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METRO INVESTMENT AND THE HOUSING MARKET ANTICIPATION EFFECT

Oskari Harjunen*

Abstract

In this paper, I estimate a series of hedonic housing price models to analyze if residential housing markets anticipate a new metro line in the Helsinki Metropolitan Area. I use the decision to build the West Metro as a quasi-experimental setting that creates variation in expected metro station accessibility in time and analyse if housing prices react to the announcement before the new metro line becomes operational. I solve the geographic extent, timing and average magnitude of the anticipation effect. Possible endogenous geography of the new metro stations is resolved by using high quality housing market data with difference-in-differences estimation methods. I find that housing markets start adjusting to the information about the infrastructure investment swiftly after the construction begins, years before the line becomes operational. Apartments within 800 meters from the new metro stations, where the accessibility will be increased the most, include a positive price premium that converges around four percent even five years before the metro becomes operational.

Keywords: Externalities, Market anticipation, difference-in-differences
JEL codes: R41, D61, D62

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1. INTRODUCTION

This paper investigates how the housing markets reacted to the announcement of a new metro line in the Helsinki Metropolitan Area (HMA) in Finland. The new West Metro became operational in November 2017, connecting neighbourhoods in southern Espoo and southwest Helsinki to the central business district (CBD) of the HMA and the existing east bound Helsinki Metro providing fast and reliable rail service. I use the announcement of this infrastructure investment as a quasi-experimental setting to analyse if housing prices react to the future accessibility improvement before the West Metro becomes operational. I use difference-in-differences (DID) estimation with high quality housing market data to identify the geographic extent, timing and magnitude of the capitalization before the metro becomes operational.

I find that housing markets anticipate the forthcoming metro line well before the constructions are finished. The positive price premium for apartments sold within 800 meters from the new metro stations, where the accessibility will be improved the most, is around four percent. Housing prices further away from the new metro stations are not affected by the West Metro. The estimated housing market anticipation takes into account the total net effects of the infrastructure investment and the effect can't be separated to different components. Total net effects include the expected accessibility improvement, expectations about the urban development that improved accessibility allows and other changes that the new metro line will bring to the area. Back of the envelope calculations suggest that the value of the existing housing stock within 800 meters is increased by almost 300 million euros due to this infrastructure investment. However, the increased value of the pre-existing housing stock is just one component of the total gains created by the West Metro and can't be used alone to evaluate the cost-effectiveness of the project.

The most obvious impact of transportation infrastructure investments are the direct accessibility improvements on the local level. Proximity to new transportation nodes provides opportunities for faster commuting to the CBD as well as other neighbourhoods in the targeted areas. Residents in these areas gain a direct saving on travel times to work, pleasure activities as well as services and there is potential for economic effects from improved accessibility, which should be capitalized in the value of land and houses.

However, infrastructure investments also have many indirect local effects that may affect housing demand in the targeted areas, potentially capitalizing into land- and housing prices. First, especially large infrastructure investments are followed by urban development that densifies urban structure by bringing more residents and services to the area which has a positive effect on its desirability (e.g. Baum-Snow 2007; Kahn 2007; Baum-Snow et. al. 2012). Second, large number of people transiting through transportation hubs may inflict both positive and negative effects on the residents of the targeted areas (e.g. Bowes and Ihlanfeld 2001; Ahlfedt and Maennig 2015; Phillips and Sandler 2015). For example transiting people may attract more services into an area promoting further its desirability. On the other hand, the attractiveness of an area might be worsened if the vast number of transiting people leads to problems with congestion, local unease or even increased criminal activity near the transportation nodes.

The direct local effects on transportation users are taken into consideration in the standard cost-benefit analysis of transportation investments in Finland. Guidelines drafted by the Finnish Transport Agency (Liikennevirasto 2010) state that all transport investments should be assessed by their direct effects on transportation users and producers, public finance, traffic safety and the environment. The direct user costs are calculated very roughly using the estimates of people affected, their time savings from improved accessibility and commuting time opportunity costs. However, the indirect local effects are usually not taken into account due to missing guidelines on the assessment of these effects[1]. This might lead to serious miscalculations concerning the real local effects, especially in the case of major infrastructure investments that shape the local urban structure and spatial distribution of property development near the effected transportation nodes. Therefore, having a profound understanding on the local net effects is needed for the policymakers to make efficient and well informed choices between different infrastructure projects.

There are multiple urban and transport economics studies estimating the effects of transportation service investments on the local level using housing and land prices. These studies are diverse in methodology as well as focus and the variation in results is substantial with positive, negative and statistically insignificant results. Although the functional forms and estimation methods vary a lot between the studies, the use of hedonic housing price theory is very common in the literature. [2]

The first type of studies looking at the capitalization of transportation investments use the spatial variation in transport access when the transportation system is operational to assess the capitalization effect (e.g. Baum-Snow and Kahn 2000; Bowes & Ihlanfeldt 2001). However, using only a cross sectional variation in transport access can be problematic for the causal interpretation of the results. The most severe problem is the possibility that the geographical distribution of transit stations is not random and therefore there might be some unobserved factors, even with a rich set of control variable used in the estimation, that are correlated with transportation hub proximity, biasing the estimation results.

Recent studies are looking to overcome the endogenous geography of transportation hubs by looking at the effects on housing prices before and after a transportation investment (e.g. Gibbons & Machin 2005; Agostini and Palmucci 2008; Billings 2011; Ahlfeldt et. al. 2016; Chin et. al. 2016). An empirical strategy which uses the variation in accessibility in time may avoid the endogeneity issues of cross section analysis and grant more plausible identification of capitalization. A new transportation system offers an exogenous change in the accessibility of peoples' homes that can be used to estimate the causal effect of the infrastructure investment on housing and land prices. Housing and land prices reveal the total net effect of the infrastructure investment including the accessibility improvement, urban development following the accessibility improvement, local disamenities and other changes that the infrastructure investment has on the targeted areas.

In general, most of the studies conclude that infrastructure investments, especially large scale investments in heavy rail traffic, have a positive effect on housing and land prices near the new transportation nodes (e.g. Deprezion et. al. 2007). More specifically areas around public transportation hubs within walking distance often seem to be particularly valuable (Gibbons & Machin 2005; Baum-Snow & Kahn 2007). However, the quantity and the total geographic extent of the effect varies a lot between different studies. In their meta-analysis looking at the impact of railway stations to residential and commercial property values, Deprezion et. al. (2007) conclude that that different features in the study settings concern-

1 It is acknowledged in the guidelines that there might be some "wider economic impacts" that are not taken into account by looking at the direct effects of transport investments and therefore these effects should be analyzed. However, it is also stated that these effects should not be taken into account when evaluating the cost effectiveness of a transportation investment due to missing guidelines on this kind of analysis.

2 For extensive reviews of the different studies and results see e.g. Deprezion et. al. (2007), Mohammad et. al. (2013) and Higgins & Kanaroglou (2016).

ing the type of property, type of railway station, type of model used to deprive valuation, presence of variables related to accessibility, demographic features and the time of data could explain the differences in the results. They conclude that on average the price effect on residential properties within 400 meters (1/4 miles) from the new transportation hubs is around 4.2 percent.

In addition to the variation concerning the magnitude and geographic extent of the capitalization, also the timing of the capitalization is dealt with differently in different studies. According to the urban economics theory, infrastructure improvements should capitalize in land value after the announcement of the improvement. There might be some market imperfections and incomplete information that could hinder the capitalization of forthcoming accessibility improvement, but in many cases it is reasonable to assume there are anticipation effects before the transportation investment becomes operational. Despite this theoretical prediction, there are many studies in which the anticipation effects are reported to be missing (e.g. Gibbons & Machin 2005; Ahlfeldt et. al. 2016; Chin et. al. 2016). There are only few papers providing empirical evidence on the anticipation effects related to public infrastructure improvements (e.g.; McDonald and Osuji 1995; Agostini and Palmucci 2008; Billings 2011). However, it is important to incorporate the anticipation effects in to the analysis when they are present and failing to do so may lead to severe underestimation of the capitalization.

The housing market capitalization caused by the Helsinki Metro has been analysed already in the 90's. E.g. Laakso (1992) and Laakso (1997) conclude that the Helsinki Metro increased the value of housing stock within one kilometer from the new stations by one to five and zero to six percent respectively, depending on the distance. Neither of the studies finds evidence on the housing market anticipation. Results of these studies also suggest that there was a negative price effect further away from the metro stations, in the feeder transport areas.

There are already some studies trying to identify the housing market anticipation effect of the West Metro. Kajova (2015) used asking price data from a property listing service from 2002 to 2014 with DID estimation to evaluate the anticipation effect. The treatment group in this study consists of areas near the new metro stations and control group of those beyond the treatment area with a maximum limit[3]. This study concludes that housing prices were positively affected by the West Metro after the constructions had started. The estimated increase in the asking prices for the apartments within one kilometer from the metro stations was around nine to ten percent. However, the results of this study can't be used to identify the actual price effect as the data only includes the asking price but not the final sale price.

Another study by Hiironen et. al. (2015) provide approximate estimations for the geographic extent and magnitude of the housing market capitalisation caused by the West Metro. They also estimate the total impact for existing housing stock around one metro station, Matinkylä. They conclude that the average anticipation price effect within 0 to 400 meters was 15 percent and within 0 to 800 meters 11 percent leading to a total impact of 122 million euros within 400 meters and 193 million euros within 800 meters from Matinkylä metro station. However, these results can't be interpreted as the causal effect as they only have one year of housing sales data from 2013 and they do not observe the actual price changes that the West Metro creates. In addition they base their perception of the geographic extent of the capitalization effect on a literature survey rather than actual data.

3 Reliability of results is tested using alternative control group near the Helsinki metro stations.

2. INSTITUTIONAL SETTING

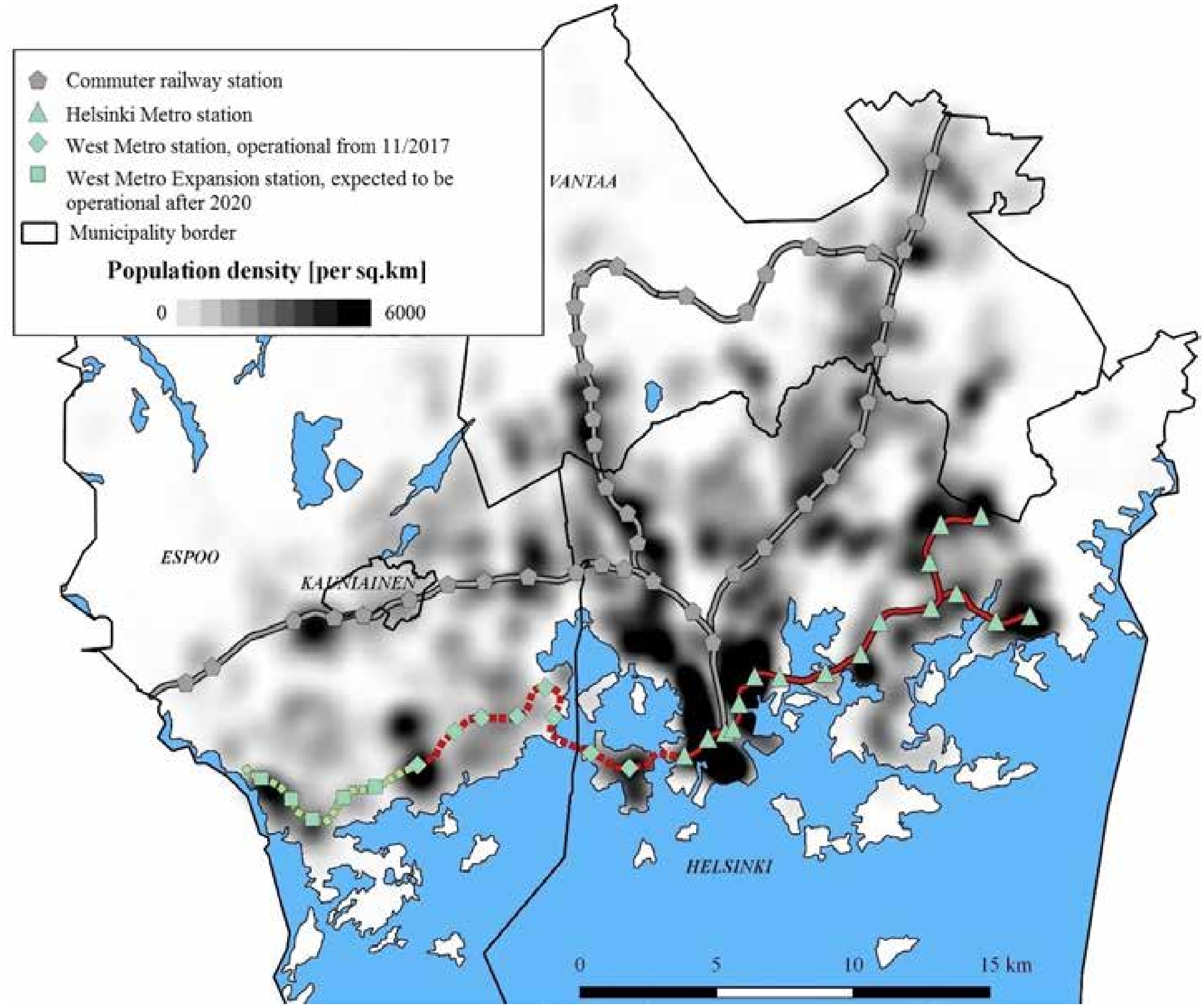
The public transportation system in the HMA consists of bus, tram, metro, local railway, city-bike and ferry services. These transportation modes are managed by a federation of municipalities, the Helsinki Region Transport (HSL). A major part of the public transportation services, including the metro, tram, ferry and city-bikes are operated by the Helsinki City Transport (HKL), a public corporation owned by the city of Helsinki. The local commuter trains are operated by the state owned VR group and the bus lines by private public transportation operators.

Passenger traffic of the Helsinki Metro started in June 1982 (Helsinki became the most northern city in the world with a metro). At first, the Helsinki Metro consisted of only one line operating on fewer stops but was expanded through the late 80's and early 90's. Today, the Helsinki Metro consists of 17 metro stations branching into two lines in the east at Itäkeskus[4].

Urbanisation development during the last years has led to fast population growth in HMA that is projected to continue in the future (Vuori & Laakso 2016). The rising demand for housing is well acknowledged amongst the public officials in the HMA and the municipalities' have a wide range of plans for infrastructure investments in the future that aim to link new residential areas and undeveloped land to the CBD (City Planning Department of Helsinki 2013). The most recent major infrastructure investment in HMA has been the construction of the West Metro and West Metro Expansion linking the southern parts of Espoo and southwest parts of Helsinki to the existing metro line, offering reliable and fast transportation service. A map with the local train lines, the earlier east bound Helsinki Metro, the West Metro and the West Metro Expansion (still under construction) are presented in Fig. 1, with population density.

4 A route map of the old Helsinki metro line is presented in fig. A2 in the Appendix III.

Fig. 1. Heavy public transportation in the HMA with population density in 2010



The decision to build the West Metro was not a totally unexpected exogenous shock to the housing market. Expanding the metro line further west to Espoo was a topic that was first discussed already in the planning stages of the Helsinki Metro in 1960's. In 2004 the possible metro line was on public display as part of the city planning process and the environmental impact assessment with different public transportation options to southern Espoo, also the current West Metro, was published in 2005 (YVA 2005). However, it was not until September 2008 that the construction of the West Metro was finally approved in the city councils of Espoo and Helsinki. The underground master plan of the West Metro was approved in January 2009. The official ceremony initiating the construction works took place 11th of November in Ruoholahti, but in large scale the constructions began after delays caused by the appeal process in 2010.[5]

The estimated completion date and projected construction costs of the West Metro were adjusted during the construction period. Before the tunnel works of the first stage of the West Metro began in 2009, the aim was that the metro would start operating in fall 2014

5 WWW-pages of the West Metro <https://www.lansimetro.fi/en/home/> 12.12.2017)

and the budget was 714 million euros (index corrected budget for 2016 was 849 million euros). However, this estimate of the opening was year later postponed to 2015 and later on to 2016. Finally, the opening date was announced to be 15th of august 2016. However, on 10th of June 2016 the council of the West Metro announced that the new metro line would not start operating as planned. Finally, the West Metro started operating in November 2017 with a total cost projection of 1 186 million euros. Both cities are responsible for construction costs borne within their own city limits and the final share of the costs is approximately 15 percent for Helsinki and 85 percent for Espoo.[6]

The West Metro has eight new metro stations – two in Helsinki and six in Espoo.[7] The new metro line will improve the accessibility of the targeted areas near the forthcoming metro stations. However, the West Metro is a part of a larger public transportation system renewal in Espoo and southwest Helsinki which may hinder the accessibility in some areas further away from the stations (e.g. YVA 2005; Strafica 2014). These parts of the HMA are linked to the CBD with a network of bus routes in the current system, and many areas are enjoying a direct bus connection to the city centre of Helsinki. In the new system with the West Metro operational, the old bus lines will be replaced by shorter and more frequent bus routes to the new metro stations. This means that people outside of walking distance from the new metro stops will have to use two forms of transportation in order to reach the CBD. It has been argued that replacing the old bus lines with the new system will actually worsen the connectivity of areas further away from the metro stations, which can harm the price development in these areas. If there are such effects, these should be taken into account when assessing the total effects of the new development in the targeted areas. [8]

Plans to expand the metro line even further into west from the West Metro started while the constructions of the first expansion of the metro was in progress. The preliminary general plan for the West Metro Expansion was published in 2011. The final project plan to add 6 metro stations and seven kilometers of metro line to the Helsinki and the West Metro was approved by the city council of Espoo in the summer of 2012. The constructions of the West Metro Expansion started in December 2014.

6 E.g. WWW-pages of the West Metro <https://www.lansimetro.fi/en/home/> 12.12.2017

7 A route map of the new metro line after the west metro becomes operational is presented in Fig. A3 in the Appendix III. The Niittykumpu station in Espoo was first reserved for future construction in 2008. However, already by 2011 it was expected that a metro station would also be built in Niittykumpu simultaneously with other stations.

8 e.g. Laakso (1997) concluded that the Helsinki Metro had a negative price effect in the areas that became feeder transport areas.

3. EMPIRICAL STRATEGY AND DATA

Empirical strategy

The starting point of the empirical analysis is that the value of an apartment is determined by its attributes. Location can be seen as one of the most important attributes determining e.g. the commuting times to work and city centre as well as availability of services. The geographical location of a house is fixed, but the relative accessibility can vary over time. A new metro line is a good example of this as it increases the accessibility of the targeted areas by decreasing the travel times of nearby residents to the CBD and other metro stations.

In this paper, I use the West Metro investment as a quasi-experimental setting with hedonic DID estimation to capture the causal effect that the West Metro has on the housing prices in targeted areas, following Gibbons & Machin (2005), Billings (2011), Zheng and Kahn (2013) and Chin et. al. (2017). More specifically I investigate the capitalization effects before the new metro line is operational by analysing how the markets anticipate this infrastructure investment after the project is publicly announced. I assess the geographical extent, timing and average rate of the anticipation effect. I use only areas near the first part of the West Metro because there are only two years of housing market observations after the building of the second stage of the West Metro began. There are also many uncertainties w.r.t. the projected completion of this project.

In the main capitalization models the price of an apartment i, in time t is expressed as follows:

$$Log(Price_{it}) = \alpha + \beta * treatment_i + \gamma * treatment_i * after_t + \partial \boldsymbol{X}_{it} + \mu_t + \varepsilon_{it} \quad (1)$$

, where the interaction between the treatment indicator ($treatment_i$) and after period indicator ($after_t$) reveals the average anticipation price effect. $\mathbf{X}_i$ is a vector that consists of a set of apartment characteristics, μ_t are the year fixed effects and ε_{it} are the error terms.

DID estimation requires a baseline for house price growth to be similar in the treatment areas near the forthcoming transportation hubs and the control areas before the announcement. However, housing price pre-trends might not be similar in the treatment area compared to all other neighbourhoods. The most common way of solving this problem is to select the control group near the treatment area (see e.g. Gibbons & Machin 2005 and Billings 2011)[9]. The basic idea behind this is that if the treatment and the control group are close enough to each other geographically, they probably face similar common price trends. However, at the same time the control area should be far enough so that the treatment does not have a direct effect on its housing prices.

In this paper, I use areas near the commuter train stations in Helsinki and Espoo (excluding the central city area) as a control group in the main estimations. Other control groups will be used in the robustness checks. The use of neighbourhoods further away from the

9 Some studies deal with this issue by using different kinds of matching methods to ensure the comparability between the price trends in the treatment and control groups. See e.g. Chin et. al. (2017).

metro stations as the control areas is in my case would be problematic for two reasons. First, the urban and socioeconomic structures are very different in the vicinity of the new metro stations compared to the areas further away and therefore the similarity of pre-treatment price trends might be questionable[10]. Second, areas further away from the metro stations might not be good control areas as the accessibility of these areas is also affected by the West Metro as the old bus lines are replaced by feeder traffic.

The final sample consists of apartments that are built before the announcement to make sure that I am comparing similar units before and after the announcement, since it is possible that the unobserved quality of apartments build after the announcement might be different from the existent housing stock if e.g. property developers react to anticipated accessibility improvement. The possible capitalization in housing prices can be seen as the capitalization on the land ingredient of the property. If consumers have rational expectations, the capitalization of the benefits should occur right after the construction of the West Metro is announced. However, there might be some uncertainties in the locations of the metro stations as well as in the probability that the project is cancelled during the construction period that might delay the market adjustment (e.g. McDonald and Osuji 1995). Therefore the actual timing of the capitalization is evaluated as part of the analysis.

The estimated housing market anticipation effect is the total net capitalization of the infrastructure investment and the effect can't be separated into different ingredients. The net effect consists of beliefs about the future accessibility improvement, urban development as well as other effects that the infrastructure investment has on the targeted area.

Data

The capitalization analysis is based on a housing market data comprising of sales in Helsinki and Espoo from 2003 to 2016. These data are collected by a consortium of Finnish real estate brokers and the dataset is refined and maintained by the Central Federation of Finnish Real Estate Agencies (KVKL). As not all real estate agencies participate, the dataset represents a sample (albeit rather large) of the total volume of transactions. The data include the transaction price and sale date for each dwelling as well as a rich set of dwelling characteristics including its exact location[11]. In this study, the sample is restricted to multi-story and row house apartment sales which are more homogenous in quality compared to single family houses. Observations with square price outside three standard deviations from the mean are dropped as outliers. Observations with missing housing characteristics are also dropped from the final sample.

The information about the important project dates as well as other information about the project were acquired from the West Metro webpage[12] and other public sources. The GIS data with the exact station and metro line locations was acquired from the City Environment Sector of Helsinki and the Helsinki Region Environmental Services Authority (HSY). Building level data that is used in the calculations of total the net effect of the West Metro comes from SeutuCD'16, which is compiled from HSY's Regional basic register.

10 See the Appendix I.

11 I have assigned every observation in these data to a nearest rail transport station (including the forthcoming West Metro stations) and calculated the Euclidean distances between these two.

12 <https://www.lansimetro.fi/en/home/> 25.10.2017

4. RESULTS

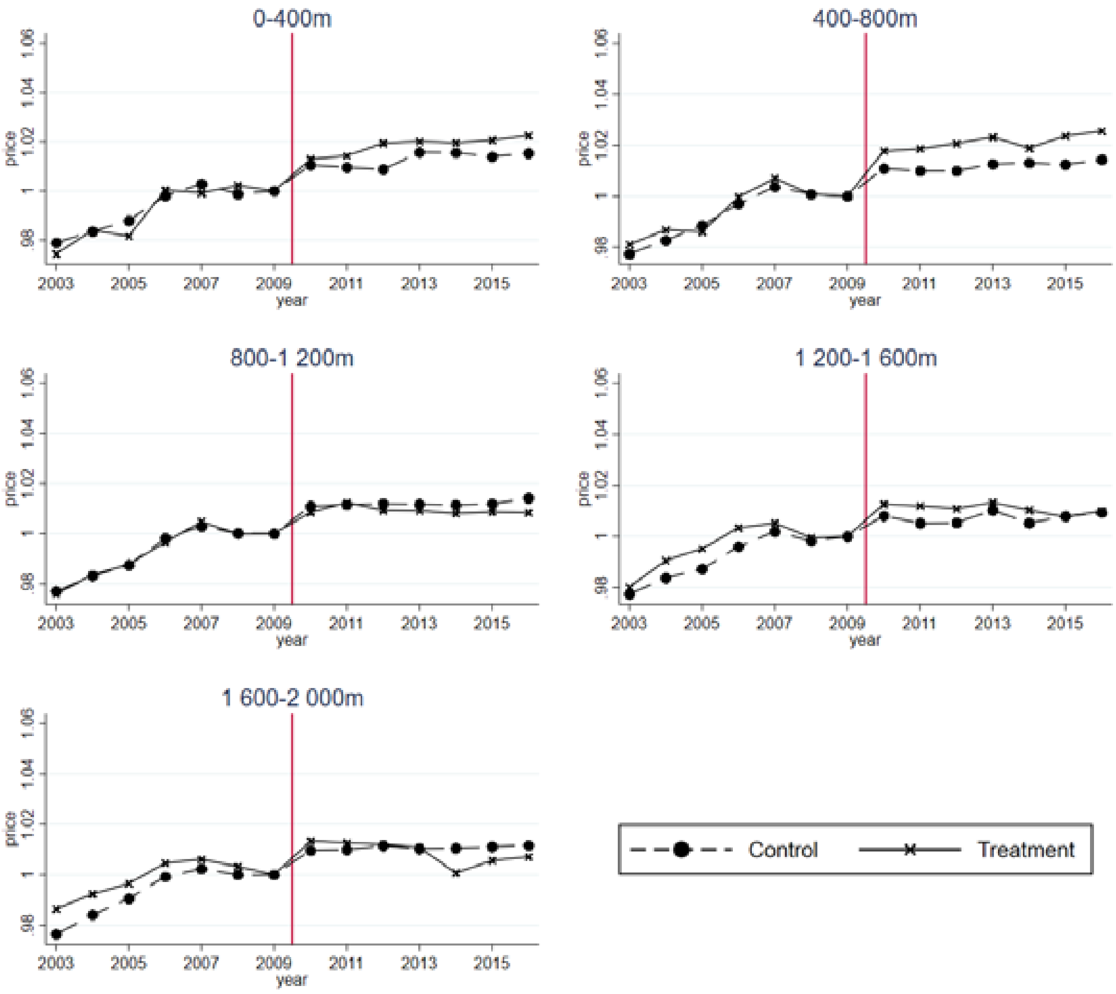
4.1. Housing market anticipation near the new metro stations

I begin the analysis by showing graphical evidence of yearly house prices within different distance bands near the new metro stations and control areas to assess the geographic extent of the anticipation effect. I will also use the graphical evidence to evaluate if the assumption of common pre-treatment trends between the treatment and control groups are fulfilled and the chosen DID setup can be used to estimate the causal anticipation effect caused by the West Metro. According to Fig. A4 in the Appendix III, there are only a few observations outside 2000 meters from the new metro stations and these are dropped from the analysis. Areas within 2 000 meters are divided into 400 meter distance intervals in this part of the analysis.

Fig. 2 illustrates how the yearly square prices in the treatment and control groups have evolved within different distance bands between 2003 and 2016. In this figure yearly prices are indexed (2009=1 in both groups) to help the comparison of the price trends[13]. The Vertical line between 2009 and 2010 illustrates the beginning of the constructions of the West Metro. According to Fig. 2, the pre-treatment trends in the treatment and control areas are somewhat similar within 1 200 meters from the new metro stations during the entire pre-treatment period prior the constructions begun in 2010. The assumption of similar pre-treatment price trends gets more unconvincing further away as the distance from the new metro stations increases. However, the price trends are still similar three years before the construction for the metro began, from 2007 to 2009, within 1 200 to 1 600 meters. Outside 1 600 meters, the yearly average prices in the treatment and control areas start to behave inconsistently and the similarity assumption is violated. This is probably due to the fact that the treatment areas further away are very different from each other and the assessment of average yearly prices might not be very informative. However, the small number of observations does not allow for looking at different areas separately. Formal tests presented in table A1 in the Appendix III support the findings of the graphical analysis indicating that the assumption of common pre-treatment trends is valid within 1 600 meters from the new metro stations, especially closer to 2010.

13 Yearly prices without indexing are presented in Fig. A5 in the Appendix III.

Fig. 2. Price trends in near the West Metro stations and commuter railway stations, index 2009=1



Based on the observed pre-treatment price trends, the selected DID specification seems plausible for solving the causal link between the West Metro and the housing market anticipation only within 1 600 meters from the new metro stations. I will focus only on these areas in the main analysis to pinpoint the capitalization effect near the new metro hubs. The possibility to estimate the causal effect of the West Metro within 1 600 to 2 000 meters using alternative model specifications is examined more closely as part of the robustness checks using alternative control groups in chapter 5.2.

Similarity of price trends during the pre-construction period and the divergence of prices within 0–400 and 400–800 meters from the forthcoming metro stations during the few years after the constructions began in 2010, as shown in Fig. 2, is a strong sign pointing out that the West Metro is anticipated in the housing market near the metro stations. Respectively, the anticipation effect within 800 to 1 200 meters and 1 200 to 1 600 meters seems to be near to zero as the price trends evolve somewhat similarly during the whole sample period from 2003 to 2016, indicating that the positive and negative effects of the West Metro could be in balance in these areas. A more careful inspection of the price trends reveals that the West Metro is not capitalized into housing prices instantly after its construction is approved in the city councils of Helsinki and Espoo in 2009, but the capitalization occurs during the first few years after the construction had started in 2010. The finding that the information about the new infrastructure investment is not capitalized instantly to housing prices after it is announced might be due to some uncertainties in the final location of the metro stations as well as informational asymmetries concerning the entire public transportation reformation after the metro becomes operational.

I continue the analysis by estimating DID models to formally confirm the graphical findings and pinpoint the average magnitude and timing of the capitalization. I use a ten year time window from 2007 to 2016 in the main estimations as the common pre-treatment price trends are more stable closer to 2010 when the constructions of the metro begun. The after period in the main DID setting begins from 2010. Table 1 presents the results of the DID estimations[14]. Regression results provide coefficients and standard errors for the treatment indicator and its interaction with the announcement indicator. Regressions include house characteristics listed in table A2 in the Appendix III as well as sale year fixed effects. Standard errors are clustered within small city district areas.

Table 1. Estimation results, average treatment effect during 2010 to 2016

Dependent variable: ln(sale price)						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Distance band	**0-400m**	**400-800m**	**800-1 200m**	**1 200-1 600m**	**0-800m**	**800-1 600m**
treated	**0.093*** **	**0.136*** **	**0.166*** **	**0.159*** **	**0.130*** **	**0.161*** **
	[0.026]	[0.023]	[0.026]	[0.032]	[0.022]	[0.024]
treated*after	**0.042*** **	**0.036*** **	**-0.010**	**0.014**	**0.040*** **	**-0.001**
	[0.011]	[0.013]	[0.015]	[0.018]	[0.011]	[0.014]
R-squared	0,87	0,88	0,89	0,90	0,88	0,89
N	7 759	14 749	9 500	6 196	22 508	15 696
# clusters	92	123	118	111	135	151

Notes: Estimated coefficient is statistically significant at *** 1% level, ** 5% level, * 10% level. Standard errors are clustered by small city districts. House characteristics include all reported in table A4 in the Appendix III (area and age also in second power)

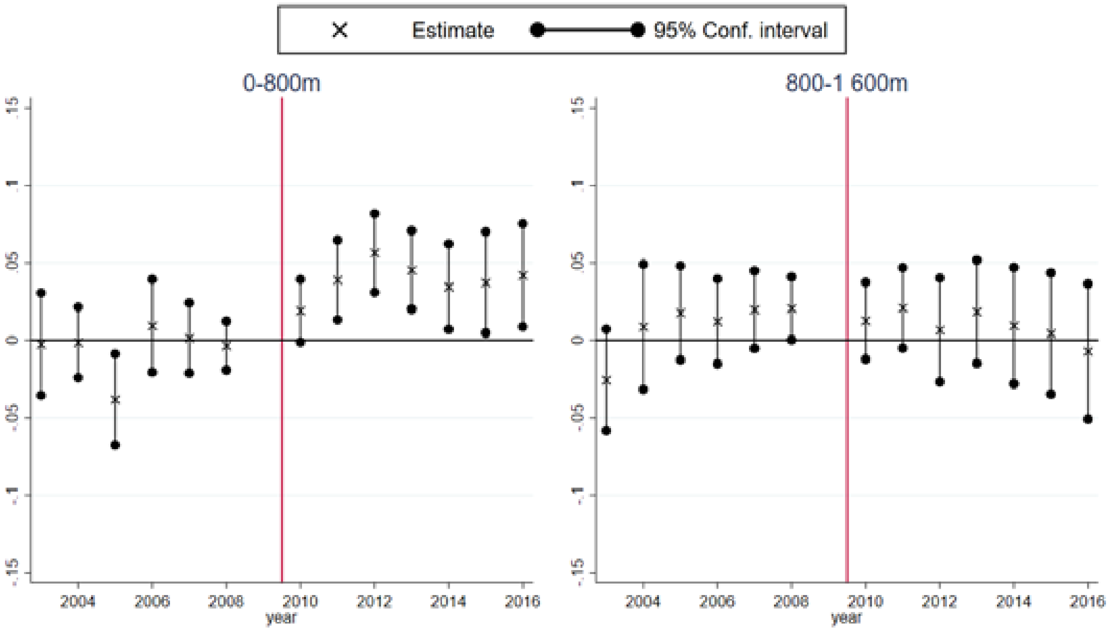
The estimation results confirm the graphical evidence indicating a positive price effect of four percent within 0 to 400 and 400 to 800 meters from the new metro stations, and no price effect further away. These results confirm the earlier findings that areas around the public transportation hubs, which are within walking distance seem to be particularly valuable after a transportation investment (Baum-Snow & Kahn 2007; Gibbons & Machin 2005). Estimation results in 400 meter distance groups within 0 to 800 meters and 800 to 1 600 meters are quantitatively similar (columns 1 and 2, columns 3 and 4), which allows the integration of these areas into two distance groups, within 0 to 800 meters from the metro stations with positive anticipation effect and within 800 to 1 600 meters with no anticipation price effect. The results of these preferred specifications are presented in columns 5 and 6. Fig. 3 presenting the estimates of yearly anticipation price effects confirm that the capitalization in the closest treatment group occurs swiftly, during the few years after the constructions for the West Metro had started in 2010, stabilizing around four percent[15]. Respectively, the yearly estimates within 800 to 1 600 meters from the new metro stations

14 Descriptive statics of the preferred specifications and the whole dataset are presented in table A2 in the Appendix III.

15 A time window from 2003 to 2016 is used in this estimation. This allows the evaluation of common pre-treatment trends for the whole pre-treatment period from 2003 to 2009.

remain very close to zero during the whole construction period. Fig. 3 also confirms that the assumption of pre-treatment common trends in the treatment and control areas holds for combined treatment areas within 0 to 800 meters and 800 to 1600 meters, especially closer to 2010 when the constructions for the West Metro begun.[16]

Fig. 3. Coefficients of yearly estimates, year 2009 omitted



The estimated housing market anticipation takes into account the total net effects of the infrastructure investment and can't be separated to different components. Total net effects include the expected accessibility improvement, expectations about the urban development that improved accessibility allows and other changes that the new metro line will bring to an area. However, positive capitalization near the metro stations where the accessibility will improve the most, and the absence of capitalization further away signals that the expected changes in accessibility are probably an important part of the capitalization.

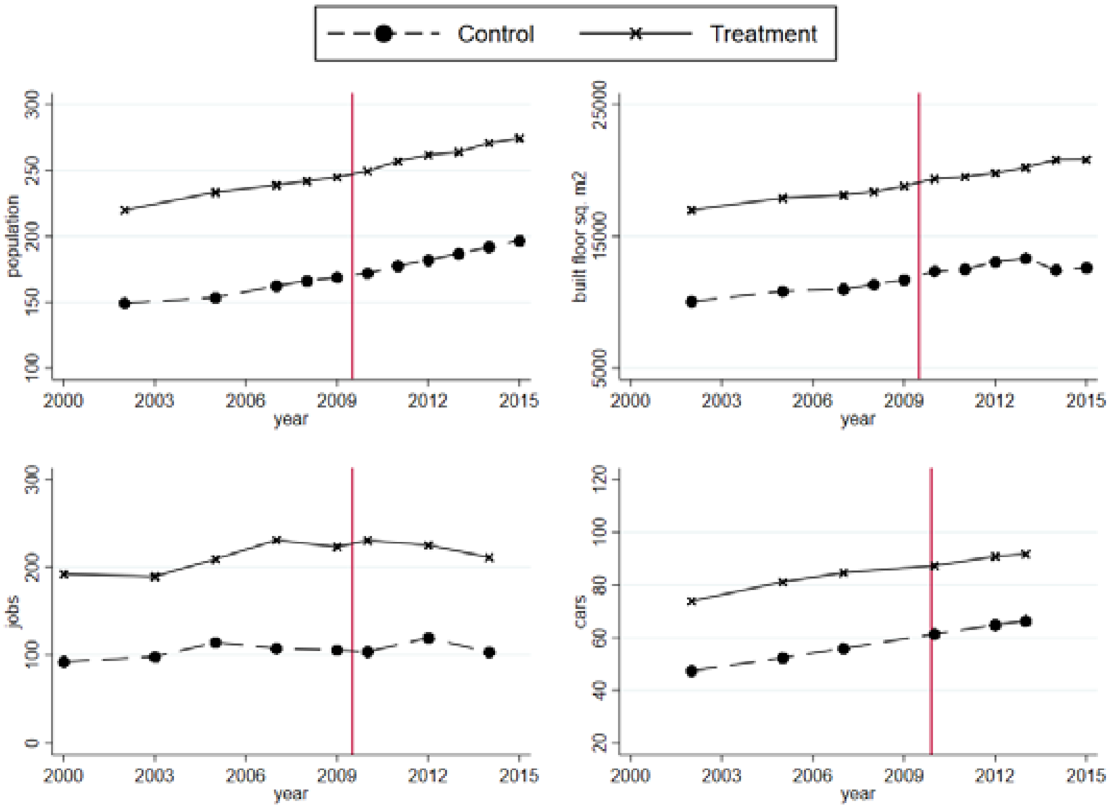
It is possible that the found effect is not totally due to expectations if parts of the urban development are completed before the metro becomes operational. I have evaluated if the construction of the metro has attracted urban development that is completed during the construction period of the metro by using population, built floor area and number of jobs as proxies for local development and using these as dependent variables in a difference-in-differences setting comparing areas near the new metro stations to areas near railway stations in Helsinki and Espoo excluding the CBD. I have also used about car ownership to evaluate if there is a new sorting of residents in the affected areas and if people preferring public transportation are displacing private car owners as the opening of the metro approaches. These variables are calculated from the Community Structure Database (YKR). This geocoded database covers whole of Finland in 250m x 250 m grids. The grids are assigned to treatment and control groups if its center point is located within the 800 meter distance interval from the station.

Fig. 4 presents graphical evidence about the urban development within 800 meters from the new metro stations compared to the control areas. Availability of yearly observations vary between different variables in the YKR dataset, and I have used all available data of

16 Regression results are presented in table A3 in the Appendix III.

the selected variables from 2000 onwards. Y-axes in the figures illustrates the mean of the used variables within the 250 x 250 meter grids. According to these figures, it seems that the urban structures near the metro stations has evolved similarly compared to the control areas. Therefore, it seems that the estimated price premium is based on the beliefs about the future and the urban development comes later on. Similarly, there are no signs of sorting of residents with respect to car ownership near the forthcoming metro stations during the construction period.

Fig. 4. Trends in the population, built floor area, number of jobs and car ownership near the West Metro stations and commuter railway stations.



4.2. Alternative control group specifications

The control group used in the main estimations is chosen arbitrarily in a way that the control areas would resemble the treatment areas w.r.t. in urban structure and price development before the constructions of the metro begin, but are not directly affected by the West metro. Similarity of price trends was tested as part of the estimations but it is possible that the control group is affected by the infrastructure investment biasing the estimation results. One way to test for this is to use alternative control groups in the estimations and see if the results remain equivalent with the preferred specifications.

Table 2 presents estimation results with different control groups. First column presents the results of the preferred specification. Second column presents results from a model where the control group consist of areas near the commuter railway stations that are situated only in Espoo. These areas are probably least affected by the metro investment as the connectivity from these areas to neighborhoods near the new stations remains almost unchanged. This is because these areas are somewhat close to neighborhoods near the new metro stations and commuting between these areas happens before and after the completion of the West Metro by other means of transport than the new metro. Third column present results from models in which areas near the old metro stations (excluding the central city area of Helsinki) are used as the control group. Fourth column shows results from a DID model where the control areas are selected with nearest neighbor matching based on the urban structure indicators before the West Metro is announced in 2009[17].

Table 2. Estimation results with alternative control groups

Dependent variable: ln(sale price)				
	(1)	**(2)**	**(3)**	**(4)**
		Panel A, 0-800m		
treated	**0.130*** **	**0.019**	**0.098*** **	**0.087*** **
	[0.022]	[0.030]	[0.028]	[0.022]
treated*after	**0.040*** **	**0.055*** **	**0.060*** **	**0.051*** **
	[0.011]	[0.011]	[0.019]	[0.013]
R-squared	0,88	0,89	0,88	0,88
N	22 508	10 676	16 487	13 788
# clusters	135	80	95	126
		Panel B, 800-1 600m		
treated	**0.161*** **	**0.091*** **	**0.158*** **	**0.151*** **
	[0.024]	[0.033]	[0.033]	[0.022]
treated*after	**-0.001**	**0.028***	**0.016**	**-0.011**
	[0.014]	[0.017]	[0.015]	[0.015]
R-squared	0,89	0,92	0,90	0,91
N	15 691	7 905	9 748	6 969
# clusters	151	91	116	117

Notes: Estimated coefficient is statistically significant at *** 1% level, ** 5% level, * 10% level. Standard errors are clustered by small city districts. House characteristics include all reported in table A4 in the Appendix III (area and age also in second power)

Estimation results with alternative control groups are somewhat similar compared to the preferred specification indicating a clear but quite local housing market anticipation effect near the new metro stations.[18] The average capitalization varies between 4 and 6 percent within 800 meters from the new metro stations, although the differences are not statistically significant. However, the four percent anticipation effect in the preferred specification is conservative w.r.t. alternative control groups. Respectively, the estimates of most of the specifications are close to zero and statistically insignificant within 800 to 1 600 meters in all but one specifications. However, the second model using areas around commuter train

17 The matching procedure is explained in the Appendix II.

18 According to Fig. A6 and A7 in the Appendix III, treatment and control groups in all of the specifications seem to follow a common pre-treatment trend especially from 2006 onwards.

stations show a small but imprecise positive price effect. All in all the results seem robust w.r.t control group specification.

The DID specification where the control group includes areas within the same distance band from the commuter train stations does not allow to estimate the causal effect of the West Metro further than 1 600 meters away from the new metro stations due to missing common pre-treatment price trends between the treatment and control areas. Using distance circles to assign observations into treatment groups according to the treatment intensity is troublesome as the distance from the new metro stations increases. In this case, the areas within 1 600 to 2 000 meters from the new metro stations are somewhat remote with low population density. These areas are also very different from each other and therefore assigning them into the same distance group might be troublesome.

Possible solution for the problem issued could be to look for a more suitable control group with more similar pre-treatment price trend that could be used in the estimations. Fig. A8 in the Appendix III presents the yearly price trends for areas from 1 600 to 2 000 meters from the metro stations compared to the control areas as defined in table 2. According to these figures the similarity of pre-treatment trends is violated in all of the control group specifications and DID setting can't be used to estimate the causal anticipation effect. However, 90 percent of the housing sales observations, where the closest heavy public transportation hub is one of the West Metro stations, are located within 1 600 meters from the new stations. Therefore it can be stated that this study reveals the anticipation effects for the West Metro investment in totality quite well.

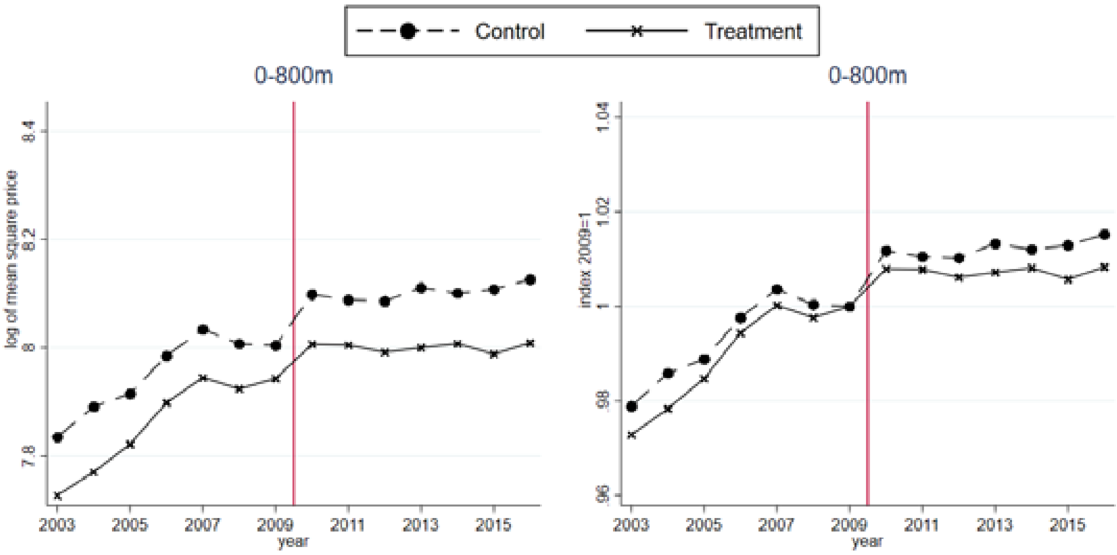
4.3. Spillover effects of the West Metro

The West Metro affects housing prices near the new metro stations and therefore it is possible that there is an opposite effect lowering housing prices in other parts of the metropolitan area. In this case the estimation would require the construction of a general equilibrium model of transportation and housing markets. However, the new West Metro has only eight new stations and the found geographical extent of the capitalization is very local. This means that the affected households are such a small proportion of the whole housing stock that the interpretation of the results can be based on the presumption of a partial equilibrium model, where only the effects in affected areas are considered (e.g. McDonald and Osuji 1995). Using a partial equilibrium model in the interpretation is commonly used in studies looking at infrastructure investments of this magnitude.

However, there are some other areas further away from the new metro stations that could be directly affected by the metro investment. Especially the residents near the east bound Helsinki metro line will be able to reach workplaces and services in southern Espoo much swifter as the West Metro becomes operational. This raises a question if the West Metro investment has increased housing prices near the old metro stations as well? I have evaluated this possibility by using a similar setting with the preferred specification near the east bound Helsinki Metro stations, excluding the central city area.

Fig. 5 presents the price trends within 800 meters from the Helsinki Metro stations and commuter railway stations. The Figure on the left is presenting the logarithm of mean square prices and the figure on the right a price index (2009=1 in both groups) to ease the comparison of price trends. The prices have evolved somewhat similarly in the treatment and control groups from 2003 to 2016 and there seems to be no positive price effect near the old metro stations that could be associated with the West Metro. Actually, estimation results in table A4 in the Appendix III point out that housing prices in the areas near the Helsinki metro in the east could be negatively affected by the metro investment as the coefficient for the capitalization is negative. However, the estimated effect is somewhat near zero and imprecise. Therefore it should be interpreted that the West Metro has not affected housing prices in these areas.

Fig. 5. Price trends within 800 meters from the Helsinki Metro stations and commuter railway stations



4.4. Rough estimate of the capitalization in total value of the old housing stock

In the previous chapters, I have solved how the housing markets have anticipated the forthcoming change in the transportation system brought by the West Metro during its' construction period. I have solved the geographical extent and the average magnitude of the causal effect of the West Metro using housing prices of the surrounding neighborhoods. These detailed information about the housing market capitalization allows me to do some back of the envelope calculations about the total net effect in the affected areas. I will use building level information about the total living area and population in the affected areas from SeutuCD'16 with the average square prices from 2016 to calculate the net effect that West metro has had on the current dwelling stock[19].

In 2016, there were almost 28 000 people living in a total of 1,7 million square meters of living area within 800 meters from the new metro stations. The average treatment effect in this area is around four percent which means that the West Metro has increased the average square prices by 160 euros leading to a total positive effect of almost 300 million euros for the whole housing stock. This total net benefit will increase after the urban development follows the infrastructure investment as increased demand will be responded

19 A building is handled as part of the treatment group if the geographical center is located within given threshold.

by new housing investments offering more housing especially to the areas nearest to the new metro stations[20].

This study is only looking at the price effects of residential properties. Naturally, the metro investment also affects the demand for commercial properties near the metro stations. In general, research results indicate that the range of the impact area around the transportation hubs is larger for residential properties but the magnitude of the effect is greater for commercial properties (e.g. Weisntein and Clower 1999; Cervero and Duncan 2001; Debrezion et. al. 2007). Even though this study can't asses the effects for commercial properties it is clear that there is a great potential for considerable net value appreciation as the commercial dwelling stock is even more concentrated near the forthcoming metro stations. For example, there were 114 office buildings with over 800 000 square meters of floor space in the positive treatment area in 2016.

20 One of the main goals behind the west metro investment is to densify the urban structure near the new transportation nodes. See e.g. https://www.lansimetro.fi/en/home/ and YVA (2005) (in Finnish only).

5. CONCLUSIONS

In this paper, I have evaluated how the housing markets have reacted to new information about a recent major infrastructure investment in HMA, the West Metro, on the local level. More specifically, I have solved how the housing markets have anticipated the forthcoming investment before the metro line was operational. I have used the announcement of the West Metro as a quasi-experimental setting that creates variation in expected metro station accessibility in time with unique datasets of metro station locations, dates of important project phases and geocoded information about the micro-level housing transaction data to assess the geographic extent, timing and average quantity of the anticipation effect, using difference-in-differences estimation.

My main finding is that the future infrastructure investment is anticipated near the new metro stations well before the project is completed – even five to six years before the metro became operational. The estimated anticipation effect includes the total net effects of the new metro investment without separating between the different ingredients – e.g. accessibility, congestion and urban development. On average, the prices of apartments within 800 meters from the new metro stations grew around four percent. Respectively, there was no anticipation effect in areas within 800 to 1 600 meters from the new metro stations. The used research design does not allow solving the causal link between the West Metro and housing prices in areas further away. However, 90 percent of the housing sales observations, where the closest heavy public transportation hub is one of the West Metro stations, are located within 1 600 meters from the new stations. Therefore it can be stated that this study reveals the anticipation effects for the West Metro investment in totality quite well.

This paper is only looking at the welfare effects w.r.t. residents living near the new metro stations and therefore the results can't be used to evaluate the cost-effectiveness of the metro project. A major transportation investment like the West Metro has many potential effects that may appear locally or on the whole HMA level affecting e.g. firms' productivity and the efficiency of labor and commodity markets. However, the local welfare effects are considerable by itself, as the population density is high (or will be after the urban development following the infrastructure investment) near the new metro stations. Back of the envelope calculations suggest that the total net effect for the value of the pre-existing housing stock alone is increased by almost 300 million euros by the infrastructure improvement.

The results of this study are useful for academic researchers as well as other practitioners in the urban field. Existence of anticipation effects in the case of the West Metro supports the urban economics theory stating that the future improvements capitalize before the projects are completed and failing to incorporate the anticipation effect to the capitalization analysis of the West Metro would lead to severe underestimation of the total effect. The presented information about the geographic extent, timing, and magnitude of the anticipation effect may be used in the planning of the urban development following the infrastructure investment. It might also be fruitful to compare these results to the direct savings that are taken into account in the traditional cost-benefit analysis and use these for the future profitability and cost-benefit analysis.

Natural continuum for this study is to investigate how the capitalization evolves after the new metro line becomes operational and the urban development has taken place. It will be interesting to see if the markets have anticipated the forthcoming change properly or if the estimates change after the development is actualized. Also, using detailed information about changes in urban structure as well as travel times may offer possibilities to look into the components of the capitalization more carefully in the future.

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Appendix I. Urban structure and socioeconomic status near the West Metro stations and commuter train stations in Helsinki and Espoo

Fig. A1. Neighbourhood characteristics in the vicinity of new metro stations and commuter railway stations

Fig. A1 provides information about the urban structure and the residents living near the new metro stations (treatment and control2) and trains stations in Helsinki and Espoo (control1) in four distance groups. The average neighbourhood characteristics in the vicinity of new metro stations (treatment) and commuter train stations (control1) are presented within 250 meters (1), between 250 meters and 500 meters (2), between 500 meters and 750 meters (3) and between 750 meters and 1 000 meters (4). Respectively the average neighbourhood characteristics further away from the metro stations (control2) are presented between 1 000 meters and 1 250 meters (1), between 1 250 meters and 1 500 meters (2), between 1 500 meters and 1 750 meters (3) and between 1 750 meters and 2 000 meters (4). Fig. A1 illustrates that the urban- and socioeconomic structures are very different close to the new metro stations and further away. Respectively, areas within same distance bands from the commuter railway stations are much more comparable and therefore it is reasonable to use these areas as control areas.

The information is calculated from Statistics Finland grid database 2010 that includes information on urban- and socioeconomic structures in 250 x 250 meter grids from 2008. A grid is taken to be part of a distance group if the centre point of the grid lies within a distance interval.

Appendix II. Matching procedure

The matched control group is constructed using urban structure indicators before the metro is announced in 2009 from Statistics Finlands' grid database 2010 that includes information on the urban- and socioeconomic structures in 250 x 250 meter grids from 2008. The match is executed in a way that all grids in the treatment areas with sale observations between 2003 and 2008 are matched with three grids located in Helsinki and Espoo that are situated more than three kilometers away from the new metro stations.

Matching is executed with a nearest neighbour algorithm. The matching is based on following covariates that are important housing price determinants: CBD distance, travel time to CBD using public transportation, number of sales, mean area of flats, number of residents, mean income, share of homeowners, share of multi-storey buildings and number of jobs.

Appendix III. Additional tables and figures

Table A1. Test for pre-treatment common trends

Dependent variable: ln(sale price)					
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Time window			**2003 to 2009**		
Distance from station	**0-400m**	**400-800m**	**800-1 200m**	**1 200-1 600m**	**1 600-2 000m**
treated	**0.101*** **	**0.138*** **	**0.139*** **	**0.150*** **	**0.049**
	[0.026]	[0.028]	[0.032]	[0.033]	[0.036]
treated*2003	**-0.002**	**-0.007**	**-0.046***	**-0.007**	**0.060*** **
	[0.015]	[0.024]	[0.025]	[0.021]	[0.027]
treated*2004	**0.007**	**-0.007**	**0.011**	**-0.020**	**0.054*** **
	[0.016]	[0.019]	[0.022]	[0.024]	[0.026]
treated*2005	**-0.058*** **	**-0.022**	**-0.004**	**0.034***	**0.050*** **
	[0.015]	[0.020]	[0.018]	[0.025]	[0.025]
treated*2006	**0.016**	**0.004**	**-0.002**	**0.017**	**0.024**
	[0.018]	[0.012]	[0.016]	[0.023]	[0.023]
treated*2007	**0.005**	**0.002**	**0.016**	**0.013**	**0.047*** **
	[0.015]	[0.017]	[0.017]	[0.016]	[0.022]
treated*2008	**-0.004**	**0.003**	**0.019**	**0.012**	**0.032***
	[0.017]	[0.009]	[0.018]	[0.016]	[0.018]
treated*2009 (omitted)					
R-squared	0,89	0,90	0,91	0,92	0,91
N	15 896	10 378	6 705	4 359	3 353
# clusters	131	117	111	104	79

Notes: Estimated coefficient is statistically significant at *** 1% level, ** 5% level, * 10% level. Standard errors are clustered by small city districts. House characteristics include all reported in table A4 in the Appendix III (area and age also in second power)

Table A2. Descriptive statistics of the housing sales data

Sample	Whole data (Helsinki and Espoo)	0 to 800m		800 to 1 600m	
Status		**Treated**	**Control**	**Treated**	**Control**
N	**43 025**	**6 868**	**15 640**	**4 429**	**11 267**
Sale price	223 668	252 024	196 154	311 661	199 122
	[110 007]	[119 458]	[78 980]	[156 343]	[82 107]
Square price	3 506	4 181	3 325	3 877	3 242
	[918]	[951]	[805]	[919]	[805]
Area	66	62	61	82	64
	[29]	[27]	[25]	[38]	[27]
Age	37	43	32	32	39
	[17]	[17]	[17]	[13]	[18]
Maint. Charge (€/m2)	3,5	3,8	3,5	3,5	3,5
	[1.2]	[1.1]	[1.2]	[1.2]	[1.3]
Floor number	2,4	2,7	2,5	2,3	2,3
	[1.6]	[1.7]	[1.5]	[1.5]	[1.4]
Floors in building	3,8	4,4	3,8	3,6	3,4
	[3.0]	[2.2]	[2.1]	[2.3]	[1.9]
Dist. to nearest station (m)	869	482	484	1 168	1 134
	[489]	[190]	[185]	[239]	[239]
Dist to CBD (km)	12	9	13	11,2	12,5
	[4.6]	[3.6]	[4.8]	[3.2]	[4.6]
Multi story building	81 %	94 %	87 %	66 %	77 %
Condition					
-Unknown	6 %	7 %	5 %	8 %	5 %
-Poor	4 %	5 %	3 %	2 %	4 %
-Decent	36 %	31 %	38 %	28 %	37 %
-Good	55 %	57 %	54 %	61 %	54 %
-Excellent	0 %	0 %	0 %	0 %	0 %
Apartment with sauna	33 %	17 %	33 %	51 %	33 %
Apartment with balcony	42 %	42 %	46 %	37 %	42 %

All prices are deflated to 2016 using consumer price index. Observations with square prices outside three std. dev. from the mean area are dropped from the data as outliers.

Table A3. Estimation results – yearly price effects (2009 omitted)

Dependent variable: ln(sale price)				
Distance from station	**0-800m**		**800-1 600m**	
	coef.	**std. err.**	**coef.**	**std. err.**
treated	**0.125*****	0,023	**0.143*****	0,026
treated*2003	**-0,002**	0,017	**-0.025**	0,017
treated*2004	**-0,001**	0,012	**0.009**	0,020
treated*2005	**-0.038****	0,015	**0.018**	0,015
treated*2006	**0.009**	0,015	**0.012**	0,014
treated*2007	**0.001**	0,011	**0.020**	0,013
treated*2008	**-0.003**	0,008	**0.021**	0,010
treated*2009 (omitted)				
treated*2010	**0.019***	0,010	**0.013**	0,013
treated*2011	**0.039*****	0,013	**0.021**	0,013
treated*2012	**0.056*****	0,013	**0.006**	0,017
treated*2013	**0.045*****	0,013	**0.018**	0,017
treated*2014	**0.035****	0,014	**0.009**	0,019
treated*2015	**0.037****	0,017	**0.004**	0,020
treated*2016	**0.042*****	0,017	**0.007**	0,022
R-squared	0,89		0,90	
N	31298		21 874	
# clusters	136		155	

Notes: Estimated coefficient is statistically significant at *** 1% level, ** 5% level, * 10% level. Standard errors are clustered by small city districts. House characteristics include all reported in table A4 in the Appendix III (area and age also in second power)

Table A4. Estimation results for anticipation effect near the east bound Helsinki metro stations

Dependent variable: ln(sale price)	
Distance from station	**0-800m**
treated	**-0.028**
	[0.021]
treated*after	**-0.026**
	[0.018]
R-squared	0,85
N	25 259
# clusters	113

Notes: Estimated coefficient is statistically significant at *** 1% level, ** 5% level, * 10% level. Standard errors are clustered by small city districts. House characteristics include all reported in table A4 in the Appendix III (area and age also in second power)

Fig. A2. A route map of the metro in Helsinki in 2016 (© HSL 2016)

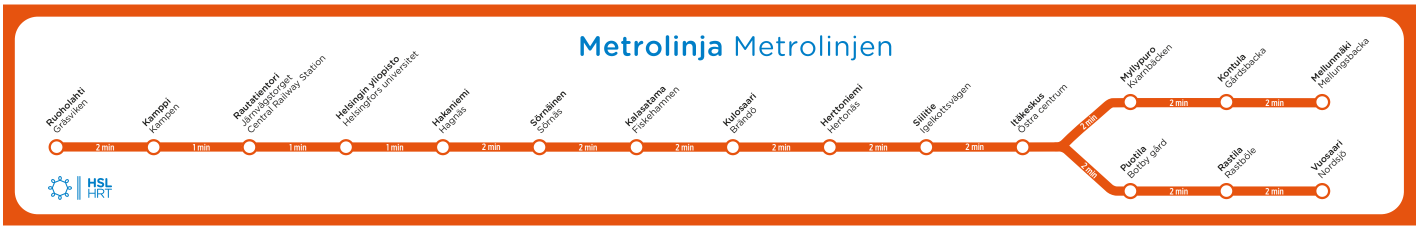


Fig. A3. A route map of the metro in Helsinki and Espoo after west metro is operational in 2017 (© HSL)

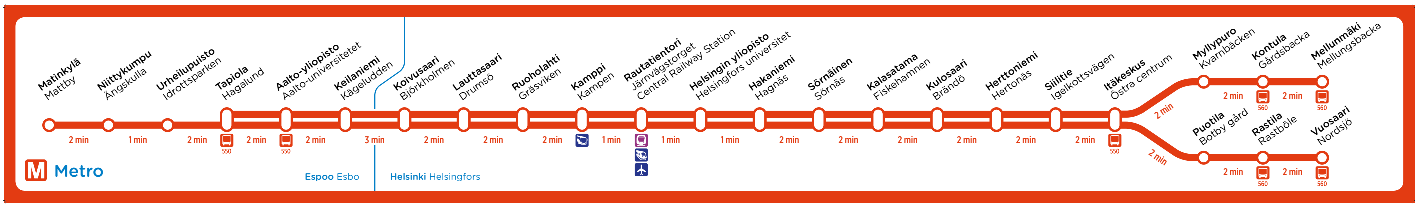


Fig. A4. Histogram of housing sales observations w.r.t distance to a new metro station

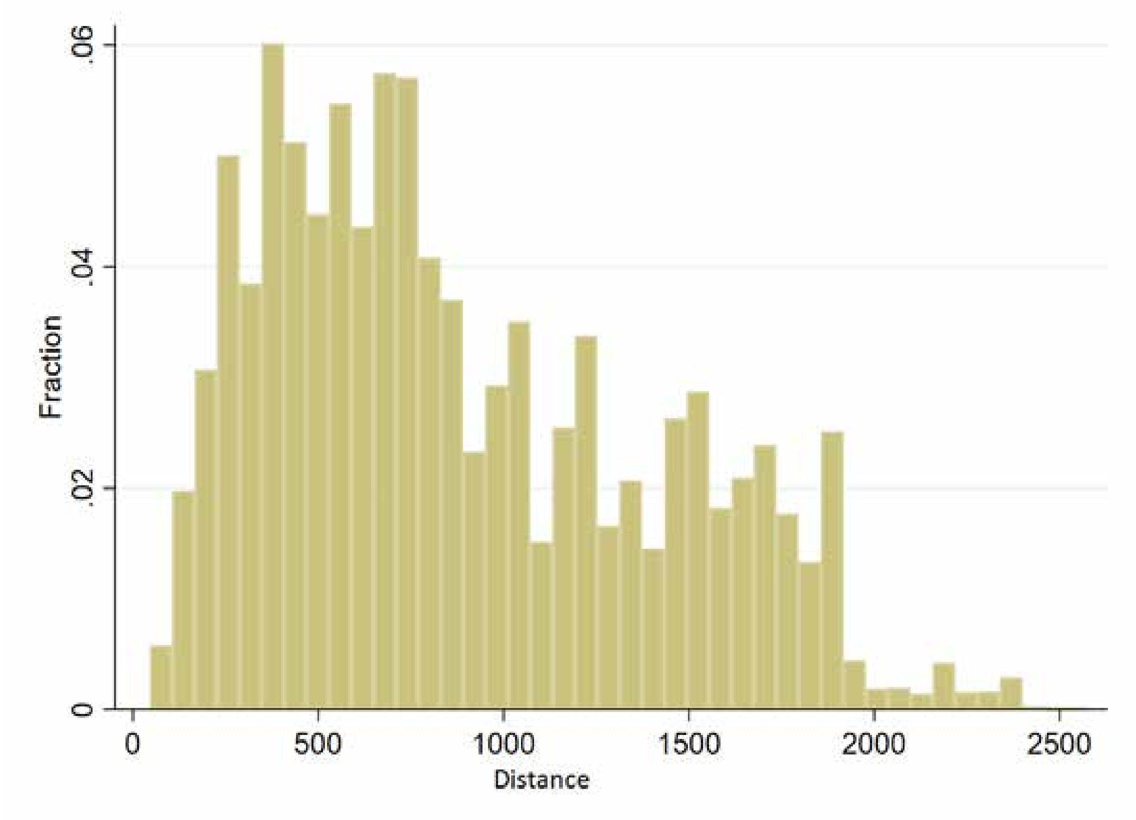


Fig. A5. Price trends w.r.t 400 meter distance intervals

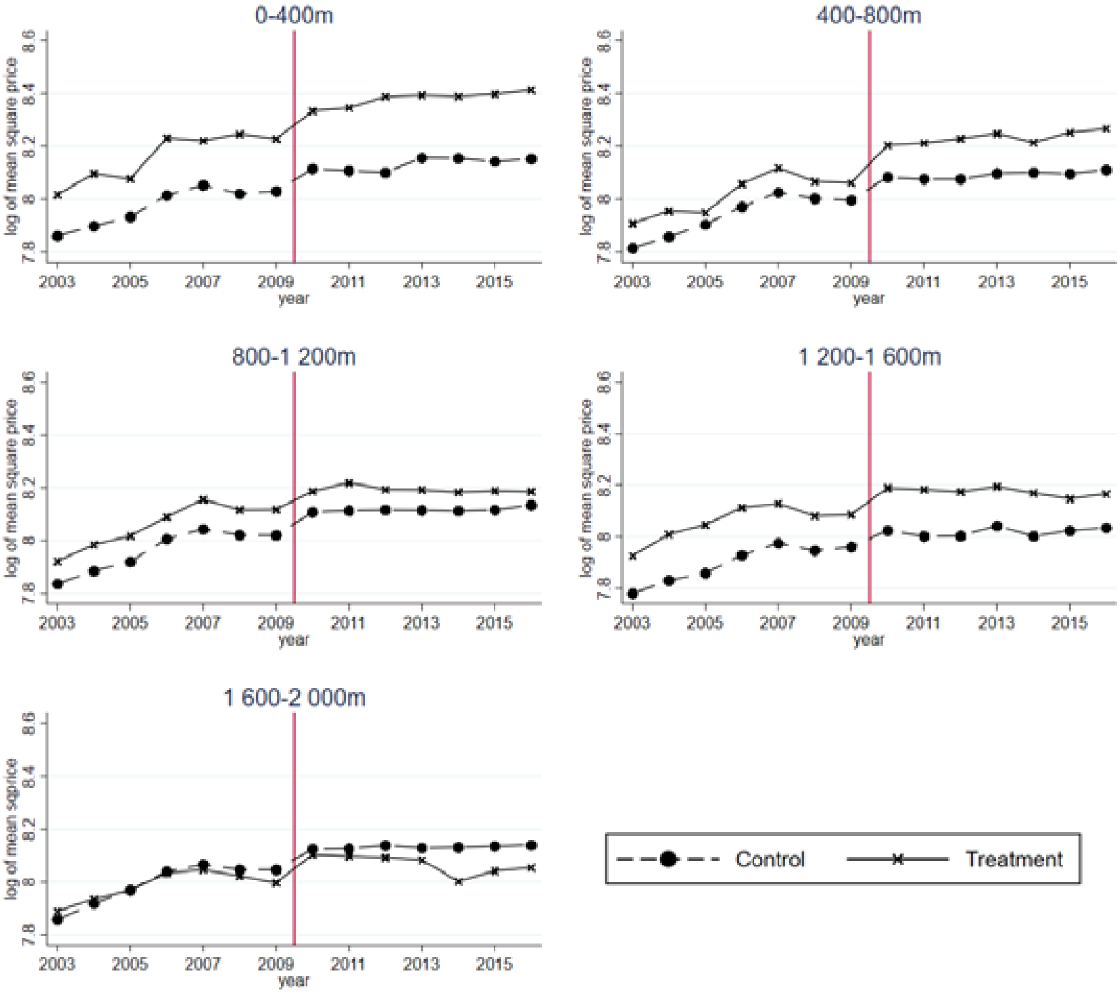


Fig. A6. Pre-treatment trends, table 2, panel A

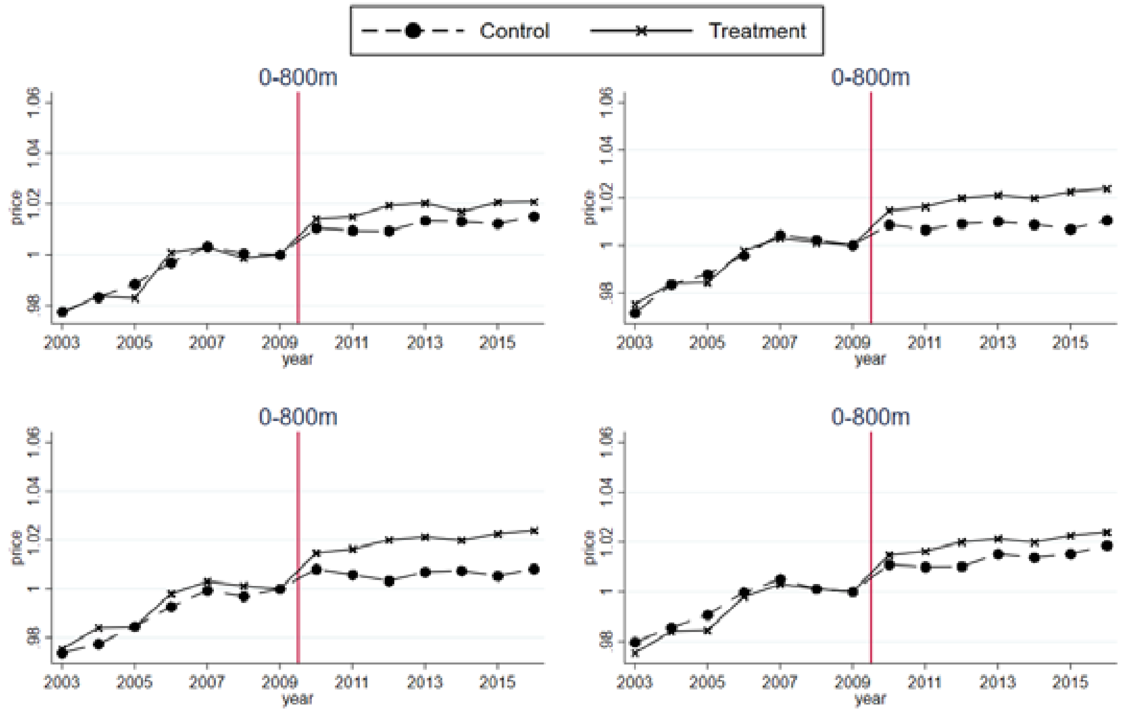


Fig. A7. Pre-treatment trends, table 2, panel B

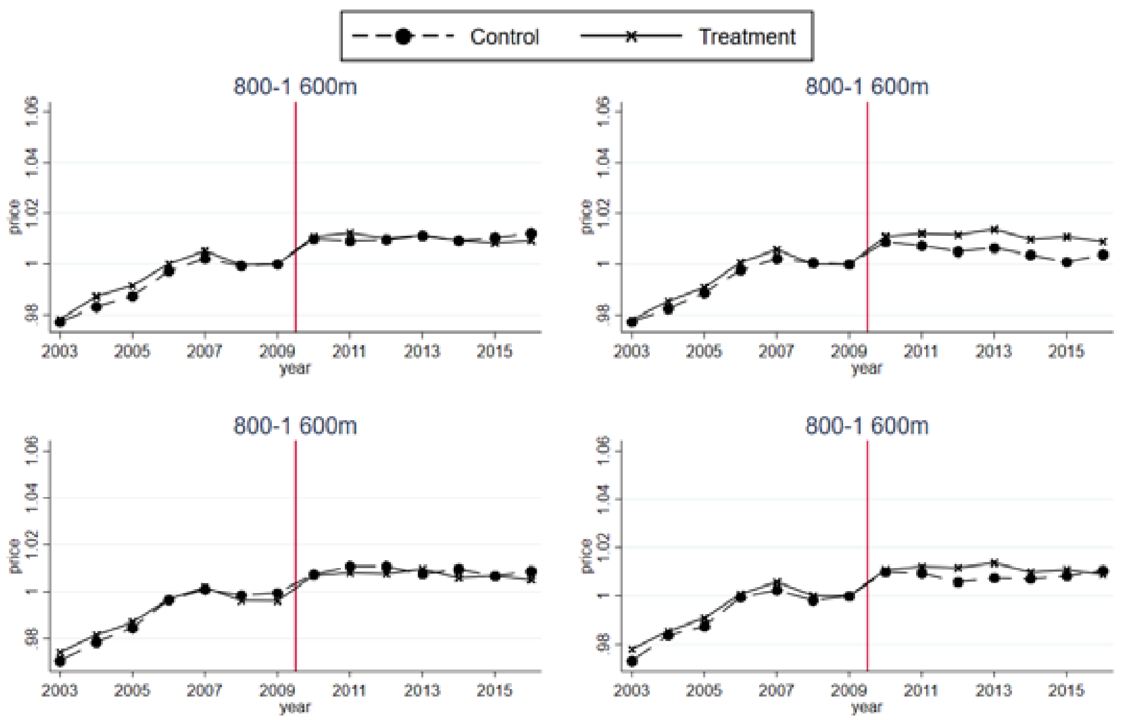
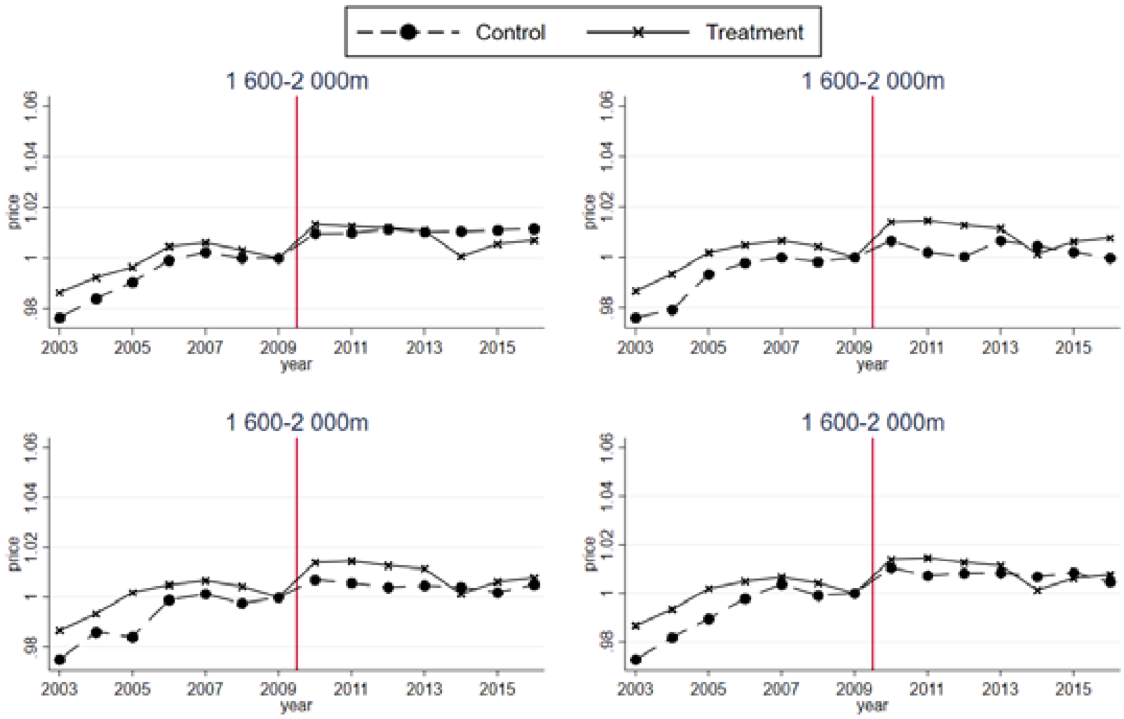


Fig. A8. Pre-treatment trends within 1600-2000 meters with alternative control group specifications



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