Aalto University
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LIFT INSTALLATION AND HOUSING PRICES

Master´s Thesis
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Abstract

The number of the elderly citizens in increasing from 1.2 million to 1.5 million in the next ten years. The policy-makers are executing actions to ensure decent housing circumstances for the physically restricted. One of these actions is to grant subsidies for lift installations to residential block of flats. The Finnish legislation determines the higher floor tenants to pay a higher share of the installation costs. However, the economic effects of the lift installations have not been answered in the literature. If the property value increase would exceed the installation costs, a threat of an undesirable outcome of the subsidy would become prominent. Moreover, if the property prices would not increase as the floor level increases, the legislation would turn out unequal.

This thesis studies how much the lift installations affect the housing prices by utilizing a hedonic pricing model with difference in differences setup. I use an extensive dataset provided by the Central Federation of Real Estate Agencies in Finland containing the majority of transactions in blocks of flats between years 2000-2018. The main finding is two percent price premium due to lift installation. On average, it brings between two and four thousand euros for the apartment owner that has an average-priced apartment in a block of flats without a prior lift. My evidence suggests that the effect of lift installation on prices increases as the floor level increases until the fifth floor. No evidence about heterogeneous effects by municipalities were found. An exception is Oulu, where the effect has been six percent.

This study mitigates the threat of undesirable outcomes of the policy. The subsidy recipients are still facing higher installation costs compared to property value increase. In addition, the study indicates the current legislation to treat the households more equally compared to evenly allocated costs. However, the cost allocation could be improved more equal by flattening increase rate of multipliers in the cost allocation principle.

Keywords Hedonic Pricing Model, Lift Installation, Difference in Differences

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Ikäihmisten määrä on kasvamassa 1,2 miljoonasta 1,5 miljoonaan seuraavan kymmenen vuoden aikana. Yhteiskunnalliset päätökset ovat pyrkineet takaamaan kelvolliset asuinolot jokaiselle ikäihmiselle. Yksi keinoista on jälkiasennettujen hissien asennuksen rahallinen tukeminen asuinkerrostaloihin, joissa ei ole ennestään hissiä. Suomen laki ohjaa korkeampien kerrosten asukkaat maksamaan suuremman osuuden jälkiasennetun hissin asentamisesta. Kuitenkaan, hissin taloudellisia vaikutuksia ei olla tutkittu aiemmassa kirjallisuudessa. Mikäli hissin asentaminen nostaa asuntojen hintoja enemmän kuin sen asentamisen kustannukset ovat, tukipolitiikka voi johtaa epätoivottuihin tulonsiirtoihin. Mikäli arvonnousu ei kasva kerrosluvun myötä, nykyinen kustannusten jakaminen voi osoittautua epätasa-arvoiseksi.

Tässä tutkielmassa selvitetään, kuinka paljon asunnon arvo nousee hissin asentamisen seurauksena käyttäen hyväksi difference in differences -tutkimusasetelmaa. Tutkimus hyödyntää Kiinteistönvälitysalan Keskusliiton tilastoimia asuntokauppoja vuosilta 2000-2018. Tutkimuksen päälöydos on kahden prosentin hintamuutos hissin asentamisen seurauksena. Keskimäärin, hissin asentaminen kasvattaa tavallisten kerrostaloasuntojen arvoa kahdesta tuhannesta eurosta neljään tuhanteen saakka. Tulokset osoittavat, että arvonnousu kasvaa kerroksittain neljänteen kerrokseen saakka. Kunnittain tehdyssä vertailussa ei havaittu, että hintavaikutus poikkeaisi tilastollisesti merkitsevästi keskimääräisestä vaikutuksesta. Oulu on poikkeus kuuden prosentin arvonnousulla.

Tutkimus osoittaa, ettei jälkiasennettua hissiä kannata asentaa vain kiinteistön arvonnousun takia. Tämä pienentää riskiä siitä, että tukipolitiikalla olisi epätoivottuja vaikutuksia. Lisäksi tutkimus osoittaa, että nykyinen hissin asentamisen kustannusten jako on tasa-arvoisempaa verrattuna kustannusten tasaiseen jakamiseen asuntojen kesken. Kuitenkin, kustannusten jako olisi vielä tasa-arvoisempaa jos kustannusten osuuden nousu kerrosluvun kasvaessa olisi nykyistä maltillisempaa.

Avainsanat Hedoninen Hinnoittelumalli, Jälkiasennettu Hissi, Difference in Differences

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1. INTRODUCTION

The Ministry of Environment started a program in 2013 to improve housing circumstances for the elderly. Projections about increasing amount of elderly citizens, and their expected housing circumstances without policy actions created the motivation for the extensive program. The length of the program was four years, and it involved multiple organizations from the public and private organizations. The Housing Finance and Development Centre of Finland (Ara), Association of Finnish Municipalities (Kuntaliitto), and Finnish Environment Institute (SYKE) had main responsibilities in the program execution. As part of the program, a nationwide lift subsidy was advertised for private housing condominiums to increase lift installations in blocks of flats without prior lifts. In 17 municipalities, teams were gathered with a purpose to prospect and inform the housing condominiums about possibilities to install a lift. The teams consisted of the municipality officials who worked at the housing sector. Some municipalities introduced their additional subsidy on top of the nationwide subsidy.

Accessible housing increases utility for the physically restricted. Those who live in inaccessible buildings with physical restrictions, are not able to go to grocery stores, common saunas, or visit their friends or families. Lift is considered being the most important component of increasing accessibility in a building (Kotilainen et. al, 2016). With assistance devices, such as wheelchairs, it is almost impossible to move the stairs. Even without any assistance devices, it requires a higher effort to go vertically rather than horizontally. Consequently, stairs tend to become obstacles, even though walking on flat surfaces was possible.

The housing stock conversion accessible with lift installations seems to have positive externalities. First, the risk of injuries decrease, which decreases medical care costs. Second, enabling accessible living for everyone in society may increase utility for rest of the population. Without subsidizing the lift installations, alternative options were for example relocating the physically restricted to a retirement home or providing other accessible housing, such as a dwelling from a municipality owned housing company.

However, the subsidy could potentially lead to socially undesirable outcomes. If the subsidy recipients had wealth to buy accessible housing in case of physical restrictions, the subsidy would become an unnecessary income transfer. For example, if the student housing company would receive the subsidies, the target of the policy would not fulfill its purposes. The threat of socially undesirable outcomes would become prominent if the property value increase would exceed the subsidized lift installation costs. In that scenario, every block of flat without a lift should theoretically invest in lifts.

As a part of hedonic pricing literature, my main intention in this thesis is to estimate the effect of lift installations on housing prices. I have not found efforts from the previous literature trying to estimate the abovementioned effect. Consequently, the study fills a gap in real estate hedonic pricing literature and provides perspectives for policy-makers when evaluating the lift subsidy. In this thesis, I refer lift installations as those, that are conducted in buildings without prior lifts. I utilize difference in differences setup with the majority of dwelling transactions conducted in blocks of flats in Finland between 2000 – 2018.

The Finnish law for the housing condominiums determines the principles of cost allocation of a lift installation (AOYL 6/32 §3). The maintenance charge allocation score multiplied by floor level determines the portion of costs. For example, if the apartments in a stairway were similar, the fourth floor tenants pay four times higher charges compared to the first floor tenants. The implicit assumption of the law is that utility from a lift increases linearly as the floor gets higher. Unfortunately, no one knows whether this assumption holds in reality creating possibly unequal cost allocation for the tenants. I study how much lift installation affects prices across the floors.

The municipalities differ in their generosity to pay additional lift subsidy. Oulu is the most generous one offering 20% additional subsidy, whereas Lahti does not grant additional subsidies. Some municipalities find the conversion of the existing housing stock accessible so important, that they have officials advising the housing condominiums in the lift installation process. I also study the effect of lift installation in eight municipalities.

My main result is that a lift installation increases dwelling prices by two percent. I find increasing lift premiums as the floor level increases until the fourth floor. Eight municipalities (Helsinki, Espoo, Turku, Tampere, Lahti, Jyväskylä, Kuopio, and Oulu) were studied. I cannot confirm that the effects were heterogenous from the average two percent in seven municipalities. An exception is Oulu, where lift premium is six percent.

My research mitigates the concern of undesirable outcomes of the subsidy policy. An indicative calculation shows, that property value increase unlikely exceeds the subsidized installation. From the other perspective, the housing condominiums can cover almost 50 percent of their subsidized installation costs after the property values increase. I find evidence that the current cost allocation principle is more equal for the households compared to a method, where installation costs were evenly distributed. However, the cost allocation could be more equal for the households, if the cost allocation multipliers increased slower than they currently do as the floor level increases.

For the study, I have interviewed experts who have the most knowledge regarding lift installations. Simo Merilä is a lift installation officer[1] from municipality of Helsinki. Furthermore, I have interviewed representatives of Ara and Ministry of Environment in Finland, but they are not referred in this thesis. I have divided this study into seven sections. Section 2 provides a short review for the hedonic pricing literature. Section 3 represents the Finnish housing market characteristics, and the subsidy policy. Discussion about the subsidy policy is provided. Section 4 gives perspective about the reliability of the results, justifies my assumptions in identification of lift installations, and helps the following researchers to do a replication of this study. In section 5, I represent the empirical model. Section 6 report the results and implications of the study. Section 7 summarizes the thesis. From the appendix, you can find fully reported regression tables and other material related to the topic.

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[1] The official title is Helsingin Hissiasiamies

2. LITERATURE REVIEW

The traditional models in economics assume that goods are homogenous within the markets that they are traded. In reality, this assumption rarely holds. If you buy morning cereals from a grocery store next to you, the option range is wide between the products. Should we then consider all of the different packages as being traded at the same of different markets?

Two approaches enable conducting economic analysis with these products. The first is to treat all of the different cereal packages as having their own monopoly[2], but still competing with the other. The competition arises, because a consumer finds the cereals being substitutes with each other at some degree. Another approach is to use a hedonic model. It assumes that goods that are bundles of their attributes. Hedonic pricing is used to discover the implicit prices of the attributes. In my context, lifts do not have their own price tags when dwellings are transacted. Hence, a hedonic model is required if the implicit price tags of lifts were ought to be found.

2.1. HEDONIC PRICING MODEL

In the beginning of the 20th century, the first steps towards hedonic pricing were taken when differences in product heterogeneity was considered affecting the pricing. Andrew Court is titled as a pioneer of hedonic pricing widely in the literature (e.g. Chau, 2003; Sheppard, 1999; Goodman, 1998). Court worked in the automotive industry, trying to generate a price index for automobiles. He found that multiple aspects, such as the amount of horsepower and number of windows, affected the pricing of automobiles. Based on his work, he published an article in 1939 describing a price index development at the automotive industry. Court´s price index was advanced, as it accounted for product heterogeneity.

The literature has also consensus that Lancaster in 1966 and Rosen in 1974 led the second phase of hedonic pricing evolvement (e.g. Chau & Chin, 2003; Sheppard, 1999; Sirmans, Macpherson, & Zietz, 2005). While Court´s approach was more influenced by practice, the second phase researchers had more generalized conclusions. Sirmans et al. (2005) interpret Lancaster´s work creating a consumer theory for differentiated goods. Lancaster (1966) found the vulnerability in the traditional consumer theory, of which I described in the beginning of this section. The classical models would treat goods (cars in Lancaster´s example) as either completely different, or homogenous products. The following paper by

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[2] Dixit et al. (1977) were pioneers in creating analysis for monopolistic competition

Rosen (1974) utilized Lancaster´s consumer theory and focused on the price determination in real estate markets. Sheppard (1999) combines the previous microeconomic literature in housing context.

Following Sheppard (1999), consumers (households) are expected to receiving utility

$$u = u(Z, Y, a) \qquad (1)$$

Utility for a household depends on consumption of differentiated good Z, all the other goods Y, and a vector of consumer´s preferences *a*. Differentiated good Z is in our case an apartment that is consisted of a vector of attributes. The utility function could take for instance a Cobb-Douglas[3] form.

A household´s willing-to-pay for an apartment depends on how much it appreciates its different attributes given its budget constraint. Budget constraint is determined by income level M and the prices of the goods. Consequently, the households make bids that are equal to their willingness-to-pay for the dwellings. Formally, the "bid-rent" function is defined as

$$\beta(Z, M, u, a) \qquad (2)$$

The partial derivative of the bid rent function $\frac{\partial \beta}{\partial z_i}$ determines how much more the consumer is would pay for a dwelling if an attribute Z_i was increased by one unit when holding the utility level constant.

There are different dwellings on the markets. The household chooses the dwelling, that maximizes the utility function (1) with respect to all the attributes Z and composite good Y such that the budget constraint (3) is satisfied. Budget constraint is determined by

$$M \leq P(Z) + Y \qquad (3)$$

The budget constraint determines that total income must be lower than price of the bundled good and prices of all the other goods. *P(Z)* is referred as hedonic price function. Price of a bundle consists of *n* attributes of *z* and their prices p_i.

$$P(Z) = p_1 z_1 + p_2 z_2 + p_3 z_3 + \ldots + p_n z_n \qquad (4)$$

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[3] Example of Cobb-Douglas: $u = Z^{a_1} * Y^{a_2}$
If Z consisted of four different attributes, the functional form for the utility function could be
$u = (z_1^{a_{11}} + z_2^{a_{12}} + z_3^{a_{13}} + z_4^{a_{14}}) * Y^{a_2}$
Note, that all the households are expected having their own vector of the preference parameters

By solving the maximization problem for the household, the price of an attribute P_i must be equal to a relationship between change in utility as amount of the consumed attribute increases, and change in utility as amount of consumed composite good increases. As a consequence from the utility maximization process, the implicit prices are determined by

$$P_i = \frac{\partial \beta}{\partial Z_i} = \frac{\partial u / \partial z_i}{\partial u / \partial Y} \qquad (5)$$

Price of attribute *i* must be equal the change in household´s payoff with respect to change of attribute *i.* The price for an attribute increases, if its preference parameter increases relatively to the other preference parameters. With competitive markets, the implicit prices must be equal their marginal costs of production. The theory implies that the consumers affect the lift prices based on their utility maximization that compares lifts to rest of the dwelling attributes, and other goods given the income level.

2.2. APPLICATIONS OF THE HEDONIC PRICING MODEL

Automobiles and real estate seem to be the most common industries, where hedonic pricing is utilized. The industries are expected to benefit from the hedonic pricing model, because their products are heterogenous, durable, and expensive. Sheppard (1999) identifies two main branches in hedonic pricing studies at the housing markets. 1) Discovering implicit price of one particular attribute. 2) Utilizing the implicit prices to discover welfare effects in the society with respect to changes in the attribute prices. Naturally, the second branch of research requires more a detailed approximation of the demand curve, and thus it is more challenging to conduct. My study belongs to the first branch of research, as I try to find price increase of a bundle (apartment) due to an attribute (lift).

The literature does not have consensus about how the housing attributes should be categorized. Chau & Chin (2003) divide three attribute categories affecting the housing prices: Locational, structural, and neighborhood –attributes. Locational relates usually the distance from the house to central business district. Structural attributes are something attached to the house such as size or building material. Neighborhood –attributes relate to the quality of the neighborhood, such as crime rate. On the contrary, Sirmans et al. (2005) identify only two categories: physical and other factors. The physical attributes consists of the similar attributes as Chau & Chin´s (2003) structural and locational attributes. The other factors could be for example school quality or air pollution.

I have found the most extensive research been conducted among the locational or neighborhood attributes. Quite often, *ceteris paribus* can be revealed after having an exogenous shock to certain area and utilizing difference in differences or regression discontinuity design. Examples of these types of exogenous shocks are often policy decisions such as public transport line installation (e.g. Harjunen 2018) or changes in school boundaries ((Harjunen, Kortelainen, & Saarimaa, 2014). The effect of structural (or physical) attributes on housing prices are prone to have a omitted variable bias[4] harming the causal interpretation of those studies.

Despite the omitted variable challenges with the structural variables, Harjunen & Liski (2014) studied the impact of energy efficiency on housing prices. They overcame the issues related to location- and neighborhood attributes issues with location-specific fixed effects. Neighborhood (250m^2 x 250m^2 area) fixed effects, and a wide set of other attributes enabled them to do a causal interpretation. This thesis overcomes the problem of locational attributes correlating with prices with building specific fixed effects.

The most interesting finding from the literature review is the low amount of real estate pricing studies, where lifts were under attention. I did not find any empirical papers where the effect of lift on housing prices was studied. Moreover, lifts are rarely used even as control variables. Sirmans et. al (2005) conducted quite an exhaustive literature review of the hedonic pricing models used in real estate pricing. They examined 125 empirical hedonic pricing studies, and collected the outcome statistics for all the dependent and independent variables. They listed over a hundred variables including variables such as cable TV -dummy, oil spill on waterfront lot, and consumer price index for fuel, but the lifts were omitted. In those 125 hedonic real estate pricing papers, no one had lifts even as a control variable.

I found only couple of hedonic pricing papers mentioning lift as an independent variable. Chiarazzo et. al (2014) found a positive impact of lift on property values using the hedonic pricing model while studying the pollution effects on housing prices. However, they did not control for the age of apartment or the condition yielding to biased[5] lift estimate. Another

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[4] Let´s say you wanted to study the causal effect of building material on housing prices. It is impossible to change the material, so you must compare different buildings with each other. After controlling a wide range of attributes with your dataset, how can you be sure that some unobserved variable is not correlated with the building material? Obviously, this is a challenge for all the researchers trying to identify causal effect of the structural attributes on housing prices.

[5] Most likely a lift correlates with age of the building. Alternatively, a lift could correlate with an overall condition of the building

discovery of lifts as control variable was hedonic pricing study conducted in Turkey. Selim (2011) used a wide range of structural variables in his hedonic OLS regression, and found that lifts increased the housing prices by 17%. However, he omitted almost completely the location-attributes yielding most likely biased estimates.

A conclusion of this chapter is that hedonic pricing model is a commonly used tool for studying prices of attributes that are sold in bundles. Thus, real estate fits well in hedonic pricing models. Exogenous shocks, such as policy interventions, create random assignments which are beneficial if causal link a dwelling attribute and price was tried to discover. Policy interventions have enabled the Finnish researchers to study effects of locational attributes on housing prices. However, it seems to be less common to attempt discovering effect of a structural variable and price. Hedonic pricing literature in real estate has covered numerous of attributes, but the absence of lifts is remarkable.

3. INSTITUTIONAL SETTING

In this section, I approximate the number of inaccessible residential blocks of flats and the number of citizens living in those buildings. I continue by presenting the lift subsidy. Last, I discuss the circumstances under which the subsidy policy is beneficial for society.

3.1. THE HOUSING STRUCTURE IN FINLAND

Table 1 shows the number of households living in different types of buildings.

Table 1 – Number of Households (2018)

Building Type	Number of households	Percentage of total
Other building	43 968	2 %
Attached houses	367 712	14 %
Detached and semi-detached houses	1 055 409	39 %
Blocks of flats	1 238 410	46 %
Total	2 705 499	100 %

Source of the data: Official Statistics Finland (OSF). Household is commonly defined as the group of people living under the same roof and eating from the same fridge. Hence, the figures of households are almost identical to the number of dwellings, when assumed zero vacancy for the dwellings.

Table 1 shows that there are 2.7 million households in Finland. Almost half of them live in blocks of flats, making it the most common building type. Of all the building types, blocks of flats do not fulfill most likely the accessibility criteria for the physically restricted. Blocks of flats have two or more floors, whereas the rest of the building types can have only one floor. Without a lift, multiple floors in a building can become an issue thus moving between them requires more effort compared to moving on the same floor. The required amount of effort may exceed the capabilities of the physically restricted. As age increases, it the probabilities to become a physically restricted increases.

Table 2 – Number of Tenants and Dwellings by Building Type

	Buildings		Dwellings		Tenants	Tenants over 65 years old
	Total	Without a lift	Total	Without a lift	Without a lift	Without a lift
Less than three floors	19 000	19 000	252 000	252 000	344 000	69 000
Three floors	18 000	*15 000*	*356 000*	*274 000*	*374 000*	*75 000*
More than three floors	*25 000*	*2 000*	630 000	58 000	79 000	16 000
Total number	*61 000*	36 000	*1 238 000*	584 000	797 000	160 000
Three or more floors	43 000	17 000	986 000	332 000	453 000	91 000

This table shows the estimated number different types of blocks of flats, dwellings in them, and tenants in them. The table is calculated based on Official Statistics Finland (2019) and report of Kotilainen et al. (2016). The italic figures are explicitly received from these sources. The non-italic figures have been extrapolated after imposing additional assumptions[6].

Table 2 shows the number of residential blocks of flats that could be converted accessible with lift installations. It shows the number of dwellings and tenants in different types of blocks of flats. I have divided blocks of flats with respect to number of floors (2, 3, 3+) and lift. Hereby, we have six different building types.

There are 61 thousand block of flats, of which almost half of them do not have lifts. However, buildings with more than two floors are eligible for the lift subsidy. Consequently, 17 thousand buildings could be installed with lifts. From the 17 000 buildings, almost 90 percent are three-floor buildings. The vast majority of all the three-floor buildings do not have lifts. On the contrary, only circa 10 percent of the 17 000 buildings have four of more floors. Based on the table 2, most of the upcoming lift installations could be expected being conducted in blocks of flats with exactly three floors. Dwellings -columns show the number of dwellings with respect to the six building types. One third of all dwellings that are eligible for the lift subsidy do not have lifts.

Tenants -column shows the total number of tenants with respect to the previously presented building types. The column shows that almost 800 thousand people are currently living in

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[6]

1) Three floor buildings include on average 20 dwellings. This figure is the same as the average amount of dwellings in blocks of flats Finland
2) Buildings have constant amount of dwellings and stairways at each floor level. Hence, the only source of variation in the number of dwellings between blocks of flats would be the amount of floors.
3) Average amount of floors in over three floor blocks of flats is 5
4) Average amount of floors in less than three floor buildings is 2
5) Household dwelling units is the same as number of dwellings
6) Average household size is 1.36 across buildings. 1.36 is calculated from three floor buildings: 374 000 tenants / 274 000 dwellings = 1.36 tenants / dwelling

blocks of flats without a lift. More than half of them live in buildings, which have three or more floors. The last column shows that 160 thousand over 65 years old people live in buildings that do not have lifts. Of them, 91 thousand people live in buildings that were eligible for the lift subsidy.

Without the lift installations, part[7] of the 160 000 people may become trapped in their homes in short-term[8] perspective. Alternatively, they need to move to accessible housing. In long-term perspective, part of 797 000 people may become trapped in their homes if they are not relocated to accessible housing.

3.2. LIFT SUBSIDY

The Finnish legislation (korjausavustuslaki 1087/2016) determines that the purpose of the lift subsidy is to remove obstacles that harm moving inside the building. The most important criterion for the subsidy is that the building must become accessible ex-post the installation. The accessibility means removal of obstacles when moving between floors. Residential blocks of flats that have over two floors and no previously installed lift can apply the subsidy. The subsidy covers nowadays 45 percent at maximum[9] of the lift installation costs. However, the subsidy percentage has varied between 40 to 50 percent between 2000-2020. In 2016, the subsidy per lift was 109 000 euros on average, and 219 lifts were subsidized in total.

On contrary to the nationwide subsidy, the municipalities differ in terms of granting additional subsidies. Table 3 shows the differences among the municipalities. Of the 25 largest municipalities, Oulu subsidizes lift installations the most (20%). Furthermore, Tampere and Kuopio are also generous with 15% subsidies. From the rest of the municipalities examined, roughly half gives 10% subsidy, while the others don´t subsidize the installations at all. Exceptions are Turku, and Mikkeli, who use fixed subsidy instead of the percentage-based subsidy. On top of the direct monetary subsidies, some municipalities offer free advisory service for the housing condominiums when they are considering the lift installation. Moreover, the municipalities´ subsidies may have varied between 2000-2018.

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[7] The portion depends on how many live in the lowest floor. The lowest floor in block of flat building can be accessible without a lift.

[8] Short-term refers likely somewhere between 0-15 years. Within the age cohort of over 65 years old, the number of people decreases as the age increases. Hence, annually a number of people become physically restricted, and the number likely increases until the whole cohort are physically restricted.

[9] In practice, no lift application receives smaller than maximum percentage subsidy from ARA, unless the application is rejected (Merilä, 2020).

Table 3 – Lift Installation Subsidy by Municipality

	Subsidy %	Fixed subsidy per lift (€)
Helsinki	10	0
Espoo	10	0
Tampere	15	0
Vantaa	10	0
Oulu	20	0
Turku	0	5 000
Jyväskylä	10	0
Lahti	10	0
Kuopio	15	0
Pori	10	0
Kouvola	0	0
Joensuu	10	0
Lappeenranta	0	0
Hämeenlinna	0	0
Vaasa	10	0
Seinäjoki	0	0
Rovaniemi	0	0
Mikkeli	0	15 000
Kotka	0	0
Salo	0	0
Porvoo	0	0
Kokkola	0	0
Hyvinkää	0	0
Lohja	0	0
Järvenpää	0	0

Notes: The table is based on the interview with Merilä (2020). It includes the largest municipalities in Finland based on the number on citizens.

3.3. PERSPECTIVES ON THE POLICY

The nationwide lift subsidy is a part of policy interventions that aim to increase accessible housing supply. The set of the policy interventions consists of legal requirements, public housing production, and subsidies (income transfers). For example, in 2005 it became mandatory to install lifts to new blocks of flats (Kotilainen et al., 2016). Publicly owned housing companies construct and offer accessible apartments for rental purposes. The lift subsidy is an income transfer from society to the housing condominiums who decide to install a lift. The policy interventions can be analyzed with *cost-benefit analyses (CBA)*[10]. The basic intuition behind the analysis is that if all benefits in the society exceed the costs, the policy creates positive net benefit. If the net benefit of the project (or subsidy program)

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[10] Boardman et. al (2017) have written a cornerstone textbook for the subject: *Cost-Benefit Analysis: Concepts and Practice*

exceeds the net benefit from the alternative options, the project should be funded. The (implicit) assumption is that total benefit is a sum of individual utilities, which are often measured in terms of monetary units.

Normally, the competitive markets allocate goods (such as lift installations) for those who are willing to pay the most for it. This is also an efficient outcome for society, thus it maximizes the net utilities. The lift subsidy decreases the lift installation market price thus increasing the amount of installations.

I divide the costs of the policy to direct and indirect costs. The direct costs for the society have been annually around 100 thousand euros per lift (ARA 2017). With 200 lifts, the annual cost is 20 million euros. The indirect costs are harder to identify. I identified two indirect sources, but they are even harder to quantify. First source comes from deadweight losses. Income transfers are financed via taxation thus creating deadweight losses from markets they are collected. However, the marginal increase for nationwide tax rates due to the lift subsidy are presumably close to zero[11]. Consequently, the costs from deadweight losses are small. Second, health care costs may increase if the healthy start using lifts instead of walking stairs. Walking stairs increases everyday physical exercise, thus avoiding many diseases caused by a bad lifestyle. However, it would require extensive research to measure the magnitude of both of the effects.

Even though there are identified direct and indirect costs, the policy may be socially beneficial due to positive externalities. Kotilainen et al. (2016) identified two types of positive externalities related to increased accessibility. First, the risk of accidents, such as falling decreases, as there are less obstacles when moving between floors. Finland has a public medical insurance, which covers bone fractures and similar injuries. Consequently, the society pays all the injuries, which can be costly. Second, it can increase the amount of living in own home by 6-8 years. Enabling the elderly to live accessible life in own home is considered to increase the utility for everyone in society. The magnitude is hard to quantify, but I have not seen any disagreements that this target would be valuable.

The benefits depend on how well the subsidy receives those who would not have otherwise moved to accessible housing due to their budget constraints. Some intervals for the *share of*

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[11] 20 million euros would be 0.03% of total budgeted government expenses for year 2020 (Ministry of Finance, 2020).

receiver[12] estimates can be imposed. If everyone in a building had tight budget constraints, the lift installation would help all of them. The subsequent tenants would also benefit from the subsidy, as lifts are one-time investments. Hereby, the share of receiver would be over 100%. On the other hand, if all of the current and the subsequent tenants were wealthy enough to move accessible housing, the share would be 0%. If we assumed a) the current share of the physically restricted without wealthy to move being 20%, b) 20 tenants in a building, and c) three rounds of new tenants, the share of receivers would be 60% and the number of receivers would be 12. For those, if the subsidized lift installation increased accessible life by six years, a subsidized lift installation would provide in total 72 years of accessible life. If everyone in Finland appreciated accessible life so that they would receive utility worth of 1€ / accessible year for other person, the simplified net benefit of the subsidy would be over 431 million euros[13]. The previous net benefit calculation is based on fragile assumptions, and it should be considered only as giving an initial framework for the cost-benefit analysis problem related to the lift subsidy. Consequently, it would require further research, before a monetary amount of the true net benefits could be published.

If the existing blocks of flats were not converted accessible with lift subsidies, alternative options seem to be even more expensive. First, society could subsidize new housing stock construction, and then allocate it to the elderly. The average cost new housing construction for Ara has been around 3000 €/m^2 in the recent years (ARA, 2017). Hereby, it costs almost 100 000€ to construct a new apartment with 33 m^2 living area. Second, society could allocate the existing accessible housing stock for the elderly. One form of the existing accessible housing is a retirement home. Merilä (2020) approximates the retirement home costs being 40 000€ per year per tenant, making it likely a more expensive option compared to the first one.

On contrast to the alternative options, subsidizing a lift in an expensive scenario[14] costs approximately 10 000€ per apartment for society. According to this simplified calculation, lift subsidy costs only one tenth compared to fully subsidized construction of new housing stock. However, the alternative options have likely a higher share of receiver, because society can decide to allocate the housing for those who truly have tight budget constraints.

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[12] The current and all the subsequent tenants with budget restrictions and need for accessible housing divided by total amount of tenants in a building

[13] Benefit is 1€ * 6 million people * 72 years = 432 000 000. Cost from the subsidy is 100 000€. I exclude time value of money from the simplified estimate.

[14] Assuming a lift converts 10 dwellings accessible. Cost per lift is 200 000€. Subsidy per lift is 50%

Still, the alternative options only enable living in accessible housing, but not living in own home. Society likely receives more utility if the people are enabled living accessible life in own home compared to living accessible life in a random house.

Another possible externality that was not covered above, is wealth equality. The people in the society may receive utility if total wealth is distributed equally among the citizens. If the subsidy was given mainly for the rich, this objective would fail. The descriptive findings of this study mitigates that concern. The dwellings that are in blocks of flats without a lift, cost 30 percent less than dwellings in blocks of flats with a lift (table 13). It would be reasonable to assume that one´s wealth would correlate with value of his/hers dwelling. Hence, the apartment owners living in a building without a lift, are less likely rich compared to living in buildings with lifts. However, there could be exceptions from the expected correlation between wealth level and having a lift in a building. Near CBD in Helsinki, there are areas[15] with high dwelling prices, but they may not have a lift because they were built in the 19th century. The concern of lift subsidy recipients being from the rich areas is mitigated by table 4. It shows than only one third of the housing condominiums with lift installations are from Helsinki. Thus, the subsidy seems to have higher changes increase wealth equality rather than increase inequality.

To conclude, a part of 160 000 people may become trapped in their homes in short-term if their dwellings are not converted accessible or they do not relocate to accessible housing. The society has multiple tools to prevent the scenario. One tool is to increase the lift installations by subsidizing lift installations. The net costs and benefits are difficult to quantify. However, the lift subsidy seems better than an alternative option, which is subsidizing new housing stock construction. The lift subsidy is likely used by those, who live in less valuable apartments. Consequently, the lift subsidy could increase wealth equality in Finland.

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[15] Such as Ullanlinna, Eira, and Katajanokka

4. DATA

I use a dataset consisting of roughly half a million dwelling transactions in blocks of flats between 2000-2018 around Finland. Each observation (transaction) can contain 36 variables. The data is not balanced, meaning that there are no observations for each time period for each apartment. Thus, the dataset could be interpreted as a repeated cross-section data. The data is gathered from KVKL, which is a consortium of real estate brokers (Central Federation of Real Estate Agencies in Finland). It collects all the apartment transactions that are made with assistance of a broker belonging to the consortium. The majority (according to the representative of the agency) of all dwelling transactions are recorded to the dataset. I start this section by analyzing the data quality and identifying the main concerns with it. Then, I describe how I have identified buildings with lift installations, because it is crucial in my main empirical model. Last, I show supporting evidence for my building identification using the official statistics from ARA.

4.1. QUALITY OF THE DATA

I categorize the quality of the data consisting of two elements: representativeness of the dwelling prices and attributes, and the information precision. In an ideal world, all the prices from each dwelling would be updated every moment similarly to stock markets. Furthermore, there would be an exhaustive list of attributes for each dwelling. Hence, even a subtle change in some variable, let´s say painting of interior wall, should lead to price change immediately after the public[16] knows about the new repair. Second, the precision of the data measures the amount and distribution of measurement errors. The more observations are measured falsely, the lower is the precision. If the distribution of the errors is distributed evenly around the true figure, we have a *classical* measurement error. Classical error in outcome variable (price) would affect only the magnitude of standard errors in the estimates. However, if there is a classical measurement error in the independent variable, the estimates become attenuated. If the error distribution is skewed, we have a *non-cla*ssical measurement error. For instance, observations could be systematically higher than true. In the outcome variable, this would not affect my results. However, in the independent variable, systematical errors may lead to biased estimates.

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[16] According to Perfect Markets Hypothesis, the price of an asset resembles all the information that exists and relates to it (Fama, Fisher, Jensen, & Roll, 1969). In the stock markets, the empirics support the theorem constantly.

Poor representativeness can harm the interpretation of the results due to selection bias, and the lack of exhaustive listing of apartment characteristics can bring omitted variable bias affecting the interpretation of causality. The poor precision of information (due to measurement error for example) may lead to attenuated or false estimates.

Selection bias could occur due to transaction data characteristics that prevail in every study. Alternatively, selection bias could occur from the study specific data. The underlying reason for the first factor is that the data covers only transactions. Transactions at this type of real estate markets are rare, because they emerge only if the tenant is willing to sell the apartment, and other person finds the apartment suitable for her. In the literature, this process is called matching[17]. Hence, the data omits all the potential transactions, where someone would like to buy a share of apartment, but is not able to do so, because the owner is not willing to sell the apartment. An application of this reasoning relates to lift installation. If the lift installation would increase only the tenants´ willingness to pay, the apartment price increase would not be recorded just because the apartment will not be on sale. The data could omit the highest (or lowest) treatment effects. However, this issue prevails everywhere when someone is dealing with real estate transaction data, and the hedonic pricing literature does not seem to address the issue often.

Second, some fraction of the transactions are not recorded to the dataset. If the transactions that are made without assistance of a real estate broker belonging to KVKL consortium differ systematically from the other transaction, the sample is not representative of all dwelling transactions conducted in old blocks of flats. Though, this should not be a critical source of bias. All the old dwellings in blocks of flats are already quite homogenous in general, and the main purpose of this research is to find only the average price effect of lift installation.

Lack of attributes (variables) within each observation could create omitted variable bias. The largest threat arises if the dataset omits crucial factors that correlates with our independent variable (*lift installation*). The potential correlation would create bias for the results. Example of this kind of factor could be *long-term maintenance plan.* The maintenance plan gives valuable information to the buyer, because it could reveal increasing maintenance costs for the tenants. If the maintenance plan information would correlate with lift installation, my results would become biased, thus the treatment effect would include changes in the long-term plan. Other crucial omitted variables are the lack of official building identification code

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[17] Coles & Smith (1998) provide an excellent view on the matching process

and stairway identification letter[18]. I deal with this by creating a proxy for the former, and imposing assumptions for the latter one.

The imprecise information may bring significant issues for the research. In my case, this is one of the main challenges thus the brokers enter the data manually and they do not have significant monetary incentives to pay attention to the input of the data after a transaction. Especially, the important dummy variables, such as lift dummy is extremely sensitive for creating bias in the estimates in case of false entry. In the following section, I cover how I have dealt with these problems. Moreover, it is almost impossible to proof whether the measurement errors are classical or systematical in my case. I do not find evidence that the brokers would have incentives to over- or underestimate the variables. Thus, I assume all measurement errors classical.

Even though I listed multiple deviations from an ideal world, the data fits well for my study. The number of observations is large and the variables are exhaustive yielding a good representativeness for transactions in blocks of flats. The information precision is more difficult to assess, but the data unlikely contains non-classical measurement errors.

4.2. DATA TREATMENT

My empirical strategy requires identifying treatment status for all the observations. Treatment group consists of all dwellings that are in buildings, where lifts will be (or were) installed. The control group consists of all other observations. Hereby, I need to identify buildings, which were installed with lifts between 2000-2018. There are some challenges for the group- and treatment identification. First, the data do not explicitly reveal precise identification codes for buildings. Second, the data do not contain information about the stairway of the apartment. Third, there is no explicit information about the lift construction year. My strategy is to identify buildings based on the variables that presumably stay constant, and compare lift-status in all of transactions conducted in each building. The variables that are expected to stay constant are postal code, street name, street number, year

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[18] In Finland, post address is most often used in informing dwelling location. An example of post address is Muurarinkuja 1 B 12. In this example Muurarinkuja is the street, 1 is number of the street, B informs the stairway, and 12 is the dwelling number. My data omits stairway letter and dwelling number.

of construction, and number of floors. Moreover, I have removed outliers[19] and obvious[20] errors from the data.

Using the building identification method, I divided the buildings into two categories based on how lift is reported in each transaction. The first category consists of buildings, where the lift-status stays constant. Either all of the transactions in a building report having a lift, or all of the transactions report missing lift. The first category is the control group. The second category consist of buildings, where lift-status changes. Treatment group building is identified if a building has first transactions without a lift, and all of the rest transactions report the existence of a lift. Hence, the transaction-data has implied a lift installation for those buildings. From the second category, a large number of buildings report transactions first with a lift, and later without a lift. Because it is not reasonable to assume a lift removal from a building, these observations are removed from the sample. Nearly half of all observations are removed. Next, I will discuss about the potential causes of the observation removal how it affects the interpretation of the upcoming results.

Firstly, there could be instances when two different buildings have the same street number, construction year, and number of floors. If the other building has a lift, while the second do not have, both of the buildings will likely end up removed from the sample. In addition, I assume that all the stairways in a building either have – or don´t have lifts. Merilä (2020) argued that, this assumption would hold in “most of the cases”. If one stairway in a building receives a lift while the others don´t, all transactions in this building will also be likely removed. Finally, the brokers enter the data manually. If they have by accident report falsely the lift-status, all of the observations in that building will be likely removed. The observation dropping affects increase concern of non-random selection thus affecting the external validity of the results. The manual entry of the data likely creates selection, that omits buildings with high transaction volume. If the probability for data entry error is constant, the more likely the high transaction volume building has at least one falsely entered lift-status compared to low transaction volume buildings.

Besides the concern of creating non-random selection, one could ask if the treatment group identification is also coincidence of the abovementioned reasons. To decrease this concern,

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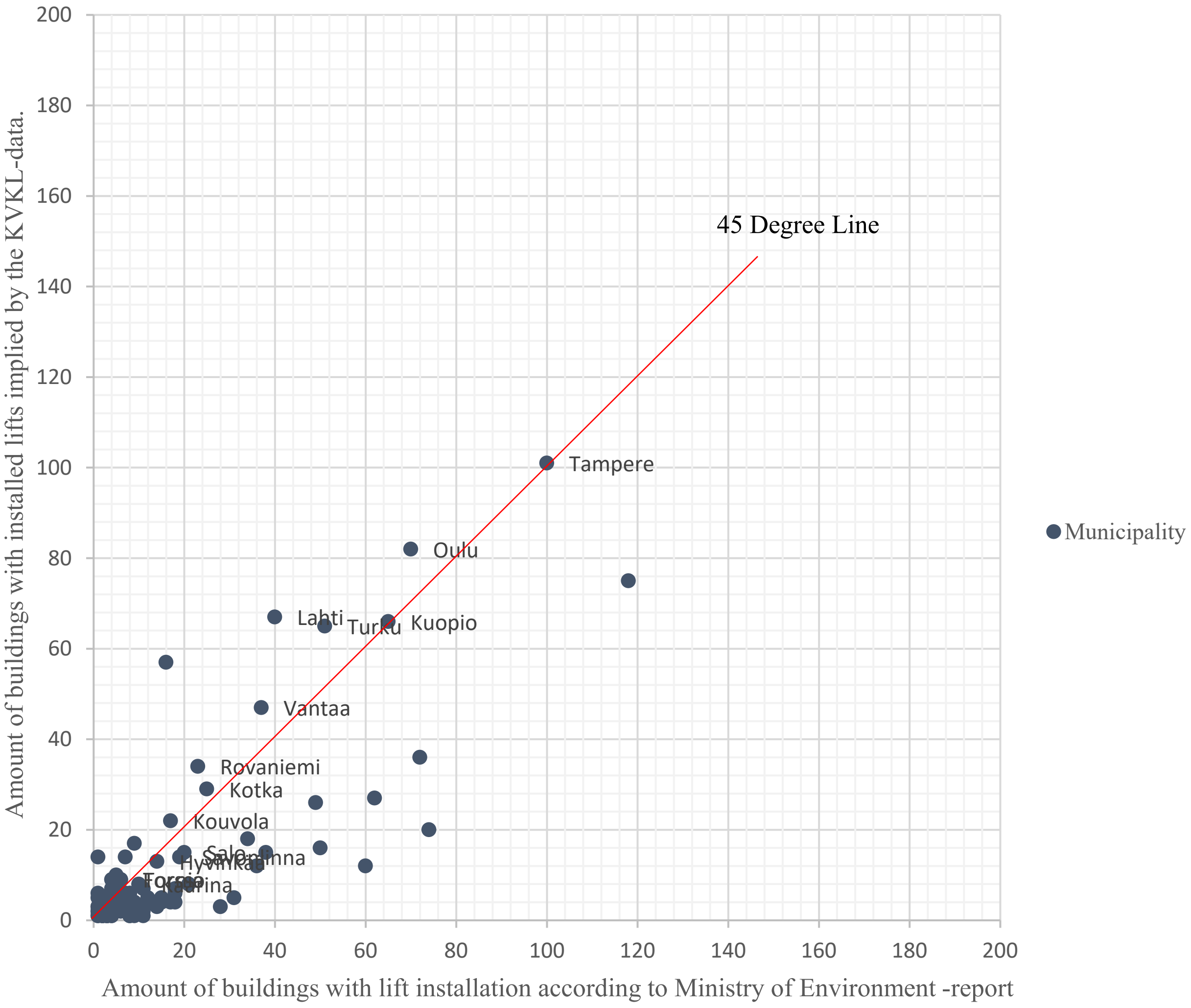
[19] Outliers by variable: 1) unencumbered sale price is less than 2000€ or over 1 000 000€. 2) number of rooms is over 13. 3) floor number over 20. 4) maintenance charge is over 2000€ / month.

[20] Obvious errors are: 1) Number of floors is less than 2. 2) Sale year is over 2019. 3) Number of rooms, or floors are not integers or they have negative values.

I show that the number of assumed lifts is close to the actual number of lifts installed. To do this, I use the findings from Kotilainen & al, (2016), who used data directly from ARA, which presumably is close to the exact figures.

Figure 1 – The Precision of Estimated Number of Lift Installations



Notes: Helsinki is excluded from the graph. If a municipality lies directly at the 45 Degree Line, the amount of buildings with lift installations are the same according to both sources.

Figure 1 supports my building identification strategy. It shows, that the implied lift buildings from the transaction data is similar what found in their report for the Ministry of Environment. The municipalities lying at the 45 Degree Line have identical amount of lift installations. The municipalities that lie above the line (such as Lahti), have according to my data more lift installations compared to ARA-data and the same vice versa for the municipalities lying below the line. The figure excludes Helsinki, because the numbers for lift installations are extraordinary high: my data implies 418 buildings that have an installed lift, whereas Kotilainen & Al, (2016) identified 749 buildings with installed lifts.

Even though figure 1 is created to proxy the precision of the data, the datasets have natural reasons to be different. Firstly, the time periods differ. My data is from 2000 to 2018, whereas the ARA-data used by Kotilainen & Al, (2016) counts buildings between 2003-2015. Secondly, my data contains only transactions conducted by the real estate brokers. Thus, it omits all the lift installations made in buildings that are outside this scope: For example, municipality owned housing companies[21] are typical buyers of lift installations Merilä (2020), and they are excluded in my data. Third, the ARA-data used by Kotilainen et. al (2016) includes only subsidized installations. The unsubsidized are excluded, whereas my data should reveal all the installations in despite of the potential permitted subsidies. Merilä (2020) do not find this to be an issue. He stated that in practice, a vast majority the applied subsidies for lift installations are accepted.

To conclude, the manual entry of the data, and lack of explicit information regarding lifts and building identification brought concerns for validity of this research. I mitigated the concerns by showing that the amount of buildings with lift installations by municipality correlates well with previous research.

4.3. DESCRIPTIVE STATISTICS

Table 4 shows the descriptive statistics of the key variables for the treatment- and control groups. Treatment group consists of observations from buildings that have a lift installation. Control group[22] consists of all other observations. The groups have been categorized to transactions and buildings. Transactions -columns contain means of the variables for the observations in the dataset, whereas the building-level is first averaged for each building, and then gathered the means for each variables. The building-level comparison is relevant when considering differences between buildings with- and without lift installations.

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[21] For instance, 13% of all inhabitants in Helsinki live in apartment owned by a municipality owned housing company *HEKA*.

[22] Alternatively, control group could be consisted of only buildings that never have lifts. In appendix, the summary statistics for the alternative control groups are provided.

Table 4 – Descriptive Statistics

	Control Group		Treatment Group	
Variable	Mean of Transaction	Mean of Building	Mean of Transaction	Mean of Building
Municipality (0/1)				
Other	50.3 %	47.6 %	44.8 %	42.5 %
Helsinki	20.6 %	22.0 %	27.4 %	27.8 %
Tampere	7.2 %	7.2 %	5.3 %	6.0 %
Oulu	3.4 %	3.9 %	4.1 %	4.1 %
Espoo	4.1 %	3.6 %	3.8 %	4.4 %
Lahti	3.6 %	4.0 %	4.2 %	4.1 %
Kuopio	2.8 %	3.1 %	3.5 %	4.0 %
Turku	4.7 %	5.7 %	3.6 %	3.9 %
Jyväskylä	3.2 %	2.9 %	3.2 %	3.2 %
Building Characteristics				
Lift (0/1)	19.5 %	34.9 %	51.6 %	53.4 %
Construction Year	1969	1 968	1 971	1 972
Age	40.9	41.1	39.2	38.4
Number of Floors	3.6	4.1	4.6	4.9
Dwelling Characteristics				
Price (€)	113 202	127 210	151 266	164 804
Price (€/m^2)	2 021	2 190	2 525	2 695
Living Area	57	58	60	61
Number of Rooms	2.2	2.2	2.3	2.3
Maintenance Charge (€)	172	169	183	186
Floor Level	2.3	2.5	2.8	2.9
Apartment condition, Broker estimate (0/1)				
Unknown	10.1 %	9.6 %	8.4 %	7.5 %
Poor	2.8 %	3.0 %	2.8 %	2.4 %
Decent	30.3 %	29.2 %	27.6 %	26.1 %
Good	56.6 %	57.7 %	60.2 %	62.5 %
Excellent	0.3 %	0.4 %	1.0 %	1.5 %
Observations	262 525	66 116	8 056	1 595

The *municipalities* describes how large fraction of the observations are in each municipality. Only the municipalities that had over 50[23] lift installations during the time period are separated as their own categories. Rest of the municipalities are aggregated with a label *Other.* Helsinki is the most popular municipality in terms all transactions and lift installations. Slightly more one fifth of transactions are conducted in Helsinki.

The second category is the *building characteristics*. Lift -variable shows how large portion of transactions or buildings have a lift. 19.5% of control group transactions have a lift, while over 34% of buildings in the control group have a lift. The interpretation for this difference is that the buildings without a lift are more often transacted compared to their relative existing amount. A half of the transactions in the treatment group have lifts. This means that almost equal amount of transactions have been conducted before lift installation and after lift installation. Another interesting finding is found from number of floors -variable. It shows that the low floor buildings have more transactions compared to high floor buildings. The finding could be explained by the previously explained selection issue regarding the building identification. Because the high transaction volume buildings are more likely excluded, they high floor buildings may as well be excluded if the height correlated with transaction volume.

The *apartment specific characteristics* show that the treatment group apartments are more prestigious compared to the control group apartments. Two variables could explain the price difference: Floor level is usually higher in treatment group apartments and apartment condition is better in the treatment group.

At the bottom of the table, number of observations are provided. The control group has circa 263 000 transactions, whereas the treatment group has c. 8 000 transactions. The control group consists of c. 66 000 buildings, while there are 1 595 buildings with lift installations. Hence, there has been 4-5 transactions in each building. The combined amount of buildings (c. 67 600) exceeds the estimated number of buildings represented in table 2. The figure in the summary statistics should intuitively be lower, because not all existing block of flats in Finland have transactions recorded to the KVKL -dataset. Hence, summary statistics are likely overestimating the amount of buildings. This is likely caused by manual entry of the

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[23] The number has been chosen quite arbitrarily. It tries to maximize number of municipalities, and also to be big enough for receiving large enough number of observations.

data by the real estate brokers. Even a single misspelling[24] in street address leads to different building identification codes. Even though there is unfortunate inconsistency between the tables, I do not find it being a crucial for the internal validity of this study. The most crucial part is to identify buildings with a changed lift-status. With the assumed misspellings for some street addresses, a “lower than true” number of buildings with lift installations are identified. This would likely lead to a small attenuation bias in the estimates of lift installations on dwelling prices. A small portion of the treated apartments are falsely in the control group.

4.4. LIFT INSTALLATIONS ON A MAP

For an illustrative purpose, I plotted a map of lift installations. The map below shows the distribution of the 1595 buildings with lift installations that I identified from the transaction data. I find two worth-of-mention -aspects from the figure: all the large municipalities have buildings with lift installations. In addition, the areas around the cities have lift installations as well. The first notions tells us that the need for lift installation is not area-specific. Second, there seems to be a need for accessibility is countrywide wherever there are blocks of flats.

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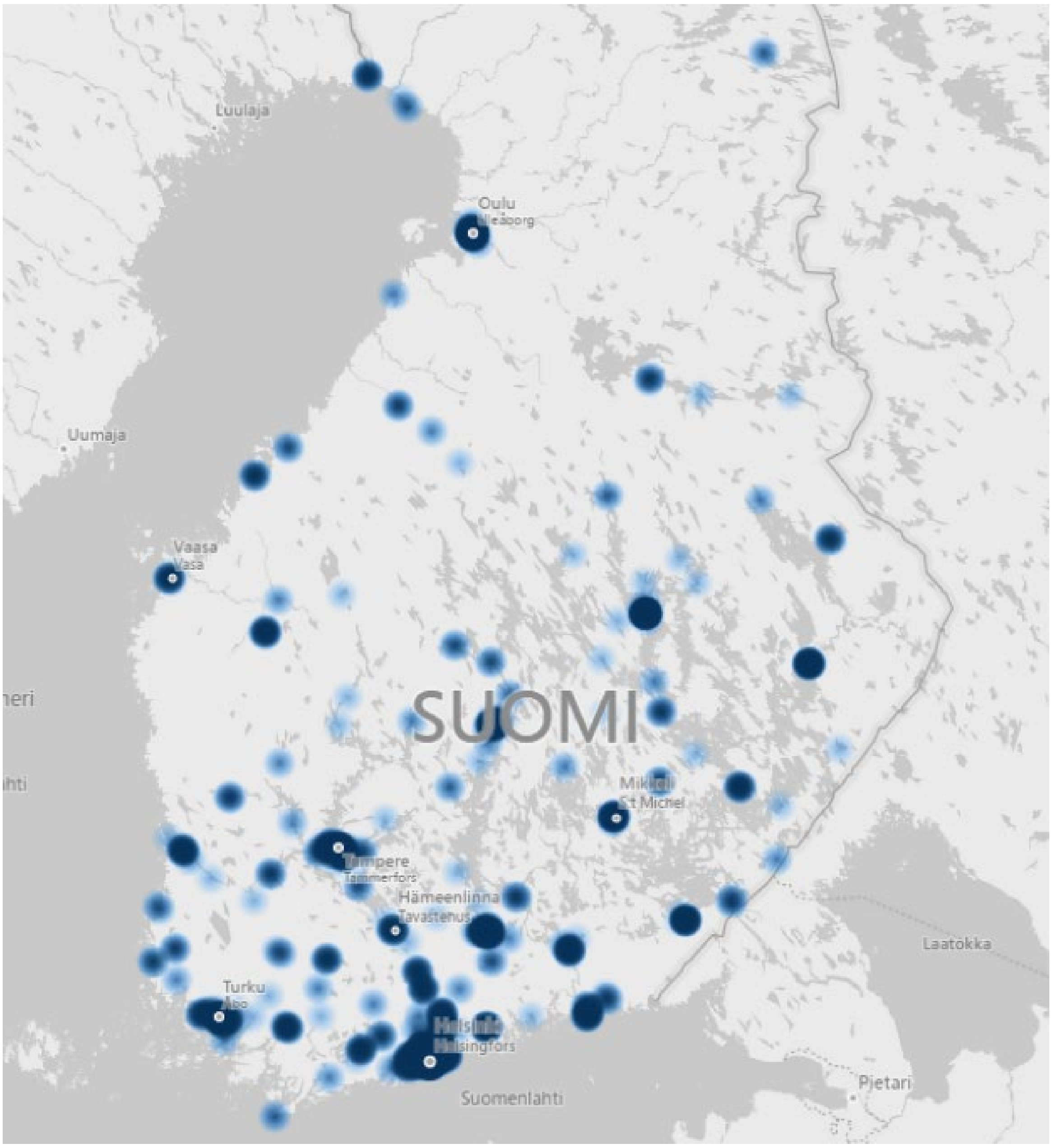
[24] Let´s say two transactions are conducted in street address called Aleksis Kiven katu 17. If the other broker spells it as Aleksis-Kiven katu 17, we end up identifying two different buildings.

Figure 2 – Heat Map of Buildings With Installed Lifts Between 2000-2018



Notes: The underlying data for constructing the map is apartment transaction data by Central Federation of Real Estate Brokers in Finland.

5. EMPIRICAL STRATEGY

5.1. DIFFERENCE IN DIFFERENCES

I use *two way fixed effects difference in differences* -model (TWFE DID) to create a *ceteris paribus* where only lift would affect the price of an apartment. The model is augmented with control variables from the hedonic pricing model.

Let us briefly start with the traditional difference in differences -model. The setup consists of two groups (treatment- and control groups) and two time periods (before- and after treatment). The outcomes of the groups are expected to evolve similarly with respect to time with absence of treatment. This *parallel trends* -assumption enables to find a counterfactual outcome[25] for the treated group. The traditional approach is referred in the recent literature as canonical DID or 2x2 DID (e.g. Goodman-Bacon, 2018). The canonical DID was utilized for example in the famous study by Card and Krueger with *Mariel Boatlift* (1990), which estimated the impact of immigration wave on minimum wages.

On contrast to the 2x2 DID, my setup consists of multiple periods and multiple units treated at different times. Each year between 2000-2018, some number of lifts has been installed. However, the econometric literature in social sciences is relatively young[26] with dealing this types of problems. Two way fixed effects (TWFE) DID and *event study* DID are commonly used in handling DID setups with multiple treatment groups and periods. TWFE DID is often determined by:

$$y_{it} = a_i + a_t + \beta D_{it} + \delta X_{it} + \varepsilon_{it} \tag{6}$$

Where a_i refers to unit dummies and a_t to time dummies, and D_{it} is indicator of being in treatment group after the beginning of treatment. This equation could be augmented with vector of control variables X_{it}. Coefficient β[27] represents the difference in differences effect due to treatment. For interpreting β as unbiased estimator of the average treatment effect on the treated, it also requires parallel trends -assumption for all the 2x2 estimators of the model.

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[25] Counterfactual is an imaginary outcome without a treatment.

[26] Apparently, TWFE was recognized in textbook in 2005 by Cameron & Trivedi. Another textbook in 2015 by Angrist & Pischke covered the issue of multiple treatment periods (Goodman-Bacon, 2018).

[27] The estimation of the coefficient has received attention recently. For instance, Baker (2019), and Goodman-Bacon (2018) say that even though the TWFE DID is used widely in the empirical literature, actually a little is known of the coefficient estimation. They show that the coefficient consists of multiple 2x2 -coefficients, that are calculated for each treatment times separately. There 2x2 -coefficients are weighted with their relative importance. Their conclusion is that β -coefficient is *variance-weighted* TWFE DID -coefficient, and it is equal to average treatment effect on the treated (ATT) if the treatment effect is same in all of the 2x2 coefficients.

The parallel trend assumption for all the 2x2 estimators is a bit tricky to confirm. However, more credibility can be obtained by enriching the *treatment*after* (D_{it}) to a vector of interaction dummies (*treatment*time relative to treatment*). If we see that on average, the differences in outcomes for the treatment and control groups do not change before the treatment, we can have more confidence that the assumption holds well enough. By enriching the interaction, the model is referred as *event study* DID. The event study enables also to find potential anticipation effects. If the markets would receive information about lift installation some years prior the installation, the treatment effect should be visible at the time of the announcement.

The event study -models have somewhat similar structure compared to the TWFE -models:

$$y_{it} = a_i + a_t + \sum_{l=-K}^{-2} \mu_l \, D_{it} + \sum_{l=0}^{L} \mu_l \, D_{it} + \delta X_{it} + \varepsilon_{it} \tag{7}$$

Once again, we have unit-, and time fixed effects, and vector of control variables. $\sum_{l=-K}^{-2} \mu_l \, D_{it} + \sum_{l=0}^{L} \mu_l \, D_{it}$ is representation for being in treatment group in K years before the beginning of treatment, to L years after treatment, while the omitted category is year -1. The omitted group consists of group without treatment and the group being in treatment group at time -1. Hence, the interpretation of each μ_l -coefficients tells what is the difference of outcomes between the groups each year relative to beginning of treatment.

I augment the empirical model with vector of control variables provided by the hedonic pricing literature and my dataset. Sirmans et al., (2005) list the most popular attributes that have been used in the hedonic pricing regressions. Table 5 combines the most common variables used in the hedonic models, and shows how they are controlled in this study. I have omitted fireplace, number of bathrooms, air-conditioning, pool, brick, and deck, due to the excessive amount of missing values in the KVKL dataset. Furthermore, many of these variables are not that relevant for this study. Examples of irrelevant control variables are fireplaces and pools thus they are extremely rare in the Finnish dwellings in blocks of flats. It would be hard to imagine that these variables would be correlated with lift-variable thus bringing omitted variable bias.

Table 5 - The most Common Variables used in The Hedonic Pricing Models

Variable	Among top 20 most popular variables	# Appearances in the previous literature	Controlled in this study
Age	Yes	78	Independent Variable
Square feet	Yes	69	Independent Variable
Garage Spaces	Yes	61	Building Fixed effects
Fireplace	Yes	57	No
Lot Size	Yes	52	Building Fixed effects
# Of bathrooms	Yes	40	No
Bedrooms	Yes	40	Independent Variable
Full Baths	Yes	37	No
Air-Conditioning	Yes	37	No
Pool	Yes	31	No
Basement	Yes	21	Building Fixed effects
Time On Market	Yes	18	Year Fixed effects
Distance	Yes	15	Building Fixed effects
# Rooms	Yes	14	Independent Variable
Brick	Yes	13	No
# Stories	Yes	13	Independent Variable
Time Trend	Yes	13	Year Fixed effects
Ln Lot Size	Yes	12	No
Ln Square feet	Yes	12	No
Deck	Yes	12	No
Apartment Condition	No	1	Independent Variable
Lift	No	N/A	Independent Variable

Notes: The table shows the most used variables in hedonic pricing literature based on findings of Sirmans et al. (2005) and how the variables are controlled in this study.

Besides the listed variables, the structural form of the regression is emphasized in the literature. The consensus is that semi-log form is the most commonly used thus it gives easy interpretation for the attribute effects on housing prices ((Chau & Chin, 2003; Goodman, 1998; Keskin, 2008; Sheppard, 1999; Sirmans et al., 2005). The logarithm of price is the dependent variable, whereas the literature (Table 5) shows the most important independent variables. With the abovementioned form, the independent variable coefficients are ought to be interpreted as percent effects on dwelling prices.

5.2. RESEARCH QUESTIONS AND EMPIRICAL MODELS

I impose three research questions: 1. How much the dwelling prices increase due to lift installations? Additionally, I change the outcome variable as sale time (see figure 4 in appendix). Because it is reasonable to assume a lift being more beneficial for the higher floor tenants compared to lower floors, the second question is 2. What is the treatment effect across the floor levels? Furthermore, because the municipalities have different policies regarding the additional lift subsidies, the third question is 3. How does the treatment effect vary across municipalities?

For the first research question, I use the event-study -and TWFE DID models which are augmented by controls hedonic pricing model. I also change the unit fixed effects being at postcode, and street -levels for robustness. Hence, the main equation for my models is:

$$y_{ijt} = a_j + a_t + \beta_0 treatment + \beta_1 treatment * after_{it} + \delta X_{it} + \varepsilon_{it} \tag{8}$$

Where I explain the logarithm of unencumbered sales price for apartment i in location j at time *t*. I vary the location fixed effects from postcode to street, and finally to building level. At the building level[28] fixed effects, the model becomes TWFE DID. Hence, the coefficient β_1 gives the effect of installing a lift on apartment prices. It is a weighted average of all the 2x2 DID estimators, where the treatment groups consists of all apartments that are located in buildings where a lift is installed at the same year. The control group consists observations from all other blocks of flats. I also run the model with event study format to find any potential anticipation effects.

The model of my second research question has similar structure than the previous one:

$$\begin{aligned} y_{ijt} = a_j + a_t &+ \beta_0 treatment * floor\ level \\ &+ \beta_1 treatment * floor\ level * after_{it} + \delta X_{it} + \varepsilon_{it} \end{aligned} \tag{9}$$

However, the vector of coefficients β_0 determine differences before lift installation at each floor in the treatment group compared to control group. β_1 coefficients show the difference in differences after treatment. The model for the third question is the same as the first, except I run it by each municipality.

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[28] Note, that according to equation (6) the unit (location) fixed effects should be for each apartment. However, the deviation should not affect the results. If the location fixed effects were at apartment level, the treatment group would be the same as with building level, and the treatment status would also change at the same time for all the units. Also with building fixed effects, $\beta_0 treatment$ drops out, and the model looks familiar to the equation (6).

6. RESULTS

I start this chapter by showing descriptive connection between lifts and apartment prices. I continue by answering the first research question with the event study and TWFE DID - models. I vary the location fixed effects in all of the models to find how robust the results are. For the second and third research question, I use only TWFE DID models.

6.1. DESCRIPTIVE EFFECT

I show first how a descriptive connection between lift and dwelling prices by increasing the amount of controls in the model. All the models in table 6 are ordinary least squares (OLS) without location fixed effects.

Table 6 – Descriptive effect

VARIABLES	(1) OLS 1	(2) OLS 2	(3) OLS 3
Lift (0/1)	0.311***	0.319***	0.0183***
	(0.00300)	(0.00286)	(0.00351)
Constant	11.36***	10.89***	10.84***
	(0.00136)	(0.0106)	(0.0452)
Observations	270,581	270,581	270,581
R-squared	0.038	0.129	0.486
Structural Controls	NO	NO	YES
Year FE	NO	YES	YES

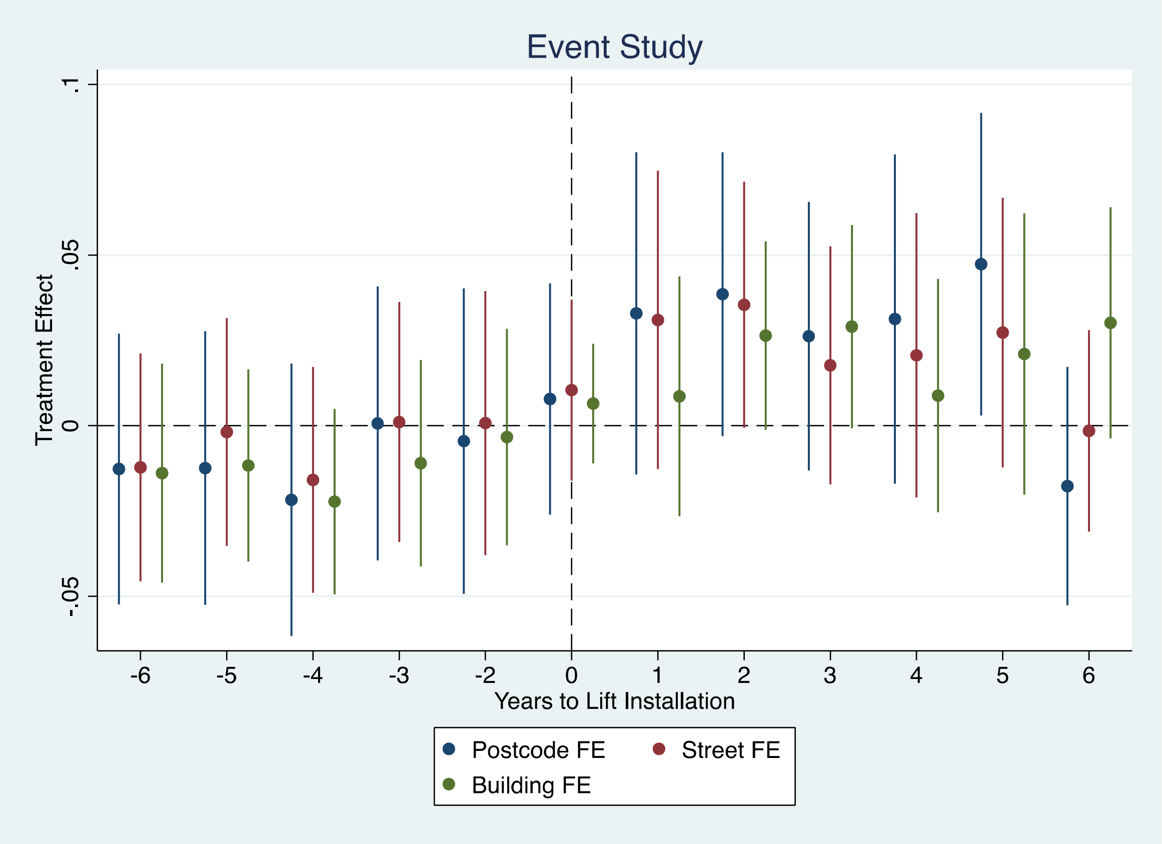
Notes: Robust standard errors in parentheses. Significance levels are *** p<0.01, ** p<0.05, * p<0.1.

The first model compares the mean of dwelling prices with lifts to mean of dwelling prices without lifts. The model suggest that dwellings with lifts are around 30% more valuable compared to other apartments. However, as discussed in the previous sections, we cannot conclude the price difference being caused of the lifts. When the model is augmented with year fixed effects, the premium even increases a little. Furthermore, we find increase in R-squared, which measures how much of the variation in price is explained by the independent variables. OLS 3 model introduces structural controls determined by hedonic pricing model. They consist of building- and dwelling attributes presented in table 4. After introducing those variables, the apartments with lifts are 1.83% more expensive compared to all other apartments. Moreover, the R-squared increases from 0.13 to 0.49 implying high relevance of the structural control variables.

6.2. AVERAGE TREATMENT EFFECT

Figure 3 shows how the price difference of the treatment- and control group apartments differ with respective to the difference of one year prior the lift installation. I vary the location fixed effects to get estimates from three models.

Figure 3 – Event Study



Notes: Year -6 includes observations -6 years or before. Year 6 includes 6 or later. Confidence interval is 95%. Standard errors are clustered at postcode level.

The figure shows that the coefficients are close to zero before lift installation. This means, that the price difference has not changed between the treatment and control groups prior the lift installation, thus supporting the parallel trends assumption. Furthermore, after lift installation (year 1 onwards), all the coefficients increase to 1-5%, and many of them are statistically significant with 95% confidence interval. The results suggest consistently similar pre-trends between the treated apartments and untreated apartments prior lift installation, and increase in prices after lift installation only for apartments that were treated.

Table 7 uses the empirical model described in equation 8 with location fixed effects varying from postcode to street and building levels. The building fixed effects model is interpreted as TWFE DID. All the models include the same structural and controls as the OLS-models. Year fixed effects are also included. *Treatment*After* –coefficient reveals the impact of lift installation on prices. It has value 1 if apartment belongs to treatment group and lift is installed, otherwise the value is zero. The last model with building fixed effects omits the treatment group –dummy, because building fixed effects already control for the same issue. The fully reported results are in appendix in table 11.

Table 7 – Average Treatment Effect

VARIABLES	(1) Postcode FE	(2) Street FE	(3) Building FE
Treatment	0.00609	-0.00554	
	(0.00690)	(0.00548)	
Treatment*After	0.0274***	0.0254***	0.0203***
	(0.00792)	(0.00657)	(0.00727)
Constant	10.78***	10.76***	9.735***
	(0.0670)	(0.0631)	(0.0700)
Observations	270,581	270,581	270,581
R-squared	0.905	0.936	0.960
Structural Controls	YES	YES	YES
Year FE	YES	YES	YES
Postcode FE	YES	NO	NO
Street FE	NO	YES	NO
Building FE	NO	NO	YES

Notes: Robust standard errors in parentheses. Standard errors are clustered by postcode. Significance levels are *** p<0.01, ** p<0.05, * p<0.1.

The lift premium is positive in every model: 2.74%, 2.54%, and 2.03% for postcode FE, street FE, and building FE respectively. All the coefficients have high statistical significance (p-value smaller than 0.01). The similar magnitude (2-3%) of the coefficients within this table is a signal of the robustness of the results. Furthermore, the results are in line with the event study model, that implied treatment effect being between 0-5%. Two percent impact means for average priced (150 000€) apartment three thousand euros value increase due to lift installation.

6.1. TREATMENT EFFECT BY FLOOR

One could argue that the main function of a lift is to avoid the need for walking stairs. A tenant may hence avoid costs of walking by using a lift thus receiving higher utility. If the tenants had the same utility preferences across the floor levels, the higher floor tenants should then receive higher utility from a lift installation. Hypothetically, this should be reflected to lift premiums across the floors.

Table 8 – Treatment Effect by Floor

VARIABLES	(1) Postcode FE	(2) Street FE	(3) Building FE
Treatment*Floor level*After			
1	0.00610	0.00714	0.00798
	(0.0129)	(0.0108)	(0.0125)
2	0.0282***	0.0158*	0.0126
	(0.0100)	(0.00855)	(0.00943)
3	0.0234**	0.0286***	0.0322***
	(0.0102)	(0.00869)	(0.0107)
4	0.0463***	0.0399***	0.0400***
	(0.0145)	(0.0113)	(0.0107)
5+	0.0385**	0.0270*	0.00832
	(0.0179)	(0.0159)	(0.0144)
Constant	10.81***	10.78***	9.749***
	(0.0663)	(0.0615)	(0.0697)
Observations	270,572	270,572	270,572
R-squared	0.904	0.935	0.960
Structural Controls	YES	YES	YES
Year FE	YES	YES	YES

Notes: Robust standard errors in parentheses. Standard errors are clustered by postcode. All the models include structural controls and year fixed effects. Significance levels are *** p<0.01, ** p<0.05, * p<0.1.

Table 8 shows estimated lift premiums by floor. *Treatment*Floor level*After* refers to coefficient β_1 from equation 9. In all of the three models, the treatment effect increases as the floor level increases until the fourth floor. The treatment effects are statistically insignificant at the first floor. At the second floor, the effects are between 2.8% to 1.26%. However, the result is statistically only with postcode FE- and street FE models. The third floor treatment effect is between 2.3% and 3.2% with low p-values. Treatment effect at the fourth floor is the highest: 4.0% - 4.6% and the precision of the estimates are the highest (p-value less than 1%). Fifth, or more floor treatment effect is ranges from 3.9% to 0.8%. However, the treatment effect for building FE model with 95% confidence interval ranges from -1.99% to 3.65%. Consequently, the treatment effect is likely lower for the fifth floor compared to fourth floor according to building FE -model. On contrary, based on the postcode- and street FE models we cannot be confident about treatment effect being lower compared to fourth floor treatment effects. Based on the results, lift installation increases prices as the floor level increases at least until the fourth floor.

6.2.TREATMENT EFFECT BY MUNICIPALITY

I used identical models compared to the table 7 by dividing the transaction sample by each municipality. *Treatment*After* –coefficients show the treatment effect of lift installations in the respective municipality.

Table 9 – Treatment Effect by Municipality

Postcode Fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Helsinki	Tampere	Oulu	Espoo	Lahti	Kuopio	Turku	Jyväskylä	Other
Treatment	-0.00734	0.0206	0.0286	-0.0187	0.0182	0.00548	0.0556**	-0.0656**	0.0146
	(0.00892)	(0.0154)	(0.0217)	(0.0181)	(0.0248)	(0.0180)	(0.0235)	(0.0277)	(0.0106)
Treatment*After	0.0290**	-0.0228	0.0458**	0.00871	-0.0475*	-0.0116	-0.00546	0.0381	0.0393***
	(0.0124)	(0.0216)	(0.0186)	(0.0335)	(0.0279)	(0.0168)	(0.0175)	(0.0381)	(0.0132)
Constant	11.11***	10.68***	10.67***	11.08***	10.50***	10.52***	10.41***	10.58***	10.46***
	(0.0403)	(0.0626)	(0.0768)	(0.0366)	(0.0451)	(0.0727)	(0.0663)	(0.0391)	(0.0336)
Observations	56,341	19,233	9,329	11,137	9,877	7,713	12,553	8,660	135,778
R-squared	0.901	0.875	0.810	0.851	0.862	0.864	0.876	0.870	0.847

Street Fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Helsinki	Tampere	Oulu	Espoo	Lahti	Kuopio	Turku	Jyväskylä	Other
Treatment	0.00186	0.0140	0.0126	-0.0165	0.00993	-0.00314	0.0112	-0.0358	-0.0105
	(0.00842)	(0.0151)	(0.0170)	(0.0358)	(0.0116)	(0.0247)	(0.0130)	(0.0282)	(0.00822)
Treatment*After	0.0157	-0.00168	0.0416**	-0.000388	-0.0148	0.0193	0.00870	0.0449*	0.0433***
	(0.0123)	(0.0156)	(0.0170)	(0.0272)	(0.0197)	(0.0145)	(0.0193)	(0.0260)	(0.00950)
Constant	11.14***	10.70***	10.62***	11.07***	10.46***	10.50***	10.50***	10.52***	10.40***
	(0.0390)	(0.0495)	(0.0631)	(0.0562)	(0.0610)	(0.0795)	(0.0317)	(0.0370)	(0.0321)
Observations	56,341	19,233	9,329	11,137	9,877	7,713	12,553	8,660	135,778
R-squared	0.923	0.917	0.877	0.896	0.900	0.897	0.927	0.906	0.901

Building Fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Helsinki	Tampere	Oulu	Espoo	Lahti	Kuopio	Turku	Jyväskylä	Other
Treatment*After	-0.00160	0.0219*	0.0641***	0.0241	-0.0418*	0.0336*	0.0166	0.0227	0.0377***
	(0.0138)	(0.0128)	(0.0136)	(0.0311)	(0.0236)	(0.0173)	(0.0230)	(0.0228)	(0.0103)
Constant	9.349***	9.336***	10.01***	10.01***	9.347***	9.420***	9.098***	9.702***	9.472***
	(0.0710)	(0.0571)	(0.0890)	(0.0846)	(0.138)	(0.156)	(0.0643)	(0.0563)	(0.0420)
Observations	56,341	19,233	9,329	11,137	9,877	7,713	12,553	8,660	135,778
R-squared	0.957	0.952	0.930	0.930	0.940	0.940	0.957	0.934	0.939

Notes: Robust standard errors in parentheses. Standard errors are clustered by postcode. All the models include structural controls and year fixed effects. Significance levels are *** p<0.01, ** p<0.05, * p<0.1.

The main finding of this table is that the confidence intervals are so large that almost all the results would fit in the previously found estimate of two percent treatment with 95 percent confidence interval. The only deviation is from Oulu, where the treatment effect is remarkable 6.41%.

6.1.Implications of the Results

Table 10 is an indicative projection about installation costs and property value increase for a housing condominium. I mimic the “base-case” -scenario about lift installation to residential block of flat with four floors.

Table 10 - Indicative Economic Effects of Lift Installation on Households

Apartment Characteristics[29]			Principle of cost allocation[30]		Costs	Benefit			Net cost
Apart-ment	Floor Level	Living Area (m^2)	Cost allocation score	Share of total	Costs allocated (€)	est. Apartment value (€)[31]	est. value increase %	est. value increase [32] (€)	Net cost (€)
A1	1	60	60	3.3 %	-2 250	128 600	0,71 %	900	-1 300
A2	1	60	60	3.3 %	-2 250	128 600	0,71 %	900	-1 300
A3	1	60	60	3.3 %	-2 250	128 600	0,71 %	900	-1 300
A4	2	60	120	6.7 %	-4 500	128 000	1,88 %	2 400	-2 100
A5	2	60	120	6.7 %	-4 500	128 000	1,88 %	2 400	-2 100
A6	2	60	120	6.7 %	-4 500	128 000	1,88 %	2 400	-2 100
A7	3	60	180	10.0 %	-6 750	128 000	2,81 %	3 600	-3 200
A8	3	60	180	10.0 %	-6 750	128 000	2,81 %	3 600	-3 200
A9	3	60	180	10.0 %	-6 750	128 000	2,81 %	3 600	-3 200
A10	4	60	240	13.3 %	-9 000	129 500	4,21 %	5 500	-3 500
A11	4	60	240	13.3 %	-9 000	129 500	4,21 %	5 500	-3 500
A12	4	60	240	13.3 %	-9 000	129 500	4,21 %	5 500	-3 500
Total		720	1800	100 %	-67 500	1 540 000		37 000	-30 000

Notes: The table shows estimated economic impact of lift installation on tenants´ net wealth. Multiple assumptions are imposed: lift installation cost is 150 000€. ARA permits 45% and municipality 10% subsidies of the total costs. Housing condominium has only one stairway. Other assumptions are described in the footnotes.

The first three columns describe the assumed apartments and their characteristics. The apartments are assumed identical (such as living area 60m2) except the floor level. The fourth and the fifth column assumes the principle of cost allocation being similar to the recommended way of sharing the costs. The sixth column shows the direct costs allocated. Columns 7-9 show the estimated property value increase. Last column is net monetary effect

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[29] Each apartment is assumed similar excluding the variation in the floor level.

[30] Maintenance charge score multiplied by floor level of the apartment determine the cost allocation score of retrolift installation. Maintenance charge score is used to determine maintenance cost allocation among the apartments. Usually it equals the living area.

[31] The estimated apartment value is based on hedonic regression model with postcode fixed effects.

[32] The estimated value increase percentages are means of postcode, street, and building fixed effects models from table 8 - treatment effects by floor.

for each of each apartment. Other assumptions are 150 000€ installation costs and 45% + 10% subsidies from ARA and municipality.

According to the costs -column, the first floor tenants pay 2250€ for the lift installation. The second floor tenants pay double the amount (4500€), third floor tenants triple times higher, and fourth floor four times higher share of the total costs. Despite wide range of direct costs allocated (2250€ – 9000€), the net costs are surprisingly close to each other for the apartments in different floors. The net cost for the first floor apartments is 1300€, for the second floor 2100€, and for the third floor and fourth floor 3200€ and 3500€ respectively. Two aspects drive the estimated property value increase: The higher floor apartments on average are more expensive compared to lower floor apartments, and the relative value increase is higher as the floor level increases.

Other outcome for the table is that the initial lift installation costs are only a fraction of the costs without the subsidies or property value increase. The initial cost is 150 000€. When the subsidies are included, the cost decreases to 67 500€. With property value increase included, the costs are only 30 000€, which is one fifth of the total costs. An alternative view is that the total discount for the housing condominium has increased from 55% to 80%. The additional discount 25%, (increase from 55% to 80%) was caused by the property value increase. The magnitude of the additional discount changes depends on the underlying assumptions. If the apartments were more expensive or the amount of apartments were higher, the additional discount would be higher.

Based on the findings regarding additional discount, table 10 mitigates also the concern of undesired outcome of the subsidy policy. It would still require over thirty thousand euros investment for the housing condominium to install a lift. Most likely, the previously mentioned companies such as student housing providers are not willing to pay this amount of investment. Some interesting findings are received, when changing the assumptions in the table. 1) The amount of total subsidies could be slightly above 75%, before the property value increase would exceed the costs of lift installation. 2) Lift installation cost should decrease from 150 000€ to 82 500€ before property value increase would exceed the costs of lift installation. 3) If the treatment effects[33] for each floor were at the upper bound of the 95% confidence interval, the property value increase would slightly exceed the investment

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[33] Property value increase at the upper bound of 95% intervals are: 2.95%, 3.84%, 5.1%, and 6.5% for floor levels 1,2,3, and 4 respectively.

cost by 5 percent. 4) If the building had only 3 floors, the net cost after property value increase would be 46 800€, which is almost 60 percent higher, even though the number of dwellings that are sharing the costs had decreased only by 25 percent. 5) For the net effects to be identical[34], the principle of cost allocation should multiply living area with figures 1.00, 1.40, 1.72, 2.22 for floor levels 1,2,3,4 respectively. This principle would yield net cost of -2 682€ for every household in the scenario. 6) If the cost allocation principle would share the installation costs evenly, the net costs for the first floor households would be -4700€, and the fourth floor tenants only -400€. Hence, the evenly allocated costs would be the more unequal method for cost allocation compared the current legislation.

To conclude, table 10 should be considered as indicative calculation of lift installation costs for a base-case block of flat with no prior lift. The housing condominiums can apply the table to calculate their costs by taking the property value increase into account. The policy makers can utilize the finding that property value increase most likely do not exceed the investment cost with the current subsidy levels. If the policy makers wanted to increase the equality of net effects among the households with the cost allocation policy, the range of the cost allocation multipliers (1-4) should be decreased.

The limitations of table 10 relate to simplified assumptions, and the external validity of the results of table 8. The lift installation costs are simplified at least in two ways. First, the cost of lift installation (150 000€ in my case) depends on many factors, such as the number of stops. The more floors, the more stops are required, and the higher is the cost. Second, the planning costs are omitted. Moreover, I have assumed no discount factor for the property value increase, even though it could be relevant in real life. The external validity of the floor level treatment effects (0-4%) is the highest for buildings shown in the descriptive statistics (table 4). Those buildings are constructed around year 1970, they have 3-5 floors, and their dwelling prices are around 2000-3000€/m^2. If a building that differs remarkably from those characteristics, the treatment effects and implications could differ as well.

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[34] I the multipliers are calculated using Excel solver with GRG nonlinear method

7. CONCLUDING REMARKS

This study has been motivated by the policy efforts to increase accessible housing supply by subsidizing lift installations. I identified positive externalities relating to the subsidy. However, the magnitude of the externalities depends on how well the subsidy reaches those who do not have enough wealth to relocate themselves to accessible housing after becoming physically restricted. The prior literature has been incomplete on how much the property values increase after lift installation. If the property value increase would exceed the subsidized installation costs, the subsidy was an income transfer for those who would not need it for living in accessible housing. Consequently, the magnitude of the positive externalities of the policy would decrease if lift installations caused a higher property value increase than the installation costs are. If there were no positive externalities, the policy would not be reasonable.

The main research question is how much lift installations affect the dwelling prices. Moreover, I studied the effect heterogeneity by floor level and by municipality. I utilized a dataset from a consortium of real estate brokers, who had collected the majority of transactions in blocks of flats between years 2000-2018. I used a hedonic pricing model with two-way fixed effects difference in differences setup with an intention to create a causal relationship between lift installations and dwelling prices.

My findings imply that between years 2000-2018, the lift installations have increased the dwelling prices by two percent on average. I increased the confidence for causal interpretation of the estimate by showing consistent pre-trends between the treatment and control groups prior the lift installation with the event-study approach. I found increasing treatment effects as the floor level increases by one unit until the fourth floor. I studied eight municipalities based on the number of lift installations. In seven municipalities, I cannot conclude that treatment effects would differ compared to the average two percent. An exception is Oulu, where the treatment effect has been six percent on average.

Based on the results, the concern about high property value increase was mitigated. The households´ lift installation net costs in a “base-case” scenario are from one to four thousand euros per household after dwelling price increase. The total subsidy could be 75% before property value increase would exceed the installation costs. Another interpretation of the results is that the housing condominiums could receive an additional 25 percent discount on top of the nationwide and municipality´s subsidies due to property price increases. The results also yield twofold perspectives on the law that determines the lift installation cost allocation criteria among households. Because lift installation increases the higher floor households´ wealth more compared to the lower floor households, it is reasonable to allocate more costs to the higher floor households. However, the results suggest that as the floor level increases, the share of costs increase slightly more than the property value increase. Thus, the cost allocation could be more equal if the rate of increase in the cost allocation multipliers between the floors were decreased.

More extensive research related to this topic could be conducted with better data quality. The more precise data regarding the building- and stairway identification is needed to increase the reliability of the results if similar studies are conducted. Moreover, before conducting more exhaustive cost-benefit analysis regarding the lift subsidy, the characteristics of the subsidy recipients (housing condominiums and their households) were ought to be collected. It would enable more precise assessments on how well the subsidy policy reaches those who could not otherwise be relocated to accessible housing due to tight budget constraints.

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APPENDIX

Table 11 – Average Treatment Effect

	(2)	(3)	(4)
VARIABLES	Postcode FE	Street FE	Building FE
Treatment	0.00609	-0.00554	
	(0.00690)	(0.00548)	
Treatment*After	0.0274***	0.0254***	0.0203***
	(0.00792)	(0.00657)	(0.00727)
Age	-0.0208***	-0.0198***	0.0163***
	(0.000662)	(0.000749)	(0.00230)
Age2	0.000204***	0.000183***	7.93e-05
	(9.74e-06)	(9.99e-06)	(5.19e-05)
Age3	-4.03e-07***	-3.50e-07***	7.42e-07**
	(3.42e-08)	(2.95e-08)	(2.91e-07)
Living Area	0.0104***	0.0104***	0.0106***
	(0.000458)	(0.000396)	(0.000374)
Maintenance Charge (€)	-0.000316***	-0.000231***	-0.000193***
	(5.91e-05)	(4.33e-05)	(4.07e-05)
Number of floors (0/1)			
3	-0.00407	0.00588	
	(0.00619)	(0.00538)	
4	0.0190**	0.0184***	
	(0.00754)	(0.00607)	
5	0.0334***	0.0302***	
	(0.00921)	(0.00688)	
6	0.0278***	0.0221***	
	(0.00942)	(0.00663)	
7	0.0336***	0.0220***	
	(0.0110)	(0.00684)	
8	0.0160	0.0180**	
	(0.0129)	(0.00709)	
9	0.0271**	0.0306***	
	(0.0109)	(0.0113)	
Number of rooms (0/1)			
1	-0.0867	-0.0695	-0.0951*
	(0.0611)	(0.0597)	(0.0574)
2	0.0660	0.0775	0.0355
	(0.0609)	(0.0602)	(0.0567)
3	0.136**	0.143**	0.0875
	(0.0616)	(0.0613)	(0.0568)
4	0.167***	0.161**	0.0956*
	(0.0629)	(0.0627)	(0.0574)
5	0.126*	0.0956	0.0402
	(0.0645)	(0.0645)	(0.0585)
Apartment Condition, Broker estimate (0/1)			
Poor	-0.163***	-0.160***	-0.156***
	(0.00587)	(0.00531)	(0.00533)
Decent	-0.0509***	-0.0485***	-0.0463***
	(0.00315)	(0.00281)	(0.00278)
Good	0.0800***	0.0718***	0.0655***
	(0.00287)	(0.00252)	(0.00244)
Excellent	0.172***	0.154***	0.133***
	(0.0143)	(0.0150)	(0.0138)

Floor Level (0/1)			
1	0.0163**	0.0120*	0.0132**
	(0.00745)	(0.00660)	(0.00660)
2	0.0226***	0.0160**	0.0159**
	(0.00740)	(0.00667)	(0.00667)
3	0.0227***	0.0173**	0.0162**
	(0.00748)	(0.00674)	(0.00676)
4	0.0387***	0.0307***	0.0277***
	(0.00784)	(0.00712)	(0.00719)
5	0.0567***	0.0491***	0.0471***
	(0.00831)	(0.00745)	(0.00747)
6	0.0657***	0.0571***	0.0604***
	(0.00909)	(0.00819)	(0.00900)
7	0.0939***	0.0864***	0.0800***
	(0.0104)	(0.00961)	(0.0104)
8	0.0927***	0.101***	0.1000***
	(0.0106)	(0.0107)	(0.0126)
9	0.103***	0.0935***	0.111***
	(0.0164)	(0.0175)	(0.0190)
Sale Year (0/1)			
2001	0.000457	0.000725	-0.0345***
	(0.00549)	(0.00509)	(0.00557)
2002	0.0675***	0.0714***	0.00571
	(0.00635)	(0.00566)	(0.00578)
2003	0.142***	0.148***	0.0461***
	(0.00617)	(0.00571)	(0.00564)
2004	0.216***	0.219***	0.0850***
	(0.00694)	(0.00654)	(0.00662)
2005	0.280***	0.286***	0.116***
	(0.00708)	(0.00665)	(0.00696)
2006	0.366***	0.370***	0.165***
	(0.00744)	(0.00710)	(0.00713)
2007	0.427***	0.432***	0.193***
	(0.00728)	(0.00716)	(0.00707)
2008	0.450***	0.455***	0.182***
	(0.00736)	(0.00715)	(0.00768)
2009	0.466***	0.470***	0.163***
	(0.00791)	(0.00713)	(0.00728)
2010	0.550***	0.556***	0.214***
	(0.00798)	(0.00758)	(0.00693)
2011	0.588***	0.591***	0.214***
	(0.00825)	(0.00787)	(0.00698)
2012	0.618***	0.620***	0.208***
	(0.00867)	(0.00822)	(0.00685)
2013	0.641***	0.645***	0.200***
	(0.00934)	(0.00892)	(0.00673)
2014	0.649***	0.653***	0.171***
	(0.00986)	(0.00944)	(0.00657)
2015	0.644***	0.646***	0.130***
	(0.0104)	(0.0102)	(0.00621)
2016	0.655***	0.658***	0.102***
	(0.0108)	(0.0109)	(0.00574)
2017	0.656***	0.655***	0.0659***
	(0.0122)	(0.0119)	(0.00530)
2018	0.662***	0.661***	0.0382***
	(0.0133)	(0.0136)	(0.00411)
2019	0.664***	0.661***	
	(0.0141)	(0.0147)	
Constant	10.78***	10.76***	9.735***
	(0.0670)	(0.0631)	(0.0700)

Observations	270,621	270,621	270,621
R-squared	0.905	0.936	0.960
Structural Controls	YES	YES	YES
Year FE	YES	YES	YES
Postcode FE	YES	NO	NO
Street FE	NO	YES	NO
Building FE	NO	NO	YES

Notes: Robust standard errors in parentheses. Standard errors are clustered by postcode. Significance levels are *** p<0.01, ** p<0.05, * p<0.1.

Table 12 – Treatment Effect by Floor

VARIABLES	(1) Postcode FE	(2) Street FE	(3) Building FE
Treatment*Floor level			
1.	0.00364	-0.0134	0.0891
	(0.0104)	(0.00865)	(0.0630)
2.	0.00882	-0.00674	0.0934
	(0.00847)	(0.00637)	(0.0630)
3.	0.0123	-0.00471	0.0951
	(0.00767)	(0.00655)	(0.0632)
4.	-0.00412	-0.00279	0.114*
	(0.0128)	(0.0103)	(0.0635)
5.	0.00660	0.0188	0.158**
	(0.0164)	(0.0146)	(0.0643)
Treatment*Floor level*After			
1.	0.00610	0.00714	0.00798
	(0.0129)	(0.0108)	(0.0125)
2.	0.0282***	0.0158*	0.0126
	(0.0100)	(0.00855)	(0.00943)
3.	0.0234**	0.0286***	0.0322***
	(0.0102)	(0.00869)	(0.0107)
4.	0.0463***	0.0399***	0.0400***
	(0.0145)	(0.0113)	(0.0107)
5.	0.0385**	0.0270*	0.00832
	(0.0179)	(0.0159)	(0.0144)
age	-0.0208***	-0.0197***	0.0163***
	(0.000663)	(0.000749)	(0.00230)
age2	0.000203***	0.000182***	7.86e-05
	(9.73e-06)	(9.97e-06)	(5.19e-05)
age3	-4.02e-07***	-3.50e-07***	7.43e-07**
	(3.41e-08)	(2.94e-08)	(2.91e-07)
Number of Floors (0/1)			
3	-0.00315	0.00690	
	(0.00619)	(0.00539)	
4	0.0242***	0.0227***	
	(0.00760)	(0.00608)	
5	0.0442***	0.0394***	
	(0.00931)	(0.00684)	
6	0.0439***	0.0357***	
	(0.00972)	(0.00674)	
7	0.0572***	0.0422***	
	(0.0115)	(0.00705)	
8	0.0449***	0.0444***	
	(0.0129)	(0.00700)	
9	0.0599***	0.0593***	
	(0.0111)	(0.0117)	
Number of Rooms (0/1)			
1.	-0.0924	-0.0758	-0.0948*
	(0.0611)	(0.0597)	(0.0575)
2.	0.0603	0.0710	0.0355
	(0.0610)	(0.0603)	(0.0568)
3.	0.131**	0.136**	0.0870
	(0.0618)	(0.0615)	(0.0569)
4.	0.161**	0.155**	0.0954*
	(0.0632)	(0.0630)	(0.0575)
5.	0.121*	0.0900	0.0406
	(0.0650)	(0.0650)	(0.0587)
Living Area (0/1)	0.0104***	0.0104***	0.0106***

	(0.000459)	(0.000398)	(0.000376)
Maintenance Charge	-0.000317***	-0.000231***	-0.000192***
	(5.90e-05)	(4.33e-05)	(4.08e-05)
Apartment Condition, Broker estimate (0/1)			
Poor	-0.163***	-0.160***	-0.156***
	(0.00586)	(0.00529)	(0.00532)
Decent	-0.0507***	-0.0484***	-0.0463***
	(0.00315)	(0.00281)	(0.00279)
Good	0.0804***	0.0720***	0.0657***
	(0.00287)	(0.00252)	(0.00245)
Excellent	0.171***	0.155***	0.134***
	(0.0146)	(0.0153)	(0.0140)
Sale Year (0/1)			
2001	0.000299	0.000522	-0.0344***
	(0.00550)	(0.00509)	(0.00556)
2002	0.0664***	0.0707***	0.00573
	(0.00633)	(0.00565)	(0.00577)
2003	0.142***	0.147***	0.0460***
	(0.00616)	(0.00570)	(0.00564)
2004	0.215***	0.218***	0.0848***
	(0.00693)	(0.00655)	(0.00662)
2005	0.279***	0.285***	0.116***
	(0.00705)	(0.00663)	(0.00695)
2006	0.365***	0.369***	0.165***
	(0.00743)	(0.00710)	(0.00713)
2007	0.427***	0.431***	0.193***
	(0.00727)	(0.00717)	(0.00709)
2008	0.449***	0.455***	0.182***
	(0.00736)	(0.00716)	(0.00769)
2009	0.466***	0.470***	0.163***
	(0.00790)	(0.00712)	(0.00729)
2010	0.549***	0.555***	0.214***
	(0.00797)	(0.00758)	(0.00693)
2011	0.587***	0.590***	0.214***
	(0.00823)	(0.00787)	(0.00699)
2012	0.617***	0.619***	0.208***
	(0.00867)	(0.00822)	(0.00685)
2013	0.641***	0.645***	0.200***
	(0.00933)	(0.00892)	(0.00672)
2014	0.648***	0.652***	0.171***
	(0.00983)	(0.00943)	(0.00657)
2015	0.643***	0.645***	0.130***
	(0.0104)	(0.0102)	(0.00621)
2016	0.655***	0.657***	0.102***
	(0.0108)	(0.0109)	(0.00574)
2017	0.655***	0.654***	0.0660***
	(0.0122)	(0.0119)	(0.00530)
2018	0.662***	0.660***	0.0382***
	(0.0133)	(0.0136)	(0.00412)
2019	0.663***	0.660***	
	(0.0141)	(0.0147)	
Constant	10.81***	10.78***	9.749***
	(0.0663)	(0.0615)	(0.0697)
Observations	270,572	270,572	270,572
R-squared	0.904	0.935	0.960
Structural Controls	YES	YES	YES
Year FE	YES	YES	YES

Notes: Robust standard errors in parentheses. Standard errors are clustered by postcode. Significance levels are *** p<0.01, ** p<0.05, * p<0.1.

Table 13 - Potential Alternative Control Groups

VARIABLE	Control Group Always lift mean	Control Group Never lift mean	Treatment Group Installed Lift mean	Total sample mean
Municipality (0/1)				
Other	39.3 %	52.9 %	44.8 %	50.1 %
Espoo	3.3 %	4.3 %	3.8 %	4.1 %
Helsinki	22.8 %	20.1 %	27.4 %	20.8 %
Jyväskylä	3.1 %	3.2 %	3.2 %	3.2 %
Kuopio	3.5 %	2.7 %	3.5 %	2.9 %
Lahti	6.3 %	3.0 %	4.2 %	3.7 %
Oulu	5.0 %	3.0 %	4.1 %	3.4 %
Tampere	7.9 %	7.0 %	5.3 %	7.1 %
Turku	8.9 %	3.7 %	3.6 %	4.7 %
Building Characteristics				
Lift (0/1)	1	0	0.52	0.20
Construction Year	1972	1968	1971	1969
Age	37.1	41.7	39.1	40.8
Number of Floors	5.65	3.06	4.64	3.60
Dwelling Characteristics				
Price[35] (€)	148 759	104 627	151 249	114 351
Price (€/m^2)	2 465	1 914	2 526	2 037
Living Area	60.0	56.4	59.6	57.2
Maintenance Charge[36] (€)	169	173	183	172
Number of rooms	2.28	2.18	2.27	2.20
Floor Level	3.32	2.06	2.81	2.32
Apartment condition, Broker estimate (0/1)				
Unknown	10 %	10 %	8 %	10 %
Poor	3 %	3 %	3 %	3 %
Decent	27 %	31 %	28 %	30 %
Good	59 %	56 %	60 %	57 %
Excellent	1 %	0 %	1 %	0 %
Obs.	51 490	212 784	8 062	272 336

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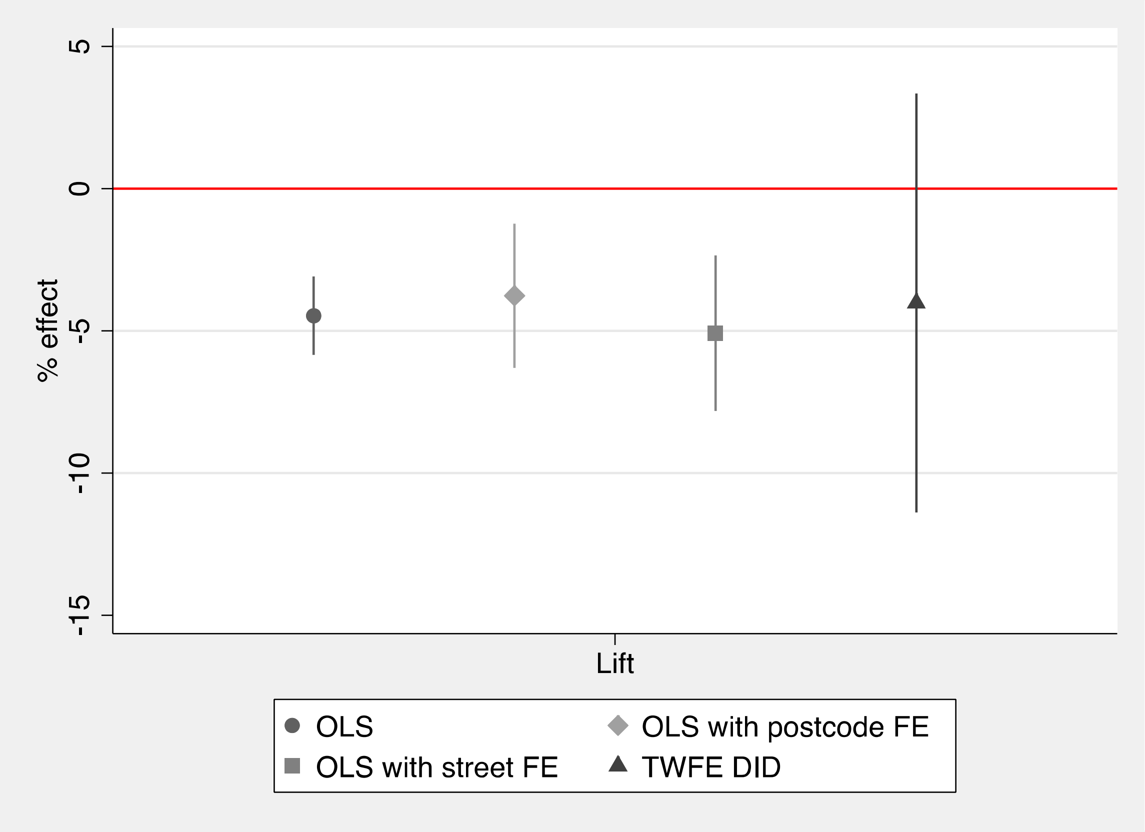
[35] Is total payment that the buyer pays in transaction

[36] Maintenance charge is monthly payment from housing condominium maintenance expenses. It does not include charge from financial costs

Figure 4 – Effect of Lift installation on Sale Time



Notes: Dependent variable is logarithm of Sale Time (days of apartment being on markets). Structural, and year fixed effects are used in all of the models. Confidence interval: 95%. Standard errors are clustered by postode. The four estimates imply 5 percent reduction in sale time.