Aalto University
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The effect of pipe repairs on housing prices

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Master's Thesis
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Abstract
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THE EFFECT OF PIPE REPAIRS ON HOUSING PRICES

PURPOSE OF THE STUDY

Pipe repair is the most expensive common renovation type in Finland and the number of repairs is growing as the buildings from the 60s and 70s building boom come to renovation age. Although repair costs are significant from the owner's point of view, there is no evidence on how the costs are transferred to housing prices. This thesis examines pipe repair effect on housing prices and transaction volumes. The objective is to see if the market values the costs of the forthcoming repair fairly i.e. whether buyers discount the selling price of the dwelling properly so that the discount covers the costs of future repair. Estimating the repair costs is rather straightforward. Thus pipe repairs offer an excellent opportunity to examine how well people account for future expenditures in the housing market setting.

DATA

I will study the pipe repair price impact by using apartment transaction and housing company data from Helsinki and Espoo area from the period January 2000 – June 2010. The data was collected from several sources: Oikotie, Kiinteistömaailma, Hintaseurantapalvelu (HSP) and three Finnish real estate managing agencies. The data from the real-estate managing agencies is unique as it was hand-collected with the help of real-estate managers. To my knowledge, I am also the first one to utilize Oikotie data for studying repairs.

RESULTS

The results show that the market pays excessively for dwellings before and during the repair. Apartment prices start to depreciate six years before the repair but the discount is at no point large enough to account for the discounted value of future pipe repair costs. The results also indicate that the shorter the time from the last pipe repair or alternatively the construction, the larger the dwelling overpricing. The price of the apartment also affects the percentage share of overpricing. Inexpensive apartments are relatively more overpriced before the repair than expensive ones.

KEYWORDS

Pipe repair, housing prices, depreciation, maintenance

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PUTKIREMONTIN VAIKUTUS ASUNNON HINTAAN

TUTKIELMAN TAVOITTEET

Putkiremontti on talon kallein tavallinen remontti. Putkiremonttien määrä kasvaa entisestään Suomessa kun loput 60- ja 70-luvulla rakennetuista taloista remontoidaan. Vaikka kustannukset ovat merkittävä kuluerä asunnon omistajan kannalta, ei ole todisteita siitä, että kustannukset näkyvät asuntojen hinnoissa. Tässä tutkielmassa tutkitaan putkiremontin vaikutusta asunnon hintaan ja myyntivolyymeihin. Tavoitteena on nähdä, otetaanko tulevan putkiremontin kustannuksen huomioon arvostettaessa asuntoja ennen putkiremonttia eli diskonttaavatko ostajat tulevan putkiremontin kustannukset kokonaan ja vähentävät ne asunnon hinnasta. Remontin kustannusten arvioiminen on suhteellisen suoraviivaista, joten putkiremontin hintavaikutuksen tutkiminen tarjoaa erinomaisen mahdollisuuden tutkia, miten hyvin ihmiset huomioivat tulevaisuuden kustannukset asuntomarkkinoilla.

LÄHDEAINEISTO

Tarkastelen putkiremontin hintavaikutusta hyödyntämällä asuntojen kauppatietoja sekä taloyhtiökohtaisia tietoja Helsingissä ja Espoossa aikavälillä tammikuu 2000 – kesäkuu 2010. Aineisto kerättiin useista eri lähteistä: Oikotieltä, Kiinteistömaailmasta, Hintaseurantapalvelusta (HSP) sekä kolmelta suomalaiselta isännöitsijätoimistolta. Isännöitsijätoimistoilta kerätty aineisto on ainut laatuaan, sillä se kerättiin käsin isännöitsijöiden avustuksella. Olen tietääkseni myös ensimmäinen, joka hyödyntää Oikotieltä saatavia remonttitietoja tutkimukseen.

TULOKSET

Tulokset osoittavat, että asunnoista maksetaan asuntomarkkinoilla liikaa ennen putkiremonttia sekä sen aikana. Asuntojen hintojen havaittiin alkavan laskea noin kuusi vuotta ennen remonttia, mutta hinnan alennus ei missään vaiheessa ole tarpeeksi suuri, jotta se kattaisi tulevan remontin kustannuksen diskontatun arvon. Tulokset osoittavat myös, että mitä lyhyempi aika edellisestä putkiremontista tai talon rakentamisesta on, sitä suurempaa ylihinnoittelu on. Myös asunnon hinta vaikuttaa ylihinnoittelun prosentuaaliseen määrään. Halvemmissa asunnoissa ylihinnoittelu ennen remonttia on suhteellisesti suurempaa kuin kalliimmissa asunnoissa.

AVAINSANAT

Putkiremontti, asuntojen hinnat, arvon alentuminen, kunnossapito

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1 INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

A rational buyer sets his bid price after having assessed all relevant factors affecting the value. In the housing market, important attributes such as size, location and condition of the dwelling are considered. Substantial future costs including costs of maintenance and repair should be discounted and incorporated in valuation in a similar manner. Wilhelmsson (2008) finds that maintenance in fact has a considerable impact on a dwelling price. According to his study, the price difference between forty-years-old maintained single-houses (both outdoors and indoors maintenance) and not maintained single houses was some thirteen percent in Sweden.

Following the same logic, the costs of future pipe repairs have to be discounted and deducted from the selling price. Consider two practically identical apartments, A and B, situated in the same neighborhood in buildings constructed in the 1960s. The only difference between the two apartments is the condition of pipes. Apartment A is in the building where water and waste pipes were renovated a couple of years ago whereas the pipes in the building of apartment B remain untouched. If you were to buy one of the two apartments, which one would you choose? It depends on the price. As the dwellings are alike, a rational person chooses the less expensive alternative. In evaluating the true cost of buying apartment B, the costs of the approaching pipe repair must be discounted and added to the selling price. If B's selling price together with the discounted repair costs, costs of discomfort and lost rent / additional living costs is lower than the selling price of A, one should prefer B to A and vice versa.

Valuing pipe renovations is straightforward in theory but the practice proves otherwise. The price effect of pipe repairs is contested and there are arguments for why both under and over discounting the costs of renovation could take place. All buyers, sellers and real-estate agents are interested in the price effect of the repair but no reliable evidence exists. For instance, when using a five percent required rate of return, approximately ninety percent of the repair's nominal costs should be carried by the seller two years before the repair. If this is not the case and the seller compensates either more or less, the apartment is wrongly valued.

The claim that the buyers ignore or underestimate future maintenance costs gets support from Knight et al. (2000) who study the impact of repair expenses on property selling prices. They find evidence that the transaction prices of badly maintained or substantially under-maintained dwellings do not significantly differ from those of normally maintained homes. There are various potential explanations for why the market would not discount the apartment price correctly. In the stock market context, DellaVigna and Pollet (2007) study how investors respond to predictable changes in profitability. They examine how and when the market accounts for predicteble demographic shifts that affect the profitability in certain industries. They find that demand changes five to ten years in the future predict annual industry stock return whereas demand changes over shorter horizons do not. They suggest that inattention to information about the distant future could contribute to the phenomena, among other things. Five years is the longest time horizon for which financial forecasts are prepared for.

Research evidence also shows that investors tend to over discount future costs and benefits (see Bazerman 2006), so a pipe repair coming in from two to five years may seem very distant, which could lead to cost underestimation. Buyers and sellers also use prices of similar apartments as reference prices and anchor their bid/ask prices to prices of other apartments less available attributes such as pipes. Corroded pipes are in most cases less obvious than awful tapestry from the 70s. Sellers or real-estate agents may play down the importance of the repair and conceal information from buyers, especially when no explicit repair decisions exist. On the other hand, the opportunity to renovate the bathroom and maybe kitchen according to one's taste may be valued by the market.

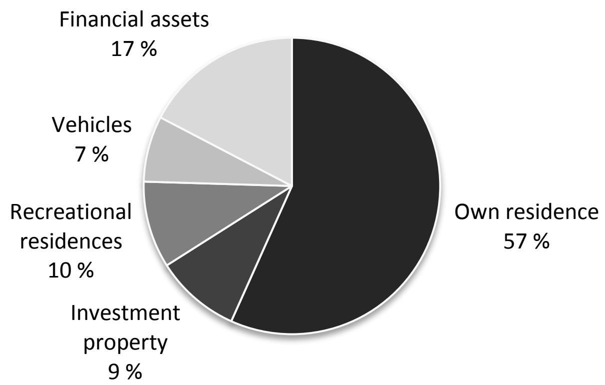
On the contrary, other anecdotes suggest that the dwellings in unrepaired houses are sold at too low prices and the buyers would benefit from getting one. If the supply for apartments exceeds the demand, the pipe repair may prolong the selling process and lower the selling price disproportionately much. However, I didn't find any empirical support for repair overpricing of this kind.

As can be deduced from the abundance of articles and discussion, pipe repairs are a hot topic in Finland. And for a reason – the number of pipe repairs is constantly increasing as pipe systems in houses built or last repaired in the 50s, 60s and 70s are getting corroded. The pipe repair market for the buildings constructed in the 60s is approximately 1.3 billion euros per annum in Finland. The estimation takes into account the number and size of dwellings built in the 60s (Statistics Finland) and assumes the cost to be 500 euros per square meter. As a comparison, the turnover of large building construction enterprises from renovation building was 4.3 billion euros in 2009 (Statistics Finland).

Purchasing a home is likely to be life's most important investment decision for most individuals. Several studies have found the wealth effect of housing consumption to be greater than that of financial assets (see e.g. Benjamin et al 2004, Campbell and Cocco 2004). In Finland, the proportion of housing assets of total household assets is remarkable – the value of own and investment dwellings as well as recreational residences make up three-quarters of an average Finn's wealth (Statistics Finland) as shown in Figure 1.

Figure 1 Distribution of a household's gross assets 2004

The pie chart shows the distribution of an average Finnish household's gross wealth in 2004. The data is from the Statistics Finland, Households' assets and debt by wealth decile 2004.



As the pipe repair costs significantly affect housing value, it is essential for individuals to be able to estimate their price effect to make financially sound decisions. This is especially crucial for investors whose primary goal for housing is to make profit. In addition, for buyers who own their apartment for a short period of time the potential rapid change in dwelling valuation may come as an unpleasant surprise.

1.2 RESEARCH QUESTIONS AND CONTRIBUTION

The purpose of the thesis is to study the effect of pipe repairs on dwelling prices. I intend to quantify the price impact before and after the renovation and determine whether the repair costs are properly taken into account before the repair. The three key research questions are:

1. *How do pipe repairs affect housing prices?*
2. *Is the change in price adequate to account for the costs of the repair?*
3. *How does the price change in time?*

In addition, I examine how two additional factors, namely the length of the repair interval and the price of the apartment, affect pipe repair pricing.

The knowledge about pipe repair price effect should benefit the market by reducing price uncertainty and shortening selling times through more accurate pricing. Despite the everyday importance, quantifying pipe repair price impact is a practically unexplored field among both the academia and the practitioners. In addition, few maintenance and depreciation related studies make use of actual or estimated repair costs. My contribution to the existing knowledge is that I am the first one to provide reliable results on the price effect. I examine how well the market succeeds in valuing future repair costs. Moreover, I intend to provide further insight into housing related behavioral biases that could explain the repair mispricing discovered.

As in Knight et al. (2000) my findings support the conclusion that the market pays excessively for dwellings before and during the repair. Apartment prices start to depreciate six years before the repair but the discount is at no point large enough to account for the discounted value of future pipe repair costs. Therefore, it seems that behavioral factors significantly affect purchasing housing. The results also indicate that the apartment overpricing reduces as the repair interval increases. The rationale for this is that if the repair comes later than expected, the value of the repair costs at the time of the transaction is diminished. The price of the apartment also affects the percentage share of overpricing. Inexpensive apartments are relatively more overpriced before the repair than expensive ones as repair costs account for a larger share of the dwelling sales price.

1.3 STRUCTURE OF THE THESIS

The rest of the thesis is structured in a following way: Section 2 introduces the practical setting for the thesis giving an overview of the Finnish housing market and pipe repairs. Section 3 sheds light on the theoretical aspects of housing market, housing price formation and hypothesized reasons for pipe repair underpricing. The methodology is explained in Section 4 and the data for the empirical part is presented in Section 0. I analyze and discuss the results in Section 6 and suggest the potential reasons for the repair underpricing detected in Section 7. To conclude, I summarize the main findings of the thesis and provide suggestions for further research in Section 8.

2 Practical setting

This section focuses on two subjects that are relevant for understanding the pricing of pipe repairs: the housing markets studied and practical information on pipe repairs. I will start by giving a brief overview of the Finnish housing markets, concentrating on the Helsinki metropolitan area (HMA) where possible. Then, I will discuss the timing, process and costs of repairing pipes.

2.1 Features and development of the Finnish housing market

This subsection gives an overview of the changes in regulation and prices in the Finnish housing market and in the HMA. I will also introduce the market's ownership structure and the proportions of subsided and private dwellings. The expansion of the HMA is also reviewed as the building age is the most important factor affecting pipe repair timing. Finally, Finnish housing preferences are reviewed.

2.1.1 Housing market development and institutional changes since 1970

The Finnish housing market has undergone major changes during the past forty years. In this section, I will quickly review the most important regulatory changes and their impact on housing prices. Other major ups and downs are also reviewed. The section is largely based on Oikarinen's (2007) more comprehensive review – other sources are mentioned where relevant.

Housing prices have been highly volatile since 1970 as can be seen in Figure 2. The first price peak occurred in 1973-74 after which the real prices dropped in the aftermath of the oil crises. Nominal prices, however, increased also during 1974-1980 but the high inflation caused a decrease in real housing prices. In 1987-89 prices peaked even more notably. This was largely the result of the gradual deregulation of the Finnish Banking system in 1986. Before that the banking system had been tightly regulated and when these regulations were removed, there was a huge growth in lending including house loans, which led to the housing boom. The bubble burst and the housing prices plummeted together with the Finnish economy in 1989–1992. However, although the deregulation took place in the second half of the 1980s, typically European longer loan periods were adopted in the 2000s, when the low interest rates made long loans a feasible option (Juntto 2007). In 1993, there was a reform in tax codes concerning the deductibility of mortgage interest payments in taxation. Additionally, rent regulation was removed in stages in 1992-1995. The market turned in 1995 and the prices soared between 1996 and 2008. The global financial crisis calmed the market down in 2008-2009 but the prices have bounced back quickly after that.

Figure 2 Real price index development 1970-2009

The chart shows the quarterly development of the real price index for old apartment block apartments in Finland 1970-2009. The development is cleaned from the effects of general consumer price changes. The data is indexed (1970=100) and shows the development separately for the HMA and the whole country. The data source is Statistics Finland (2010).

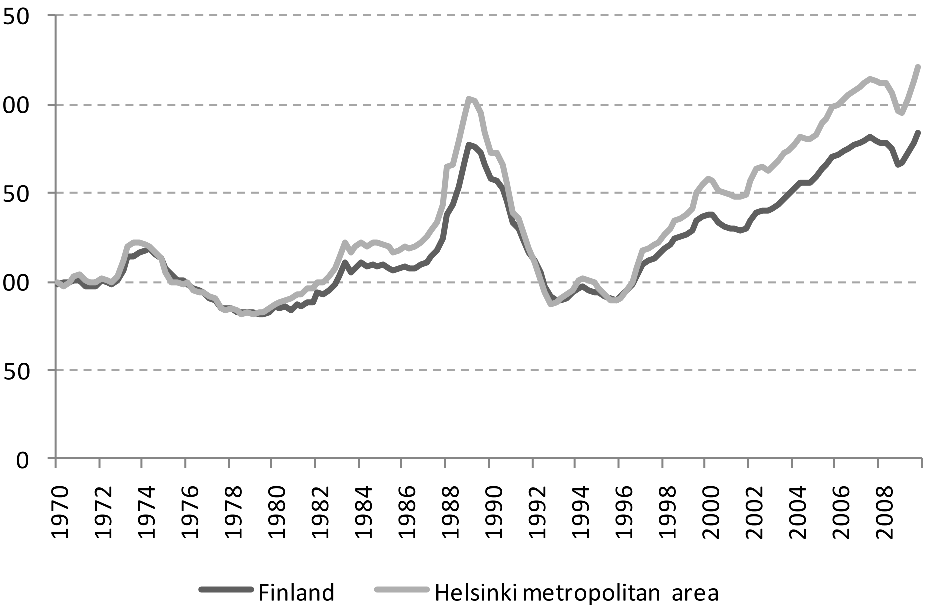


Figure 2 also shows that prices have developed more favorably in the HMA than in the rest of the country. The difference in price growths has enlarged since 1996. The rapid growth in housing market valuation has raised questions on the sustainability of current price levels. But as Oikarinen notes a long-lasting growth in real price index does not automatically mean overheated housing markets as long as the growth is based on fundamentals. Furthermore, housing prices tend to differ from region to region and the national housing price index should not be used to assess price development in different submarkets. In the HMA and in a couple of other centers, the regional price levels have diverged from the whole country due to increased migration from peripheral areas, especially since the 1990s.

2.1.2 FINNISH AND HELSINKI METROPOLITAN AREA HOUSING MARKETS IN BRIEF

The Finns have a strong preference for owning instead of renting their home. In 2008, 59 percent of dwellings were owner-occupied and only 30 percent were rental dwellings. About one percent of the dwellings are so called "right of occupancy" dwellings. Job related and unspecified housing accounts for the remaining ten percent (Statistics Finland, Housing statistics). The Finnish housing market comprises the publicly subsidized and the privately financed sectors. In the rental market, both sectors are somewhat equally sized (Juntto 2007), but in the owner-occupied market, the share of subsidized dwellings is much lower. The subsidized sector is left out from the scope of this study as the selling prices are regulated to an extent and these cases could distort the results. The rental market is similarly out of the scope of the study.

According to Statistic Finland (2010), the Finnish housing stock comprised 2,768,000 dwellings of which 2,499,000 were regularly inhabited at the end of 2008. The two most common dwelling types are apartment houses (43 percent of the dwelling stock) and single-houses (41 percent). Other housing types include row houses and semi-detached houses that account for 14 percent of the stock. The number of apartments has doubled and the number of row houses has grown tenfold since 1970. However, only one third of the population lives apartment buildings, which is explained by the small average size of the apartment buildings. (Ibid.) In the Helsinki metropolitan area, as well as in other densely populated areas, the share of apartment buildings is high above the national average. The housing stock in the HMA consists of roughly half a million dwellings of which as much as three quarters is located in apartment houses. (Oikarinen 2007.)

The small size of dwellings characterizes the Finnish housing market. 45 percent of dwellings have one or two rooms, which is in line with the fact that 73 percent of all housing units comprise one or two people. The average size of a housing unit was 2.1 people in 2008. (Statistics Finland 2010.) In Helsinki, the share of small households is even larger: some 50% of housing units are one-person households and some 30% are two-person households (City of Helsinki Urban Facts 2010).

As compared to EU averages, the Finns move a lot. This is caused by at least the following factors: the size of the dwelling has gradually increased (room-by-room), urbanization, changes in the family and children becoming independent early. The transaction costs are also relatively low as families who have lived in their dwelling for at least two years are exempt from any capital taxes.

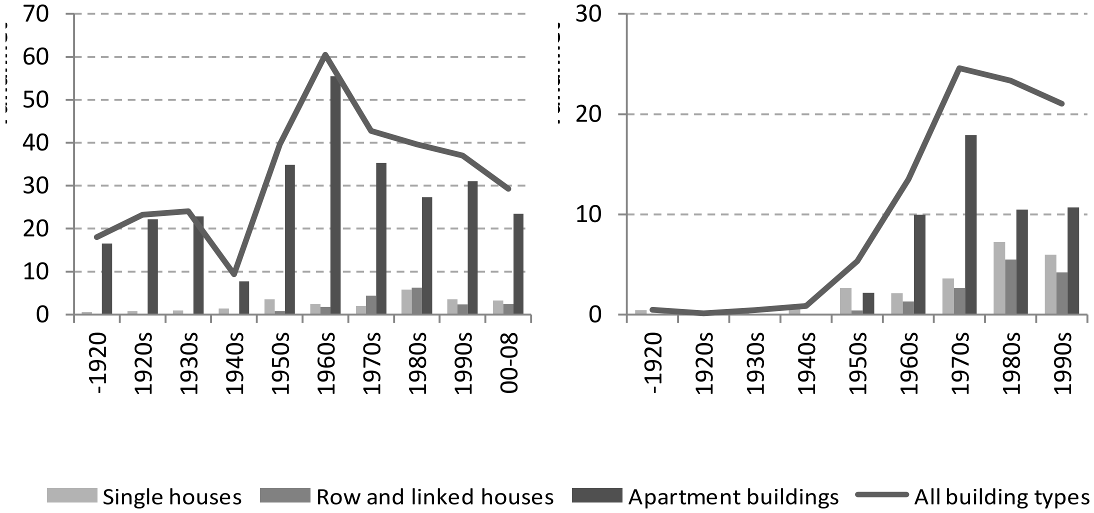
2.1.3 Development of the Helsinki metropolitan area

Helsinki became the capital in 1812 after which its population figure doubled every 20-30 years up until the 1960s. In the 60s, part of the population started to look for more spacious dwellings in the neighboring communities and the growth calmed down a bit. The migration to other communities, however, increased strongly in the 80s followed by an even sharper increase in the 90s. Nowadays, the Helsinki region is home for 1.32 million inhabitants. The Helsinki region consists of the HMA (Helsinki, Espoo, Kauniainen and Vantaa) and outer communities comprising ten municipalities. During the past ten years, the population of the Helsinki region has increased by 130,000 inhabitants i.e. by around one percent per year. (City of Helsinki Urban Facts 2009.)

The development of the HMA is interesting from the point of view of this study as the construction time of the building largely determines the timing of the pipe repair. Figure 3 illustrates the development of new housing construction in Helsinki and Espoo.

Figure 3 Construction of housing buildings in Helsinki and Espoo

These charts illustrate the construction activity in Helsinki and Espoo. The figures show the total number of dwellings (in thousands) built before 2009 by construction decades. The data also shows the distribution of dwellings by the dwelling type. The data is from Helsingin seudun aluesarjat.



The housing construction in Espoo started significantly later than in Helsinki as the capital grew from the center and expanded to cover larger and larger areas. Apartment buildings have been by far the most popular buildings in Helsinki while single houses and row and linked houses are gaining popularity in Espoo. From the point of the view of this study, it is most interesting to see that 1950–1970 was the most active construction period in Helsinki. In Espoo, the housing population is newer on average, but the number of houses from the 60s and the 70s is still substantial. In both cities, areas have been developed in batches – for instance, Tapiola in Espoo has been constructed mostly in the 50s and 60s.

As already discussed, prices have risen more in the HMA than in the whole country since 1996. Overall, dwellings in the HMA are valued roughly twice as high as in the rest of the country. Nevertheless, the quality of living is inferior especially regarding size of dwellings. (Juntto 2007.)

2.1.4 *HOUSING PREFERENCES AND TRENDS*

The Finns have a strong preference for owning their apartment. The Finnish households aspire to improve their quality of housing gradually, which in practice means moving from rental dwellings to more esteemed housing forms such as single houses and other spacious and well-equipped houses in well-reputed neighborhoods. Financial reasons are seen as the most important reasons for owning versus renting. (Juntto 2007.) There are clear financial incentives to own one's apartment in Finland – the interest on mortgage is tax deductible in Finland. Other reasons for preferring owning include wider selection, security and suitability for life situation (ibid.).

The income level also impacts housing choices. Low-income households often live in apartment buildings whereas high-income households typically dwell in single houses. The proportion of owner-occupiers also increases with income and wealth. Juntto (2007) reports that eighty percent of those with lowest income live in rental dwellings, while the figure is ten percent for the highest earning group. In addition, the socioeconomic status affects the ownership choice. Students and the unemployed often live in rental apartments while the majority of the employed choose to own their dwelling.

According to Juntto (2007), the single most important factor affecting the choice of neighborhood is the central location of the dwelling. Other factors in the descending order of importance include closeness to nature, safety and peacefulness, familiar neighborhood, good transportation network and good public and private services. The importance of these issues depends on life situation. For instance, young singles and couples have an especially strong preference for central location whereas families with teenagers put much weight on nature and safety.

The Finns are relatively satisfied with their current choice of housing. They generally like their neighborhood and dwelling. However, parents with small children and those living in Helsinki area feel that their dwelling is too small for their needs more often than the others.

The Finns move relatively often and this trend seems to continue in future. One fourth of the respondents of Juntto's study (2007) expressed their intention to move from their current dwelling. 43 percent of them were planning to move within a year and 18 percent within two or three years. 38 percent hadn't decided when to move.

In a recent Talouselämä review, Korhonen (2010) examined Finnish housing preferences of two typical households: a family of two adults and two kids and a thirty-year old single person. The key takeaway of the review is that housing preferences are changing in time. In the HMA area, the migration from central to suburban areas is slowing down as a response to increasing transportation costs and other economic costs such as time used commuting. Although single- and row houses are preferred options, many choose to live in apartments. Regarding structural characteristics, families want to have room for each child but they are ready to compromise on space as well as on own sauna, fireplace and balcony. Singles are similarly satisfied without sauna or balcony. When it comes to locational and neighborhood characteristics, access to school and other services is rather important for families whereas singles value the proximity to the city center more. The Talouselämä study indicates that the preferences in the HMA are gradually changing. The price effect of these changing preferences, however, is assumed to be minuscule, so these potential changes are not dealt with in the study.

According to Juntto (2007), the standards of living improve in future. So far, the quality of housing has not improved together with economic conditions and the quality of living is behind that of many similar countries. Slow town planning and insufficient construction have contributed to the problem. In future, the demand for owner-occupied housing and the demand for non- apartment dwellings are likely to increase. Dwellers want larger apartments in more spacious neighborhoods. On the other hand, some housing megatrends including urbanization and increased demand of dwellings close to services for the elderly will increase the demand for small apartments. Differing lifestyles and heterogeneous housing units put increasing pressure for developing new solutions in housing.

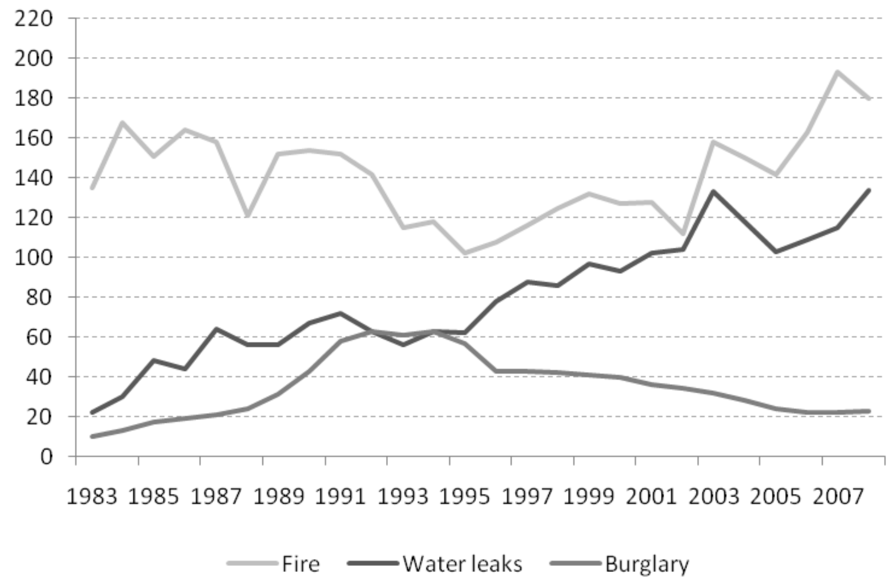
2.2 PIPE REPAIRS

Repairing water and waste pipes is the most delicate and expensive renovation project in a building’s life (the Building Information Foundation RTS and LVI-Keskusliitto 2003). Pipe repairs involve a large number of stakeholders and several project phases. There are multiple opinions regarding repair plans, implementation etc. and several issues have to be agreed on. Furthermore, the renovation makes it complicated or even impossible to live in one’s own home during the repair work.

The number of pipe repairs is constantly increasing as pipe systems in houses built or last repaired in the 50s, 60s and even 70s are getting corroded. The increase in indemnities paid on pipe leaks illustrates the magnitude of costs of leaking pipes for the insurance companies (Federation of Finnish Financial Services 2009). In 2008, the companies paid 134 million euros on damages.

Figure 4 Costs of water leak and fire damages and burglary 1983-2008

The chart shows the development and the magnitude (millions of euros) of insurance compensation for water leaks, fire damages and burglary in Finland 1983-2008. The data is from a Federation of Finnish Financial Services study, (2009). The figures are converted into 2008 value.



The Finnish market for renovations is some three billion euros annually, but the number is expected to double by 2020 (Finnish Real Estate Management Federation, see Koskela 2010). The discussion on renovations has been abundant lately reinforced by the he fact that the Finnish state wanted to promote the construction industry during the recent recession and compensated housing companies ten percent of renovation costs in 2009. Although the one year subsidy period was too short to implement totally new pipe repair projects, the subsidy encouraged housing companies to start planning repairs and it accelerated ongoing processes.

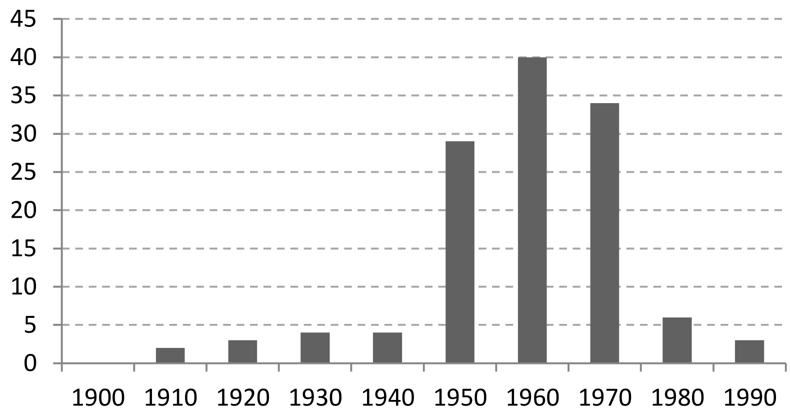
In the remainder of this section, I will discuss general issues related to pipe repairs including pipe durability, main repair techniques and monitoring and repair processes. Then, I will present review average repair costs and factors affecting the costs. Finally, the decision making process will be reviewed. The purpose of this section is to familiarize the reader with basic issues and the decision-making process. I feel that understanding the basics is very important for understanding the research setting. For instance, one should have the knowledge on average cost levels and how the repair scale affects the costs to be able to come up with a cost estimate. The process phase reflects the proximity of the repair.

2.2.1 PIPE SYSTEM DURABILITY AND REPAIR TECHNIQUES

Metal is the oldest raw material used for producing water and waste pipes. Copper and steel are commonly used. Plastic cold water and waste pipes were introduced in the 1970s and plastic hot water pipes in the 1990s. The life of metal pipes varies from thirty to fifty years in normal conditions. The life of plastic pipes is still unknown but they are expected to last as long as metal ones. However, the durability varies and therefore it is important to keep track on the condition of pipes. In extreme conditions, hot water pipes have corroded in four years whereas some cold water pipes have resisted over seventy years. Figure 5 shows the distribution of repairs done by construction decades of the buildings (FREMF 2010). One should note that buildings built before the 1950s probably had a second round of repair.

Figure 5 Latest pipe repairs by the construction decade of the building

The chart shows the distribution of latest pipe repairs by the construction year of the building. The data is from a FREMF's study, Putkiremonttibarometri 2010, where Finnish real estate managers provided information about the pipe repair they had been last involved in. The numbers in the figure are repairs done in the decade, the total number of observations being 125.



The scope of repairs and repair techniques vary to some extent. The shareholders of the housing company have the final word on scope and technique but in practice, also the experts influence decisions. Scope and repair technique impact future renovation needs as well as renovation costs. Although there are theoretically thousands on combinations for conducting repairs, the following three give quite a good picture of the most common alternatives: traditional pipe renovation (putkistosaneeraus), water pipe renovation (käyttövesisaneeraus) and coating and other new techniques (pinnoittaminen / sukittaminen). These alternatives are presented briefly below. (Siekkinen 2009.)

Traditional pipe renovation

> The oldest and currently by far most common way is to renew all water and waste pipes, bathrooms and toilets. The project also involves renewing electricity – at least in the bathrooms. Other repairs, such as renovating the common facilities of the housing

company, heating, air-conditioning and even elevators, are also often included. The traditional way is the most time and energy consuming, expensive and comprehensive type of repair that improves living quality and building's condition. The life of the renewed pipes is around fifty years.

Water pipe renovation

The water pipe renovation is a less heavy form of repair than the traditional repair as it, as the name suggests, involves repairing water pipes only. Repairing bathrooms and toilets is optional. The renovation is easier to do and the costs are lower than in the traditional repair. The repair is also a lot easier for the dwellers that most often are able to live in their apartments as there are only occasional breaks in water supply. It is crucial to accurately check the condition of waste pipes before the renovation. If the need to renew the waste pipe system is discovered afterwards, the total costs soar.

Coating and other new techniques

Coating the existing pipes with different coating materials is a recently emerged technique. The other alternative is to insert a so-called "sock" inside the pipes. The renovation of bathrooms and toilets is up to the apartment owners. This is the less expensive repair method. (Ibid.) However, there is not yet any evidence on the expected extension of life of coated pipes. Therefore, for instance, the Finnish insurance companies have been highly skeptical about covering damages happened to the coated pipe systems, but this may change in future. (Kuittinen 2010.)

From the buyer's perspective, it makes a big difference whether the pipes are renewed or coated. Dwellers with short holding period expectations may prefer much cheaper coating solutions whereas long-term dwellers probably appreciate pipe endurance that comes with renewal. Coating, however, has not been widely used so far. According to FREMS' pipe repair study (2011), 82 percent of waste pipes and practically all water pipes were renewed in 2008–2009.

2.2.2 MONITORING AND REPAIR PROCESS

In this subsection, I will go through the main phases of monitoring and repairing pipe system for a housing company. The goal of the subsection is to provide the reader with knowledge on the main phases and complexity of planning and implementing the repair process. I will also discuss the major stakeholders and their influence on different phases and hypothesize on potential motives of different stakeholder groups. The following process description is adapted from the Building Information Foundation RTS and LVI-Keskusliitto's instructions (2003).

It is worth noting that pipe repairs take a long time. The design phase generally lasts approximately 12-18 months. The actual renovation is also a lengthy stage – for instance a renovation of a relatively small forty-apartment building with two staircases takes some 8-10 months. The pipes of a single apartment are normally out of use between one and three months.

In short, a housing company should start checking the condition of pipes well before the expected renovation. As the renovation comes closer the condition is to be investigated thoroughly and, if necessary, project planning begins. Next steps include technical design, implementation and supervision, and, finally, maintenance.

Monitoring (kunnonseuranta)

> The durability of pipes varies and therefore, it is essential to monitor the condition of a pipe system in order to ensure feasible timing for the repair. Long-term real estate strategy and long-term real estate management plan (kunnossapidon pitkän tähtäimen suunnitema, PTS) should be considered, as well. The building's water damage history is an important factor in planning the timing of the repair. When the damage history indicates an increase in the number and severity of damages, a further study on the pipe system's condition (kuntotutkimus) is conducted. In addition to the pipe system condition, other considerations such as living conditions, health risks, costs and the expected value increase, affect the timing decision.

Project planning (hankesuunnittelu)

> The members of the board of the housing company and several experts e.g. designers, supervisors, consultants and contractors are involved in the project-planning phase. The phase includes drafting an initial project schedule, deciding preliminarily on the project scope, and making first cost estimates.

Design decision

> The board introduces the initial project plan to the general meeting. The meeting empowers the board to start designing and drafting different implementation alternatives to be approved or rejected by a subsequent general meeting. The board can then e.g. send invitations for design bids and select designers.

Technical design and implementation decision

> Several specialized designers are involved in the technical design. Exact drawings on all apartments and other facilities are made and one or a few implementation alternatives are

prepared for the general meeting. When the exact plans are complete, the board presents them to the general meeting. The general meeting makes the implementation decision based on these plans.

Construction and supervision

After the implementation decision has been made, the board puts the project or subprojects out to tender and selects the supervisor and contractors after which the actual renovation begins. Conventionally, all bathrooms, toilets and saunas are renewed in a pipe repair. In practice, this means tearing down and replacing all existing fixtures, pipes and facings. When it comes to the kitchen, at least water and waste pipes and taps are renewed. Dwellers' life quality tends to deteriorate remarkably during the renovation and many prefer to move out for some time if possible. Dust, frequent breaks in water and electricity supplies, and periods during which the dwellers can't use their bathroom and kitchen, among others, make the traditional repair a nuisance. (Siekkinen 2009.)

As a result of the renovation, drawings are updated and the exact condition of facilities is recorded at both housing company and apartment levels. This documentation is to be continuously updated and it offers valuable information for buyer candidates.

2.2.3 DECISION-MAKING AND DIFFERING INTERESTS

There are multiple parties involved in the pipe repair: shareholders, tenants, the board of the housing company and the real-estate manager not to mention designers, supervisors and contractors. However, the decision-making process in a housing company is similar to that in other companies: the board is the governing body who decides upon most important issues and shareholders hold the ultimate power that they exercise in general meetings. There are typically two general meetings related to pipe repairs: In the first one the general meeting authorizes the board to conduct the project planning. In the second one, the go/no go decision is taken and repair type and timing are agreed on.

The board is probably the most important and powerful party in the planning and decision-making process. With the help of experts, the board defines the desirable scope and timing for the repair. Although the board receives advice from specialists, it also possesses much discretionary power on how and which repair alternatives to present to the general meetings. Because the board is rather deeply involved in the repair, its members have informational advantage over other shareholders and the board may put their own preferences before the common good. The real-estate manager is another strong agent in the process. He or she is involved practically in all planning and decision-making. Because the real-estate manager is often technically the most experienced person and he has probably been involved in other similar projects, his opinion carries much weight.

Shareholders can affect the repair through general meetings or informal ways. Individual shareholders can influence the repair through large shareholdings or by being able to influence board members or the members of the general meeting. Shareholders' repair preferences can differ quite substantially. Some don't want their bathroom or kitchen to be demolished so they prefer coating or no repair at all to the traditional method. The elderly may want to live with old leaking pipes until the end of their days. Moving out from the apartment would be hard for them but they couldn't live in their apartments because of the bad living conditions including not being able to use the bathroom. Some owners may lack the financial capacity to pay the increased charges for financial costs (not to speak of paying back the debt).

Also, should the market overprice the apartments before the repair, those who wish to sell their dwelling soon have incentives to procrastinate the repair. Sellers want the cost estimations to look as low as possible. Also real estate investors expectedly favor low costs as, depending on their investment horizon, they are unlikely to ripe the fruits of good piping and bathrooms in full. Long-term owners, on the other hand, are probably less concerned about short-term value effects and want to maximize the quality of living over years. Thus the composition of the stakeholders can impose a strong influence on the repair solution chosen. For instance, if many of the apartments are owned by investors, more costs effective solutions are expected.

2.2.4 Repair costs

As pipe repair costs play such an important part in the study, they are worth examining in greater detail. First, it is important to note that the costs vary a lot depending on repair scope, repair technique and characteristics of the building. The smaller the apartment, the higher the costs per square meter for the housing company as the proportional number of bathrooms and kitchens increases. Also, the availability of workforce and competing repair techniques affect prices. To my knowledge, the Finnish Real Estate Management Federation is the only organization that has compiled and published comprehensive data on Finnish pipe repair prices starting from 2006. Table 1 shows how much the costs vary depending on scope and geographical area.

Table 1 Pipe repair costs by repair scope and area

The table shows the average costs of a pipe repair per square meter for different repair scopes. Prices are shown separately for the HMA and all Finland. The data is from a FREMF's study, Pipe repair 2008 study, where Finnish real estate managers provided information about the pipe repair they had been last involved in.

REPAIR SCOPE	Everything*	Water pipes, external and internal waste pipes, and bathrooms	Water and waste pipes and bathrooms	Water pipes
Average €/m^2	611	436	425	154
Median €/m^2	575	375	325	125
HMA €/m^2	758	508	-	-
Rest of Finland €/m^2	-	412	-	-

**Water pipes, water heating, internal and external waste pipes, bathrooms, bathroom underfloor heating, apartment specific water meters*

Table 1 shows that the scope affects the repair price notably. Renovating all water and waste pipes and bathrooms instead of only water pipes almost triples the costs. There is also a clear Helsinki metropolitan area extra in prices. This may stem from the typical characteristics of buildings or supply related issues. Finally, one should note the vast price spread. The average price for renewing water and waste pipes and bathrooms is 426 euros but the range goes from 175 euros to 875 euros.

3 THEORETICAL BACKGROUND

This section sheds light on the theoretical aspects of housing and repair pricing. First, housing as a commodity differs from most other commodities so I will start by reviewing the most important housing characteristics. Second, hedonic pricing, a method used in a number of housing market studies will be introduced. I also introduce the most commonly used structural, locational and neighborhood attributes that affect housing prices internationally and in Finland. I will also review studies on maintenance and repair and conclude this section by discussing theoretical aspects related to valuing pipe repairs.

3.1 HOUSING PRICE FORMATION

Housing prices depend on a vast number of characteristics. Some factors are macroeconomic while others are purely local. Macro level aspects such as interest rates and economic outlook may influence both supply and demand of dwellings. The demand is further affected by people's preferences and ability to pay, rent level and population growth and immigration. The supply comes from old dwellings and new construction. Price development, availability of land and future expectation, among others, affect new construction. Part of the old dwelling stock deteriorates and is abandoned while most buildings are renovated. Pipe repairs and other renovations play an important role in modernizing old buildings to meet current requirements.

Because of the local factors, countries comprise several regional submarkets. In Finland, for instance, not only the HMA constitutes a submarket but also different municipalities in the markets and even smaller regions such as zip code areas can be thought of as distinct submarkets. Price level, growth and dynamics may vary significantly between regional housing markets. For instance, the average income of a housing unit in south Helsinki was 47,700 euro in 2007, which was some 11,200 euros above the city average (City of Helsinki Urban Facts 2010).

The price of a dwelling is made up of two components: the physical structure and the land the dwelling is built on (e.g. Smith 2004, Abraham and Hendershott 1993). Thus, the appreciation/depreciation of a dwelling depends on the development of the weighted values of building and lot. The value of land is associated with the location, size, and attractiveness of land. The price of the structure is commonly measured as the replacement cost of the building after having accounted for depreciation. (Oikarinen 2007.) The focus of this thesis is on the structure and finding out whether the depreciation is fairly accounted for. The land component is indirectly incorporated when assessing neighborhood and locational attributes.

In the short run, housing supply is extremely inelastic. According to Juntto (2007) the Finnish housing stock transforms extremely slowly and the new production accounts for only a little more than one percentage of the total stock. The production volume naturally depends on the market situation and economic conditions. The slow adjustment to demand has caused price and quantity problems in the housing market.

3.1.1 HOUSING AS A COMMODITY

Housing is an exceptional commodity in many respects. The following characteristics distinguish housing from most other goods: heterogeneity, immobility, durability, expensiveness, high switching costs and importance of the neighborhood. (O'Sullivan 1996.) Housing is also indivisible and the markets are thin as there might be only a few similar housing units in the market at a certain point (Laakso 1997). As heterogeneity, immobility and durability play important part in valuing housing attributes including the condition of pipe systems, I will shortly review them.

Heterogeneity and immobility

The heterogeneity of housing stock refers to the fact that each dwelling offers a different bundle of features. The housing features can be divided into two groups: dwelling and site characteristics. Dwelling characteristics include size, layout, floor, interior design etc. The condition of the dwelling and the pipes also belongs to this category. The immobility of housing makes site characteristics central. Examples of site characteristics include attainability of jobs, shopping possibilities, provision of public and private services, environmental quality and neighborhood characteristics.

Durability

Housing endures longer than most other goods. If maintained properly, some buildings are practically everlasting but most are finally replaced. Dwellings deteriorate at a low pace, but they need to be repaired in order to maintain the required condition. Durability has certain important implications for the housing market: First, the rate of physical condition can be controlled by repair and maintenance. Second, the housing market is dominated by the supply of old housing. Roughly speaking, the new construction is some 2-3 percent of the total supply in the US (O'Sullivan 1996) and a little over one percent in Finland (Juntto 2007). The second implication leads to the third: the supply of housing is inelastic and changes in price have rather small effect on quantity supplied.

As Laakso concludes, none of the above-mentioned characteristics is solely related to housing. It is more the combination of the characteristics and the significance of housing in our everyday lives that distinguishes the analysis from the analysis of other goods.

3.1.2 HEDONIC PRICING

Housing pricing skills are vital in making financially good decisions when buying and selling real estate. All sellers, buyers and real estate agents are eager to gain more insight on valuing houses in order to facilitate the process and maximize their outcome. However, valuing houses requires knowledge of a rainbow of structural, locational and neighborhood attributes as well as information on the market prices. Assigning prices for different attributes is complex as dwellings are sold as packages and no explicit prices for different attributes exist. Sheppard (1999) illustrates the problem of estimating attribute prices in the following way: Imagine that you were to study the demand and prices for food items by sitting outside the grocery. You have the chance to take photos of shopping baskets and you can pretty well see the total cost of all the items bought from the counter. From the photographs you can fairly well see what each customer has bought although some items are blurred. Can you now infer the price for tomatoes? The assignment is challenging and resembles the task of finding prices for specific housing attributes.

Hedonic analysis is essentially finding prices for the attributes bought assuming that we have somewhat imprecise observations of what attributes are purchased and fairly good observations on what is spent on the entire bundle. This is done with the help of statistical analysis. Hedonic analysis is in the core of this study – we want to estimate the implicit price impact of a pipe repair on housing prices. To be able to estimate the price impact we have to take other features affecting the price, such as location, floor and the number of rooms, into account.

Over the past three decades, hedonic estimation has developed from a new methodology to the standard way to deal with housing heterogeneity when estimating rents and housing prices (see Sirmans et al. 2005). The origins of the model, however, are claimed to date back to the 1930s when Court (1939) came up with a hedonic pricing model for valuing cars. Whether Court really was the first to use hedonic modeling or not is unclear. Later often cited articles are Lancaster (1966) and Rosen (1974). Lancaster presents a microeconomic foundation for valuing utility-generating attributes and his model was later applied in the housing market context. Rosen focused more in determining prices for different attributes and his work provides the basic foundation for non-linear hedonic pricing models. For a further review on the history and recent developments of hedonic pricing see e.g. Sirmans et al. (2005) or Malpezzi (2003).

A caveat of hedonic analysis is that the results are often location-specific and it is difficult to generalize them across different geographical locations (Sirmans et al. 2005). In the next section, more light will be shed on the attributes that are known to have either positive or negative price impact. Finnish studies on housing pricing give local perspective on the preferences of Finns.

3.1.3 Attributes affecting housing prices

In the theory of hedonic pricing, housing is considered as a multi-dimensional differentiated good. All structural, locational and neighborhood characteristics should affect dwelling prices but taking all of them into account is not feasible in practice. The purpose of this subsection is to review literature on housing price attributes and identify the most commonly used attributes.

There's no such thing as an unambiguous price for an extra-bedroom. Homebuyers value housing attributes differently – some like it art nouveau, some empire. Certain housing characteristics are differently valued in different geographical and cultural areas. For instance, a sauna is probably more valuable in Finland than in the United Arab Emirates. These preferences can also change in time. Nevertheless, several clear common preferences exist and they can be statistically verified.

There's a wide selection of characteristics that can be used as independent variables in regressing housing prices. While the theory offers little advice on finding the relevant ones, Sirmans, Macpherson and Zietz (2005) have summarized attributes used in 125 hedonic studies. Although the studies differ in their ways to define and measure variables, the authors compiled a list of most commonly used attributes.

Table 2 shows the top eighteen characteristics used in hedonic pricing equations. The table shows the number of appearances of each variable and whether its price effect was positive, negative of neutral (as a percentage of all studies including the attribute).

Table 2 Common attributes in hedonic pricing model studies

The table shows the eighteen most commonly used housing pricing characteristics based on the literature review by Sirmans, Macpherson and Zietz (2005). The observations are from altogether 125 studies on hedonic housing pricing models. Natural logarithms of floor area and lot size were merged with non-log variables.

Variable	# of appearances	% positive	% negative	% not significant
Floor area	81	91	5	4
Age	78	9	81	10
Lot size	64	84	0	16
Garage spaces	61	79	0	21
Fireplace	57	75	5	19
Number of bathrooms	40	85	3	13
Bedrooms	40	53	23	25
Full baths	37	84	3	14
Air-conditioning	37	92	3	5
Swimming pool	31	87	0	13
Basement	21	71	5	24
Time on market	18	6	44	50
Distance	15	33	33	33
Number of rooms	14	71	7	21
Brick	13	69	0	31
Number of floors	13	31	54	15
Time trend	13	15	23	62
Terrace	12	83	0	17

Floor area, dwelling age and lot size appear to be the three most commonly used attributes. Floor area is rather a self-evident price component. All other things being equal, the bigger the apartment, the more valuable. Age is another essential price component and, as expected, the value of dwellings depreciates in time. However, housing prices may also appreciate over time thanks to the so called vintage effect. Lot size also has a positive effect – the more land you have, the higher the price. Amenities including garage spaces, fireplace, extra bathrooms, air conditioning and swimming pool also have a positive price effect.

Good scenery is also valued. Although more rarely studied, the authors found that lake and sea views and views rated as “good” increased the price. For more detailed analysis on different attributes and their effects, see the original paper of Sirmans et al. (2005). Other studies on hedonic attributes include Can (1992) and Knight and Sirmans (1996).

As many of housing price studies utilize US data, it is interesting to take a further look at the Finnish market. Previous studies on Finnish housing markets include Laakso (1997), Oikarinen (2007), Einiö, Kaustia and Puttonen (2008) as well as Moilanen and Terho (2010). Oikarinen’s doctoral thesis comprises four essays on housing market dynamics and housing as an investment. Einiö et al. show that Finns are loss-averse regarding the sale of their dwelling and that many dwellings are sold exactly at the same price they were originally purchased.

Laakso (1997) appears to be the most comprehensive study on regarding the valuation of housing characteristics in Finland. Laakso measures the impact of structural, locational and neighborhood characteristics based on micro-level data from the HMA. Laakso finds that housing prices increase with respect to apartment size. The price per square meter, however, decreases with size. Lot efficiency (floor area per lot area) is positively correlated with price. Dwellings in leased lots are valued lower than similar dwellings in owned lots as the market, at least to some extent, incorporates future rents in the price. The dwelling type also has a major price impact: dwellings in semi-detached and terraced houses are valued 15 percent higher than comparable apartments in apartment buildings.

The effect of age is less obvious. Laakso (1997) finds that the price effect is somewhat u-shaped. Housing prices decrease monotonically up to 50-60 years, but after that the price starts to appreciate again. There are two things to be noticed here. First, the decline in prices is expected because of depreciation. However, the price appreciation of old dwellings can be explained by the vintage effect, the pure taste for old buildings (Asabere and Huffman 1991, Smith 2004, Coulson and McMillen 2008). Second, pipe repairs are done when buildings are around fifty-years-old, which could explain the appreciation for buildings older than fifty years. There is no direct variable for pipe repairs in Laakso's study, so the possible effect is likely to be absorbed in the age effect.

Laakso also considers various locational and neighborhood variables in his study. Among others, he finds that the seacoast has a strong positive price effect (25-30 percent), which is consistent with other studies. Vicinity to a local shopping center or other concentration of local services as well as the vicinity to a local railway station has a moderate positive price effect. Close vicinity to metro stations, main streets, airports and power plants has a negative effect because of negative externalities. This can vary, though, as is the case with the closeness to metro that sometimes has a positive price effect due to the increased accessibility.

Laakso's study confirms that the distance to the central business district (CBD) significantly affects prices. Other factors controlled, dwellings located within 10-15 minutes transport distance from the CBD are approximately 50 percent more expensive than dwelling with a distance of 40 minutes or more. The distance to major sub-centers is also an important attribute to consider. Laakso finds that living in a sub-center has a negative effect while dwelling within 5-10 minutes to a sub-center are more valuable.

To form a more comprehensive up-to-date picture of attribute values, I will review the findings by Moilanen and Terho (2010) who use housing advertisement data from Oikotie from 2002–2008. The authors examine the differences in rental yields and find that the more valuable the apartment, the lower the average rental yield. Also, the rental yields seem to decrease as the size of the market increases, Helsinki having the lowest mean yield. As a side product, the authors report the price effect of various attributes. Similar to Laakso (1997) they find that the total price increases with size and that distance to center reduces prices. On the contrary, they find that apartments are somewhat more valuable than dwellings in other types of buildings. They also study the price effect of the floor an apartment is situated in and find that being located on the ground / first floor has a negative effect. They didn’t find any significant positive effect for apartments on top floors but this might be due to the bad quality of data.

The impact of the neighborhood is clear. Laakso (1997) finds the highest status areas to be one forth more expensive than the lowest status areas. Moilanen and Terho (2010) detect that the average area income has a positive impact on housing prices whereas unemployment has a negative price effect.

3.2 STUDIES ON HOUSING PRICE DEPRECIATION AND MAINTENANCE

Housing prices depreciate with time. Clapp and Giaccotto (1998) define depreciation as “the decline in value with respect to age due to the increased maintenance costs and decreased usefulness. By increased maintenance costs the authors mean that the present value of maintenance expenditures increases with the dwelling’s age.

Wilhemsson (2008) builds on Clapp and Giaccotto’s (1998) definition and divides the reasons for depreciation in three categories: physical deterioration, functional obsolescence and external obsolescence. Physical deterioration happens when the dwelling wears out – roof and pipes start leaking and the parquet floor becomes full of scratches. Changes in preferred layout design and technology cause functional obsolescence. External obsolescence, on the other hand, is not related to the dwelling itself but rather stems from changes in the neighborhood e.g. increasing traffic volumes.

External obsolescence is out of the control of the owner. Wilhelmsson suggests that functional depreciation is also difficult to impact but I don’t fully agree as, although costly, changes in technology and design can be made to a large extent. In either case, the owner who decides upon the dwelling’s maintenance can most easily affect the rate of physical depreciation. Physical depreciation is expected as the property ages, but with good maintenance is it possible to decrease the depreciation rate. There are several studies on depreciation rates of dwellings including studies on the effect of maintenance on depreciation rates. In the remainder of this subsection, I will summarize the findings of selected studies.

The age is a commonly used proxy for measuring depreciation in housing literature. Malpezzi, Ozanne and Thibodeau (1987) extensively review the literature on depreciation and housing prices. They find that depreciation rates vary significantly from study to study partly due to the differences in the definition of the concept and partly because of the different methods and time periods used. The main purpose of the authors is to examine how deprecation rates differ across markets. They discover that even though prices on different markets depreciate, there is significant variation between markets. The average depreciation rate went from 0.9 percent in year one to 0.28 percent in year twenty. In a more recent article, Smith (2004) confirms that the intra-market location impacts the observed depreciation rate significantly. He also finds evidence that the selling year affects the depreciation rate.

Shilling, Sirmans and Dombrow (1991) tackle the task of evaluation the effect of the tenure status on housing depreciation. They point out that tenants and landlords have different incentives for maintaining property and find empirical evidence that the tenant occupied dwellings depreciate faster than the owner-occupied. This feels intuitively right – owners are more likely to invest more in housing as they are able to enjoy the enhanced quality of living themselves.

Certain housing and neighborhood characteristics and housing from certain periods are preferred over the others. The taste for charming old houses can lead to premium prices for old dwellings. For instance, Asabere and Huffman (1991) observe that residential parcels within historic districts attract a significant price premium of 131%. Although this sounds abnormally high in normal circumstances, the vintage effect has also been spotted in the Finnish and Swedish markets (Laakso 1997, Wilhelmsson 2008). A recent study by Coulson and McMillen (2008) sheds light on the simultaneous estimation of vintage, age and time of sale effects. Rubin (1993) suggests an opposing hypothesis. He argues that consumers have a taste for new houses and they dislike the aesthetics, image or feel of older units resulting in a price premium for new housing. There might be some truth in this but I doubt that this could be the whole story bearing in mind that there are studies showing that the maintenance affects the depreciation rate (e.g. Wilhelmsson 2008, Knight & Sirmans 1996).

Goodman and Thibodeau (1995) examine the relationship between the dwelling age and the market value of owner occupied housing. They argue and empirically show that housing depreciation is nonlinear and that age-related heteroscedasticity occurs in hedonic housing price equations. Because housing is a durable good whose value decreases in time, the older the house the more the level of renovation affects the price. Furthermore, the older the house, the more the level of renovation varies, which leads to increasing probabilities to wrongly predict the price. As Wilhemsson (2008) notes, "if information of renovation were available, age-related heteroscedasticity would not be a problem”. This means that controlling for the level of maintenance and renovations including pipe repairs should reduce age-related heteroscedasticity. In an extension of the earlier study, Goodman and Thibodeau (1997) incorporate additional structural and neighborhood characteristics into their hedonic specification and further confirm their earlier studies.

As age solely is an insufficient estimate of depreciation, several studies have incorporated the maintenance aspect in their hedonic specification. Knight and Sirmans (1996) do this by using the remarks on the dwellings condition by the seller’s real estate agency. They find that neglected and poorly maintained dwellings depreciate much faster than dwellings with average maintenance levels. Similarly, well-maintained dwellings depreciate more slowly than normally maintained homes. Wilhelmsson (2008) extends Knight and Sirmans’s study by distinguishing between indoor and outdoor maintenance. He further divides both of indoor and outdoor maintenance into subcategories including e.g. the condition of electricity and kitchen. He confirms that the depreciation rate is significantly lower for maintained property than for non-maintained property. For a twenty-year-old single house, the depreciation rate is 0.42 percent per year for a well-maintained house and 0.84 percent for property that hasn’t been maintained in- or outdoors. According to Wilhelmsson’s results, outdoor maintenance has a larger effect on prices than indoor maintenance. Out of the indoor maintenance categories the need to upgrade the kitchen and the drainage system had the greatest negative impact. This implies that the need to repair pipes is taken into consideration when buying housing, but does not indicate whether the price adjustment matches the costs.

Gyourko and Saiz (2004) study if homeowners behave similarly to real estate entrepreneurs who will not generally redevelop assets when their values are below replacement costs. They find that, in general, owners reinvest in their property only if the combined consumption and investment benefits of doing so exceed the costs.

Knight, Miceli and Sirmans (2000) wrote an interesting article on the price impact of true repair expenses. The data used includes actual dollar amounts of repairs stipulated in the settlement statement. They assume that buyers want to purchase a “normally” maintained home. Buyers can do so in four ways: 1) by purchasing a home that is normally maintained, 2) by requiring the seller to renovate an under maintained home at the seller’s expense, 3) by receiving a repair allowance from the seller as a part of the settlement statement, or 4) by discounting the selling price enough to cover for the renovation costs. Based on their sample of 264 transactions, Knight et al. argue that most homes would be restored to a normally maintained state at the time of sale and that the selling price measured in transaction-based data is representative of the value of a normally maintained home. Their study has its major drawbacks, however. First of all, they are unable to distinguish between groups 1 and 4, normally maintained houses and houses whose price is discounted because of bad maintenance. Wilhemsson (2008) also expresses his concerns noting that “the assumption that all properties without a repair clausal in the selling contract are well maintained seems to be unrealistic”. Furthermore, in a little less than 90 percent of the relatively few cases, the allowances in the settlement statement were between zero and two thousand dollars. As repairs often cost much more than two thousand dollars it sounds unfeasible that all costs are taken into account in allowances. For instance, there could be a case where the buyer receives some allowances *and* the selling price is discounted to cover for other costs. In any case, more reliable results are needed for further conclusions.

In a rather recent article, Harding, Rosenthal and Sirmans (2007) study US housing data from 1983 to 2001. The data indicates that American houses depreciate some 2.5 percent annually gross of maintenance and some 2 percent net of maintenance. They point out that widely used measures of house price appreciation overstate capital gains from homeownership because depreciation and maintenance are not accounted for.

Finally, Heino (2006) is the only study I could find that quantifies the effect of repairs on housing prices. The goal of Heino’s work is much similar to that of mine: he aims to determine how underpinning projects affect apartment sales prices. His results, however, are somewhat dubious. Heino states that “awareness of an upcoming underpinning project causes a slow descending of the values of the apartments which continues far into the future”. There are plausible explanations on why apartment prices would stay lower than the prices in general many years after the repair. As a conclusion, the scarcity of transactions and attributes included reduces the reliability of the results. Also the methodology used does not seem to fulfill all the requirements of excellent empirical work.

3.3 THEORETICAL ASPECTS OF VALUING PIPE REPAIRS

In order to respond to the question whether pipe repairs are fairly priced or not, we must start by building a common understanding of what is considered “fair”. There are basically two sources of costs to the owner of the apartment that goes through the repair: monetary costs and non-monetary costs such as the discomfort caused by noise and dust. Monetary costs are predominantly caused by the repair work and materials. Other monetary costs may stem from having to pay for temporary accommodation or losing rent income for the time of the repair. Non-monetary costs are complex if not impossible to estimate and minor as compared to the monetary expenses, so they are left out from the scope of this study.

Housing costs as such do not rise before the renovation. In practice, although some costs incur during planning and renovation stages, the housing company does not allocate costs to shareholders until the renovation is done. The price of the repair should, however, be reflected in the prices of apartments as the expected repair price costs should be added to the actual selling price.

The time value of money has to be considered as well. I estimate whether the buyers paid too much or too little for the apartment at the time of the transaction and, thus, I consider the present value of repair costs at that time. Assuming that repair costs are correctly estimated on average, the discount rate is the most important factor to be defined. Capital asset pricing model (CAPM) is a common way to determine an appropriate required rate of return for an asset in finance. The basic assumption behind CAPM is that the investors have to be compensated for two things: time-value of money and risk. The expected return of a theoretical risk-free asset accounts for the time value of money. An asset's non-diversifiable riskiness i.e. market risk is reflected in the quantity of beta.

In order to calculate the expected return on the asset, I must find an appropriate risk free rate and estimate an appropriate beta and the market return. Government bonds are often used as benchmarks for risk-free rates so I chose to use the Finnish government bond rates as a risk-free rate. I utilize annual interest rates for both five-year and ten-year government bonds. These rates are shown in the graph below.

Figure 6 Finnish benchmark government bond yields 2000-2010

The table shows the annual yields for Finnish government benchmark bonds in 2000-2010. The two benchmark bonds selected are the 5-year bond and the 10-year bond. The data is from the Bank of Finland that has calculated the figures based on Reuters' data on primary dealers' daily average selling prices of debt instruments.

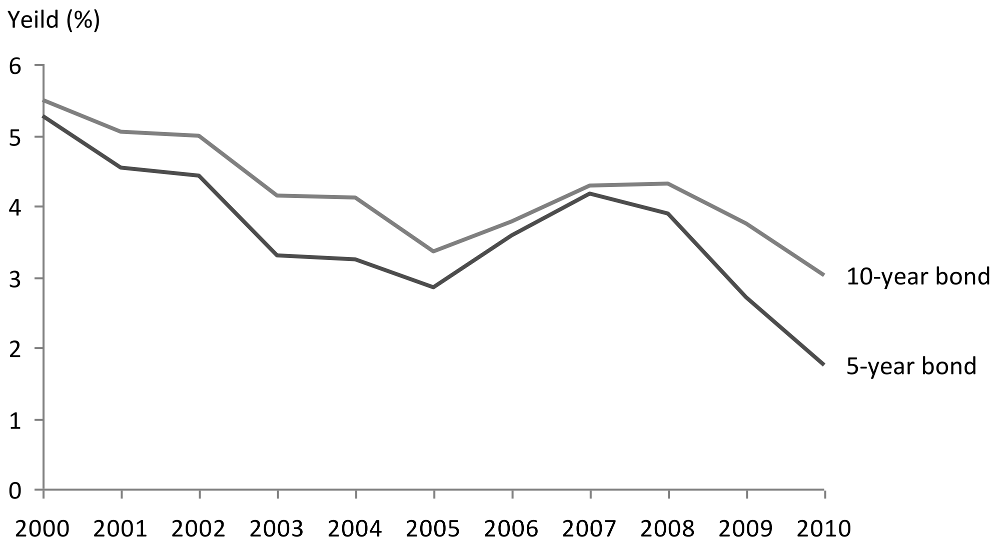


Figure 6 shows that the ten-year bond yield has remained slightly above that of the five-year bond for the whole period. Which one is more suitable for a certain pipe repair case depends on the time to repair. However, as the difference between the two yields is minor, I chose to use the same benchmark yield for all apartments to be repaired. I tested both benchmark yields in the empirical part of the study and it turned out that the choice of benchmark bond doesn't significantly affect the results.

The repair cost beta is yet to be determined. The beta measures the systematic risk of an asset comparing the asset's price moves to those of the whole market. In this setting, I study whether pipe repair prices move with the market or against it and see how significant the effect is. I use historical price data from 2000-2010 to estimate the beta.

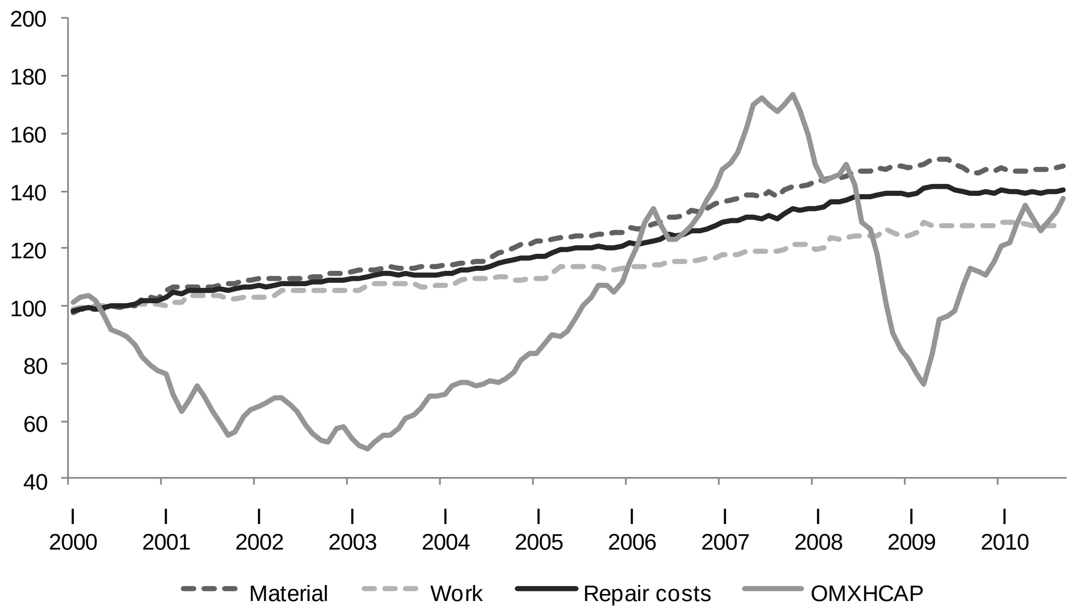
The first task is to find an appropriate proxy for pipe repair price development. I used two indexes from Statistics Finland: material cost index for heating, water and air-conditioning and construction labor cost index. I created a proxy for the repair project costs by weighting the two indexes. The materials are weighted at 60 percent and the work at 40 percent of the total project costs based on the estimation of a Finnish contractor. The drawback of the estimated index is that is reflects the contractors costs and not the housing company's costs. Although those are likely to be closely related, some more variation due to e.g. business cycles could exist. Planning and monitoring costs are not accounted for in the index.

The next thing is to choose a proxy for the overall market. I use the OMX Helsinki Cap index (OMXHCAP) that includes all shares with a ten percent weight cap. I also tried Standard & Poor's 500 but the results did not differ remarkably and the R^2 was even lower. The overall problem with applying CAPM to price repair cost risk is that all investment opportunities including real estate are not included in the market portfolio. However, I believe that it is the most feasible way to estimate the risk premium because of its simplicity.

Figure 7 plots the monthly development of construction labor costs and heating, water and air-conditioning material costs as well as the constructed pipe repair index for years 2000-2010. OMHCAP is also showed. The figure shows a clear and relatively steady growing trend for both material and labor costs whereas the stock market has fluctuated remarkably.

Figure 7 Pipe repair cost index and OMXHCAP development 2000-2010

The graph shows the development of construction labor cost index and heating, water and air-conditioning material cost index 2000-2010. The data is monthly data and it is from the Statistic Finland. Further, an index for pipe repair costs is estimated based on these two indexes by weighting material to 60% and labor to 40% of total repair costs. Monthly data on OMX Helsinki Cap index (OMXHCAP) index is also included. The data was obtained from Bloomberg.



I calculated the beta for pipe repair costs by using monthly observations on the pipe repair index and the OMXHCAP index. As the figure suggests, the two do not move hand in hand during the observation period. The beta coefficient is -0.0062 and the R^2 is only 0.0038. This suggests that: (1) the beta's effect if there was one is likely to be very small, and (2) the beta obtained is not significantly different from zero.

To conclude, the development of pipe repair value i.e. costs is very different from that of the stock market. Because the beta for repair costs seems insignificant, I choose to leave the risk premium out and use only the risk-free interest as the discount rate *r*. As long as we don't have better data and don't find any similar examples of the right risk premium in the academia, this is the best available way to model the discount rate.

4 METHODOLOGY

In this section, I will review literature related to the methodology used in this study. I will begin by discussing functional forms used in hedonic pricing. Then, I will discuss the Differences-in-Differences method utilized for distinguishing the effect of repairs from other market developments.

4.1 HEDONIC PRICING FUNCTIONS

The idea of hedonic pricing is to consider housing as a multi-dimensional differentiated good as discussed in Section 3.1.2. Hedonic equations are used to decompose housing rent or value into measurable prices and quantities that can be used to estimate rents or values of different dwelling combinations. A hedonic estimation is simply a regression of expenditures on housing characteristics. The regression coefficients may be transferred into implicit price estimates of these characteristics.

As discussed in Section 3.1.3, there are many features affecting housing prices the most common categories being structural, neighborhood and locational characteristics. Malpezzi (2003) presents the fundamental hedonic equation simply as follows:

$P = f(S, N, L, C, T)$, where: (1)

P = price / value of the dwelling, S = structural characteristics, N = neighborhood characteristics, L = location, C = contract conditions or characteristics, and T = the time rent or value is observed.

There is no such thing as an established functional hedonic form in the literature of urban economics (see e.g. Halvorsen and Pollakowski 1981, Malpezzi 2003). Pioneering papers on hedonic analysis like Lancaster (1966) and Rosen (1974) provide little help for choosing the functional form. One of the most important findings of the hedonic pricing theory is the nonlinearity of the value function (Laakso 1997). Non-linearity stems from the non-divisibility feature of housing. In practice the nonlinearity is taken into account by using the natural logarithm of price as the dependent variables.

Different authors have tried different models to find the best fit. For instance, in his literature review on empirical studies on housing prices, rents and land prices, Laakso (1997) concludes that the most common functional forms are log-linear and semi-log forms. Flexible functional forms and the Box-Cox transformation are also common. Laakso himself uses five different specifications including (1) semi-log models with dummy and continuous variables with first-order terms, (2) semi-log models with dummy variables and continuous variables with first, second and third order terms, (3&4) two models with all variables classified as dummies, and (5) model consisting of spline functions. Laakso concludes that when the size of the data set allows the use of dummy variables, dummy variable models are superior as compared with continuous variable models regarding R^2 statistics and homoscedasticity. Furthermore, the results of dummy models are simple to interpret. Type (2) models with continuous independent variables with higher terms give better results than type (1) models, but the results based on first, second and third order terms are complicated to interpret. After having reviewed a number of hedonic pricing studies, Sirmans et al. (2005) conclude that linear and semi-logarithmic specifications are the most common ones.

Halvorsen and Pollakowski (1981) propose the general functional form that is said to combine the best sides of Box-Cox and flexible functional form approaches. The form is meant to incorporate other functional forms of interest as special cases.

In their Master's Thesis, Moilanen and Terho (2010) also review papers related to the choice of functional form. They test the goodness of the general form suggested by Halvorsen and Pollakowski (1981) without the interaction terms and conclude that the simpler form of the general functional form, the double log-form, suits their purposes well. The data used is similar to the data used in this study as it is partially from the same source, Oikotie.

The double-log expression for estimating housing prices is:

$$\ln P = \alpha_0 + \alpha \ln X + \varepsilon \tag{2}$$

Another simple and commonly used functional specification is the log-linear form. Malpezzi (2003) discusses the benefits of the simple log-linear form over the linear form. The log-linear form is:

$$\ln P = \alpha_0 + \alpha X + \varepsilon \tag{3}$$

Using log-linear specification instead of linear specification allows for variation in the value of a characteristic so that the price of one component (e.g. additional room) is dependent on other characteristics of the dwelling. Second, the coefficients are simple to interpret. The coefficient roughly approximates the percentage change in value – even better estimate for the change is $e^{a_i}-1$.

The price of a certain attribute, X_i, at a given level of X_i and other *m*-1 attributes, $X_{i\neq 1}$, can be calculated in euros as:

$$P = e^{\alpha_1 X_1} \tag{4}$$

As Malpezzi (2003) puts it: “There is art as well as science in the (hedonic model) specification”. In order to find a functional form that is statistically suitable and whose results are as intuitive to interpret as possible, I test the double log form, log-linear for and different combinations of the two. The results of three different specifications are presented and discussed in Section 6.1. I choose not to test the general functional form by Halvorsen and Pollakowski (1981) as Moilanen and Terho already did that with similar data and found no clear benefits.

Econometrically, hedonic price models are estimated with the Ordinary Least Squares (OLS) methods. I also used multiple of dummy variables that according to Laakso (1997) offer the best fit. All pipe repair variables are dummy variables.

4.2 DIFFERENCES-IN-DIFFERENCES

The goal of the empirical work is to measure the price effect of pipe repairs. I utilize the differences-in-differences (DID or DD) technique in order to be able to distinguish the effect of repairs from other changes in the market. Differences-in-differences method is commonly used in estimating causal relationships. Its appeal comes from its simplicity and its potential to avoid many of the endogeneity issues that arise when comparing heterogeneous individuals. (Bertrand et al. 2004.)

In the basic DD-setting, outcomes are observed for two groups and two time periods. One of the groups is exposed to a treatment in the second period but not in the first period – this group is called the *treatment group*. The second group called the *control group* is not exposed to the treatment during either of the periods. In order to see how a given treatment affected the treatment group, the average gain in the control group is subtracted from the average gain in the treatment group. Controlling for other attributes removes biases caused by differences between the two groups. Differences-in-differences method is also used for problems with multiple subpopulations and outcomes that are measured in each group before and after the policy intervention (Athey & Imbens 2006). It is not necessary to observe the same units every time period (panel data) but the use of cross-sectional data is also possible.

With repeated cross sections the differences-in-differences outcome for individual i can be expressed as:

$$y_{igt} = \lambda_t + \alpha_g + x_{gt}\beta + z_{igt}\gamma_{gt} + v_{gt} + u_{igt}, \quad i = 1,\ldots,M_{gt} \quad (5)$$

where i indexes individual, g indexes group and t indexes time. The model has a full set of time effects, λ_t, a full set of group effects α_g, group/time control variables, x_{gt}, individual-specific control variables, z_{igt}, unobserved group/time effects, v_{gt}, and individual-specific errors, u_{igt}. The group/time control variables are also called policy or treatment variables or dummies that are defined to be unity for groups and time periods subject to the policy. The coefficients of treatment dummies show the effect of the treatment.

The goal of this thesis is to see the price impact of repairing the pipes for the group of dwellings whose pipes were renewed (the treatment group). Identifying this effect requires controlling for any systematic shocks to the prices of the treatment group that are correlated with, but not caused by the repair. To be able to see the price effect of pipe repairs we need to compare the treatment group's selling prices to the selling prices of apartments that are not affected by pipe repair (the control group). The control group used in the thesis includes sales transactions from housing companies that were either built after 1980 or from companies that underwent comprehensive pipe repair between 1980 and 1998. The treatment group contains transactions from companies that were renovated between 2000 and 2010. In addition, I will control for monthly and yearly price fluctuations by including dummies for each month/year combination. I will use many location, housing company and apartment specific attributes as control variables.

5 Data

In this section, I will discuss the data used in the empirical part of this study. I will start by introducing the data and the four main data sources and continue by explaining the adjustments to the data. Finally, descriptive statistics will be presented in the second subsection.

5.1 Data description and adjustments to the data

The data used in this study comprises 69,000 apartment sales transactions from 2000–2010. The transactions are from Helsinki and Espoo. The number of observations in control and treatment groups was 34,358 in total of which 8,781 belongs to the treatment and 25,577 to the control group. The data comes from four sources: (1) Oikotie sales advertisement data, (2) Kiinteistömaailma sales data, (3) HSP sales data, and (4) data gathered from three Finnish real estate management companies. Information on housing companies including repair information was gathered from housing advertisements published in Oikotie and from the real estate agency Kiinteistömaailma's sales database. Obtained housing company attributes were next combined with data on housing transaction from Hintaseurantapalvelu (HSP), a price monitoring service that combines data from most Finnish real estate agents. Finally, three housing management companies provided me with detailed data on repairs done. By combining data from all of the above-mentioned sources I achieved to form a relatively rich dataset that contains information on dwelling transactions and characteristics including pipe repairs. The datasets used and the data sources are presented more in depth in this subsection.

5.1.1 Oikotie and Kiinteistömaailma datasets

I used data from Oikotie and Kiinteistömaailma in order to gather comprehensive data on housing company characteristics including pipe repair data. These two datasets together cover the period January 2002 - June 2010. The main piece of data gathered from these two data sets was the timing of pipe repairs done. The timing information was filtered from free text fields concerning renovations. Additional information on repair plans and studies was also gathered from this source. The dataset was originally formed by using a set of text functions after which it was manually inspected in order to avoid wrong matches and to remove all minor repairs (e.g. repairs of pipes in the basement only). Oikotie dataset was also used to enrich transaction data with other housing company related attributes.

Oikotie is a Finnish web-based marketplace for various articles including apartments and houses and Kiinteistömaailma is a Finnish real estate company. Both companies are widely recognized and they are among market leaders in their own fields. The initial data set from Oikotie consisted of 937,100 sales and rent advertisements from the period 2000–2008. The data was adjusted to meet the specific purposes of this study by e.g. removing the rental ads and dwellings outside Helsinki and Espoo as well as ads with missing important data. The Kiinteistömaailma dataset has fewer observations as it only includes Kiinteistömaailma's transactions from January 2005 to June 2010. The initial sample consists of 19,100 sales transactions.

5.1.2 HSP SALES DATA

Another very important data source for the study is the Hintaseurantapalvelu (HSP) database which contains all sales transactions from major Finnish real estate companies. The database covers the majority of the transactions in which a real estate agent has been involved but it doesn't contain any information on transactions without a broker. It's also important to notice that the share of transactions covered is lower before year 2005 than after as Realia Group joined the system back then. The HSP data is from January 2000 – June 2010 and it contains 81,000 sales observations from Helsinki and Espoo. The data I received is includes apartment transactions only i.e. row houses, single-houses and other houses are excluded from this study.

The HSP dataset contains basic information on housing attributes including floor, elevator, size and condition of dwellings. It also contains some housing company level attributes and price data including debt-free sales price. The quality of HSP data is in generally much better than that of Oikotie data. This is due to two main factors: First, only real estate agents have filled in data, which enhances the data quality as they are professionals. Second, the number of free text fields is notably lower and the number of obligatory fields higher. The flipside of the HSP data is that it covers less information than the Oikotie data (where one can add practically anything one desires). Most notably, it didn't contain data on repairs, which made me to turn to Oikotie data.

5.1.3 REAL ESTATE MANAGEMENT DATA

Detailed data on pipe repairs was collected from real estate managers in cooperation with the Finnish Real Estate Management Federation (FREMF). The FREMF is the national federation of Finnish real estate management and its members represent two-thirds of real estate management in Finland and they manage the property of more than one million Finns. Three real estate management firms, Tapiolan Lämpö, SKH Isännöinti and Isännöitsijätoimisto Jarmo Rantamäki, kindly provided me with data on pipe repairs they had steered between 2000 and 2010.

The number of pipe repairs I managed to collect comprehensive info on is 40 completed repairs. The data includes a comprehensive set of basic housing company attributes including housing company size, lot ownership status as well as size and the number of buildings and sections. Information on pipe repairs done covers the repair scale (which pipes were repaired, whether all pipes were repaired or all bathrooms renewed). Information on the repair method was also collected. However, the repairs in my sample were basically all done in the traditional method, which makes it practically impossible to study whether the repair type affects the effect on housing prices.

The pipe repair data collected from the real estate agents is unique. Collecting this kind of data is laborious many interviews and going through a pile of documentation is probably needed. This makes the study hard to emulate and is probably one of the reasons why pipe repairs and repairs overall have not been extensively studied in the past. The weakness of the data lies in the limited number of observations and, in this case, in the fact that 82% of the buildings are from Espoo area where the dwelling base is relatively newer than in Helsinki. The number of observations and geographical areas could be further increased to gain more insight.

5.2 DESCRIPTIVE STATISTICS

In this section, the characteristics of the data will be examined in further detail. As the quality of data is essential for the work, the data has been carefully collected and unreliable observations and observable outliers have been left out. The adjusted transaction sample that combines information from all data sources includes altogether 69,000 observations. The data set includes sales transaction data from Helsinki and Espoo between January 2000 and June 2010. Table 3 shows averages for certain attributes for Helsinki, Espoo and the whole sample.

The average size of an apartment is 59 square meters which corresponds to 2.3 rooms. The average size of the apartments is five square meters smaller in Helsinki than in Espoo. The buildings are also taller and the housing companies have more apartments. The average age shows, that the buildings are newer in Espoo and the share of new buildings is higher (20 percent vs. 11 percent). Apartments are substantially more expensive in Helsinki (average debt-free price 3,200 euros per square meter) than in Espoo (2,500 euros). In Helsinki, the City of Helsinki still owns 27% of the lots while in Espoo, almost all the lots are owned by housing companies.

Table 3 Average values for apartment and housing company attributes

The table shows average values for a set of sample attributes. Figures are presented separately for Espoo and Helsinki and for the whole sample. The sample consists of 69,000 observations. The data includes transactions from Helsinki and Espoo between Jan 2000 – Jun 2010. The original data includes all apartment sales transactions in Helsinki and Espoo areas but some necessary removals due to unreliable and missing data have been done.

Variable	Espoo	Helsinki	Whole sample
Apartment size (m^2)	63	58	59
Number of rooms	2.47	2.25	2.31
Floor	2.96	3.04	3.02
Price (€)	154,895	187,578	179,255
Price per square meter (€/m^2)	2,513	3,197	3,023
Share of new apartments	20 %	11 %	13 %
Share of apartments with elevator	57 %	49 %	52 %
Construction year	1983	1961	1966
Number of apartments in housing company	73	82	80
Lot size (m^2)	6,224	6,144	6,165
Share of own lots	97 %	73 %	79 %

Figure 8 shows the annual distribution of transactions. There has been a dramatic increase in the number of the transactions between 2004 and 2005. This is mainly due to the fact that Realia Group, a major real estate company joined HSP back then. The financial crisis can be seen in the drop in the transaction volume in 2008 and 2009. Year 2010 is not comparable as the data is from January–June.

Figure 8 Annual distribution of transactions 2000 – June 2010

The graph shows the distribution of volume of the 69,000 observations in the sample. The data includes transactions from Helsinki and Espoo between Jan 2000 – Jun 2010. The original data includes all apartment sales transactions in Helsinki and Espoo areas but some necessary removals due to unreliable and missing data have been done. The figures are in thousands.

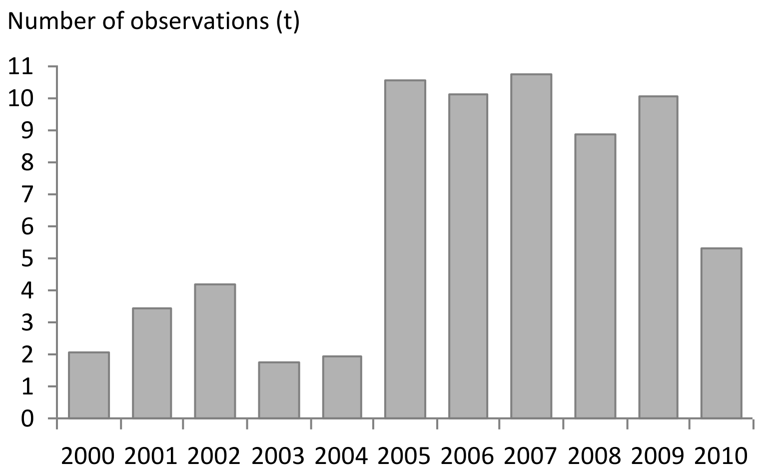
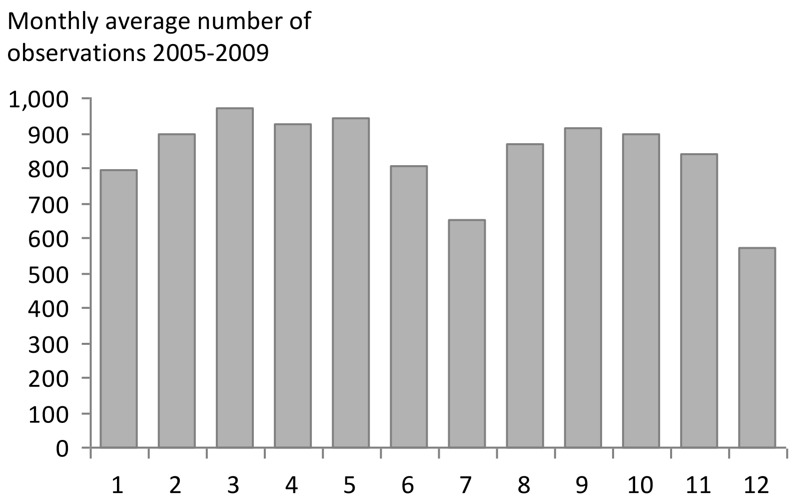


Figure 9 reports the monthly distribution of transactions. It shows that the time of the year impacts transaction activity. The sales activity drops around winter and summer holidays and peaks in the spring and in the beginning of autumn. The data is for years 2005–2009 only because the number of transactions was lower before 2005.

Figure 9 Monthly average distribution of transactions 2005–2009

The graph shows the average monthly number of transactions in 2005-2009. The data includes transactions from Helsinki and Espoo between Jan 2000 – Jun 2010. The original data includes all apartment sales transactions in Helsinki and Espoo areas but some necessary removals due to unreliable and missing data have been done.



The average price per square meter has increased quite steadily since the beginning of the millennium as can be seen from Figure 10. There was a slight drop in years 2002–2003 and the prices stayed level in 2008-2009, but otherwise the trend has been strongly positive. The development looks fairly similar to that presented in Figure 2.

Figure 10 Average prices per square meter 2000 – June 2010

The graph shows the price per square meter development for the whole sample between Jan 2000 – Jun 2010. The original data includes all apartment sales transactions in Helsinki and Espoo areas but some necessary removals due to unreliable and missing data have been done. The number of observations in the refined sample is 69,000.

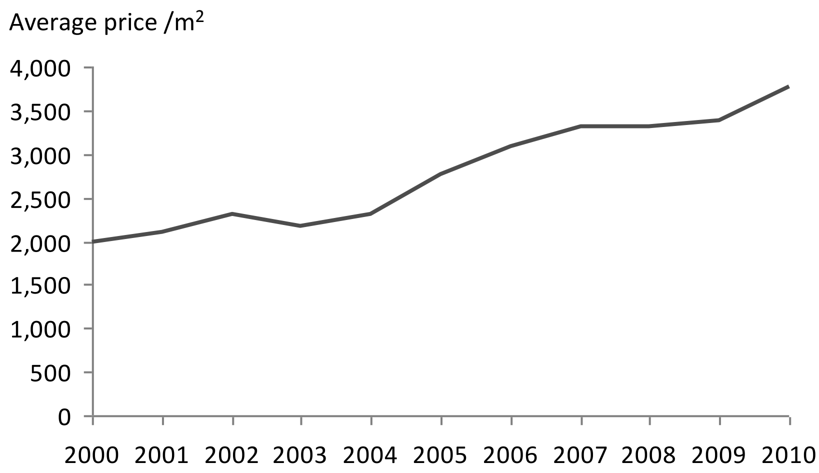
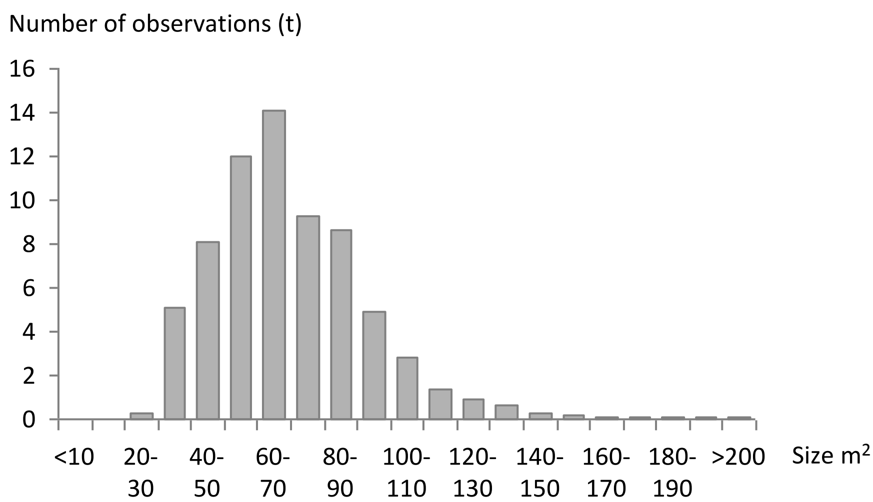


Figure 11 shows the distribution of apartment sizes in the sample, which is positively skewed. As said before, the average size of apartments of the sample is 59 square meters.

Figure 11 Apartment size distribution

The graph shows the size distribution of the 69,000 observations in the sample. The data includes transactions from Helsinki and Espoo between Jan 2000 – Jun 2010. The original data includes all apartment sales transactions in Helsinki and Espoo areas but some necessary removals due to unreliable and missing data have been done. The number of observations in the refined sample is 69,000. The figures are in thousands.

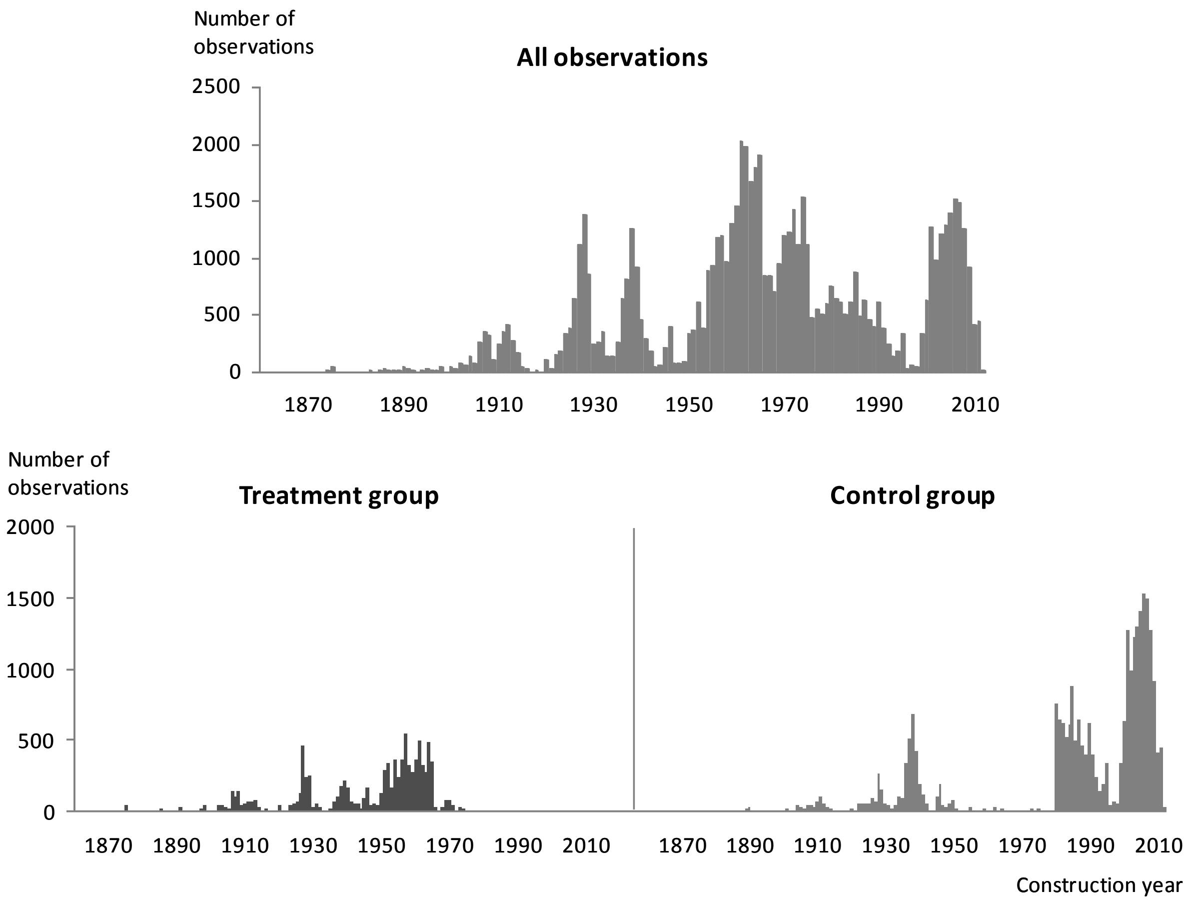


The share of apartments with less than 30 or more than 150 square meters is very small. The distribution presents a slightly biased picture of the whole apartment base if smaller apartments are sold more frequently than larger ones.

Figure 12 presents the distribution of construction years which is highly interesting from the point of view of this study. When looking at the whole sample, one can observe clear construction booms before World War I, between World Wars I and II, and after World War II. The 1990s and the 2008-2009 recession are shown as sharp drops in the construction activity. There are plenty of apartments built between 1950 and 1970, and these apartments are of special interest when it comes to pipe repairs.

Figure 12 Construction year distribution

The graph shows the construction years for the whole sample and for the treatment group and the control group. The data spans from Jan 2000 to Jun 2010. The original data includes all apartment sales transactions in Helsinki and Espoo areas but some necessary removals due to unreliable and missing data have been done. The number of observations in the refined sample is 69,000.



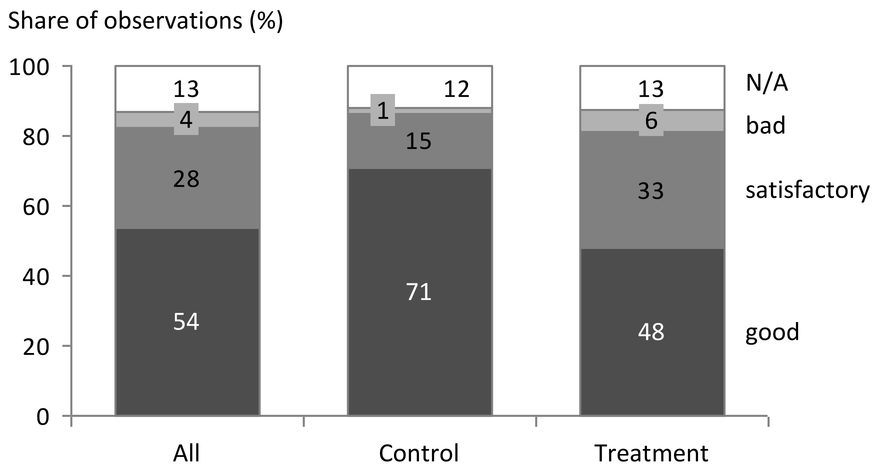
The treatment and control group graphs in Figure 12 show the construction years for these two groups separately. The treatment group graph shows that buildings that underwent pipe repairing in January 2000 – June 2010 were mainly built between 1940 and 1970. Other groups of buildings were constructed around the 1910s and the 1920s and those buildings are likely to have undergone a second repair round. When looking at the control group, it can be easily seen that the control group was defined so that it includes apartments built and apartments repaired after1979.

Finally, we will take a look at the condition of the apartments. “Good” is the by far most common attribute used (54 percent of all observations) while the word “bad” describes only 4 percent of observations. One should, however, keep in mind that real estate agents are inclined to overstate the condition.

There is still a visible difference between control and treatment groups – the apartments in the treatment group are generally in worse condition. This is in line with intuition as the apartments in the control group are newer on average. Also, the condition of the apartments is likely to be relatively worse before pipe repairs as the renovation of bathrooms (and sometimes kitchen) is often postponed to the repair.

Figure 13 Distribution of the condition of the apartment

The graph presents the condition of the apartments sold for all transactions and for the treatment and control group. The transactions are from Jan 2000 – Jun 2010. The original data includes all apartment sales transactions in Helsinki and Espoo areas but some necessary removals due to unreliable and missing data have been done. The number of observations in the refined sample is 69,000.



6 RESULTS

This section presents the results of my thesis. I will begin by showing the pure price effect of pipe repairs. Other attributes affecting housing prices will also be studied. After that, I will study the repair effect on prices when accounting for the cost of the pipe repair. I will utilize both real repair costs and cost estimations for examining the effect. I will also examine whether the price of the apartment affects repair pricing. Finally, I will study how pipe repair interval and housing prices affect the price impact in the vicinity of the repair.

6.1 PIPE REPAIR EFFECT ON APARTMENT PRICES

The first set of regressions studies the pure price effect of pipe repair. The results show that apartments are, in effect, discounted before the repair and that a small premium is paid after the repair. The regressions are done with all observations in the treatment and control groups. The number of observations was 34,358 in total of which 8,781 belongs to the treatment and 25,577 to the control group. The control group includes all observations for which the pipe repair is not relevant i.e. transactions from housing companies that were either built after 1980 or that underwent a comprehensive pipe repair between 1980 and 1998. The treatment group contains transactions from housing companies that were renovated between 2000 and 2010.

I tried different functional forms to see which would be the most suitable specification and to see how different specifications affect the results. Selling price is used as a proxy for the value of a dwelling as it offers more objective measure than e.g. an owner's self-assessment and thus minimizes potential biases (Sirmans et al. 2005). In this section, both the natural logarithm of the total debt-free selling price and of the debt-free selling price per square meter are used as dependent variables. The total debt free-price is commonly used in housing market research but, looking at the debt-free price per square meter is more insightful in this context. Pipe repair costs are commonly expressed as costs per square meter due to the fact that the costs are divided to apartments according to the same principles that guide the division of maintenance fees. Therefore, the costs are distributed according to the share of the area or the share of shares in the company. The amount of shares is also most often directly or closely relational to the size of the apartment, so the size of the apartment is an excellent proxy of the costs that will incur.

I also tried different modifications of log-linear and log-log forms to find the best fit. Three different specifications for independent variables are presented in Table 4: (1) all linear or dummy variables, (2) all natural logarithms of variables or dummies, and (3) all except apartment size linear, natural logarithm of apartment size and dummies. The pipe repair related variables are presented in the first page and other variables in the second page.

Table 4 Pipe repair effect on apartment prices

The table presents the regression results on how pricing of the treatment group differs from that of the control group. Figures in parentheses below the coefficients are the t-statistics. Respectively, ***, ** and * denote statistical significance at 1%, 5% and 10% levels. The dependent variable is the natural logarithm of either the total debt-free price of the apartment or the debt-free price per square meter as indicated below. Three different specifications for independent variables are reported: (1) all linear or dummy variables, (2) all natural logarithms of variables or dummies, and (3) all except apartment size linear, natural logarithm of apartment size and dummies.

	Ln(Total debt-free price as a dependent variable)			Ln(Debt-free price per square meter as a dependent variable)		
Variable	Regression (1)	Regression (2)	Regression (3)	Regression (1)	Regression (2)	Regression (3)
Time to repair: 10 years	-0.023	-0.008	-0.007	-0.010	-0.008	-0.007
	(-0.55)	(-0.22)	(-0.19)	(-0.26)	(-0.22)	(-0.19)
Time to repair: 9 years	-0.013	0.001	-0.002	0.000	0.001	-0.002
	(-0.58)	(0.03)	(-0.11)	(0.01)	(0.03)	(-0.11)
Time to repair: 8 years	-0.002	-0.004	-0.006	-0.008	-0.004	-0.006
	(-0.10)	(-0.28)	(-0.45)	(-0.57)	(-0.28)	(-0.45)
Time to repair: 7 years	0.001	0.005	0.004	0.002	0.005	0.004
	(0.11)	(0.40)	(0.32)	(0.17)	(0.40)	(0.32)
Time to repair: 6 years	-0.027**	-0.028***	-0.028***	-0.031***	-0.028***	-0.028***
	(-2.31)	(-2.65)	(-2.72)	(-2.89)	(-2.65)	(-2.72)
Time to repair: 5 years	-0.035***	-0.038***	-0.039***	-0.041***	-0.038***	-0.039***
	(-3.43)	(-4.29)	(-4.34)	(-4.50)	(-4.29)	(-4.34)
Time to repair: 4 years	-0.049***	-0.051***	-0.051***	-0.054***	-0.051***	-0.051***
	(-5.66)	(-6.66)	(-6.76)	(-6.92)	(-6.66)	(-6.76)
Time to repair: 3 years	-0.065***	-0.064***	-0.065***	-0.067***	-0.064***	-0.065***
	(-8.58)	(-9.66)	(-9.75)	(-9.84)	(-9.66)	(-9.75)
Time to repair: 2 years	-0.069***	-0.075***	-0.076***	-0.079***	-0.075***	-0.076***
	(-10.31)	(-12.64)	(-12.76)	(-12.98)	(-12.64)	(-12.76)
Time to repair: 1 year	-0.085***	-0.087***	-0.088***	-0.089***	-0.087***	-0.088***
	(-13.02)	(-15.09)	(-15.36)	(-15.08)	(-15.09)	(-15.36)
Repair on-going	-0.052***	-0.057***	-0.054***	-0.056***	-0.057***	-0.054***
	(-8.73)	(-10.78)	(-10.32)	(-10.39)	(-10.78)	(-10.32)
Last year of repair	-0.012**	-0.007	-0.003	-0.002	-0.007	-0.003
	(-2.04)	(-1.32)	(-0.61)	(-0.39)	(-1.32)	(-0.61)
Time from repair: 1 year	0.027***	0.025***	0.031***	0.031***	0.025***	0.031***
	(4.16)	(4.48)	(5.45)	(5.31)	(4.48)	(5.45)
Time from repair: 2 years	0.024***	0.027***	0.032***	0.033***	0.027***	0.032***
	(3.56)	(4.52)	(5.34)	(5.34)	(4.52)	(5.34)
Time from repair: 3 years	0.035***	0.029***	0.033***	0.032***	0.029***	0.033***
	(4.74)	(4.45)	(5.11)	(4.82)	(4.45)	(5.11)
Time from repair: 4 years	0.024***	0.021***	0.025***	0.026***	0.021***	0.025***
	(3.11)	(3.08)	(3.65)	(3.66)	(3.08)	(3.65)
Time from repair: 5 years	0.013	0.009	0.013*	0.010	0.009	0.013*
	(1.60)	(1.27)	(1.80)	(1.37)	(1.27)	(1.80)
Time from repair: 6 years	0.026***	0.025***	0.028***	0.027***	0.025***	0.028***
	(2.78)	(3.04)	(3.42)	(3.20)	(3.04)	(3.42)
Time from repair: 7 years	0.033***	0.021**	0.023**	0.019*	0.021**	0.023**
	(2.88)	(2.08)	(2.30)	(1.89)	(2.08)	(2.30)
Time from repair: 8 years	0.022	0.006	0.009	0.005	0.006	0.009
	(1.53)	(0.43)	(0.69)	(0.41)	(0.43)	(0.69)
Time from repair: 9 years	0.029*	0.041***	0.043***	0.042***	0.041***	0.043***
	(1.67)	(2.67)	(2.85)	(2.70)	(2.67)	(2.85)
Time from repair: 10 years	0.039	0.004	0.008	-0.005	0.004	0.008
	(1.41)	(0.16)	(0.32)	(-0.19)	(0.16)	(0.32)
Time from last repair plan	Yes	Yes	Yes	Yes	Yes	Yes
Time fom last repair study	Yes	Yes	Yes	Yes	Yes	Yes

Table 4 Pipe repair effect on apartment prices – continued

	Ln(Total debt-free price as a dependent variable)			Ln(Debt-free price per square meter as a dependent variable)		
Variable	Regression (1)	Regression (2)	Regression (3)	Regression (1)	Regression (2)	Regression (3)
Constant	11.39***	8.77***	8.853***	8.291***	8.77***	8.853***
	(477.41)	(343.85)	(357.05)	(383.77)	(343.85)	(357.05)
Apartment size	0.012***			-0.001***		
	(162.39)			(-13.4)		
Ln(Apartment size)		0.861***	0.826***		-0.139***	-0.174***
		(209.16)	(207.61)		(-33.84)	(-43.86)
Number of rooms	0.035***		0.011***	-0.029***		0.011***
	(19.25)		(6.80)	(-17.76)		(6.80)
Ln(Number of rooms)		-0.012***			-0.012***	
		(-3.26)			(-3.26)	
Debt share of debt free price	0.032***		0.03***	0.029***		0.03***
	(4.02)		(4.33)	(4.02)		(4.33)
Ln(Debt share of debt free price)		0.004***			0.004***	
		(9.72)			(9.72)	
Has elevator	0.005**	0.007***	0.007***	0.006***	0.007***	0.007***
	(2.31)	(3.61)	(3.55)	(3.16)	(3.61)	(3.55)
Condition: new	0.028***	0.027***	0.034***	0.034***	0.027***	0.034***
	(6.44)	(7.20)	(8.67)	(8.53)	(7.20)	(8.67)
Condition: bad	-0.135***	-0.115***	-0.116***	-0.111***	-0.115***	-0.116***
	(-24.3)	(-23.53)	(-23.7)	(-22.22)	(-23.53)	(-23.7)
Condition: good	0.042***	0.032***	0.031***	0.03***	0.032***	0.031***
	(1600)	(13.64)	(13.46)	(12.4)	(13.64)	(13.46)
Condition: satisfying	-0.037***	-0.034***	-0.035***	-0.033***	-0.034***	-0.035***
	(-12.1)	(-12.78)	(-12.96)	(-11.88)	(-12.78)	(-12.96)
Top floor	0.023***	0.029***	0.029***	0.028***	0.029***	0.029***
	(11.05)	(15.28)	(15.3)	(14.78)	(15.28)	(15.3)
Bottom floor	-0.032***	-0.028***	-0.028***	-0.027***	-0.028***	-0.028***
	(-14.68)	(-14.69)	(-14.46)	(-13.89)	(-14.69)	(-14.46)
Rented lot	-0.117***	-0.124***	-0.124***	-0.126***	-0.124***	-0.124***
	(-35.86)	(-42.86)	(-42.94)	(-42.33)	(-42.86)	(-42.94)
Transaction month and year	Yes	Yes	Yes	Yes	Yes	Yes
Construction year	Yes	Yes	Yes	Yes	Yes	Yes
Zipcode	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0,913	0,932	0,932	0,846	0,854	0,854
Number of observations	32 676	32 676	32 676	32 676	32 676	32 676

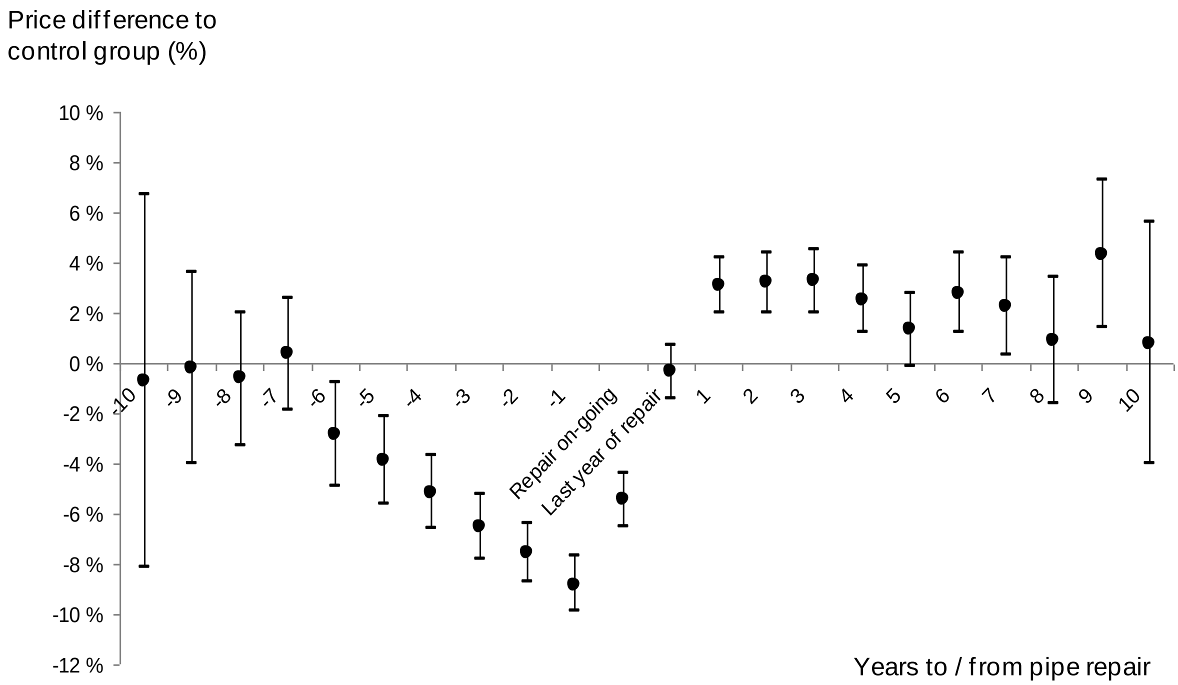
As can be seen from Table 4, the results are generally highly significant. Regressions done with the total debt-free selling price as the dependent variable have higher adjusted R^2 values because apartment size (absolute number of square meters) has a remarkable influence on prices. In regressions done with price per square meter as the dependent variable, the effect of size on price per square meter is shown – the price decreases as the size increases. I chose to use the price per square meter as the dependent variable as it better illustrates the effect of pipe repairs. Furthermore, I decided to use the third specification in further analysis because it yields as good results as specification (2) but the coefficients are more intuitive to interpret. This specification is used from here onwards. The coefficients present approximately the percentage change in apartment price when the value of the dependent variable is increased by one unit or the dummy variable gets the value of one. Equation (6) presents the actual model using specification (2). The following variables are dummy variables: elevator, transaction month and year, zipcode, old vs. new apartment, condition, construction year, top floor, bottom floor, time to repair, time from repair, repair ongoing, last year of repair, time from last repair plan, time from last repair study, lot ownership. Equation (6) is:

$$
\begin{aligned}
&Ln(Debt - free\ price\ per\ square\ meter) \\
&\quad = \beta_0 + \beta_1 \ln(Apartment\ size) + \beta_2 Number\ of\ rooms + \beta_3 Debt\ share\ of\ debt \\
&\quad - free\ price + \beta_4 Has\ elevator \\
&\quad + \beta_5 Transaction\ month\ and\ year_{2/2000} + \cdots + \beta_{130} Transaction\ month\ and\ year_{7/2010} \\
&\quad + \beta_{131} Zipcode_{00120} + \cdots + \beta_{235} Zipcode_{02940} + \beta_{236} New\ apartment \\
&\quad + \beta_{237} Condition: bad + \beta_{238} Condition: satisfactory + \beta_{239} Condition: good \\
&\quad + \beta_{240} Construction\ year_{1860} + \cdots + \beta_{365} Construction\ year_{2012} + \beta_{366} Top\ floor \\
&\quad + \beta_{367} Bottom\ floor + \beta_{368} Time\ to\ repair_{10} + \cdots + \beta_{377} Time\ to\ repair_1 \\
&\quad + \beta_{378} Time\ from\ repair_1 + \cdots + \beta_{387} Time\ from\ repair_{10} \\
&\quad + \beta_{388} Repair\ ongoing + \cdots + \beta_{389} Last\ year\ of\ repair \\
&\quad + \beta_{390} Time\ from\ last\ repair\ plan_1 + \cdots + \beta_{400} Time\ from\ last\ repair\ plan_{11} \\
&\quad + \beta_{401} Time\ from\ last\ repair\ study_1 + \cdots + \beta_{413} Time\ from\ last\ repair\ study_{13} \\
&\quad + \beta_{414} Rented\ lot
\end{aligned}
\tag{6}
$$

After having selected a suitable specification, the pipe repair related results, which are of most interest, can be reviewed. The dummy coefficients showing the time to/from repair illustrate how the apartment value develops before, during and after repair. When looking at the coefficients, we see that the repair has a clear impact on prices. The prices of apartments start to fall six years before the repair. The discount six years before is 2.8 percent and the discount increases smoothly to 8.7 percent one year before the repair. A premium of 3.1 percent is paid soon after the repair. The discount is somewhat lower (5.4 percent) when the repair is in progress. The coefficient of the variable "last year of repair" cannot be interpreted reliably because some of the apartments may have the debt already included in the debt free-price while my calculations assume they don't. This problem is caused by the fact that we don’t know the exact date when the debt is allocated to the apartments. Figure 14 shows how the price of the treatment group evolves in the vicinity of the repair.

Figure 14 Pipe repair price effect development before, during and after the repair

The graph shows how the price of the treatment group develops in the vicinity of pipe repair. The dependent variable is the debt free price per square meter. Statistical significances of coefficients are shown in Table 4, regression (3). The data is from Oikotie, Kiinteistömaailma, HSP and real estate managers. The data is from Jan 2000 – Jun 2010. The number of observations is 32,676.



The 95 percent confidence interval is also shown in Figure 14. Coefficients for years from minus ten to minus seven are not statistically significant as implied by vast confidence intervals. Similarly coefficients for years eight and ten after the repair are not statistically significant.

In conclusion, pipe repair clearly impacts apartment prices and can be seen as a discount before the repair and as a premium paid after the repair. Nevertheless, nothing can be said about potential mispricing based on these regressions alone as they do not consider the costs of repair. Mispricing is studied in Section 6.2.

Next, let's take a look at the rest of the regression coefficients. The two first ones are pipe repair related while others are there to control for the effects of important housing attributes.

i. *Repair study and plan:* Dummies for repair study and repair plan seek to explain whether better information mitigates potential repair underpricing. It seems that repair plans and studies have a slightly negative impact. Prices are estimated to be some 1.5 percent discounted both one year after a repair plan and after a repair study. However, only some of the coefficients are significant. As a conclusion, it seems that when it comes to repair studies, more information available makes repairs slightly less underpriced. However, one must bear in mind that information on these variables may be lacking. The data was gathered by going through Oikotie announcements. Thus we don't have any information not included in the announcements.

ii. *Apartment size and number of rooms:* Apartment size has a negative effect on price per square meter. This means that the bigger the apartment, the less expensive is the price per square meter. This is consistent with Moilanen and Terho's (2010) findings. The number of rooms as opposed to apartment size has a slightly positive coefficient in most regressions. This is consistent with Sirmans et al. (2005) who find that the number of rooms has a positive coefficient in 71 percent of studies reviewed.

iii. *Debt share of debt-free price:* This variable illustrates how much of the total debt-free price was debt. According to the results, when the share of debt increases from none to hundred percent, the price of the apartment goes up by three percent. One explanation for this could be the tax deductibility of interest payments. As the share of debt normally is quite limited, the expected 'debt premium' is expected to be rather small.

iv. *Elevator:* Apartments in buildings that have an elevator are on average seven percent more expensive than those with no elevator. Moilanen and Terho (2010) also found a positive price effect.

v. *Condition of the apartment:* The condition of the apartment also has a clear impact on housing prices as intuitively expected. The basic assumption in the regressions is that the condition is unknown. As compared to this, apartments whose condition is classified as "new" are 3.4 percent more valuable. Attribute "good" increases price by 3.4 percent, "satisfactory" decreases it by 3.5 percent and "bad" by 11.6 percent. One should keep in mind, though, that classifications are somewhat discretionary and the condition is likely to be positively biased.

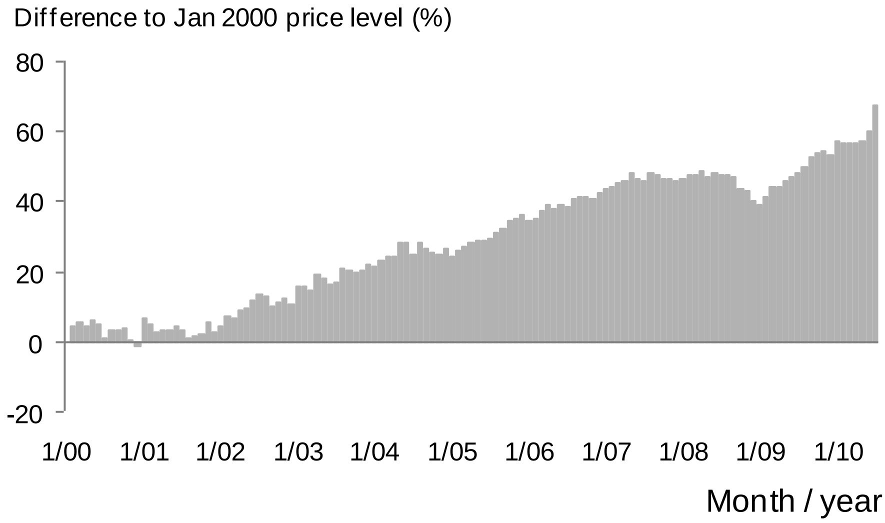
vi. *Floor:* The floor also has an expected effect on price. In these regressions, I used dummy variables for top and bottom floor. The top floor is 2.9 percent more expensive than the middle floors and the bottom floor 2.8 percent less.

vii. *Lot ownership:* Lot ownership appears to have a relatively large negative price effect of -12.4 percent.

viii. *Transaction year and month:* Transaction time has a significant effect on prices. The results suggest that nominal prices have increased by 60 percent from January 2000 to June 2010. Almost all coefficients are highly significant even at one percent level. Figure 15 illustrates the development of prices. The downturn of years 2008 and 2009 is reflected in prices. Year 2010 shows a recovery in the housing markets but it only contains data from the first six months of the year.

Figure 15 Transaction year and month coefficients 2000–2010

The graph shows the dummy regression coefficients for transaction year and month except for January 2000 which is the base month. The data is from Oikotie, Kiinteistömaailma, HSP and real estate managers. The data is from Jan 2000 – Jun 2010. The number of observations is 32,932.

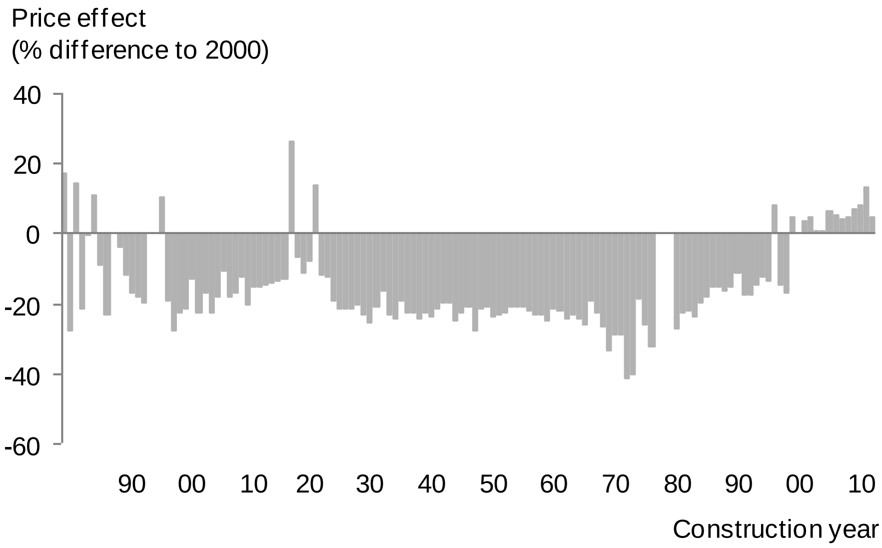


ix. *Zip code:* There are altogether 106 zip code areas included in the study. The price effect of each was determined by using dummies for each zip code (except for 00100 which is the base category). The results indicate that, for instance, a similar apartment in Tapiola (zip code 02100) is estimated to be 29.4 percent less valuable than in the 00100 area.

x. *Construction decade:* Figure 16 shows how the construction year impacts housing value. The graph shows the difference in value to the apartments built in year 2000. Buildings from 1970s seem to be the least valuable. This is likely to be caused by the low quality of construction in that decade. The results are similar to Laakso (1997) who finds that the prices were lowest for the dwellings from the 60s and the 70s. Two other observations can be made from the graph: new apartments are more expensive than older ones whereas really old ones are again more valuable than apartments in between. As discussed earlier, the higher value of old dwellings can be explained by the vintage effect (Coulson and McMillen 2008). It must be noted, however, that the volume of really old apartments sold is relatively low. In addition, although the number of observations is generally high, there are some years with fewer observations including years during World War I and Finnish Civil War, which explains the spikes in the 1910s.

Figure 16 Construction year coefficients 1860–2010

The graph shows the dummy regression coefficients for construction years. Year 2000 is the base year. Statistical significances of coefficients are shown in Table 4. The data is from Oikotie, Kiinteistömaailma, HSP and real estate managers. The data is from Jan 2000 – Jun 2010. The number of observations included is 32,676.



6.2 MISPRICING RESULTS

The focus on this section is in the core of this thesis: in determining if apartments are mispriced before pipe repair. In order to be able to evaluate mispricing, either the real costs of repair have to be known or the costs have to be estimated. Furthermore, the repair costs have to be adjusted so that they represent the discounted value of costs at the time of the transaction. Calculations in this section show whether the price discount discovered in Section 6.1 is rightly sized so that it compensates for the repair costs.

As discussed in Section 3.3, there are two cost components that are fairly straightforward to estimate: actual repair costs and costs of lost rent / opportunity to live in the dwelling. I will start by explaining how the estimates for repair costs were done (Section 6.2.1 and Section 6.2.2). These estimates are used in Section 6.2.3. Also observations with actual repair cost information gathered from real estate managers are studied in the same section. Finally, I studied how the pipe repair interval and apartment price affect housing pricing in Section 6.2.4 and Section 6.2.5.

6.2.1 PIPE REPAIR PRICE ESTIMATES

When gathering data from the three real estate agencies, I obtained price and scale information on actual pipe repair cases. The pipe repair cost estimates are based on 32 pipe repairs in Helsinki and Espoo. I estimated the repair cost per square meter based on these observations, taking into account the repair end year, the average size of the apartments in the housing company and the size of the housing company as shown in Equation (7). I tested several linear and non-linear specifications, and the specification where the natural logarithms of the average size and the total area of the apartments turned out to offer the best fit. The data from housing company management companies is quite detailed and would allow the use of additional attributes (e.g. repair technique, whether the outside and basement pipes and bathrooms had been renovated), but renovation data from Oikotie doesn't generally go this deep. Therefore, there are bound to be some missing attributes but given also the limited number of observations, the number of independent variables that can be used is limited.

A few additional words about renovation technique: My original purpose was to also study if different renovation techniques have different price effects. However, the pipe repair cases I studied in further detail were practically all done in the traditional way. When discussing the matter with real estate managers, they told me that although coating and other new techniques have been available for some years already, they have gained popularity only recently. FREMS's pipe repair study (2011) confirms this statement – 82 percent of waste pipes and practically all water pipes were renewed in 2008–2009. Similarly, in the Oikotie renovation data, it was rarely mentioned that the repair had been done with new techniques.

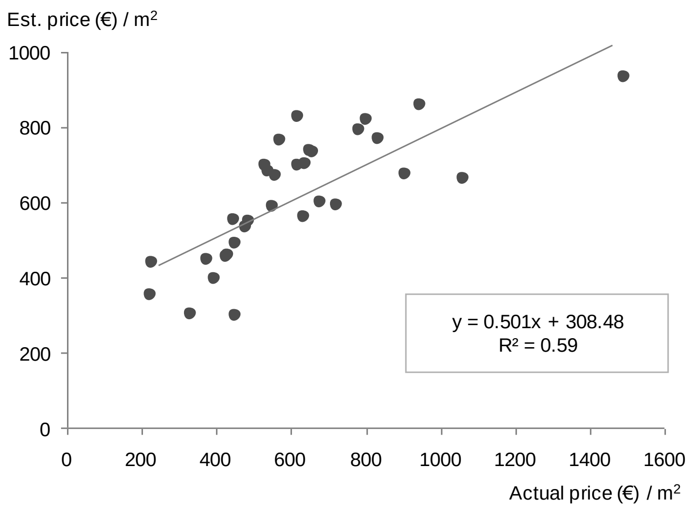
Equation (7) shows the regression for estimating repair costs. The average size of apartments in a housing company affects the repair price because small apartments have relatively more bathrooms and kitchen's to be renovated. The total area of the apartments also seems to affect the price: the bigger the housing company, the lower the cost per square meter. The renovation year also affects the costs and, therefore, renovation year dummies are added. There were no observations about renovations ending in 2000 and 2001, so the 2002 price level was used for respective observations. Year 2002 is the base year in the estimation. The repair costs per square meter were estimated as follows:

$$\begin{aligned}
&Repair\ costs\ per\ square\ meter \\
&\quad = \beta_0 + \beta_1 \ln(average\ size\ of\ apartments\ in\ a\ housing\ company) \\
&\quad + \beta_2 \ln(total\ area\ of\ apartments\ is\ a\ housing\ company) \\
&\quad + \beta_3 D_1(last\ repair\ year\ 2003) + \beta_4 D_2(last\ repair\ year\ 2004) \\
&\quad + \beta_5 D_3(last\ repair\ year\ 2005) + \beta_6 D_4(last\ repair\ year\ 2006) \\
&\quad + \beta_7 D_5(last\ repair\ year\ 2007) + \beta_8 D_6(last\ repair\ year\ 2008) \\
&\quad + \beta_9 D_7(last\ repair\ year\ 2009) + \beta_{10} D_8(last\ repair\ year\ 2010)
\end{aligned} \tag{7}$$

Figure 17 shows that the estimated repair costs correspond relatively well to real costs. The model appears to flatten out the largest price differences, which I consider to be a reasonable property as we don’t have detailed information on each repair.

Figure 17 Comparison of real and estimated pipe repair costs

The graph plots real costs per square meter against estimated costs for the same housing companies. The number of housing companies used in regressions is 32. The data is from the following real estate management companies: Tapiolan Lämpö, SKH and Real estate management company Jarmo Rantamäki. The data is from 2002-2010.



Finally, the pipe repair cost estimate accounts for the costs of the repair that are common to all shareholders of the housing company. It is, however, quite common that the owners also decide to do some extra renovation at their own costs e.g. they renew the kitchen. As these costs are not included in calculations, the real costs are, in many cases, even larger.

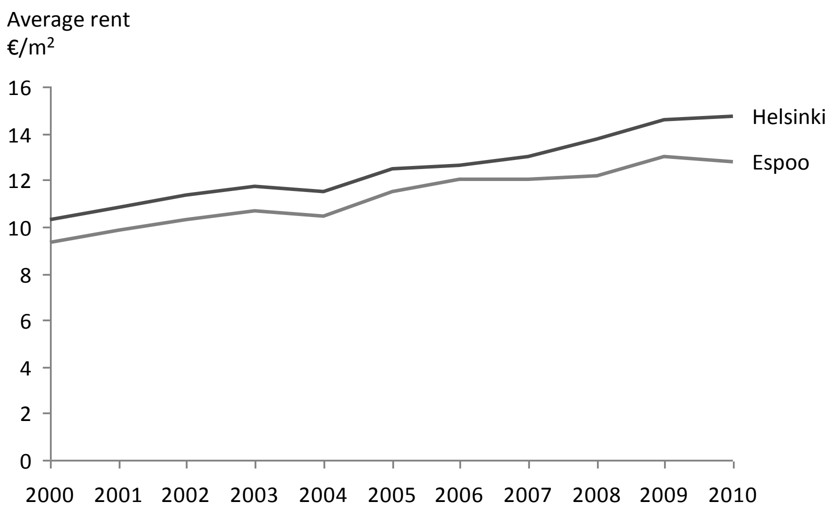
In conclusion, partly because of data limitations but more importantly because the traditional method has been by far the dominating repair method, the estimated repair prices reflect the prices of traditional renovations. In addition, the price of coating can in many cases be very close to that of total renovation. I believe that the regression used for estimating the repair costs gives the best available approximation and suits our purposes well.

6.2.2 LOST RENT ESTIMATES

Second component that adds to the total repair costs from the dweller's point of view derives from the fact that dwellers cannot usually live in their dwellings during some two to three months of the repair. For landlords, these costs realize in the form of discounted / lost rent payments, while those who own the apartment they live in probably have to find an alternative place to live and pay for it. Estimates of lost rent are calculated based on average annual rents per square meter in Helsinki and Espoo areas. The total cost for a given apartment is estimated to be the cost per square meter times the number of square meters times three months. Three months represents the estimated duration of renovation. The annual average costs per square meter are illustrated in Figure 18.

Figure 18 Average rents in Helsinki and Espoo 2000–2010

The graph shows average annual rents of private dwellings in Helsinki and Espoo 2000–2010. 2010 rent is not for the whole year but for Q1–Q3. The data source is Statistics Finland.



6.2.3 *Pipe repair mispricing with estimated and actual repair costs*

The results of the regressions in this section show that apartments are overpriced before renovation. In other words, pipe repairs are underpriced, i.e. their price is not fully reflected in debt-free selling prices. This is true both for the sample with estimated pipe repair costs and for the sample with true repair costs. The underpricing seems to be even greater with the real repair costs.

Table 5 presents the regression results on mispricing. The results differ from those in Section 6.1 in that the dependent variable here is the ‘fair' debt-free price i.e. the discounted value of direct repair costs and lost rent income have been added to announced debt-free price. No matter which of the three discount rate alternatives are used, the repair underpricing remains remarkable. It seems that the market, on average, pays too high a price prior to the repair.

When looking at the coefficients, apartments are some 10-20 percent overpriced before the pipe repair depending on the time to repair. When using the ten-year government bond and the estimated repair prices, apartments seem to be 19.6 percent overpriced seven years before the repair. The amount of overpricing diminishes as the repair comes closer but is still 11.1 percent one year prior to the repair. A premium of approximately 2-4 percent is paid after the repair according to the estimated repair cost sample, which is more accurate for after-repair figures. The oddity of the coefficients "last-year of repair" can be explained by the fact that we know the starting and ending times of repairs at one year's precision. This causes that the end year is problematic – discounted costs are added even though they would in reality already be included in the debt-free sales price. Therefore some apartments sold during the last year of repair look highly overpriced, although this would not be the case in reality.

Table 5 Apartment mispricing in the vicinity of pipe repair

The table presents the regression results on the pricing of apartments before and after pipe repair. Figures in parentheses below the coefficients are the t-statistics. Respectively, ***, ** and * denote statistical significance at 1%, 5% and 10% levels. The dependent variable is the natural logarithm of the debt-free price plus the discounted value of repair costs and costs of lost rent per square meter. There are two groups of regression – in the first ones, estimated repair costs are used whereas the second ones are based on real repair costs. Both groups are discounted with three different discount rates, five- and ten-year Finnish government bond rates and five-year bond rate plus a two percent risk premium.

	Regressions with estimated repair costs			Regressions with real repair costs		
Variable	Ln(price/m² discounted with 10-yr bond)	Ln(price/m² discounted with 5-yr bond)	Ln(price/m² discounted with 5-yr bond + 2%)	Ln(price/m² discounted with 10-yr bond)	Ln(price/m² discounted with 5-yr bond)	Ln(price/m² discounted with 5-yr bond + 2%)
Time to repair: 10 years	0.161***	0.165***	0.134***	n/a	n/a	n/a
	(4.31)	(4.42)	(3.61)			
Time to repair: 9 years	0.173***	0.179***	0.150***	n/a	n/a	n/a
	(9.09)	(9.38)	(7.89)			
Time to repair: 8 years	0.185***	0.191***	0.162***	0.246***	0.253***	0.225***
	(13.93)	(14.41)	(12.22)	(4.85)	(4.99)	(4.44)
Time to repair: 7 years	0.196***	0.203***	0.177***	0.315***	0.322***	0.297***
	(17.16)	(17.75)	(15.46)	(8.24)	(8.42)	(7.76)
Time to repair: 6 years	0.175***	0.181***	0.157***	0.256***	0.264***	0.242***
	(17.00)	(17.66)	(15.34)	(7.04)	(7.24)	(6.64)
Time to repair: 5 years	0.157***	0.162***	0.142***	0.223***	0.230***	0.210***
	(17.82)	(18.45)	(16.2)	(8)	(8.28)	(7.56)
Time to repair: 4 years	0.149***	0.153***	0.136***	0.217***	0.223***	0.207***
	(19.8)	(20.34)	(18.09)	(8.05)	(8.26)	(7.66)
Time to repair: 3 years	0.134***	0.136***	0.123***	0.179***	0.182***	0.169***
	(20.39)	(20.78)	(18.8)	(6.19)	(6.31)	(5.86)
Time to repair: 2 years	0.125***	0.126***	0.116***	0.165***	0.166***	0.157***
	(21.3)	(21.58)	(19.89)	(6.34)	(6.39)	(6.05)
Time to repair: 1 year	0.111***	0.112***	0.106***	0.163***	0.163***	0.158***
	(19.71)	(19.88)	(18.78)	(6.85)	(6.88)	(6.65)
Repair on-going	0.132***	0.133***	0.129***	0.195***	0.195***	0.193***
	(25.44)	(25.61)	(24.78)	(5.72)	(5.74)	(5.67)
Last year of repair	0.178***	0.177***	0.178***	0.181***	0.181***	0.180***
	(33.89)	(33.87)	(33.94)	(6.81)	(6.81)	(6.80)
Time from repair: 1 year	0.022***	0.022***	0.023***	0.055*	0.054*	0.054*
	(4.03)	(4.01)	(4.08)	(1.95)	(1.94)	(1.94)
Time from repair: 2 years	0.025***	0.025***	0.025***	0.063*	0.062*	0.062*
	(4.24)	(4.23)	(4.27)	(1.77)	(1.76)	(1.76)
Time from repair: 3 years	0.027***	0.027***	0.027***	0.018	0.018	0.017
	(4.30)	(4.29)	(4.32)	(0.34)	(0.34)	(0.33)
Time from repair: 4 years	0.021***	0.021***	0.021***	-0.028	-0.029	-0.029
	(3.10)	(3.09)	(3.11)	(-0.60)	(-0.60)	(-0.60)
Time from repair: 5 years	0.011	0.011	0.011	0.014	0.014	0.014
	(1.52)	(1.51)	(1.52)	(0.32)	(0.31)	(0.31)
Time from repair: 6 years	0.024***	0.024***	0.024***	0.007	0.007	0.007
	(2.96)	(2.96)	(2.97)	(0.11)	(0.10)	(0.11)
Time from repair: 7 years	0.020**	0.020**	0.020**	0.045	0.045	0.044
	(2.07)	(2.07)	(2.07)	(0.35)	(0.35)	(0.34)
Time from repair: 8 years	0.012	0.012	0.012	-0.013	-0.013	-0.014
	(0.93)	(0.93)	(0.92)	(-0.10)	(-0.10)	(-0.11)
Time from repair: 9 years	0.044***	0.044***	0.044***	n/a	n/a	n/a
	(2.92)	(2.92)	(2.91)			
Time from repair: 10 years	0.004	0.004	0.004	n/a	n/a	n/a
	(0.17)	(0.17)	(0.18)			
Time from last repair plan	Yes	Yes	Yes	Yes	Yes	Yes
Time fom last repair study	Yes	Yes	Yes	Yes	Yes	Yes

Table 5 Apartment mispricing in the vicinity of pipe repair – continued

	Regressions with estimated repair costs			Regressions with real repair costs		
Variable	Ln(price/m² discounted with 10-yr bond)	Ln(price/m² discounted with 5-yr bond)	Ln(price/m² discounted with 5-yr bond + 2%)	Ln(price/m² discounted with 10-yr bond)	Ln(price/m² discounted with 5-yr bond)	Ln(price/m² discounted with 5-yr bond + 2%)
Constant	8.821***	8.82***	8.822***	8.846***	8.846***	8.846***
	(361.09)	(361.01)	(361.06)	(276.03)	(276.03)	(276.03)
Ln(Apartment size)	-0.17***	-0.17***	-0.17***	-0.16***	-0.16***	-0.16***
	(-43.43)	(-43.41)	(-43.48)	(-31.9)	(-31.9)	(-31.89)
Number of rooms	0.01***	0.01***	0.01***	0.004**	0.004**	0.004**
	(6.50)	(6.48)	(6.52)	(2.27)	(2.27)	(2.28)
Debt share of debt free price	0.024***	0.024***	0.025***	0.003	0.003	0.003
	(3.54)	(3.51)	(3.59)	(0.42)	(0.42)	(0.42)
Has elevator	0.005**	0.005**	0.005**	0.005**	0.005**	0.005**
	(2.52)	(2.51)	(2.51)	(2.09)	(2.10)	(2.09)
Condition: new	0.034***	0.034***	0.034***	0.039***	0.039***	0.039***
	(8.95)	(8.90)	(8.94)	(9.63)	(9.63)	(9.63)
Condition: bad	-0.11***	-0.11***	-0.11***	-0.123***	-0.123***	-0.123***
	(-22.76)	(-22.75)	(-22.79)	(-16.82)	(-16.82)	(-16.82)
Condition: good	0.03***	0.03***	0.03***	0.023***	0.023***	0.023***
	(13.01)	(12.99)	(13.06)	(8.52)	(8.52)	(8.52)
Condition: satisfying	-0.033***	-0.033***	-0.033***	-0.035***	-0.035***	-0.035***
	(-12.38)	(-12.38)	(-12.38)	(-10.71)	(-10.71)	(-10.71)
Top floor	0.029***	0.029***	0.029***	0.032***	0.032***	0.032***
	(15.51)	(15.51)	(15.54)	(14.71)	(14.71)	(14.71)
Bottom floor	-0.027***	-0.027***	-0.027***	-0.027***	-0.027***	-0.027***
	(-14.28)	(-14.28)	(-14.29)	(-12.14)	(-12.14)	(-12.14)
Rented lot	-0.122***	-0.122***	-0.122***	-0.157***	-0.157***	-0.157***
	(-42.71)	(-42.71)	(-42.73)	(-48.2)	(-48.2)	(-48.2)
Transaction month and year	Yes	Yes	Yes	Yes	Yes	Yes
Construction year	Yes	Yes	Yes	Yes	Yes	Yes
Zipcode	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0,848	0,848	0,849	0,849	0,849	0,849
Number of observations	32 676	32 676	32 676	24 355	24 355	24 355

Figure 19 plots the coefficients for the sample with estimated repair costs. 95 percent confidence intervals are also shown for each coefficient.

Figure 19 Pipe repair price effect development – estimated costs

The graph shows how the price of the treatment group develops in the vicinity of pipe repair. The dependent variable in the regression is the debt free price per square meter plus discounted cost of the pipe repair per square meter. The discount rate is the ten-year Finnish government bond. Statistical significances of coefficients are shown in Table 5. The data is from Oikotie, Kiinteistömaailma, HSP and real estate managers. The data is from Jan 2000 – Jun 2010. The number of observations is 32,676.

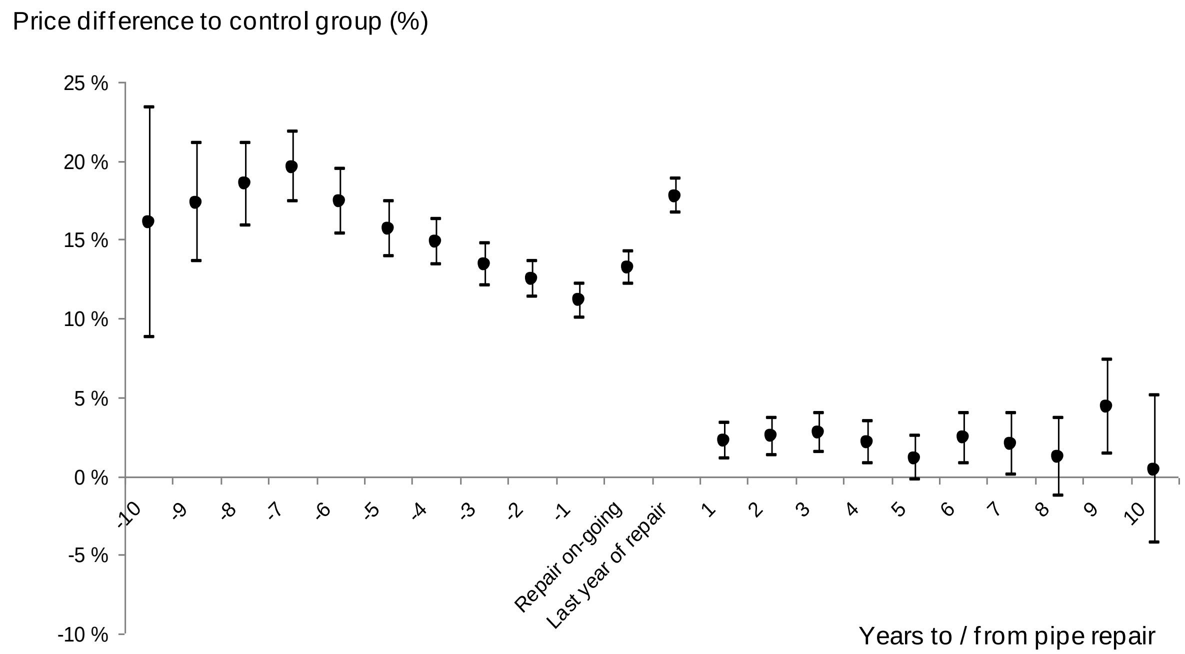
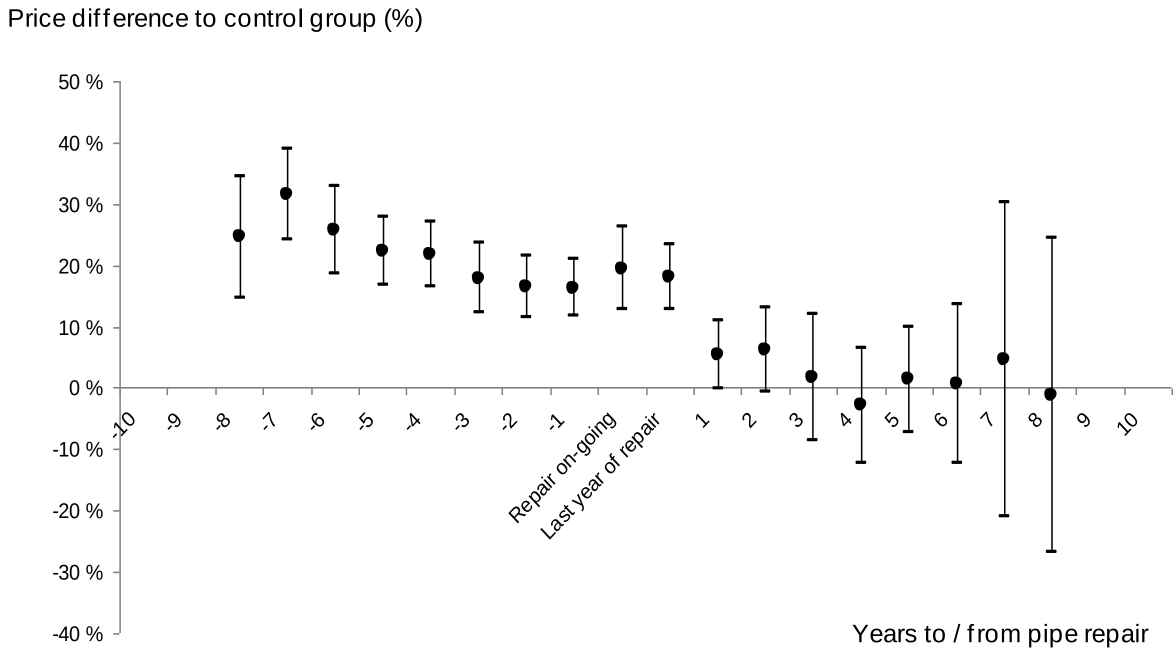


Figure 19 illustrates the fact that the pipe repairs are underpriced i.e. apartments are too expensive before pipe repair. The price is 11.1 percent higher than that of the control group one year before the repair and 2.2 percent higher after repair. Thus the drop in the value during pipe repair between those two years is 8.9 percent. A similar effect was found when studying the sheer debt-free prices – the overpricing is greatest in year seven after which it decreases. Before that, the repair underpricing appears to grow although the effect is not quite clear. A natural explanation for this is that the discounted value of repair costs starts to decrease more rapidly the further the repair is.

Figure 20 is similar to Figure 19, the only difference being that real repair costs are used instead of estimated costs. The number of observations in the treatment group is reduced from 8,781 to 434 transactions, but the results similarly indicate that repair underpricing takes place. The number of observations in the treatment group remains the same.

Figure 20 Pipe repair price effect development – real costs

The graph shows how the price of the treatment group develops in the vicinity of pipe repair. The dependent variable in the regression is the debt free price per square meter plus discounted cost of the pipe repair per square meter. The discount rate is the ten-year Finnish government bond. Statistical significances of coefficients are shown in Table 5. The data is from Oikotie, Kiinteistömaailma, HSP and real estate managers. The data is from Jan 2000 – Jun 2010. The number of observations is 24,355.



When looking at these results, the pipe repair underpricing effect is even more prominent. Apartments are as much as 31.5 percent overpriced seven years and 16.3 percent overpriced one year before the repair. Coefficients for the years after the repair are not statistically significant probably due to the scarce number of observations. Therefore, estimates from the previous regression best represent the premium paid. Here observations for years -10, -9, 9 and 10 are not available.

There's an additional aspect to the repair pricing which has not been discussed so far. That is: the condition of the bathroom and toilets may improve if they are renovated in the repair and the buyers may be willing to pay for this, which would reduce the overpricing. I studied the issue with a set of regressions with apartments in good condition only. The idea here is that because the apartments already are in good condition, the value of the dwelling should not gain much additional value because of the improvement in condition. The results show that the overpricing effect is almost identical for apartments in good condition and all apartments (see Appendix for comparison). I thus conclude that the underpricing effect is not significantly affected by the potential improvement in a dwelling's condition.

6.2.4 REPAIR INTERVAL'S EFFECT ON MISPRICING

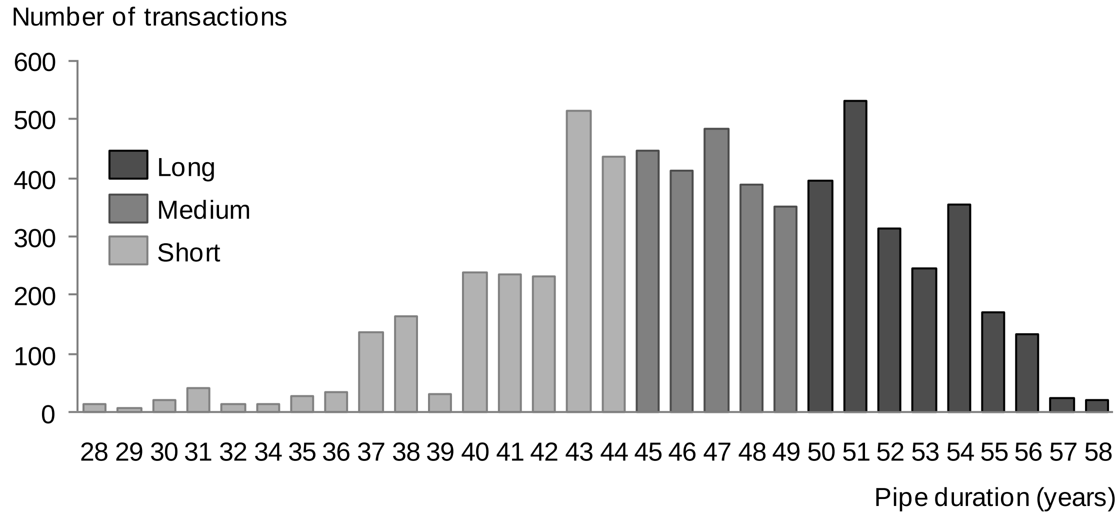
The purpose of this section is to study if the repair interval i.e. the time from the previous repair or construction affects repair underpricing. As discussed in Section 2.2.1, the durability of pipes varies and is some 40-50 years on average. Therefore, the market doesn't often estimate the timing of the repair exactly right. From the financial perspective, the later the repair takes place the better for the owner as the present value of the repair costs reduces when the time to repair increases. Assuming that the market uses the average durability of the pipes in estimating the repair timing, the repair underpricing discovered in Section 6.2.3 should be larger for apartments for which the repair is done sooner than expected and smaller for apartment for which the repair is overdue. Therefore, I hypothesize that the apartment overpricing reduces as the repair interval increases.

I tested for the repair timing's effect on repair underpricing by calculating the repair interval for observations in the treatment group and by dividing the observations into three groups based on the length of the repair interval. The repair interval was calculated in the following manner: I collected information on previous repair timing for the housing companies. For the companies this information existed, the interval was calculated as the difference between the first year of the second repair and the first year of the first repair. In addition, I assumed that the repair done in 2000-2010 was the first one for housing companies built in 1950-1970. Thus, the repair interval for the apartments sold from these companies was assumed to be the difference between the first repair year and the construction year. Apartments that did not fulfill either of these conditions were left out from the regressions.

The first group where the pipe system appears to endure the shortest time is called Short and it includes 2,159 transactions. The next group is called Medium (2,081 observations) and the last group Long as the pipes last longest (or alternatively are postponed as much as possible) and it contains 2,190 observations. The distribution of transaction is shown in Figure 21 below. The medium repair interval is 47 years for all of the observations.

Figure 21 Distribution of repair intervals

The graph shows how the pipe repair intervals are distributed. The observations are divided into three groups according to the time it took form the last pipe repair of the construction to the repair. The data is from Oikotie, Kiinteistömaailma, HSP and real estate managers. The data is from Jan 2000 – Jun 2010. The number of observations is 31,990.



I calculated the pipe repair price effect for the three groups separately as shown in Table 6.The first part of the shows the price effects separately for each group and the second part the variables which are commonly estimated for all observations. One regression with separate group dummies was used for the regression. One must note that the first column, Short, shows the overpricing for the apartments with the shortest repair intervals. Coefficients in columns Medium and Long represent the price effect as a difference from group Short. For instance, seven years before the repair, apartments in group Short were 24.1 percent overpriced as compared to the control group. Apartments in group Medium were 10.8 percent less valued than those in group Short i.e. they were 13.3 percent overpriced.

Table 6 shows that apartments with longer repair intervals indeed seem to be less overpriced. Almost all coefficients for groups Medium and Long are negative. The majority of the coefficients are not statistically significant but those that are confirm the expected price effect. One should bear in mind, however, that there are in many cases other sources of information that provide additional information on the expected timing of the repair.

Table 6 Effect of the pipe system durability on apartment mispricing

The table presents the regression results on the pricing of apartments before and after pipe repair in relation to the time it took form the last pipe repair or the construction to the repair. The observations are divided into three samples of approximately the same size. Group "Short" represents the group of observations for which the repair was done relatively soon i.e. the pipe system duration was short. For observations in group "Long", the repair was done relatively late. Figures in parentheses below the coefficients are the t-statistics. Respectively, ***, ** and * denote statistical significance at 1%, 5% and 10% levels. The dependent variable is the natural logarithm of the debt-free price plus the discounted value of repair costs and costs of lost rent per square meter. The discount rate is the ten-year Finnish government bond rate.

	Pipe system duration		
Group specific variables	Short	Medium (difference to Short)	Long (difference to Short)
Time to repair: 10 years	0.142	0.085	-0.031
	(1.47)	(0.73)	(-0.28)
Time to repair: 9 years	0.151***	0.025	-0.005
	(3.43)	(0.46)	(-0.10)
Time to repair: 8 years	0.201***	-0.060	-0.036
	(5.33)	(-1.39)	(-0.86)
Time to repair: 7 years	0.241***	-0.108***	-0.076***
	(10.17)	(-3.46)	(-2.60)
Time to repair: 6 years	0.195***	-0.042	-0.049*
	(9.37)	(-1.55)	(-1.85)
Time to repair: 5 years	0.176***	-0.049**	-0.012
	(11.02)	(-2.25)	(-0.55)
Time to repair: 4 years	0.149***	-0.034*	-0.021
	(8.93)	(-1.77)	(-1.05)
Time to repair: 3 years	0.134***	-0.012	-0.026
	(9.23)	(-0.69)	(-1.48)
Time to repair: 2 years	0.144***	-0.054***	-0.043***
	(11.91)	(-3.63)	(-2.88)
Time to repair: 1 year	0.123***	-0.032**	-0.044***
	(10.82)	(-2.31)	(-3.18)
Repair on-going	0.122***	-0.003	-0.029**
	(13.57)	(-0.28)	(-2.26)
Last year of repair	0.176***	-0.013	-0.031**
	(16.42)	(-1.05)	(-2.35)

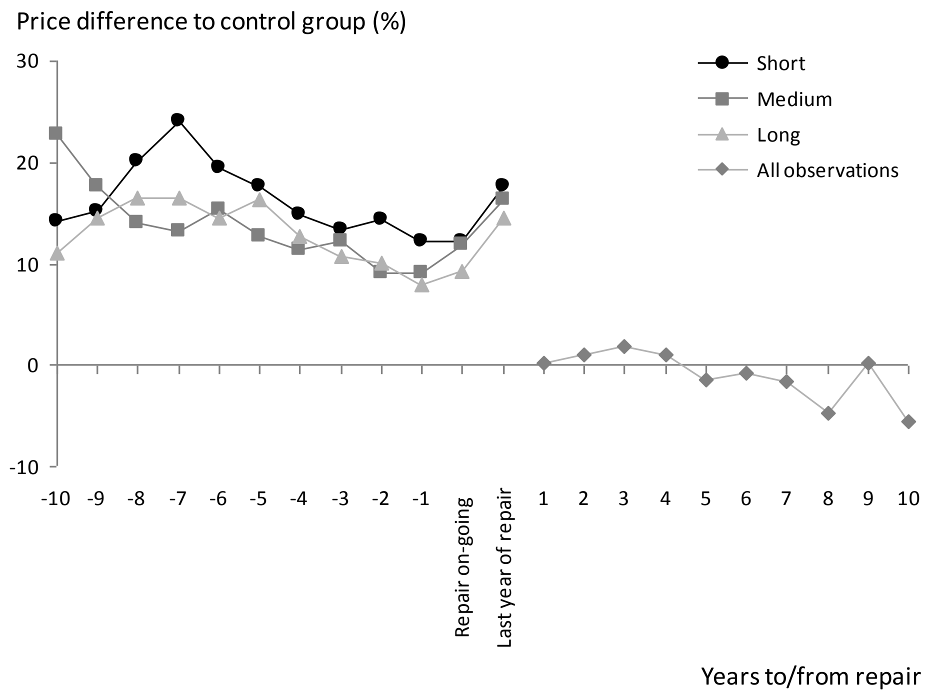
Table 6 Effect of the pipe system durability on apartment mispricing - continued

Common variables	All observations	Common variables	All observations
Time from repair: 1 year	0.003 (0.37)	Number of rooms	0.008*** (4.88)
Time from repair: 2 years	0.010 (1.16)	Debt share of debt free price	0.048*** (6.83)
Time from repair: 3 years	0.019** (2.17)	Has elevator	0.006*** (3.01)
Time from repair: 4 years	0.010 (1.02)	Condition: new	0.025*** (6.49)
Time from repair: 5 years	-0.015 (-1.24)	Condition: bad	-0.107*** (-19.39)
Time from repair: 6 years	-0.008 (-0.64)	Condition: good	0.025*** (10.26)
Time from repair: 7 years	-0.016 (-0.99)	Condition: satisfying	-0.036*** (-12.6)
Time from repair: 8 years	-0.047* (-1.87)	Top floor	0.028*** (14.47)
Time from repair: 9 years	0.003 (0.09)	Bottom floor	-0.025*** (-12.51)
Time from repair: 10 years	-0.055 (-1.37)	Transaction month and year	Yes
Constant	8.845*** (312.19)	Construction year	Yes
Ln(Apartment size)	-0.169*** (-38.3)	Zipcode	Yes
		Adjusted R-squared	0,831
		Number of observations	31 861

Figure 22 illustrates the price development for the three groups before pipe repair. Observations are combined after the repair because the coefficients were statistically little significant separately. Although not all coefficients in Figure 22 are statistically significant (for statistical significances see Table 6), it seems that the apartment overpricing is greatest for apartments that were renovated relatively early. This is all rational when no exact information on the repair timing exists. It is surprising, though, that the overpricing is lower also one year before the repair as one would expect that detailed information about the timing would exist by then and therefore no differences between the groups would exist anymore.

Figure 22 Effect of the pipe system durability on apartment mispricing

The graph shows how the price of the treatment group develops in the vicinity of pipe repair. The observations are divided into three groups according to the time it took form the last pipe repair of the construction to the repair. The dependent variable in the regression is the debt free price per square meter plus discounted cost of the pipe repair per square meter. The discount rate is the ten-year Finnish government bond. Statistical significances of coefficients are shown in Table 6. The data is from Oikotie, Kiinteistömaailma, HSP and real estate managers. The data is from Jan 2000 – Jun 2010. The number of observations is 31,861.



6.2.5 Apartment price's effect on mispricing

In this subsection, I will study the impact of apartment price on apartment overpricing in the vicinity of pipe repair. I would expect the apartment overpricing to reduce as the apartment price increases. The rationale for this derives from the fact that as the pipe repair costs are basically independent from apartment prices, the repair costs are relatively significantly larger for inexpensive apartments. For instance, when the repair costs 500 and the apartment price is 2,000 euros per square meter, the repair cost equals to 25 percent of the total apartment value. When the price is 5,000 euros per square meter, the costs is only ten percent of the value.

To study the apartment price's impact on apartment overpricing before the repair, I divided all transactions in five price groups of equal size. When forming the classes, the general price development and pipe repair costs were accounted for. One regression with separate repair related group dummies was used for the regression. Other variables are common to all price groups. I also tested doing a separate regression for each of the five price groups as it could be argued that all variables should be group specific. The results regarding the lowest price group were similar with five separate regressions and one regression with repair specific dummy variables.

Table 7 shows the results for the five price groups with one regression and group specific dummy variables. A central note regarding the interpretation of the results must be made: The level of mispricing indicated by Table 7 and Figure 23 is misleading. The overpricing is smaller than in Section 6.2.3. The problem derives from the specification of the regression i.e. we have the apartment price on both sides of the specification. Therefore the price groups absorb some of the pipe repair price effect and lead to lower apartment overpricing. Therefore, it must be borne in mind that although the results show how the price groups are priced relative to each other, the level of mispricing is deceptive.

Table 7 reports the results for the five price quintiles. The group called Lowest includes least valuable apartments and serves as the base group in the regression. The coefficients for other quintiles show the difference to the group Lowest. For example, one year before the repair, 2^{nd} quintile was 3.4 percent less valuable than the lowest price quintile, so the prices were approximately 5.7 percent higher than in the control group. The second part of Table 7 shows the variables common to all groups.

Table 7 Effect of apartment price on apartment mispricing

The table presents the regression results on the pricing of apartments before and after pipe. The sample is divided into five price classes. The prices have been adjusted for the general price development and pipe repair costs. One regression with separate repair dummies for years before the repair is used. Figures in parentheses below the coefficients are the t-statistics. Respectively, ***, ** and * denote statistical significance at 1%, 5% and 10% levels. The dependent variable is the natural logarithm of the debt-free price plus the discounted value of repair costs and costs of lost rent per square meter. The discount rate is the ten-year Finnish government bond rate.

	Apartment price quintile				
Apartment price	Lowest	2nd quintile (diff. to Lowest)	3rd quintile (diff. to Lowest)	4th quintile (diff. to Lowest)	Highest (diff. to Lowest)
Time to repair: 10 years	0.147***	-0.022	-0.108*	-0.099	n/a
	(3.14)	(-0.24)	(-1.83)	(-1.51)	
Time to repair: 9 years	0.166***	-0.061	-0.103**	-0.114***	-0.209***
	(5.33)	(-1.43)	(-2.56)	(-3.08)	(-4.97)
Time to repair: 8 years	0.159***	-0.078***	-0.091***	-0.114***	-0.155***
	(7.33)	(-2.65)	(-3.48)	(-4.32)	(-5.39)
Time to repair: 7 years	0.155***	-0.083***	-0.078***	-0.102***	-0.125***
	(9.01)	(-3.11)	(-3.41)	(-4.84)	(-5.78)
Time to repair: 6 years	0.149***	-0.075***	-0.076***	-0.098***	-0.154***
	(6.59)	(-2.76)	(-2.98)	(-3.90)	(-6.02)
Time to repair: 5 years	0.127***	-0.070***	-0.061***	-0.084***	-0.107***
	(8.32)	(-3.43)	(-3.31)	(-4.83)	(-5.78)
Time to repair: 4 years	0.105***	-0.043***	-0.051***	-0.057***	-0.113***
	(8.29)	(-2.61)	(-3.53)	(-3.85)	(-7.08)
Time to repair: 3 years	0.109***	-0.048***	-0.056***	-0.060***	-0.112***
	(9.17)	(-3.37)	(-4.04)	(-4.42)	(-8.25)
Time to repair: 2 years	0.104***	-0.045***	-0.057***	-0.064***	-0.091***
	(12.53)	(-4.17)	(-5.42)	(-6.42)	(-8.79)
Time to repair: 1 year	0.091***	-0.034***	-0.045***	-0.053***	-0.080***
	(11.08)	(-3.42)	(-4.53)	(-5.32)	(-7.83)
Repair on-going	0.086***	-0.029***	-0.036***	-0.039***	-0.078***
	(11.29)	(-3)	(-3.99)	(-4.53)	(-8.91)
Last year of repair	0.110***	-0.044***	-0.054***	-0.058***	-0.073***
	(10.07)	(-3.46)	(-4.29)	(-4.91)	(-6.36)
Price group	-	0.191***	0.312***	0.431***	0.612***
		(106.85)	(150.50)	(187.33)	(234.34)

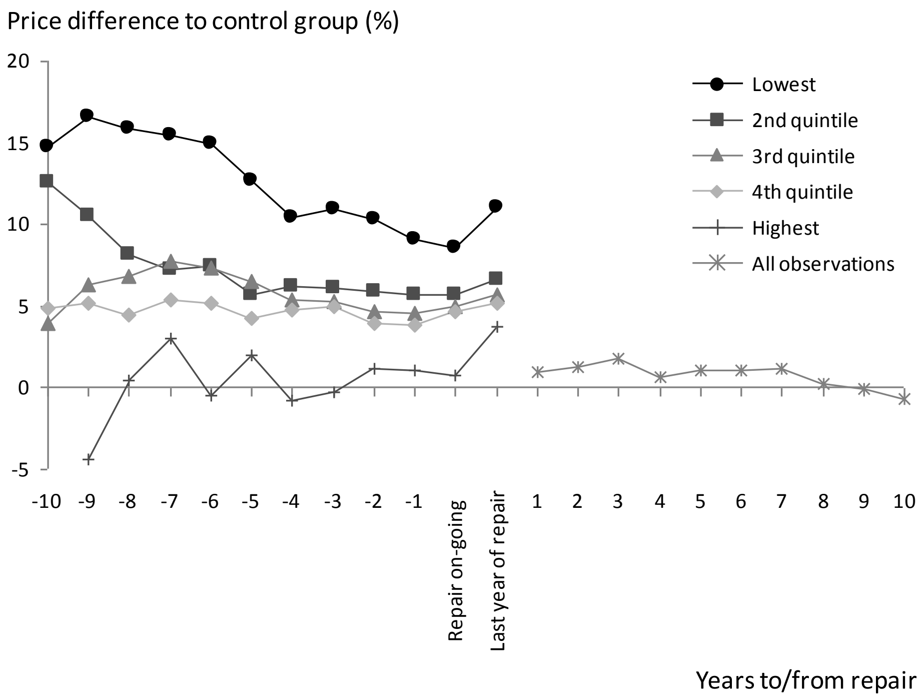
Table 7 Effect of apartment price on apartment mispricing - continued

Common variables	All observations	Common variables	All observations
Time from repair: 1 year	0.010*** (2.91)	Number of rooms	0.003*** (3.29)
Time from repair: 2 years	0.013*** (3.47)	Debt share of debt free price	0.027*** (6.37)
Time from repair: 3 years	0.017*** (4.37)	Has elevator	0.002 (1.36)
Time from repair: 4 years	0.007* (1.65)	Condition: new	-0.003 (-1.44)
Time from repair: 5 years	0.010** (2.21)	Condition: bad	-0.035*** (-11.47)
Time from repair: 6 years	0.010** (2.03)	Condition: good	0.006*** (4.43)
Time from repair: 7 years	0.011* (1.85)	Condition: satisfying	-0.015*** (-8.85)
Time from repair: 8 years	0.002 (0.25)	Top floor	0.013*** (11.34)
Time from repair: 9 years	-0.001 (-0.05)	Bottom floor	-0.004*** (-3.57)
Time from repair: 10 years	-0.007 (-0.44)	Transaction month and year	Yes
Constant	7.727*** (481.6)	Construction year	Yes
Ln(Apartment size)	-0.044*** (-17.73)	Zipcode	Yes
		Adjusted R-squared	0,939
		Number of observations	34 190

The results confirm the hypothesis that the repair underpricing is less of an issue for more expensive apartments - at least when considering mispricing relative to the total value of the dwelling. The majority of group specific coefficients are highly significant demonstrating that the groups are statistically different from each other. The results are illustrated in Figure 23. The majority of coefficients are statistically significant (see Table 7 for exact figures).

Figure 23 Effect apartment price on apartment mispricing

The graph shows how the price of the treatment group develops in the vicinity of pipe repair. The observations are divided into five price classes. The general price development and pipe repair costs have been accounted for when forming the classes. The dependent variable in the regression is the debt free price per square meter plus discounted cost of the pipe repair per square meter. The discount rate is the ten-year Finnish government bond. Statistical significances of coefficients are shown in Table 7. The data is from Oikotie, Kiinteistömaailma, HSP and real estate managers. The data is from Jan 2000 – Jun 2010. The number of observations is 34,190.



7 DISCUSSION ON POTENTIAL EXPLANATIONS FOR MISPRICING PIPE REPAIRS

The idea of *homo economicus* or economic man – the notion that humans think and choose unfailingly well – is vastly accepted in economics. As Thaler and Sunstein (2009) put it:

> *If you look at the economics textbooks, you will learn that homo economicus can think like Albert Einstein, store as much memory as IBM's Big Blue, and exercise the willpower of Mahatma Gandhi.*

But that's just not how we are. Real people do err. Psychology and behavioral finance have shown that human decision-making is prone to many biases and the use of rules of thumb that in some cases lead to suboptimal or terrible decisions. Gyourko and Saiz (2004) argue that uncertainty about market values or bounded rationality can lead to homeowners investing in projects that are losers from the financial perspective. In the context of Finnish housing markets, Moilanen and Terho (2010) find that net rental yield falls as the value of the dwelling increases i.e. the housing market is inefficient.

As apartment overpricing before pipe repair i.e. repair underpricing discovered in Section 6.2 is substantial, I argue that there could be several possible behavioral reasons that could cause the overpricing. In this section, I will review both rational explanations and common decision making biases that could contribute to the phenomena. As there is no previous research on the pipe repair topic, I will use examples from other contexts. There is no evidence on what truly causes repair underpricing. Examining reasons for the phenomenon would be an interesting topic for further research.

Biases and when decisions are likely to be biased

People often do amazingly good job at choosing. When you choose an ice cream flavor at a café it will rarely be a disappointment. Other decisions or actions turn out to be suboptimal. For instance, many Americans fail to save enough for their retirement (Thaler and Sunstein 2009). The question is: what factors affect the quality of our judgment? When are we prone to do suboptimal decisions such as paying too much for a soon-to-be-renovated apartment?

Thaler and Sunstein (2009) conclude that people need guidance "for decisions that are difficult and rare, for which they do not get prompt feedback, and when they have trouble translating aspects of the situation into terms that they can easily understand". People are least likely to make good choices when these circumstances apply. Consider a typical family buying a house:

The situation is complex as there is a rainbow of attributes to consider (size, price, neighborhood etc). Pipe repair is one of the attributes to consider. Furthermore, it is likely that the family hasn’t been involved too in many similar transactions before (if any), and it's also probable that the family doesn't have firsthand experience on pipe repairs. Feedback on how good the buying decision ultimately was is poor. Concrete feedback on the value of the dwelling is received only when the family finally sells the dwelling. It is not clear whether the decision to buy an apartment before the repair was better than that of buying an already repaired apartment as determining this requires extensive statistical analysis and controlling for various other price components.

Additionally, people tend to make inferior decisions when the situation calls for self-control. Thaler and Sunstein (2009) divide goods that require exercising special self-control in investment goods and sinful goods. For investment goods like dieting and exercising the costs are borne immediately but the benefits are delayed. For sinful goods, such as smoking and eating a brownie with ice cream, the benefits come immediately and the costs are suffered later. (Ibid.) Buying a dwelling of your dreams with corroded pipes is much like consuming a sinful good. You get the apartment instantly and worry about the pipes later. The experience shows that in general people consume too much sinful goods and too little investment goods.

Researchers of psychology and behavioral finance have recognized several biases distorting our decision-making. Psychologists Tversky and Kahneman were the first to report three systematic biases – anchoring, availability and representativeness – back in 1973-74. Many of the behavioral biases stem from the fact that we can’t spend all day long analyzing every decision from top to bottom in our busy lives. The issue comes problematic when we make biased, hasty decisions even if the benefits of analyzing the situation more thoroughly would be significant. Furthermore, most decision makers aren’t aware of these biases and their effects.

Next, I will review some biases that could lead to mispricing pipe repairs. I discuss each bias and its hypothetical, positive or negative, effect on repair pricing. The behavioral biases and some rational reasons that can affect valuing the repair are summarized in Table 8 below. More detailed explanations follow.

Table 8 Behavioral and rational explanations for mispricing pipe repairs

The table summarizes the hypothesized explanations for why pipe repairs could be mispriced. The reasons are divided into two groups: behavioral and rational. Short descriptions are included in the second column and further explanations follow the table.

Behavioral explanations	Description
Availability and vividness	Pipe repairs are rarely directly observable and therefore easy to be left unnoticed. On the contrary, vivid experiences could also lead to overemphasizing their importance in decision making
Anchoring and reference prices	Sellers of dwellings to-be-repaired set their bid prices to levels of similar dwellings that need no renovation
Focusing effect	Buyers focus on few dwelling attributes and may underweight the importance of pipe repairs
Disposition effect, loss-aversion and mental accounting	Sellers are loss averse and have reserve prices that may not be low enough to account for full pipe repair costs
Winner's curse	Because of incomplete information and differing buyer expertise the winning bid may fail to take repair costs into account
Irrationally high future discount rates	People discount future pipe repair costs at overly high discount rates, which lowers the present value of the costs excessively

Rational explanations	Description
Informational asymmetries	Sellers has informational advantage and may play down the proximity and the costs of repair
Economic repair costs	Costs stemming from repair related discomfort and possible extra lodging costs or cost of lost rent
Chance to refurbish to one's taste	Buyers may value the possibility to have the bathroom renewed according to their own taste

Availability and vividness

Availability is a cognitive heuristic in which the decision maker uses knowledge that is readily available rather than examines all other alternatives or procedures. People assess the frequency of a class or the probability of an event by how easily these instances or occurrences can be brought to mind (Tversky and Kahneman 1974). Availability can stem from several sources: ease of recall based on vividness and recency, retrievability based on memory structures, and presumed associations (Bazerman 2006). In the pipe repair context, the vividness of the repair is likely to matter. One cannot often notice corroded pipes with naked eye while, for instance, the bad condition of the kitchen is more available. Pipe repairs are not very vivid as such as information on them is usually presented in the house manager's certificate. On the other hand, as there has been a lot of public discussion about pipe repairs in Finland, vivid and recent examples of repair project costs and other horrors could come to people's minds easily (whether personal or heard). The impact can be reinforced by the focusing effect, the human tendency to put too much importance on few attributes. If pipe repairs are readily available, people can start to overemphasize its monetary and economic costs, which leads to pipe repair overpricing. On the other hand, if repairs are not easily available, pipe repair underpricing and apartment overpricing takes place. In the light of the results of this study, it seems that the latter case reflects the reality better.

Anchoring and reference prices

Anchoring means that when making decisions, people tend to overly rely on information on values given as starting points i.e. anchors. Once the anchor is set, people adjust their estimates based on additional information but the final outcome still remains biased towards the initial anchor. Anchoring is one of the first biases discovered by Tversky and Kahneman (1974) and it's been recognized to apply in multiple circumstances thereafter. Reference prices in the housing market have been studied by Simonsohn and Loewenstein (2006) who find that people moving from more expensive cities rent pricier apartments than those arriving from cheaper cities. They also conclude that when dweller stayed in the new city for some time, they adjusted their reference prices to prevailing levels. Also Einiö et al. (2008) show that many dwellings are sold exactly at the same price they were originally purchased. The purchase price appears to act as an anchor.

Prices of other goods are commonly used as anchors for pricing similar goods. We call these prices reference prices. I hypothesize that prices of houses of about same size in the same area are used as reference prices when valuing houses. This is all rational as long as reference prices reflect all major price components. On the other hand, if these reference prices generally reflect prices of houses with no upcoming repair, reference prices may lead to housing overpricing before the repair.

Focusing effect

The focusing effect depicts the human tendency to put too much importance on a few attributes. When making judgments, we tend to weight attributes and factors unevenly, putting more importance on some aspects and less on others. The focusing effect was first identified by

Schkade and Kahneman (1998). They asked people to estimate who would be happier, Californians or Midwesterners. Those living outside California over-weighted climate-related aspects and assumed Californians to live happier because of the more favorable climate. The impact of higher crime rate and threat of earthquakes in California were given little focus. In reality, there was no difference between the happiness of Californians and Midwesterners. Depending on which attributes people focus on when valuing dwellings, pipe repairs can be either over or under considered. If pipe repairs and their costs are largely ignored, the focusing effect leads to underpricing.

Disposition effect, loss-aversion and mental accounting

The reason behind the disposition effect is that investors are predisposed to holding losers too long and selling winners too early. This phenomenon has been found to apply to investors in stock market (e.g. Shefrin and Statman 1985) as well as homeowners in housing markets (Einiö et al. 2008), among others. The prospect theory by Tversky and Kahneman (1979) suggests that loss-averse agents may consider the original purchase price as a reference point in their value function. Therefore they are unwilling to realize any loss i.e. to sell the dwelling for less than the original purchase price. Lastly, sellers may indulge in mental accounting and they want to break even (Shefrin and Statman 1985). Genesove and Mayer (2001) demonstrate that sellers are averse to realize nominal losses. In the Finnish context, Einiö, Kaustia and Puttonen (2008) find loss realization aversion in the greater Helsinki area. They also find that the number of sales occurring exactly at the original purchase price of the apartment is disproportionally high.

The reluctance to realize losses could also lead to pipe repair underpricing. This should especially apply to dwellings that have been bought quite recently. Imagine that a person purchased a fifty square meter apartment five years ago. Back then, renovating pipes was not discussed but now when the owner decides to sell the apartment, it has been decided that the plumbing system will be repaired one year from now, at an expected cost of 700 euros per square meter. Other things being equal, is the owner willing to lower the selling price by the total amount of repair costs i.e. 35,000 euros? Discounting all pipe repair costs can lead to nominal losses especially when the holding period is short or housing price appreciation has been moderate or negative.

Winner's curse

The winner's curse is a phenomenon that occurs in auctions with incomplete information. The winning bid often exceeds the intrinsic value of the item purchased. Bidders find it difficult to determine the intrinsic value because of incomplete information, emotions or any other factors regarding the item being auctioned. Hence, the buyer candidates who overestimates the value of the good most ends up winning the auction. Ashenfelter and Genesove (1992) study condominium prices and compare the prices paid in face-to-face bargaining with the prices of condominiums sold at auctions. They find that auction prices for identical units were 13 percent higher and that face-to-face buyers received larger discounts than early bidders in auctions. The Finnish selling process falls somewhere between auction and face-to-face. Buyers typically submit undisclosed bids and the seller can make counteroffers if wanted. If there are several buyers, the winner's curse might well realize but when only one buyer is involved at a time, the negotiation turns into face-to-face.

Theoretically, if each of the many buyers possessed the very same and truthful information on pipe repair process and costs, no over- or underestimation of costs should take place. However, people evaluate the costs differently and some people might be willing to bid high because of emotional or other reasons. Also, if one of the bidders is not sophisticated enough about pipe repair costs and totally or partially ignores them, he's likely to bid higher and win, which leads to repair underpricing.

Irrationally high future discount rates

Empirical evidence shows that people tend to use extremely high discount rates regarding the future costs and benefits. For instance, a university in the United States initiated a huge project to improve its infrastructure but the administrators failed to choose the building materials that would be most cost-efficient in log-term when pursuing low immediate project costs (Bazerman 2006). Loewenstein (1988) suggests that very high discount rates occur partially because of the common human bias towards increasing consumption. People want to consume more now even though it would cause harm in future. In the repair context this would mean that buyers want to consume dwelling immediately and they discount future pipe repair costs at irrationally high discount rates.

Informational asymmetries

Informational asymmetries exist in the housing markets because buyers and sellers do not possess identical information on dwellings. Because of informational problems the seller and the buyer value housing attributes differently. (See e.g. Laakso 1997.) As Gyourko and Saiz (2004) exemplify it: "The quality of an expensive investment in some system such as plumbing may be known precisely by the present homeowner, but not by prospective buyers." When it comes to pipe repairs, the seller has the obligation to mention the forthcoming repair if any decisions have been made. For instance, the Supreme Court of Finland imposed a 30,000 euro fine to SKV because one of SKV’s real estate agents hadn’t presented the buyer the findings of an earlier investigation of the pipe system’s condition (the Supreme Court 2009). In any case, the owner is likely to be familiar with the condition of the pipes and to have a view on when the repair will be done even before any official decisions through unofficial discussion with the real-estate agents and other shareholders and dwellers.

Other explanations

There are also some other economic costs and benefits related to pipe repairs. On the cost side: dwellers suffer from discomfort during the repair. In this study, the additional living costs have been accounted for but each individual's economic cost may vary from those. On the benefit side, renovating the bathroom and often the kitchen provides the dweller a relatively low-cost chance to renovate those rooms according to his or her taste. A potential buyer of a to-be-repaired dwelling might be willing to pay a premium for this chance.

To conclude, the reasons presented in this section could cause or alternatively reduce pipe repair underpricing. I'm looking forward to reading studies that would measure the price effect of the suggested reasons and perhaps add further explanations.

8 CONCLUSIONS

A dwelling is likely to be the most valuable investment in an individual's investment portfolio. Thus valuing housing correctly is essential from wealth perspective. This thesis studies the effect of pipe repairs on dwelling prices before and after renovation. To my knowledge, I am the first to quantify the price impact and to determine whether the repair costs are properly taken into account before the repair. The research questions of the thesis are: How do pipe repairs affect housing prices? How does the price effect change in time? In addition, I study how the length of the repair interval and the price of the apartment affect pricing.

Discovering how the market values pipe repairs is intriguing as the knowledge should benefit the market by reducing price uncertainty and by shortening selling times through more accurate pricing. Despite the everyday importance, quantifying pipe repair impact on prices is a practically unexplored field among both the academics and the practitioners. In addition, few maintenance and depreciation related studies make use of actual or estimated repair costs. My contribution to the existing knowledge is that I am the first one to provide reliable results on the price effect. I study if the housing market acts rationally in valuing future repair costs. Finally, I aim to provide further insight into housing related behavioral biases that could explain repair mispricing discovered.

The data includes apartment transactions from Helsinki and Espoo between Jan 2000 – Jun 2010. Four different data sources are combined for the analysis. Transaction data and data on characteristics of individual apartments (2000-2010) were obtained from Hintaseurantapalvelu, a database used by most Finnish real estate agents. Specific data on pipe repairs including scope and costs was gathered from three Finnish real estate management firms. In addition, Oikotie and Kiinteistömaailma databases were employed for gathering more repair and housing company related information. The total combined sample consists of 179,255 observations. Observations with insufficient data and observations not belonging to either treatment or control group were left out and so the final number of observations used for most regressions is 34,358 of which 8,781 belong to the treatment and 25,577 to the control group.

The results show that the market pays excessively for dwellings before the repair. In other words: the pipe repairs are generally underpriced as the market fails to take future repair costs fully into account ending up paying disproportionately much for a dwelling. According to the results, the apartment prices start to depreciate approximately six years before the repair (prices nearly three percent less than in the comparison group). One year before the repair the market discounts the apartments by nine percent. This, however, is not enough. The evidence shows that when the discounted estimated costs of the future repair are considered, the market pays eleven percent extra while the premium paid after the repair is only some 2–3 percent. In practice, this means that buying an apartment one year before and selling it right after the repair would lead to losses worth nine percent of the debt-free selling price. For an apartment that costs 200,000 euros, the average loss would equal 18,000 euros. When studying the apartments for which we know the exact real repair costs, the repair underpricing is even more prominent: Apartments are approximately 16 percent more expensive one year prior to the repair than prices of otherwise similar apartments. Finally, the apartment overpricing detected in this thesis accounts for the costs of the repair that are common to all shareholders of the housing company and the costs of lost rent. It is, however, quite common that the owners also decide to do some extra renovation at their own costs e.g. they renew the kitchen. As these costs are not included in calculations, the repair underpricing effect should be even larger in reality.

The discovered repair underpricing induces to study the phenomena more in depth. There are two additional factors I studied that should theoretically affect the amount of pipe repair underpricing: the first one is the length of the repair interval and the second one is the price of the apartment. The hypothesis behind the repair interval is that apartment overpricing should reduce as the repair interval increases. If the market uses the average durability of the pipes in estimating the repair timing and the value of the costs at the time of the transaction, repair underpricing should be larger for apartments for which the repair is done sooner than expected and smaller for apartment for which the repair is overdue. The results in Section 6.2.4 indicate that this indeed is the case. Although not all coefficient are statistically significant, the later the repair, the less overpriced the apartments are in general. For instance, seven years before the repair, the apartments with the shortest repair interval were 24 percent overpriced and apartments with medium repair interval were 13 percent overpriced.

The second interesting aspect is the price of the apartment and its effect on repair mispricing. Section 6.2.5 shows that the apartment overpricing reduces as the apartment price increases. The rationale for this derives from the fact that as the pipe repair costs are basically independent from apartment prices, the relative repair costs are significantly larger for inexpensive apartments. Therefore, when the repair mispricing is estimated as a share of the total debt-free price, this share should naturally be lower for more expensive apartments. Although one cannot draw conclusions on the level of overpricing based on the results, the conclusion is that the more inexpensive the apartment, the larger the expected overpricing. It could also be argued that the buyers of the cheaper apartments should be more price-sensitive, which would reduce overpricing but the price-sensitivity doesn't seem to play a big role. Alternatively, one could argue that the buyers of pricier apartments are probably more sophisticated when it comes to financial decision-making.

As discussed in Section 7, there are several behavioral and some rational reasons that could lead to pipe repair underpricing. The behavioral phenomena that are suggested to contribute to repair underpricing include loss-aversion, anchoring, focusing effect and extremely high discount rates effect. Information on pipe repairs is often not readily available i.e. they are hard to notice. Other sources of cost underestimation include the winner's curse and informational asymmetries – information may even be concealed. There's strong theoretical and empirical support in financial research for these theories and I am convinced that they contribute to the repair underpricing phenomenon - to which extent remains a subject for further studies.

The practical implications of the results differ depending on one's role and position. The owners who wish to sell their dwelling with a coming pipe repair would be on average better off by selling their apartment before the repair, rather than after. Also, the sellers have incentives not to present all information and rumors on the coming pipe repair should the buyers claim more discount, the more information is available. The sellers may even wish to postpone the repair in order to be able to sell their dwelling before.

Those who wish to buy an apartment should be highly careful when considering buying a dwelling with a pipe repair coming as the market, on average, pays excessively before the repair. For instance, the overpricing was quantified to be 13 percent in the group with estimated costs and 18 percent in the group with real repair costs three years before the renovation. The premium the market pays afterwards is only 2–3 percent. Thus the buyers are wise to calculate the present value of repair costs when considering such a transaction and to negotiate the price down respectively. Real estate agents can benefit from the results of this study by understanding the repair's price effect better and taking it into account when setting bid prices and negotiating with transaction parties.

As this is, to my knowledge, the first study on the pipe repair effect on housing prices, several questions for future research remain. As the focus of this study was on identifying and measuring the repair impact, the most interesting follow-up questions are related to explaining what causes repair underpricing. Some potential explanations were touched upon in Section 7 and testing them and identifying further explanations would increase the understanding of the important behavioral factors that prevail in the housing market. In addition, one could experiment with data from other areas of Finland or international data and expand to studying other repair types as well. Another interesting topic for further studies would be to study how different repair techniques affect pricing.

The characteristics of transaction parties and their effect on repair valuation would also be a fascinating topic if the data is available. Thaler and Sunstein (2009) argue that people improve their decisions when they have experienced similar situations earlier and have received feedback on their previous choices. In the housing market context: the more frequently people value, buy and sell dwellings, the more accurate their price estimates should be – including the price effect of a pipe repair. Thus, it would be interesting to know how the experience of sellers and buyers affects the goodness of decisions. Additionally, it would be interesting to know if investors who own dwellings for purely monetary reasons value apartments differently than homebuyers.

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APPENDIX

Table 9 Comparison between all apartment and apartments in good condition

The table presents the regression results on mispricing of apartments before and after pipe repair. There are two regressions – the first one is done with all observations in treatment and control groups, the second one with only apartments in good condition. The first figure is the coefficient and the figure in parentheses is the t-statistic. Respectively, ***, ** and * denote statistical significance at 1%, 5% and 10% levels. The dependent variable is the natural logarithm of the debt-free price plus the discounted value of repair costs and costs of lost rent per square meter. The ten-year Finnish government bond rate is used as a discount rate.

	Ln(price/m² discounted with 10-yr bond)	
Variable	All conditions included	Only apartments in "good" condition
Time to repair: 10 years	0.161***	0.039
	(4.31)	(0.49)
Time to repair: 9 years	0.173***	0.143***
	(9.09)	(3.81)
Time to repair: 8 years	0.185***	0.173***
	(13.93)	(6.92)
Time to repair: 7 years	0.196***	0.170***
	(17.16)	(8.23)
Time to repair: 6 years	0.175***	0.180***
	(17.00)	(11.15)
Time to repair: 5 years	0.157***	0.162***
	(17.82)	(1200)
Time to repair: 4 years	0.149***	0.144***
	(19.8)	(12.83)
Time to repair: 3 years	0.134***	0.126***
	(20.39)	(12.9)
Time to repair: 2 years	0.125***	0.120***
	(21.3)	(13.44)
Time to repair: 1 year	0.111***	0.109***
	(19.71)	(12.79)
Repair on-going	0.132***	0.128***
	(25.44)	(16.47)
Last year of repair	0.178***	0.181***
	(33.89)	(23.97)
Time from repair: 1 year	0.022***	0.030***
	(4.03)	(3.93)
Time from repair: 2 years	0.025***	0.028***
	(4.24)	(3.66)
Time from repair: 3 years	0.027***	0.027***
	(4.30)	(3.16)
Time from repair: 4 years	0.021***	0.024***
	(3.10)	(2.72)
Time from repair: 5 years	0.011	0.027***
	(1.52)	(2.78)
Time from repair: 6 years	0.024***	0.028**
	(2.96)	(2.51)
Time from repair: 7 years	0.020**	0.009
	(2.07)	(0.63)
Time from repair: 8 years	0.012	-0.012
	(0.93)	(-0.69)
Time from repair: 9 years	0.044***	0.036*
	(2.92)	(1.88)
Time from repair: 10 years	0.004	-0.023
	(0.17)	(-0.71)
Time from last repair plan	Controlled	Controlled
Time fom last repair study	Controlled	Controlled

Table 9 Comparison between all apartment and apartments in good condition - continued

	Ln(price/m² discounted with 10-yr bond)	
Variable	All conditions included	Only apartments in "good" condition
Constant	8.821***	8.734***
	(361.09)	(169.02)
Ln(Apartment size)	-0.17***	-0.134***
	(-43.43)	(-25.71)
Number of rooms	0.010***	0.000
	(6.50)	(-0.12)
Debt share of debt free price	0.024***	0.01
	(3.54)	(1.34)
Has elevator	0.005**	0.001
	(2.52)	(0.56)
Condition: new	0.034***	0.04***
	(8.95)	(9.37)
Condition: bad	-0.11***	
	(-22.76)	
Condition: good	0.030***	
	(13.01)	
Condition: satisfying	-0.033***	
	(-12.38)	
Top floor	0.029***	0.036***
	(15.51)	(15.62)
Bottom floor	-0.027***	-0.03***
	(-14.28)	(-12.6)
Rented lot	-0.122***	-0.148***
	(-42.71)	(-42.69)
Transaction month and year	Yes	Yes
Construction year	Yes	Yes
Zipcode	Yes	Yes
Adjusted R-squared	0,848	0,842
Number of observations	32 676	20 925

Table 9 above and Figure 24 on the next page illustrate the difference between two regressions: the first one is done with all observations in the treatment and control groups and the second one is done with apartments in good conditions only. The comparison shows that the two groups do not significantly differ from each other. Therefore, I conclude that the underpricing effect is not significantly affected by the potential improvement in a dwelling's condition.

Figure 24 Comparison between all apartment and apartments in good condition

The figure shows the regression results on mispricing of apartments before and after pipe repair. Only statistically significant coefficients are included in the graph. The dependent variable is the natural logarithm of the debt-free price plus the discounted value of repair costs and costs of lost rent per square meter. There are two regressions – the first one is done with all observations in treatment and control groups, the second one with only apartments in good condition. The ten-year Finnish government bond rate is used as a discount rate.