The effect of six vehicle-free pilot areas on nearby housing prices in Oslo

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Abstract

On the way to a vehicle-free city center, the municipality of Oslo launched six pilot areas in June of 2017. More than 760 public on-street parking spots were removed in and around these pilot areas. The parking spots got replaced by outdoor furniture, street art as well as with other initiatives aimed at stimulating a more sociable city environment deprived of private passenger vehicles. This thesis studies the impact of these six pilot areas on the surrounding real estate prices. Using a difference-in-difference hedonic price estimation approach, this thesis compares the house price development of apartments located close to the pilots with those located further away. Statistical evidence was found signifying that the launch of the pilot areas increased home values located within a radius of 750 meter to the pilots by around 1.77%.

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1. Introduction

1.1 Motivation

In the past decades, housing prices in the Oslo market have been on the rise both in nominal as well as in real terms[1]. In the last decade alone, the average for used dwellings increased more than double that of other consumer goods (SSB, 2020). A common tool used to measure the housing affordability in Norway is the so called "nurse index"[2.] The index illustrates an increase in the housing affordability in the country over the past 10 years, however Oslo is the exception to the rule. In 2010, around 20% of the dwellings sold in Oslo were obtainable for a single person with an average income. This share was reduced to about 2.5% in 2019 (Eiendomsverdi, 2020). Consequently, low-income groups struggle to enter the housing market in Oslo. The issue of housing affordability is a concern for politicians and government officials (Norges Bank, 2005; Norges Bank, 2005; Finansdepartementet, 2011; Departementene, 2018). Historically speaking, Norway has had a high share of inhabitants owning their own homes. In 2019, more than 70% of all Norwegians owned their own dwelling (Rejeringen, 2020). Among the high-income groups, the figure is above 80% and has been stable over the past decade. On the other hand, amongst low-income households, the share declined from 39% to 29% in the same period (Rejeringen, 2020). The quality of housing is considerably lower in the rental market, and the majority of renters are experiencing high costs of living (Rejeringen, 2020). An increase of housing prices in real terms shifts the economic surplus between property owners and renters, increasing the gap in the income distribution (Eiendomsverdi, 2020). Moreover, when it homes becomes unaffordable for people to live within a reasonable commuting time to their workplace, they encounter a large personal cost in the form of time spent traveling to and from work. This personal cost translates to loss in overall productivity for the economy as a whole and could contribute to a loss in personal well-being (Eiendomsverdi, 2020; Novaco & Gonzalez, 2009) Thus, it is in the public interest to ensure that homes remain affordable for all groups of society, even within the main cities.

After the 2015 municipal election, a newly elected city council proposed a radical shift in Oslo's city planning that gained a lot of attention in the popular press. The area inside ring-road 1, an area of 1,3 square kilometer, was projected as a future vehicle-free zone. The Trade Association of Oslo argued the new policy would hamper businesses located inside the newly proposed zone by physically hindering customer access (NRK, 2015). In addition, the federation of real estate agents claimed that as a

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[1] See Appendix 1.

[2] Sykepleierindeksen (The nurse index) is a tool developed by Eiendom Norge/Eiendomsverdi that is used to analyze the affordability of the Norwegian housing market. The index looks at the share of the housing market a single nurse could afford. The nursing proficiency is used as the foundation of the index because it is a close representation of a typical income in Norway.

consequence of a fast roll-out of the proposed vehicle-free policies, people would move closer to their workplace, intensifying the competition on urban housing markets. Hence, as a result of changes in people's location pattern, house prices in the city center would climb (NRK, 2015). Politicians ought to pay attention to asset price developments because it has both real economic and societal consequences. Moreover, the housing market is tightly connected to the rest of the economy and has in many cases a direct impact on the financial markets, henceforth the development in the housing market affects the developments in the real economy (Bezemer, 2014).

1.2 Scientific Relevance

Six pilot projects were launched in the summer of 2017 in the inner-city center of Oslo. These pilots are part of a larger policy change aimed at reducing the vehicle traffic in the inner-city center of Oslo in favor of pedestrians. In and around the pilot areas, around 760 on-street parking spots were removed and replaced with street art and outdoor furniture. Although there are several studies linking location, amenities and neighborhood attributes to the development of housing prices (Luttik, 2000; Geoghegan, 2002; Anderson & West, 2006; Agostini & Palmucci, 2008; Debreizon, et al., 2010;), there are little to no studies linking house price developments to vehicle-free areas. It seems reasonable to believe that a fundamental change to the driver's ability to access the city center will change the inhabitant's perception of safety and comfort, consequently leading to changes in house prices. The literature provides empirical evidence supporting both increased accessibility as well as pedestrian-oriented infrastructure as value enhancing attributes (Lee, et al. 2013; Song and Knaap, 2003; Li, et al. 2015). At one hand, the removal of on-street parking spots and the constraint on thru traffic reduces accessibility and removes a potentially important neighborhood amenity which could be perceived as a nuisance, thus reducing the house prices. On the other hand, the promotion of pedestrian oriented infrastructure is associated with a more social and safer street design, that could hike up the value of the nearby homes.

Moreover, as the project has not yet been completely finalized, any conclusions regarding the effect after project completion cannot be drawn. However, studies linked to redevelopment have uncovered a so-called anticipation effect (Schwartz, et al., 2006; van Duijn, et al., 2016). In a perfectly efficient market, homeowners are able to tell whether or not their homes will appreciate or depreciate in the future due to physical interference in their nearby surroundings (van Duijn, et al., 2016). Thus, if they suspect a redevelopment project will be an added improvement to their neighborhood after project completion, the house prices will start to increase before the project has been completed.

1.3 Research Problem Statement

This paper attempts to explore: *Has the introduction of the pilots resulted in a change in the surrounding house prices?* To the knowledge of the author, this is the only paper that tries to quantify the effect of the pilot areas on nearby housing prices in Oslo. To help answering the research question, a dive into the real estate literature was carried out by looking into various publications with keywords like; *difference-in-difference, hedonic price model, vehicle-free, redevelopment, anticipation effect,* etc. Furthermore, official documents regarding the pilot areas and the future plan for the surrounding area was accessed at the website of "Oslo municipality" and the website of "transportøkonomisk institutt". In addition, econometric books like Hill, et al., (2012) and real estate economics books like Evans, (2004) were particularly helpful.

In addition to answering the overall research question, a few sub-questions have also been created to further elaborate on the topic of vehicle-free areas.

Sub-question 1: Do homes in the target group sell for a different average price than homes in the control group before the introduction of the pilot areas?

Sub-question 2: Do homes in the target group sell for a different average price than homes in the control group after the introduction of the pilot areas?

This paper uses a difference-in-difference hedonic price model that has been adopted from Hill, et al., (2012) and van Duijn, et al., (2016). The difference-in-difference estimation model makes it possible to compare the price development of two different groups of homes. The homes are separated into a *target group* of dwellings located within 750meter radius of the pilots, and a *control group* of homes located between 751-1500meters away from the pilots. Moreover, the hedonic price model allows for treating dwellings as heterogenous goods by indirectly pricing their unique housing characteristics. For this research, the square meter size of each dwelling and the distance to some important amenities are used as uniquely defining characteristics. This paper uses individual sales data of more than 25.000 apartments located within a 1500meter radius of the pilot areas. Furthermore, the sales data span from the 1st of January 2010 to the 31st of December of 2019, making it possible to compare the sales data prior, interim, and post the launch of the pilots.

1.4 Outline

The remainder of this paper is organized as follows: Section 2 provides an overview of the relevant literature used to generate the research question and the hypothesis of this thesis, while section 3 presents an overview of the events leading up to the policy change. Section 4 presents the data, the methodology, the empirical model, and the descriptive statistics. The empirical results and its implications are presented in section 5. Finally, section 6 concludes the paper.

2. Theoretical Framework

To be able to identify the effect the six pilot areas has had on the surrounding house prices in Oslo, it is necessary to disclose the nature of real estate value determinants. This section starts with common real estate value drivers through internal and external characteristics and amenities in subsection 2.1. In subsection 2.2 the literature, regarding the effect vehicle-free areas have on real estate prices, is discussed. Subsequently, subsection 2.3 discusses the anticipation effect and how it influences real estate prices. Finally, in subsection 2.4 the hypothesis of this paper is derived from the basis of the previous subsections.

2.1 Characteristics and Amenities

Real estate values are affected by a bundle of internal characteristics that uniquely define a property, as well as external attributes shared by multiple homes in the same area. Academics researching the drivers of house prices often include individual housing characteristics such as the square meters size of the dwelling and the lot, the age of the dwelling, the number of bedrooms and bathrooms, and whether or not there is a swimming pool, fireplace or air conditioning installed in the homes (Sirmans, et al., 2006). External characteristics such as transport accessibility, distance to recreational amenities, quality of schools, and crime rate, amongst others, also affect the property values of homes (Tse, 2002; Gibbons & Machin, 2008). Although, it is difficult for homeowners to alter the spatial environment, changes to it are absorbed by nearby real estate (Ki & Jayantha, 2010; Atkinson, 2010). Consequently, their monetary implications can be studied as the alterations of the urban environment are reflected in property value changes (Cervero, et al., 2009).

External characteristics can be a source of value enhancement, but they could also reduce the value of a home. Neighborhood disamenities that unfold after moving into a new home generate windfall losses to the homeowners. Likewise, homeowners that experience the development of additional neighborhood amenities, profit from windfall gains (Kohlhase, 1991). The real estate market is efficient enough to instigate a price discount or a premium on properties that are located in close proximity to a source of distress or convenience. Such unforeseen asset developments have real consequences on the economic behavior of homeowners. When an asset increases in value, the owners tend to spend more on goods and services as they feel richer. This phenomenon inverts as the asset falls in value (Kohlhase, 1991). Thus, wealth effects resulting from external neighborhood characteristics are of public interest and their concerns go beyond the neighborhood boundaries. Hughes Jr. and Sirmans (1992) studied data collected between 1985 and 1989 of single-family homes in two different mid-sized cities in the US. They used a hedonic price model and identified a significant price discount for dwellings located in traffic heavy neighborhoods. Conversely, research on the value effect of positive external amenities identified a price premium for properties with a nice view, properties located in the central business district (CBD), and properties in close proximity to public transport hubs (Simons & Saginor, 2006; Agostini & Palmucci, 2008; Debrezion et al., 2011; Evans, 2004).

There is an extensive literature linking the variation in house prices to the physical proximity of a property to the CBD. The influence *accessibility* has on property values was first formally theorized by von Thünen, who is often accredited as the founder of land value economics (Evans, 2004). His theory rationalizes the differences in farmland rent experienced by farmers with similar fertile grounds, but with different degrees of accessibility to the marketplace where farmers sold their crops (Evans, 2004). Building on his work, (Alonso, 1960; 1964), Muth (1969), and Mills (1967) developed the bid-rent theory which predicts the differences in property values based on each market actor's willingness to pay for the property based on its proximity to the central business district (CBD). In their theory, all jobs were assumed to be in the CBD and profit is directly offset by transportation costs. Following this logic, location is determined by the profit maximizing behavior by individual market actors (Harvey & Jowsey, 2004) and accessibility is a fundamental attribute determining property values. Thus, one can expect to see higher rents the closer to the CBD the property is located.

Accessibility in itself can be seen as property specific attribute. There are lots of empirical evidence indicating that people are willing to pay a price premium for properties located in close proximity to public transportation hubs (Agostini & Palmucci, 2008; Debrezion et al., 2011). Public transportation systems are one of many attributes regarded by residents as an instrument that increases accessibility to the rest of the city. A study by Debrezion et al. (2011) analyzed the impact the accessibility of rail transport had on surrounding house prices in Amsterdam, Rotterdam and Enschede. By using data on Dutch housing transactions over the period of 1996 and 2001, they constructed a cross sectional hedonic price model that incorporated physical, environmental, temporal and accessibility characteristics. Included in the accessibility variables, the distance to the nearest train station and the distance to the most frequently visited stop were both accounted for. They found that the proximity to a train station positively affected nearby house prices, however the proximity to the most frequently visited stop was more influential than the proximity to the closest station (Debrezion et al. 2011). This further support the notion that proximity to transportation hubs adds economic value.

Other important external driver for the variation in house prices is the proximity to local amenities (such as retail) (Chang & Kang, 2015), institutions (such as schools) (Fack & Grenet, 2010), and nature (such as parks) (Daams, et al., 2016). Using a hedonic model on data over properties in the Oslo area between 2009 to 2012, Osland, et al. (2020) mapped the physical distance from individual properties to waters larger than $50m^2$. They found that homes located closer to a lake or the ocean sold for a price premium. Moreover, they found that it is the access to such an amenity, and not necessarily the dominance of the amenity in the neighborhood that made a significant impact on the house prices (Osland , et al., 2020).

As Oslo is situated at the fjord, it is expected that homes located closer to the ocean sell for a price premium, regardless of whether these have a direct view of the ocean or not.

2.2 Vehicle-free Areas

There is little academic research on the economic effect vehicle-free areas inflict on the surrounding property values. On one hand, studies focusing on the walkability aspects, provide empirical evidence that a walkable neighborhood adds economic value. A study by Li, et al. (2015) used a hedonic regression model to identify the impact the level of walkability in neighborhoods had on property values in Austin, Texas. By using a walkability index, they found that people were willing to pay a price premium for single-family homes located in walkable neighborhoods. Another study by Lee, et al. (2013) found evidence of increased property values due to pedestrian focused infrastructure designed to enhance walkability. In line with these findings, a study by Song and Knaap (2003) identified a 15.5% price premium of properties sold in areas that have features often associated with *New Urbanism*[3]. On the other hand, studies look into the physical presence of cars and how it affects surrounding house prices. Studies have shown that street layouts designed to promote the use of cars cause nuisance in the neighborhoods by hampering pedestrian's usage of public space. As streets are designed for cars to park or pass through, they are perceived less safe, less child friendly, and as places that are less social (Isaacs, 2010; Mullan, 2003). A study by Staats and Swain (2020) researched whether street parking affected the willingness to pay for a property. By the help of a survey, they asked 281 participants at Leiden University if the presence of several, few, or no cars in different neighborhoods had implications on their willingness to pay for a specific property. Their research, however, was inconclusive and no significant result was found regarding this issue.

The Netherlands has a long list of cities with restricted vehicle access in their city-centers. These measures were means to protect the historical centers and to improve the quality of residential life. The policy resulted in boosted real estate prices in those areas where private vehicles were prohibited, however it remains unclear how strong the effect is (Nederveen, et al., 1999). One interesting study regarding the transformation from a car focused infrastructure to a pedestrian one is a study by Cervero et al. (2009). They examined the impact of the transformation of the central freeway to an attractive boulevard in the San Francisco area. By using a hedonic price model, they studied the impact of this urban regeneration project on the surrounding house prices. Empirical evidence shows that on average, house prices in the area increased by USD 116,000 after the opening of the boulevard, and that this effect fell as the distance to the project increased. The outcome of their research shows that people living in the area valued pedestrian oriented infrastructure at a higher rate than the car focused freeway.

[3] The idea of New Urbanism includes, amongst others, walkable neighborhoods, access to public transportation networks, strong citizens participation, affordable housing, and social and economic diversity.

2.3 The Anticipation Effect

Real estate prices are not only derived from its physical characteristics, but they are also influenced by future price expectations. Market actors make decisions based on information that is available to them at any given point in time. When the information is forward looking and fueled by expected asset price changes, it generates a positive anticipation effect. In a perfectly efficient marketplace, any future looking information is absorbed by the market and is immediately translated into asset price changes (Poterba, 1984; McMillen & McDonald, 2004). Thus, when homeowners anticipate a future asset price increase, demand for dwellings in this area starts to rise. This in turn pushes up the prices. Similarly, the reverse effect occurs if homeowners anticipate asset price contractions (van Duijn, et al., 2016).

Although Schwartz, et al. (2006) conducted research on the redevelopment of subsidized housing and measured the economic effect it imposed on surrounding house prices, it gives an insight into the various stages of the anticipation effect. Four asset price development stages can be categorized; before the announcement of a project, between the announcement and the start of a project, between the start and the completion of a project, and after the project completion (Schwartz, et al., 2006). An overview of a hypothetical asset price change is presented in figure 1. Figure 1 illustrates the asset price developments in relation to new information available to the market actors. The new information can be categorized as *the announcement of the project, the start of the project,* and *the completion of the project*.

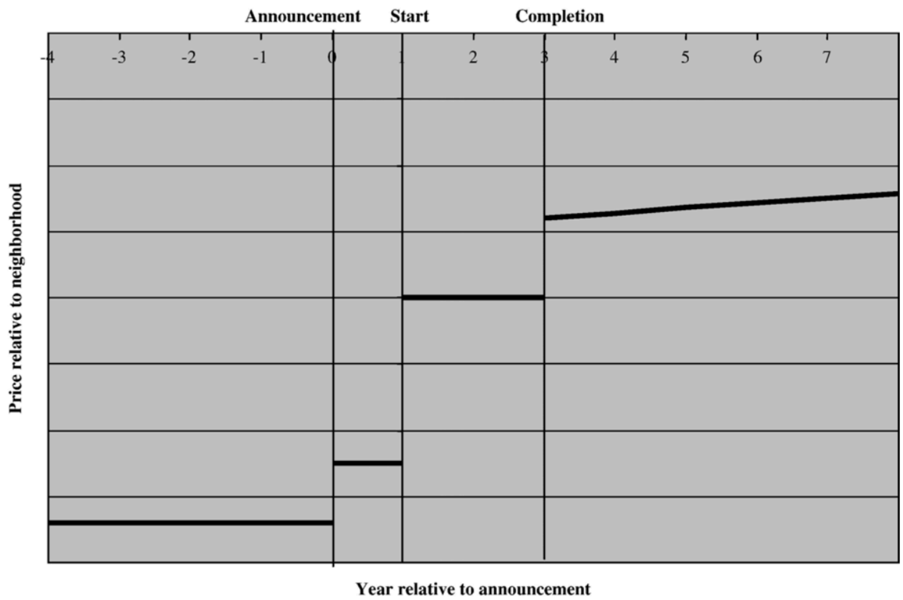


Figure 1. *The anticipation effect with a hypothetical positive asset price development (Schwartz, et al., 2006).*

The asset price development follows a stepwise increase as a consequence of positive news about the development project. Development projects are associated with a level of uncertainty and some projects may never materialize. Thus, it is realistic that the asset price increases as the uncertainty level decreases. In figure 1, the asset price increases as soon as the announcement of a development project has occurred.

This new piece of information generates a speculative behavior regarding the expected future asset price. However, due to the high level of uncertainty associated with project completion, the price hike is only moderate. As soon as the project has entered its start phase, there is a reduction in the level of uncertainty. Thus, the asset price increases even further. Lastly, after project completion the project uncertainty has been mitigated, and the subsequent price development is incremental at best (Schwartz, et al., 2006). However, the information in regard to a development project is not always positive. Noise pollution and undesirable aesthetical changes are some of several negative externalities that could be generated. These negative externalities could trigger a price discount for dwellings located in close proximity to the blight both during, but also after project completion. Finally, the impact the anticipation effect has on real estate is strongest on dwellings in immediate proximity and diminishes with increased distance (van Duijn, et al., 2016).

By combining a hedonic price model and an average treatment effect estimation, Agostini & Palmucci (2008) analyzed the effect the anticipated metro line in the Greater Santiago area had on the surrounding house prices before it opened. The metro line opened in 2005, and the authors used data of house transaction between December 2000 and March 2004 to study the anticipated effects prior to the realization of the line. They found empirical evidence stating that an average apartment rose by 4.9% to 7.9% after announcement, and an additional 3.1% to 5.5% when a certain location for the line had been established. These results support the notion that the anticipation effect follows a step-wise development.

In summary, the past literature on the subject of external characteristics and real estate values suggest that residents are willing to pay a price premium for positive neighborhood attributes. Furthermore, neighborhood disamenities trigger a price discount for properties located in close proximity to the disamenity. As soon as a new amenity is generated, or the transformation of a disamenity takes place, an anticipation effect kicks in and property values start to increase. People are prepared to pay more for homes located in close proximity to public transport hubs, signifying that accessibility is an important value determinant for properties. Despite the large focus on *New Urbanism* in academia, little to no research has been done on the effect vehicle-free zones instigate on surrounding property values. It reasonable to believe that homeowners see passing traffic and on-street parking as negative externalities, thus reducing house prices. By removing parking facilities and restricting the movement of private vehicles the neighborhoods become safer and more social urban areas. Consequently, we could expect to see an increase in the surrounding housing prices after the pilots were introduced. However, at the same time, the removal of parking spaces may in fact restrict accessibility, an attribute that is highly valued by homeowners. Henceforth, the effect of these two mechanisms on real estate values appears contradictive, thus it is not clear which effect the introduction of a vehicle-free area has on the surrounding house prices.

2.4 Research Question and Hypothesis

The aim of this research is to study the effect of the introduction of a vehicle-free city center on surrounding house prices in Oslo, Norway. Previous literature has failed to quantify the effect vehicle free areas have on property values. Thus, this paper intends to fill this gap. To this date, a full vehicle free city center has not yet been fully realized in the city of Oslo. However, six pilot areas have been initiated in which several hundred parking spots have been replaced by outdoor furniture, street access by car has been blocked, and several other initiatives have been implemented to foster the transition from a car-oriented city to one built for pedestrians. The overall research question for this paper is: *Has the introduction of the pilots resulted in a change in the surrounding house prices?* With a dataset of more than 25.000 individual apartments, this research will be the first study to examine the economic effect generated by this new political reform. Drawing from the past literature, hypothesis 1 to 3 were created.

Hypothesis 1: *The introduction of the six pilot areas instigated a price premium or a discount for properties located within a 750meter radius.*

Hypothesis 2: An anticipation effect can be identified between the announcement and the start of the pilot projects.

Hypothesis 3: An anticipation effect can be identified after the start of the pilot projects.

3. The Road to a Vehicle-free City Center

Car ownership has been a political discussion issue for several decades in Norway. After the 2nd world war, the Norwegian government created a quota scheme that potential customers had to sign up to in order to be allowed to purchase a car. During the 1950s, it is presumed that only 3-4% of the applications were granted. However, since October 1st 1960, the quota scheme ceased to exist, and the sales of cars increased manifold. In the following years, mass consumption of cars took place in Norway. In the course of only 4 years, the number of cars on Norwegian roads doubled to about 410.000. By 1976, 1 million cars had been registered, a number that grew to 1,78 million by 1998 (SSB, 1999). This rapid increase in car sales were calling for fundamental changes in the way city streets and the road network in and around Oslo were designed. Lots of families could now for the first time live in the suburbs and commute to work located in the city. Already by the early 1970s, noise, pollution and congestion had become a significant problem in the city of Oslo, henceforth the first car-free street was introduced in 1970 (OBOS, 2018). From the 2nd half of the 80s to 2013, only the areas around "Aker Brygge" and "Karl Johan", including a few side streets have been defined as car free (OSLO KOMMUNE, 2019)

The most significant measures to combat the traffic in Oslo have been formalized in three "*Oslo Packages*" initiated in 1990, 2002 and 2008 (Rognlien, 2015). The main goal of the first package was to reduce traffic in the inner city. By 1990 a new 1.8 km underground tunnel, "*Festningstunnelen*", located below the City Hall Square opened. It took four more years to remove the 4-lane highway above, transforming the City Hall Square into a recreational area for pedestrians (Rognlien, 2015). The tunnel was partly financed by a toll road that got erected around the city center in 1990. This toll road also partly financed other upcoming infrastructure projects, including several tunnels, as well as new public transportation measures. Although additional tunnels were realized under the 2nd "package", the strengthening of the public transportation in the city was the main priority. In "package 1" only 20% of the income from the toll road went to public transportation, whereas in "package 2", the number had grown to 40%. For instance, several of the tram and bus stations in the region of Oslo were upgraded. Moreover, the tram wagons themselves were renewed. "Transportøkonomisk institutt", the public institution for transportation, evaluated the impact of the first two packages. They concluded that the two first "packages" have been successful in its stimulation to enhance the development of the infrastructure in the region of Oslo (Rognlien, 2015). Starting in 2008 and with an end planned in 2036, the 3rd and final "package" was launched. This "package" further builds upon the priority areas laid out in the previous "packages" (Rognlien, 2015).

The municipal election in 2015 became a turning point in the way Oslo's city planning were to be carried out. For the first time, the center-left "green party" gained enough votes to position itself above the 4% minimum threshold. Thus, "Arbeiderpartiet" (the Worker's party), "Miljøpartiet de Grønne" (the Green Party), and Sosialistisk Venstreparti (the Socialist Left Party) gained enough votes to form a coalition to rule the city council, shifting the balance of power from the right to the left after 18 years. With that, the parties signed an agreement for the future of the city planning in Oslo. The main goal of this agreement was to create a better urban environment by making the area inside ring road 1, an area of 1.3 square kilometres, vehicle free. In comparison to other comparable mid-sized European cities, such as Munich, Copenhagen and Brussels, the proposed vehicle-free zone for Oslo is larger by 6.5, 2.2, and 2.6 times, respectively (Tønnesen, et al., 2016). Inside the area of 1,3 square kilometres only around 1000 people live, however more than 100.000 cars commute to and from the area every day (OSLO KOMMUNE, 2019). By December 2015 "Project Vehicle-Free City Center" was announced (Oslo Kommune, 2017). The final date for a fully vehicle-free city center was initially set to 2019 (Tønnesen, et al., 2016), however this was later pushed back.

In 2017, six pilot areas were launched in order to test various tactics to make the streets more social places and to reduce pollution in the city center. The pilot areas were located in parts of "*Øvre Slottsgate"* as well as the south part of *"Møllergata"*. In addition, both the south and the north part of *"Kongens gate"* were separate pilots. Morover, "*Fritjof Nansensplass, Roald Amundsen gate and Kjeld*

Stubs gate" were regarded as one pilot, and finally, *"Tordenskiolds gate and Rosenkrantz gate"* were also one pilot area (OSLO KOMMUNE, 2020). A visual representation of the pilot areas can be found in map 1. In June of 2017, the removal of around 760 public parking spots on street level began inside the pilot areas. These parking spots were replaced by outdoor furniture, planter boxes and street art. These areas were further developed in both 2018 and 2019 by changing parts of the traffic network, introducing a playground for children, cultural areas for pedestrians, and more benches and greenery in those areas where the parking spots were discontinued (OSLO KOMMUNE, 2020). To this date, a fully vehicle-free inner-city center has not yet been realized. However, the current action program used to increase Oslo's urban life ends in 2027 (Oslo Kommune, 2018). A report designed to evaluate the effects of the measures undertaken since 2017, showed a reduction in traffic of around 30% as compared to 2016 (SWECO, 2020). However, due to inadequate measurements it was not possible to figure out to what a degree the pilots had contributed to this figure.

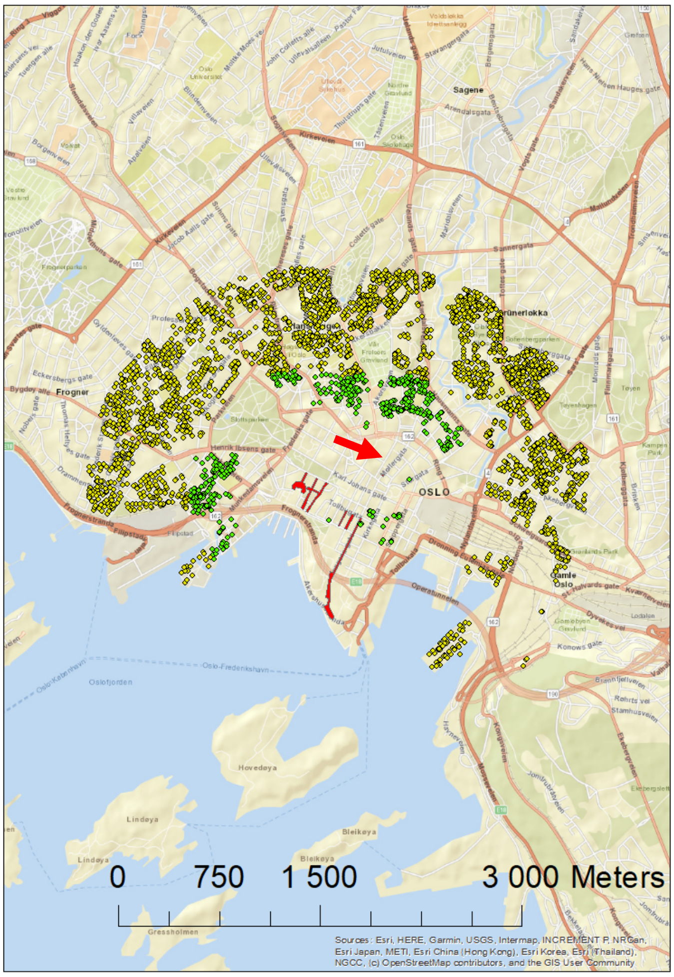
4. Data and Methodology

This section provides an overview of the data and methodology used to answer the research question and to test for the hypothesis presented in section 2.4. Subsection 4.1 gives an overview of the data used in the research, while subsection 4.2 discusses the methodology. Subsection 4.3 discusses the empirical model and subsection 4.4 showcases the associated descriptive statistics of this research.

4.1 Data

This research uses data from *Eiendomsverdi*, a private corporation that has collected sales data of all Norwegian properties sold since 1985. Their databank provides the largest overview of sold homes in Norway and they are a market leader in this field. The dataset used for the research in this paper includes all dwellings sold in the municipality of Oslo from January 1st of 2010 to December 31st of 2019. Furthermore, the dataset includes variables such as the sales date, the selling price, the number of square meters, the number of rooms, the estate type and the city district for each individual dwelling. The latitude and longitudinal coordination data for each individual data entry are also included, making it possible to map out every single dwelling by the use of a Geographic Information System (GIS) program. Finally, data of the post codes were retrieved from *Esri*, the operator of the GIS system.

Initially, the dataset has more than 180.000 entries of individual dwellings sold in 17 different municipal districts over the period in question. The focus area of this paper includes apartments located up to 1500 meter away from the pilot areas. The distance between the pilot areas and the closest parking garages, t are about 750 meters away. It seems unlikely that people are willing to park further away than that if they are to visit these areas. Thus, based on past studies using similar empirical models, the target and the control group[4] are defined as properties located between 0-750 meters and 751-1500 meters away from a pilot area, respectively. After including homes located within this parameter, the number of observations is reduced to 25223. After inspecting the dataset and excluding datapoints with missing values, 25048 individual observations spanning five different districts remains. The focus area is on the price development of apartments, as too little of the other estate types is located in this area to perform an adequate analysis on these dwellings. Nevertheless, the dataset covers the vast majority of the dwellings in the area as apartments make up 92% of the total amount of homes in the inner city of Oslo (Oslo Kommune, n.d.). Finally, the variable recording the number of rooms had less than 50% entries, hence the number of missing values were too high for this variable to be included in the analysis. A visual representation of the data is presented in Map 1.



Map 1. *A map of the city of Oslo with a visual representation of each dwelling located between 0-1500meters away from the pilot areas. The green dots represent the homes in target area while the yellow dots represent the homes in control area. The red areas represent the pilot areas. NB! Do not overlook the pilot area in "Møllergata" which is represented by a red arrow.*

[4] See equation 1.2 for an overview of the functions of the target and the control groups.

4.2 Method

Building on the work of Schwartz et al. (2006) and van Duijn et al. (2016), this paper uses a difference-in-difference (DID) hedonic price estimation model to identify the effect the pilot areas have on surrounding housing prices. Due to the general characteristic of real estate being a heterogeneous good with different value determining characteristics, hedonic price model is commonly used when determining the current market value of housing (Hill, et al., 2012). In the hedonic price model, the value of the real estate is determined by a number, *n*, of different attributes, *Z*, such as the square meter size of the unit (Hill, et al., 2012). The price, (*P)*, of each attribute cannot be observed directly in the marketplace, however each attribute can be indirectly priced, and their total value is reflected in the value of the unit, *i* (Hill, et al., 2012). The price of a unit based on its individual value determining characteristics can be described as:

$$P_i = P(Z_i, \dots Z_n) + e_i \tag{1.1}$$

Equation 1.1 shows how each individual dwelling has a unique composition of value determining attributes making up the final price of that dwelling. It is possible to identify the average value of these attributes with a large enough data sample.

The DID estimation uses information from two separate groups of data that both were observed before and after a particular policy change. The estimation approach assumes that both groups undergo a common trend, however one group, the treatment group, is affected by the policy change. The second group, the control group, remains unaffected by the policy change. Henceforth, the trend the control group follows is assumed to be the same trend the treatment group would follow if it was unaffected by the policy change, a so called "counterfactual" (Hill, et al., 2012).

In order to estimate the treatment effect, $ß3$ in equation 1.2, one can run a simple regression model. The DID estimation model define y_{it} as the observed outcome for individual *i* in period *t*. Moreover, $AFTER_t$ is a dummy variable that takes the value of *one* after the policy change and *zero* for the period before. $TREAT_i$ represents an indicator variable that takes the value of *one* if an individual is a part of the treatment group and *zero* if it belongs to the control group. Finally, the treatment effect can be calculated by introducing an interaction term between $AFTER_t$ and $TREAT_i$. The interaction term takes the value of *one* if a data entry is in the treatment group and the time variable is post policy change, and *zero* otherwise (Hill, er al., 2012). The standard DID regression equation is described as:

$$y_{it} = ß0 + ß1TREAT_i + ß2AFTER_t + ß3(TREAT_i \times AFTER_t) + e_{it} \tag{1.2}$$

4.3 Empirical Model

The dependent variable used in this paper is the logarithm of the sold price, $lnPrice_{itd}$, for an individual dwelling i sold in year t, and located with a distance d to the pilot areas. In addition, the variable has been converted from nominal terms to real terms by using a house price index (SSB, 2020). A common attribute with monetary variables is that they are positively skewed with a long tail to the right. A logarithmic transformation brings the variable more in line to a normal distribution[5], thus this is a standard practice in research on house prices (Hill, et al., 2012). Moreover, a logarithmic transformation was also performed on the variable for total square meter of each individual dwelling, $Size_i$, to bring it closer to a normal distribution.

Similar to van Duijn, et al. (2016), this research includes an announcement period prior to the start of the intervention. This paper distinguishes between three important periods. This includes a *pre-*announcement period, ranging from 1st of January 2010 to the 30th of December 2015. The vehicle free-city center project was launched in the midst of December 2015 (Oslo Kommune, 2017). Since this research is using data on a monthly basis, January 2016 is used as the momentous date. The *Interim* period is defined as the time between the announcement and the introduction of the pilot areas. Thus, the interim period spans between the 1st of January 2016 to the 31st of May 2017. Finally, the introduction of the pilot areas started its rollout in June 2017, thus the *Post* period starts June the 1st and ends the 31st of December 2019, which is the end of the dataset. In order to generate three different time periods, two dummy variables, *Interim* and *Post* were created. If an individual dwelling is sold in the interim period, it takes the value of *one*. Likewise, a dwelling sold in the *post* period takes the value of *one*. If the dwelling is sold in neither of these two periods, the values of *Interim* and *Post* will both be *zero*. Hence, the dwelling is sold in the *Pre* period.

The target group, $Target_i$, is defined as each individual dwelling that is located within a 750meter distance to a pilot area. The control group is defined as each individual dwelling located between, and including, 751 to 1500 meter away from a pilot area. This is a distance dummy that takes the value *one* if the dwelling falls in the target group and *zero* if it falls in the control group.

Time fixed effects in the form of year dummies, $Year_t$, is included in the model to minimize a time based omitted variable bias. Likewise, zip code dummies, Zip_Code_i, for each individual dwelling is added to control for zip code fixed effects. The variable takes the value of *one* if a dwelling is located within a specific post code area, and *zero* otherwise.

[5] See Appendix 2.

Finally, due to a lack of individual housing characteristics in the dataset, several distance controls were generated in an attempt to create more diversity among each individual house. Thus, the distance to some important nearby amenities were added. Based on findings in past literature, it seems that homes closer to a train station, beautiful scenery, as well as the central business district, sell for a price premium. Thus, this paper controls for the distance to the central station, $Dist\_OsloS_i$, the distance to the fjord, $Dist\_Fjord_i$, and the distance to the central business district, $Dist\_CBD_i$. Together with $Size_i$, these three distance controls are represented as $Characteristics_{kit}$ in the empirical model, where *k* represents the type of characteristic, *i* represent each individual dwelling, and *t* represents the year.

Model 1.3 specifies the econometric model specification used to generate the estimation results, and table 1 gives an overview of the different variables included.

$$lnPrice_{it} = ß0 + ß1Target_i + ß2(Target_i \times Interim) + ß3(Target_i \times Post) + ß4Characteristics_{kit} + ß5Year_t + ß6Zip\_Code_i + \varepsilon_{it} \quad (1.3)$$

4.4 Descriptive Statistics

After the data had been collected, the preparation process of the dataset was performed. The initial screening was done by looking for missing values. The variable, number of rooms for each individual dwelling, had a missing value percentage of more than 50%. Consequently, this variable was deemed unsuitable for further examination and was dropped from the dataset. Moreover, a small fraction of dwellings had missing values for their transaction value. These dwellings were dropped from the dataset. Moreover, as this research is interested in dwellings located up to 1500meters away from the pilot area, the homes located further away were excluded from further analysis. The selection procedure was carried out by using a geographical information system (GIS) software. Each individual dwelling has its longitudinal and latitudinal coordinates recorded in the dataset. Thereby, it was possible to map them out and measure the physical distance to the pilot areas, the CBD, the Oslo fjord, and the central station. The cut-off point of 1500 meters was made after eyeballing the dataset, reading past literature, and reading official documents. Moreover, there some parking garages located within a radius of 750-1000 meters from the pilot areas. It is not very likely that people visiting the city will park much further away. Thus, a target area of up to 750meters and a control area between 751-1500meters away from the pilot areas seemed fitting. Initially, there were over 180,000 individual homes over a 10-year period present in the dataset. However, after the initial screening process a total of 25,222 homes were included in the analysis. Table 1 presents the descriptive statistics of the variables included in the analysis.

The DID estimation model is an adaption of the multivariate regression model. Hence, before any of the analysis could take place, the dataset was checked for compliance with the classical OLS assumptions.

Descriptive statistics

	Target Group		*4283 observations*		*Control Group*		*20939 observations*	
Variable	Mean	Std.Dev.	Min	Max	Mean	Std.Dev.	Min	Max
Price (NOK)	3782176	1722500	1271591	2.62e+07	4064261	1868449	842268	2.57e+07
Size (m²)	66.16	31.53	16	318	73.37	33.44	13	390
Year	2014	2.77	2010	2019	2014	2.81	2010	2019
dist_Pilots (meters)	588.94	136.56	5	750	1181.96	206.08	751	1500
dist_Oslos (meters)	1061.42	426.21	171	1706	1449.94	533.69	337	2466
dist_CBD (meters)	941.53	251.22	28	1309	1517.40	258.11	855	2072
dist_Fjord (meters)	760.85	379.54	7	1297	1182.116	482.54	8	2043

Table 1. *Descriptive statistics of the variables used in the research. A total of 25222 individual dwellings are used in the analysis.*

The OLS assumptions are presented in appendix 2. After a careful analysis of the data, it is clear that it complies with the OLS assumptions. When these assumptions are met, the estimators are said to be unbiased and efficient (Hill, et al., 2012). Thus, the expected value of the estimated parameter is equal to the true parameter. Furthermore, an efficient estimator holds the smallest variance among the other unbiased estimators. Henceforth, it is the most precise estimation.

5. Results and Discussion

This section presents and discusses the regression output that is presented in table 3 in subsection 5.1. Moreover, the implications of the regression output are also discussed. Finally, subsection 5.2 discusses some of the limitations of this research.

5.1 Estimation Results

Firstly, three different regression models have been created. The first regression model includes year dummies, but not housing characteristics, nor post code dummies. It is clear by the adjusted R-squared, the BIC, and the rss that more controls added to the model strengthens the overall model fit. The overall model fit is severely strengthened by adding housing characteristics such as the square meter size and the distance to various nearby amenities. When post code dummies are added to the model, the model fit further improves. As estimation model 3 has the best overall fit, the remaining analysis will focus mostly on this model.

The first variable, *pre*, is both negative and statistically significant for all the estimation models. As more control variables are added to the model, the effect becomes less strong. For model estimation 3, homes located within the target area sold on average for 2.67%[6] less than homes in the control area. This implies that during the period before the announcement of a vehicle-free city center, homes located within the target area were subjected to a price discount. The price discount could stem from the notion that a lot of traffic is present in the surrounding area and that people are seeing it as a form of blight.

The *interim* variable is not statistically significant for any of the estimation model, however the sign of the coefficient for model estimation 3 is negative. Thus, there are no statistical evidence to infer that homes located in the target areas, and sold during the interim period, sold with either a price discount or a price premium as compared to homes in the control area. Hypothesis 2, stating that "*an anticipation effect can be identified between the announcement and the start of the pilot projects",* is not supported by statistical evidence. In a market with perfect information and no mobility costs, households would know that homes in their neighborhood would become more or less worth. Hence, in a perfectly efficient

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[6] $((e^{-0.027}0 - 1) \times 100)$ = -2.67%

market, an announcement period would be prominent as homeowners expect higher or lower sales prices (van Duijn, et al., 2016). Henceforth, the absence of house price changes during the *interim* period might be due to either a rigid housing market, or inadequate communication from the side of the policy makers.

The *post* variable on the other hand is statistically significant at a 1%, 5% and 10% level for estimation model 1, 2 and 3, respectively. The coefficient sign is negative for all estimation models, and the effect becomes less strong and less statistically significant as more control variables are added. Nevertheless, model estimation 3 shows that homes in the target area and sold after the pilot areas were introduced, sold on average with a 0.90%[7] price discount as compared to homes located in the control area. It is worth mentioning that the price discount in the area is less severe when comparing it to the *pre* period. After the introduction of the pilot areas, the price discount experienced by homeowners living in the target area has become less severe. In the period, *pre,* homes in the target areas sold with a 2.67% price discount, whereas homes sold in the *post* period sold with a 0.90% price discount. Thereby, after the introduction of the pilot areas, homes in the *target* area rose by 1.77%. There is enough statistical evidence to support hypothesis 1, stating that "*the introduction of the six pilot areas instigated a price premium or a discount for properties located within a 750meter radius.*" In addition, there is statistical support for hypothesis 3, stating that "*An anticipation effect can be identified after the start of the pilot projects.*" The house prices have increased even though the project has not yet been completed. This might be due to the fact that the homeowners anticipate a price premium in the future as a result of vehicle-free project. Since there is still a price discount in the area, the city center is still subject to some sort of blight even after the roll-out of the pilot areas. However, as the vehicle-free city center project has not yet reached its completion, nuisances generated by the project could hinder a further increase in house prices.

Model estimation 3 shows that for homes with a higher square meter size sell with a price premium. This is in line with previous literature on the subject. Model estimation 3 shows that for a 1% increase in square meter size, a home in Oslo sells on average with a 0.75% price premium. Furthermore, homes that are located in close proximity to the CBD and the fjord sell with a price premium. This is in line with previous literature. For every 100 meters a home is located away from the CBD, it sells on average with a price discount of approximately 2.93%.[8] Similarly, for every 100 meter a home is located away from the Oslo fjord, it sells with a 0.37% price discount.[9] Interestingly, homes located closes to the central station sell in fact with a price discount. This is not in line with previous literature, suggesting

[7] $((e^{-0.009}) - 1) \times 100)$ = -0.90%

[8] $((e^{-2.927e04}) - 1) \times 100) * 100$ = 2.93%

[9] $((e^{-3.691e05}) - 1) \times 100) * 100$ = 0.37%

that there is some kind of blight in the area. For every 100 meters a home is located away from the central station, it sells for a 2.68% price premium. What this blight entails remain however unclear.

Estimation results

	(1)	(2)	(3)
Sample size	≤1500m	≤1500m	≤1500m
Target area	0-750m	0-750m	0-750m
Control area	751-1500m	751-1500m	751-1500m
pre	-0.063***	-0.058***	-0.027***
	(0.009)	(0.004)	(0.005)
interim	0.025	-0.010	-0.001
	(0.018)	(0.007)	(0.006)
post	-0.037***	-0.014**	-0.009*
	(0.014)	(0.005)	(0.005)
LnSize		0.756***	0.748***
		(0.002)	(0.002)
dist_CBD		-2.892e-04***	-2.927e-04***
		(6.447e-06)	(6.397e-06)
dist_oslos		2.652e-04***	2.682e-04***
		(3.150e-06)	(3.104e-06)
dist_fjord		-3.899e-05***	-3.691e-05***
		(2.370e-06)	(2.337e-06)
_cons	15.111***	12.015***	11.930***
	(0.009)	(0.012)	(0.015)
Year fixed effects	**Yes**	**Yes**	**Yes**
House characteristics	**No**	**Yes**	**Yes**
Post code dummies	**No**	**No**	**Yes**
N	25222	25222	25222
adj. R-sq	0.007	0.864	0.888
BIC	23477.858	-26626.379	-30827.601
rss	3726.479	510.343	420.054

Standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 2. *Estimation results. The dependent variable is lnPrice. The variable pre, interim, and post represent b1, b2 and b3, in the econometric estimation model 1.3 respectively. Thus, interim and post are interaction variables between the target group and the respective time period.*

As can be concluded from this research, the transformation of the pilot areas resulted into a spill-over effect for private homeowners. Since the transformation of the pilot areas is a part of a public spending program, it is important to take into consideration the effect it has on surrounding house prices. Thus, by transforming the function of the city space, public resources are funneled to these pilot areas. This spill-over effect is important to keep in the minds of policymakers as they are indirectly increasing housing prices of private individuals through a publicly financed program. This research is only looking into the effect of the six pilot areas, however the effect may be even more pronounced as the vehicle-free area expands. When homes become unaffordable and people involuntarily have to commute long distances to get to work, the society as a whole experience a loss in productivity. Loss in productivity does in turn result in a loss in public revenue. Henceforth, it is important to assure housing affordability for a wide range of societal groups in and around these areas.

5.2 Limitations

As with all types of research, this paper includes some limitations. The most obvious limitation is the "newness" of this research. As the suggested vehicle-free area is not yet fully converted, one can only evaluate the consequences of the six pilot areas. Moreover, there might also be an inseparable anticipation effect of a fully vehicle-free area mixing with the effect of physically revitalizing the neighborhoods. This is due to the fact that while removing the parking spots, and hence the cars, they are transforming the use of the space at the same time. A way of clarifying the most important mechanisms could be to conduct in-person interviews with residents living in the area. Moreover, the newness of the research allows us only to draw conclusions for a relative short time period. Hence, the results may differ as the project keeps progressing. Another limitation of the research stems from the fact that the dataset in question lacks more detailed real estate specific characteristics such as age, number of rooms, number of bathrooms etc. By having a dataset that includes this type of information it is possible to increase the model fit and get a more accurate reading of the true effect of the pilot areas on the surrounding house prices. However, the square meter and distance controls improves the model fit when including the real estate characteristic alone. Finally, this research is looking at the home-owner's market and not on the rental market in Oslo. The majority of homes in Norway are in the home-owner's market, however it is reasonable to believe that there is a higher share of rental homes in the city center than in less urbanized areas. By only focusing on the home-owner occupier's market, one neglects the effect the transformation to a vehicle-free urban landscape has on rental homes, retail and the office market. I would recommend that future research on the topic of vehicle free areas also to incorporate these markets.

6. Conclusion

This research is one of the first studies done on a vehicle-free areas and how it affects the homeowner's market. It was carried out as it is important for policy makers to identify the value driver for the homeowner's market and to what extent their policy interventions contribute to value creating or destruction for private individuals. This paper attempts to research the effect vehicle free initiatives had on the surrounding house prices in the city center of Oslo. The 1st of June 2017, six pilot areas were launched in the city center. Various different initiatives were launched, including the removal of more than 760 public on-street parking spots that got replaced by outdoor furniture, bike lanes and street art. By the use of a difference-in-difference hedonic price estimation regression, this researched looked into whether homes located within a 750meter radius of one of the pilot areas sold with a price premium or with a price discount due to the policy change. The research did find statistically significant evidence that the house prices of these homes sold for a 2.67% price discount prior to the announcement. In addition, after the introduction of the pilot areas, *post*, negative significant results of -0.90% were found. The *post*-effect was less severe than the *pre*-effect. Hence, after the physical interreference, house prices in the target area did in fact increase, although they were not completely offset. This can be seen as an anticipation effect kicking in after the introduction of the pilots. As people see some projects materialize, they might anticipate that their homes increase in value as the project towards a vehicle-free city-center progresses.

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Appendices

Appendix 1.

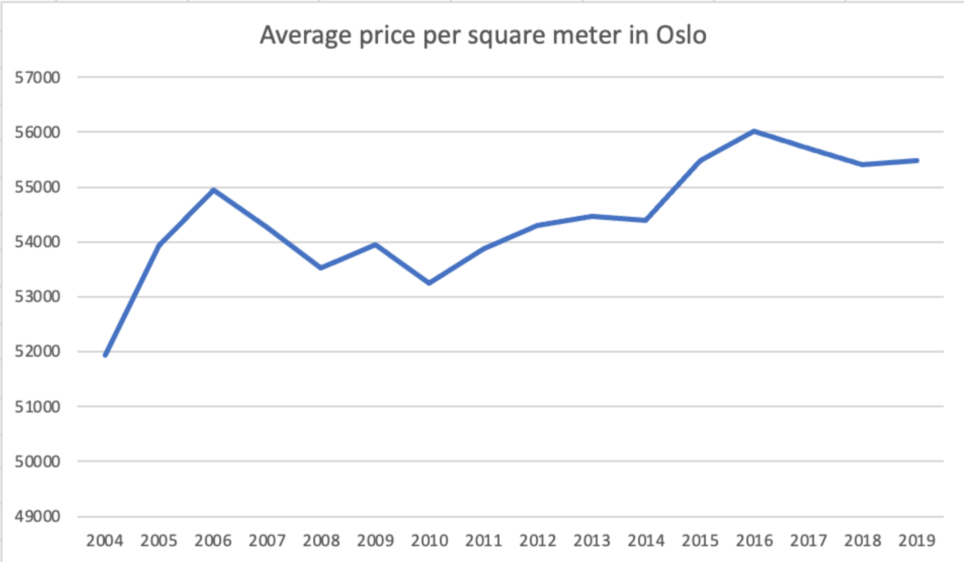

Figure 1. *The real average price per square meter for existing dwellings in Oslo calculated by using the HPI reported by SSB*. (SSB, 2020).

Appendix 2. The OLS Assumptions.

The DID model is a specific case of the multiple regression model, making it susceptible to the five classical assumptions of the ordinary least square (OLS) regression equation. The first assumption, assumes that the dependent variable, y_i, is a linear function of the independent variables, x_i.

$$y_i = \beta_1 + \beta_2 x_2 + \cdots + \beta_k x_{ik} + e_i, \qquad i = 1, \ldots, N \tag{1.4}$$

When creating scatterplots between the dependent variable and the independent variables, there is a clear linear relationship. However, the dependent variable used in this paper is a monetary value that measures the price of dwellings. In general, such variables are often characterized by having positively skewed distributions (Hill, et al., 2012). Indeed, when examining the histogram of the real sales price in figure 2, it is positively skewed. Thus, a logarithmic transformation was performed on the sales price to bring it closer to a normal distribution. After this transformation, there is no longer a linear relationship between the dependent variable and the size of the dwelling. The transformation is presented in figure 3. Hence, a logarithmic transformation of the independent variable, $size_i$, was carried out to restore the linear relationship between these two variables.

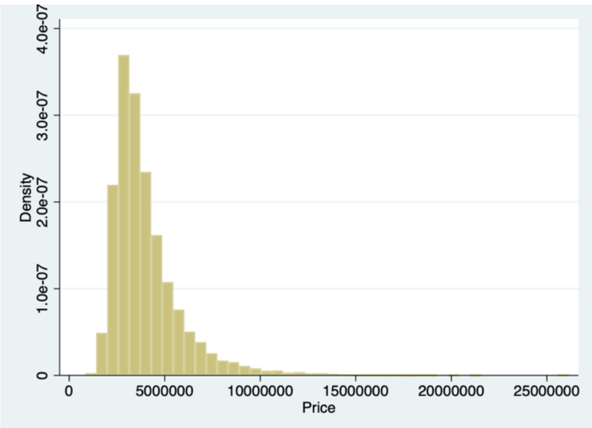

Figure 2. *The histogram of the transaction price, measured in real terms, before the logarithmic transformation*.

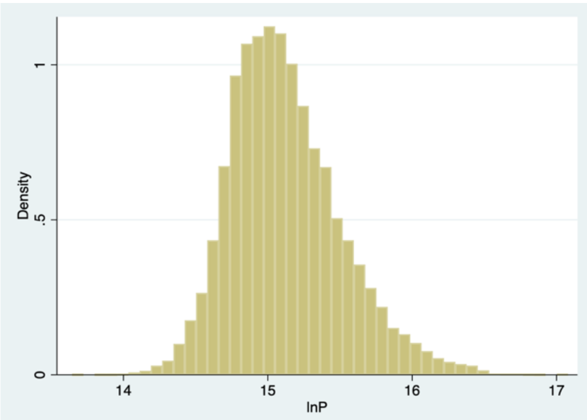

Figure 3. *The histogram of the transaction price, measured in real terms, after the logarithmic transformation*.

The scatterplot between the various variables used in the model is available in figure 4.

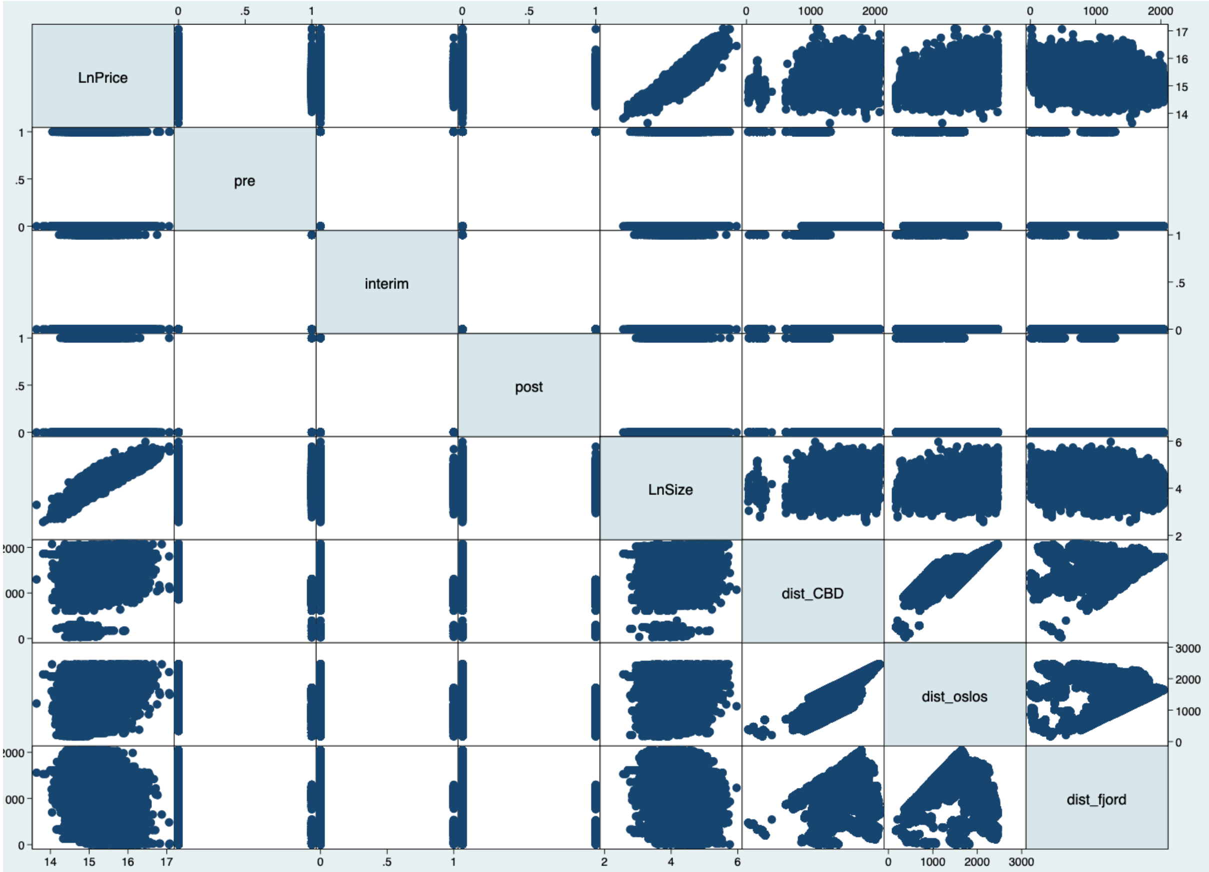

Figure 4. *The scatterplots of interest are between LnPrice and LnSize. After the log transformations there is a clear linear relationship among the two variables.*

The second assumption assumes that each random error has a probability distribution with a zero mean. The error term measures the variation in the dependent variable that is unexplained by the independent variables. Some of the errors are positive and some are negative, however on average they are zero (Hill, et al., 2012).

$$E(y_i) = \beta_1 + \beta_2 x_2 + \cdots + \beta_k x_{ik} \Leftrightarrow \mathrm{E}(e_i) = 0 \qquad (1.5)$$

A way to test for this assumption is to run a residual vs. predictor plot. When the assumption holds true, the residuals are randomly centered around 0, and they show no sign of any distinct pattern indicating their average to be different from 0. Figure 5 shows the residual vs. predictor plot for *lnsize* as an example. By running the same plot on the rest of the independent variables, it is clear that the assumption holds for all the independent variables included in the model.

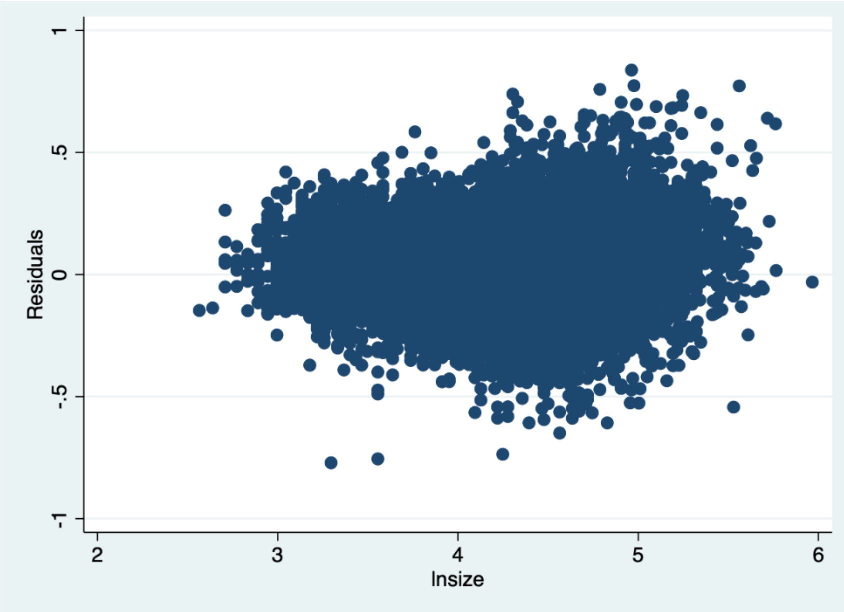

Figure 5. *Residual vs. predictor plot for Lnsize. This plot sets an example for the rest of the predictive variables.*

The third assumption assumes that each of the random errors has a probability distribution with a variance, σ^2, which is the same for each observation (Hill, et al., 2012).

$$var(y_i) = var(e_i) = \sigma^2 \tag{1.6}$$

When this assumption holds, the residuals are homoscedastic. On the contrary, the violation of the assumption indicates heteroscedasticity in the model. The scatterplot between LnP_i and $Lnsize_i$ shows sign of the characteristic cone like shape that indicates heteroscedasticity between the two variables. Moreover, a Breusch-Pagan and Cook-Weisberg test was performed to also statistically test for heteroskedasticity in the model. The test showed statistical evidence that there were indeed heteroscedasticity present. Thus, in order to account for the presence of heteroskedasticity, robust standard errors are used in the model.

The fourth assumption assumes that any pair of errors is uncorrelated (Hill, et al., 2012).

$$cov(y_i, y_j) = cov(e_i, e_j) = 0 \quad (i \neq j) \tag{1.7}$$

This implies that the size of the error of one observation has no effect on the likely size of an error for another observation. By mapping the residuals against the time variable, it is clear the residuals are randomly scattered around 0, hence there is no sign of serial correlation. This is presented in figure 6.

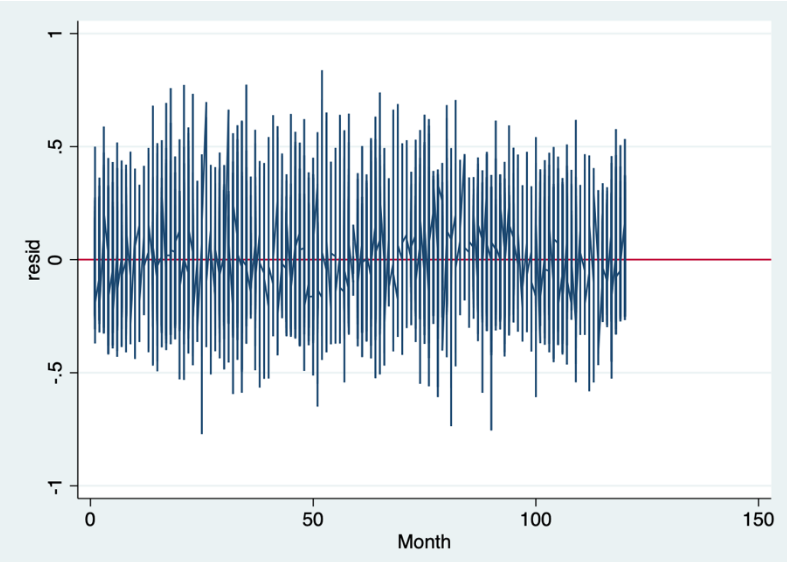

Figure 6. *Shows the time, measured by months, randomly scattered around the residuals.*

The last assumption assumes that the value of each x_{ik} are not exact linear functions of the other explanatory variables. Hence, when the assumption holds true, there is no collinearity in the model. By the help of a correlation matrix, it is possible to detect the presence of multicollinearity among the regressors. In table 3 , the results for the matrix of correlations are presented. If the correlations are higher than 0.8, multicollinearity is assumed to be present (Hill, et al. (2012). By looking at table 3, one can see that all the independent variables are correlated on a level which is below the threshold. Hence, no multicollinearity is assumed to be present.

Based on the 5 assumptions presented above, it is clear thar the dataset used for this research comply with the expectations for an OLS regression. Therefore, the analysis can proceed.

	LnPrice	Pre	Interim	Post	LnSize	dist_CBD	dist_Oslos	dist_Fjord
LnPrice	1.0000							
Pre	-0.0668	1.0000						
Interim	0.0000	0.3633	1.0000					
Post	-0.0389	0.4733	-0.0352	1.0000				
LnSize	0.8973	-0.0979	-0.0217	-0.0558	1.0000			
dist_CBD	0.1899	-0.6439	-0.2313	-0.3143	0.1530	1.0000		
dist_Oslos	0.3609	-0.2706	-0.0942	-0.1432	0.2035	0.7775	1.0000	
dist_Fjord	-0.1245	-0.3210	-0.1239	-0.1419	-0.0369	0.3230	0.0502	1.0000

Table 3. *Correlation matrix. None of the independent variables are highly correlated among each other. The threshold is set to 0.8 as suggested by Hill, et al. (2012).*