***	(404.3) ***	(65.7)	0.00	10.407 ***	(129.6) ***	(93.6) ***	(49.0)	0.00
ln(Property age)	-0.124 ***	(-64.3) ***	(-43.2) ***	(-8.6)	3.45	-0.061 ***	(-27.9) ***	(-22.5) ***	(-3.0)	4.14	-0.090 ***	(-20.8) ***	(-16.6) ***	(-3.1)	4.33
ln(Unit size)	0.680 ***	(135.9) ***	(89.8) ***	(18.5)	8.77	0.745 ***	(162.1) ***	(133.8) ***	(27.3)	6.26	0.640 ***	(42.2) ***	(25.1) ***	(16.4)	7.22
ln(Building size)	-0.013 ***	(-11.9) ***	(-9.6) **	(-2.2)	1.54	-0.016 ***	(-11.2) ***	(-10.2) ***	(-2.9)	1.42	-0.026 ***	(-7.0) ***	(-6.5) ***	(-2.9)	1.75
ln(Weeks on market)	-0.041 ***	(-59.1) ***	(-55.8) ***	(-15.8)	1.89	-0.043 ***	(-49.2) ***	(-46.0) ***	(-10.2)	1.95	-0.038 ***	(-17.5) ***	(-16.7) ***	(-4.7)	1.86
ln(Number of rooms)	0.031 ***	(7.6) ***	(5.4)	(1.5)	8.11	0.003	(0.9)	(0.8)	(0.3)	5.66	0.037 ***	(3.0) *	(1.8) *	(1.7)	6.83
Community loan: LTV	0.120 ***	(14.3) ***	(9.4) ***	(2.9)	2.21	0.243 ***	(25.3) ***	(14.2) ***	(6.7)	2.18	0.253 ***	(12.7) ***	(8.3) ***	(3.2)	2.17
ln(Maintenance fee)	-0.007 ***	(-9.6) ***	(-7.3) ***	(-3.9)	1.23	-0.007 ***	(-6.5) ***	(-4.5) **	(-2.5)	1.33	-0.005 **	(-2.1)	(-1.4)	(-1.0)	1.30
Floor	0.008 ***	(22.3) ***	(21.0) ***	(6.4)	1.16	0.011 ***	(24.9) ***	(20.8) ***	(6.6)	1.18	0.012 ***	(10.5) ***	(10.3) ***	(3.6)	1.25
I{New construction}	0.061 ***	(13.1) ***	(8.0) **	(2.4)	3.02	0.133 ***	(23.8) ***	(16.8) ***	(4.0)	3.01	0.097 ***	(9.1) ***	(6.3) *	(1.9)	3.45
I{Sauna}	0.110 ***	(54.9) ***	(45.9) ***	(8.9)	1.99	0.118 ***	(43.9) ***	(38.6) ***	(8.8)	1.95	0.093 ***	(15.1) ***	(13.6) ***	(6.5)	2.17
I{Property condition: Acceptable}	-0.076 ***	(-56.4) ***	(-59.0) ***	(-45.5)	1.20	-0.087 ***	(-49.8) ***	(-51.4) ***	(-31.6)	1.21	-0.087 ***	(-19.1) ***	(-21.6) ***	(-16.8)	1.33
I{Property condition: Poor}	-0.166 ***	(-48.0) ***	(-41.2) ***	(-29.7)	1.06	-0.173 ***	(-46.1) ***	(-45.9) ***	(-36.2)	1.09	-0.190 ***	(-16.4) ***	(-13.4) ***	(-12.3)	1.09
I{Property condition: Unavailable}	-0.041 ***	(-18.2) ***	(-18.6) ***	(-10.9)	1.13	-0.052 ***	(-17.5) ***	(-16.6) ***	(-7.2)	1.14	-0.020 **	(-2.6) **	(-2.6) *	(-1.7)	1.20
I{Land lease}	-0.044 ***	(-19.9) ***	(-20.5) ***	(-5.8)	2.47	-0.057 ***	(-21.8) ***	(-20.6) ***	(-6.0)	2.29	-0.044 ***	(-6.5) ***	(-6.7) *	(-1.9)	2.88
I{Proportion of rented flats: 0-25 %}	0.010 ***	(8.1) ***	(8.0) ***	(3.2)	1.11	-	-	-	-	-	-	-	-	-	-
I{Proportion of rented flats: >50-75 %}	-	-	-	-	-	-0.014 ***	(-9.0) ***	(-8.9) **	(-2.2)	1.02	-	-	-	-	-
I{Proportion of rented flats: >75 %}	-	-	-	-	-	-	-	-	-	-	-0.029 ***	(-7.3) ***	(-7.2) *	(-1.7)	1.09
Year indicators:	Included (14 variables)					Included (14 variables)					Included (14 variables)				
Sub-market indicators:	Included (142 variables)					Included (137 variables)					Included (133 variables)				
Adjusted R^2:	89.77 %					89.42 %					88.27 %				
Observations:	49,556					36,376					5,996				

**** = 1 % significance level, ** = 5 % significance level, * = 10 % significance level*

Appendix 3: *Table 11. Statistical inference based on heteroscedasticity robust (HC) and within zip code clustered standard errors for Table 3. Variance inflation factors (VIF) are reported for the evaluation of presence of multicollinearity.*

	(1)					(2)					(3)				
Variable	*Coefficient*	*(t-stat)*	*HC*	*Clustered*	*VIF*	*Coefficient*	*(t-stat)*	*HC*	*Clustered*	*VIF*	*Coefficient*	*(t-stat)*	*HC*	*Clustered*	*VIF*
Intercept	8.961 ***	(160.0) ***	(141.1) ***	(40.5) ***	0.00	8.967 ***	(150.0) ***	(124.8) ***		0.00	9.001 ***	(138.4) ***	(113.9) ***	(43.1) ***	0.00
ln(Property age)	-0.055 ***	(-13.0) ***	(-5.3) ***	(-4.1) ***	3.69	-0.052 ***	(-11.4) ***	(-4.3) ***	(-3.5) ***	3.89	-0.067 ***	(-11.4) ***	(-10.5) ***	(-5.7) ***	2.30
ln(Unit size)	0.713 ***	(52.0) ***	(43.0) ***	(14.3) ***	5.94	0.703 ***	(47.8) ***	(40.0) ***	(14.4) ***	5.92	0.689 ***	(41.2) ***	(32.5) ***	(21.8) ***	6.49
ln(Building size)	0.024 ***	(6.2) ***	(5.8) *	(1.8)	1.72	0.025 ***	(6.2) ***	(5.6) *	(1.7)	1.77	0.040 ***	(9.1) ***	(8.1) ***	(3.1) ***	2.16
ln(Weeks on market)	-0.025 ***	(-11.0) ***	(-11.9) ***	(-7.5) ***	2.18	-0.026 ***	(-10.6) ***	(-12.0) ***	(-8.8) ***	2.20	-0.026 ***	(-9.6) ***	(-9.3) ***	(-9.5) ***	2.20
ln(Number of rooms)	0.033 ***	(3.1) **	(2.5)	(1.3)	5.58	0.038 ***	(3.3) ***	(2.7)	(1.3)	5.55	0.042 ***	(3.3) ***	(2.6) *	(1.8)	5.95
Floor number	0.010 ***	(8.4) ***	(8.6) ***	(4.9) ***	1.24	0.010 ***	(8.1) ***	(8.7) ***	(4.2) ***	1.24	0.009 ***	(6.3) ***	(6.2) ***	(3.4) ***	1.35
I{New construction}	0.094 ***	(10.6) ***	(9.7) ***	(3.0) ***	3.15	0.085 ***	(8.7) ***	(8.0) **	(2.4) **	3.28	0.200 ***	(11.6) ***	(10.0) ***	(6.9) ***	1.68
I{Sauna}	0.193 ***	(33.6) ***	(16.4) ***	(12.3) ***	2.09	0.202 ***	(32.0) ***	(14.7) ***	(10.9) ***	2.10	0.200 ***	(28.0) ***	(26.3) ***	(16.9) ***	1.90
I{Elevator}	0.064 ***	(9.0) ***	(9.7) ***	(3.8) ***	2.62	0.058 ***	(7.5) ***	(8.4) ***	(3.6) ***	2.56	0.021 **	(2.4) **	(2.3) **	(2.5) **	2.24
I{Condition: Acceptable}	-0.091 ***	(-18.1) ***	(-21.7) ***	(-21.3) ***	1.22	-0.099 ***	(-18.1) ***	(-22.1) ***	(-16.5) ***	1.23	-0.091 ***	(-16.5) ***	(-16.7) ***	(-13.2) ***	1.18
I{Condition: Poor}	-0.167 ***	(-9.8) ***	(-12.3) ***	(-16.4) ***	1.03	-0.180 ***	(-9.8) ***	(-11.4) ***	(-12.7) ***	1.03	-0.183 ***	(-10.4) ***	(-10.2) ***	(-8.2) ***	1.04
I{Condition: Unavailable}	-0.023 ***	(-3.4) ***	(-2.8) **	(-2.0) **	1.11	-0.039 ***	(-5.2) ***	(-5.6) ***	(-3.0) ***	1.12	-0.056 ***	(-7.1) ***	(-7.1) ***	(-4.6) ***	1.17
I{Land lease}	-0.014 ***	(-2.6)	(-1.6)	(-0.6)	1.85	-0.014 **	(-2.5)	(-1.5)	(-0.6)	1.83	-0.046 ***	(-6.6) ***	(-6.3) ***	(-2.3) **	2.21
Proximate*Period$_{t-2}$	-0.006	(-0.8)	(-0.9)	(-0.3)	1.27	-0.005	(-0.6)	(-0.7)	(-0.2)	1.29	0.028 ***	(3.2) ***	(3.5) ***	(3.5) ***	1.30
Proximate*Period$_{t-1}$	0.002	(0.3)	(0.3)	(0.1)	1.15	0.004	(0.4)	(0.5)	(0.2)	1.16	0.005	(0.5)	(0.5)	(0.4)	1.24
Proximate*Period$_{t}$	0.016 **	(2.5) **	(2.4)	(1.1)	1.28	0.015 **	(2.2) **	(2.1)	(1.0)	1.29	0.019 ***	(2.6) ***	(2.8)	(1.5)	1.26
Proximate*Period$_{t+1}$	0.021 **	(2.5) ***	(2.8)	(1.5)	1.14	0.025 ***	(2.8) ***	(3.0) *	(1.8)	1.14	0.039 ***	(3.8) ***	(4.2) ***	(3.0)	1.13
Proximate*Period$_{t+2}$	0.041 ***	(6.2) ***	(7.5) ***	(4.0)	1.28	0.045 ***	(6.1) ***	(7.2) ***	(4.3)	1.30	0.046 ***	(5.3) ***	(5.3) ***	(3.4)	1.26
Year indicators:	Included (14 variables)					Included (14 variables)					Included (14 variables)				
Sub-market indicators:	Included (21 variables)					Included (19 variables)					Included (19 variables)				
Adjusted R^2:	87.19 %					88.06 %					91.82 %				
Observations:	7,366					6,258					3,312				

Appendix 4: *Table 12. Statistical inference based on heteroscedasticity robust (HC) and within zip code clustered standard errors for Table 4. Variance inflation factors (VIF) are reported for the evaluation of presence of multicollinearity.*

	Base model					Spline regression				
Variable	*Coefficient*	*(t-stat)*	*HC*	*Clustered*	*VIF*	*Coefficient*	*(t-stat)*	*HC*	*Clustered*	*VIF*
Intercept	9.920 ***	(77.9) ***	(79.2) ***	(34.1)	0.00	9.863 ***	(77.2) ***	(77.5) ***	(32.3)	0.00
ln(Property age)	-0.141 ***	(-6.1) ***	(-6.0) **	(-2.6)	11.09	-0.134 ***	(-5.8) ***	(-5.7) **	(-2.3)	11.13
ln(Unit size)	0.578 ***	(59.2) ***	(50.8) ***	(10.6)	12.20	0.577 ***	(59.3) ***	(51.1) ***	(10.8)	12.20
ln(Building size)	-0.022 ***	(-7.0) ***	(-6.5) ***	(-3.1)	3.19	-0.017 ***	(-5.3) ***	(-4.8) **	(-2.2)	3.44
ln(Weeks on market)	-0.018 ***	(-14.0) ***	(-14.4) ***	(-3.3)	2.67	-0.017 ***	(-13.5) ***	(-14.3) ***	(-3.4)	2.69
Community loan: LTV	0.349 ***	(13.4) ***	(6.8) ***	(2.7)	1.52	0.357 ***	(13.8) ***	(7.0) ***	(2.7)	1.53
ln(Maintenance dues)	-0.001	(-0.7)	(-0.7)	(-0.5)	1.63	-0.001	(-0.5)	(-0.6)	(-0.4)	1.63
Floor number	0.006 ***	(9.7) ***	(9.8) ***	(3.3)	1.37	0.006 ***	(9.7) ***	(9.9) ***	(3.3)	1.37
I{Sauna}	0.031 ***	(3.3) ***	(3.2) *	(1.7)	1.49	0.031 ***	(3.3) ***	(3.2) *	(1.7)	1.49
I{Condition: Acceptable}	-0.077 ***	(-32.9) ***	(-31.6) ***	(-12.8)	1.72	-0.079 ***	(-33.3) ***	(-31.9) ***	(-13.1)	1.76
I{Condition: Poor}	-0.165 ***	(-29.5) ***	(-23.4) ***	(-23.0)	1.41	-0.166 ***	(-29.7) ***	(-23.5) ***	(-23.8)	1.42
I{Condition: Unavailable}	-0.053 ***	(-13.0) ***	(-12.0) ***	(-9.0)	2.18	-0.050 ***	(-12.3) ***	(-11.4) ***	(-9.5)	2.21
I{Land lease}	0.010 **	(2.4) **	(2.0)	(1.0)	3.68	0.008 *	(1.8)	(1.5)	(0.7)	3.73
I{1 Room}	-0.036 ***	(-6.3) ***	(-6.0) ***	(-2.7)	5.68	-0.036 ***	(-6.4) ***	(-6.1) ***	(-2.7)	5.68
I{3 Rooms}	0.043 ***	(9.3) ***	(8.0) ***	(3.9)	3.65	0.043 ***	(9.4) ***	(8.2) ***	(4.1)	3.66
I{4 Rooms}	0.147 ***	(19.1) ***	(15.0) ***	(3.6)	3.36	0.148 ***	(19.1) ***	(15.1) ***	(3.6)	3.36
Close	-0.014 ***	(-3.5) ***	(-3.3)	(-1.3)	4.76	-0.022 ***	(-2.7) ***	(-3.1)	(-1.1)	20.61
Close*After	0.023 ***	(3.5) ***	(3.2)	(1.3)	13.33	0.031 ***	(3.2) ***	(3.4)	(1.3)	28.64
Close*After*Trend	0.001	(1.2)	(1.2)	(0.7)	9.30	-0.008	(-1.4)	(-1.5)	(-1.0)	614.24
Spline 1						-0.005 ***	(-3.2) ***	(-3.3)	(-1.2)	9.46
Spline 2						0.008	(1.6) *	(1.7)	(1.2)	644.11
Zip-quarter indicators:	Included (977 variables)					Included (977 variables)				
R^2:	93.85 %					93.88 %				
Adjusted R^2:	93.02 %					93.05 %				
Observations:	8,363					8,363				

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