Universiteit van Amsterdam

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Master's Thesis

Changing (spatial) housing preferences in the Dutch housing market during Covid-19: an empirical study

Abstract

This paper studies the effect of the Covid-19 outbreak on (spatial) housing preferences in the Dutch housing market. To do this, I use a relatively new difference-in-difference hedonic price model. I find that urbanized areas are negatively affected by the lockdown. However, it is not sure whether this is a causal effect of the Covid-19 outbreak. Covid-19 seems to have continued an already existing trend of deurbanization in the Netherlands. I find that an important driver of this trend is the affordability of houses in urbanized areas. Additionally, houses with larger house sizes, outdoor space, non-apartment house types, and houses with more types of insulation are positively impacted by the lockdown.

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Statement of Originality

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1. Introduction

The recent Covid-19 outbreak impacted the world fiercely. The outbreak caused a global health crisis of unimaginable size. This has resulted in huge damages on the Dutch economy like the Global Financial Crisis in 2009 (DNB, 2020). Thereby, the outbreak leads to extensive changes in people's lives. Stay-home orders were introduced by the government and companies ordered their employees to work from home (FD, 2020). Companies and its employees were obedient and according to TNO (2020), 44% of all working people worked from home in three months after the new Covid-19 measures were announced. Especially higher educated people worked from home. In the past couple of years, working from home had already taken a more important role as the share of people that work (partially) from home is increasing over the years (Doling & Arundel, 2020). This is especially true for knowledge workers. The Covid-19 outbreak has accelerated this trend (TNO, 2020).

Stay-home orders have an impact on how homeowners perceive their own home. As people are "locked-up" at home, the Covid-19 outbreak has made home an absolute center of our lives. In the lockdown period, for example, people may appreciate their outdoor space or larger house size more. The use of houses by households may lead to different behaviors and more intense consumption of the house (Nanda et al., 2021). Thereby, working from home can have an important consequence for the housing market. If that is the case, a home is not only a place to stay during your own time, but also needs to comply with the requirements of working from home. However, housing markets generally find it difficult to adapt to such quick demand shifts as most housing markets around the world (including the Dutch housing market) are severely supply-constrained and typically slow to adjust (Nanda et al., 2021; Vermeulen & Rouwendal, 2007). Normally, price fluctuations are a direct consequence of such a demand-supply mismatch (Thanos & White, 2014).

Due to the accelerated trend of working from home and its implications for the Dutch housing market, a large public debate is taking place about the necessity of living in the city center of a large city when work from home is prevailing. In multiple news articles, stakeholders in the Dutch housing market state that the Covid-19 outbreak causes deurbanization now that working from home is the new standard, and is expected to stay after the Covid-19 crisis (Het Parool, 2021; NOS, 2020; AD, 2020; FD, 2021).

In this paper, I investigate the effects of Covid-19 on (spatial) housing preferences. The main purpose of this research paper is to explore the effects of the Covid-19 outbreak on prices in areas with different degrees of urbanization. From the public debate and existing literature, I expect that the Covid-19 pandemic causes prices in more urbanized areas to decrease and prices in less urbanized areas to increase. I expect that work-from-home orders have increased the need for larger housing and more outdoor space for homebuyers. Houses with these characteristics are more common in less urban areas, therefore increasing demand and prices in those areas.

I use a micro transaction dataset supplied by the Dutch Association of Real Estate Brokers and Real Estate Experts (NVM), which is the largest real estate broker organization in the Netherlands. The dataset includes individual transactions of houses in the Netherlands and reports various house characteristics. This dataset covers 65.7% of all transactions over the sample period of May 1st, 2017, to May 18th, 2021. I start by performing descriptive analysis on the data gathered. Subsequently, I am building on the research of Gupta et al. (2021) by constructing a bid-price curve for the G4 cities as well as Groningen, Eindhoven, and Den Bosch. Finally, I move on to the main analysis of this research paper. For the main analysis, I use a relatively new difference-in-difference hedonic price model framework to analyze the effect of the Covid-19 outbreak on (spatial) housing characteristics. The model is based on the difference-in-difference specification used in Hassink et al. (2020) and Hang et al. (2020). Unlike in a normal difference-in-difference setting where different groups or regions are compared at the same time, I make the comparison time-dependent. To identify the net effect of the introduction of the lockdown, I employ the time when the lockdown is introduced as the treatment. The net effect can then be obtained by subtracting the difference between the treatment house prices after the lockdown and the control prices after the lockdown, with the treatment house prices before the lockdown and control prices before the lockdown.

The results following the descriptive analysis show that price levels of different degrees of urbanization converge during the lockdown period due to higher price growth in less urbanized areas. Also, non-apartment house types seem to have profited from the lockdown period. To analyze price effects within cities, a bid-price curve is constructed. The findings of the bid-price curve show that the flattening effect of the curve in the US found in the study by Gupta et al. (2021) is not directly present in the Netherlands. Of the seven cities that are included in the analysis, the bid-price curve only flattened in Amsterdam during the lockdown period compared to before the lockdown. To identify a causal effect of the Covid-19 outbreak on (spatial) housing preferences, the difference-in-difference framework is employed. Following the results of this framework, prices in more urbanized areas seem to be negatively impacted by the lockdown compared to moderately urbanized areas. Less urbanized areas show the opposite effect and are positively impacted by the lockdown compared to moderately urbanized areas. Performing the same model on the three different macro areas (Randstad, intermediary zone, and periphery), I find that prices in the Randstad are negatively impacted by the lockdown compared to the intermediary zone with -3.5%. Prices in the periphery are positively impacted by the lockdown showing a 1.2% positive price effect compared to the intermediary zone. The effect is in line with the previous analysis as the Randstad includes more urbanized areas compared to the periphery. To extent the analysis, the same model is applied to house specific characteristics such as house size, garden size, house type, and types of insulation. The results show that houses with a larger house size, outdoor space, non-apartment house types, and more insulated houses are positively impacted by the lockdown.

A set of robustness checks are performed on the difference-in-difference results to test whether the causal relationship with the lockdown holds as is described in the news articles mentioned earlier. One of the concerns is the change in transfer tax as of January 2021 for people aged below 35. Younger people traditionally prefer more urbanized areas and buy smaller, cheaper houses compared to older households. This can influence the results as the new transfer tax system period is included in the sample. Excluding this period does not seem to change the results much. Another concern is the availability of houses in the more urbanized areas. Although the data that is available does not include demand and supply figures, the number of transactions per degree of urbanization are constant over the full sample period.

Yet, maybe the most important concern is the affordability of houses in urbanized areas. I perform the difference-in-difference models on subsamples of transactions up to €400,000, €400,000 to €1,000,000, and more than €1,000,000. Only for the subsample with transactions up to €400,000, the results stay the same. For the other two subsamples, only very urban areas are significantly affected by the lockdown. This indicates that the price developments are not necessarily a causal effect of the lockdown, but an affordability issue that coincides with the lockdown period.

Also, when excluding the Covid-19 outbreak by applying the model to a sample one year earlier (May 1st, 2016, to May 18th, 2020), I find the same results as described earlier. This confirms that the price developments found in the model are part of a trend of deurbanization started in 2013 (de Vries, 2021; CBS, 2021). However, the Covid-19 outbreak seems to have continued this trend. The effect of deurbanization is most significant in a subsample of transactions in the Randstad.

My paper adds to the literature studying the effect of health pandemics on financial markets in general (Ichev & Marinč, 2018; Feng & Li, 2021; Chen et al., 2007) and real estate in particular (van Dijk et al., 2020; Ramani & Bloom, 2021; Hoesli & Malle, 2021; Ling et al., 2021). Thereby, I contribute to the international literature by performing one of the first empirical studies on the effect of the Covid-19 outbreak on the Dutch housing market. The results of my study complement international theory in housing markets during Covid-19 by adding the perspective of the Dutch housing market (Wang, 2021; Zhao, 2020; Duca et al., 2021; Gupta et al., 2021). Finally, my research contributes to the public debate by using empirical data to test the statements made by stakeholders in the Dutch housing market (Het Parool, 2021; NOS, 2020; AD, 2020; FD, 2021; CBS, 2021; TNO, 2020).

2. Related literature

2.1. Theory

2.1.1. Historical outbreaks and financial markets

There is a broad range of studies into behavioral finance. Several of those studies investigate the effect of investor sentiment on asset pricing (De Long et al., 1990; Cen & Liyan, 2013). During health pandemics, investor sentiment and information flow play an important role in worldwide economics and stock markets (Ichev & Marinč, 2018; Blendon et al., 2004; De Long et al., 1990; Cen & Liyan, 2013). Blendon et al. (2004) found that media tend to disproportionally cover dramatic and rare events during the Severe Acute Respiratory Syndrome (SARS) outbreak (i.e., events with high mortality rates like outbreaks). This is especially affecting financial markets as investor's decisions are more affected by news to which more attention has been given, than to other news to which less attention is given even though it has the same fundamental value (Klibanoff et al., 1998). Thereby, periods of economic uncertainty have a significant effect on volatility of commodity future returns (Watugala, 2019).

During the 2014-2016 Ebola outbreak, financial markets experienced negative returns (Ichev & Marinč, 2018). Ichev and Marinč also confirm that the importance of the event is increased by the geographic proximity of the information to financial markets. This, in turn, impacts stock returns of companies. Additional tests show that the effect is larger on more volatile stocks and stocks of small firms. Another explanation given by Ichev and Marinč is that bad mood and anxiety induce an increase in the degree of risk aversion by investors. They find that implied volatility increases on the day the Ebola outbreak events and therefore affects investors' perceived risk.

Feng and Li (2021) focus on the causal inference of the SARS and Covid-19 outbreak on financial markets. They find that the SARS outbreak caused an average negative impact of 5.4% on stock prices in China. They also find that the effect of the SARS outbreak on financial markets is similar to the impact of Covid-19 (negative 5.3%) on stock prices. However, the negative impact on financial markets caused by the SARS outbreak lasted longer than the impact caused by the Covid-19 outbreak (Feng & Li, 2021). Yet, the impact of the SARS outbreak is different across industries (Chen et al., 2007). Chen et al. (2007) found that the impact of the SARS outbreak resulted in significantly negative cumulative mean abnormal returns for Taiwanese hotel stocks on and after the day of the SARS outbreak.

2.1.2. Covid-19 and financial markets

Several research papers have been published on the impact of the Covid-19 outbreak on financial markets. Izzeldin et al. (2021) investigated the impact of Covid-19 on stock markets across G7 countries and sectors. Although strong transition evidence to a crisis regime is present in all countries and sectors, health care and consumer services sectors were the most severely affected (Izzeldin et al., 2021). This can be caused by the race to produce a vaccine, as well as international travel restrictions (Izzeldin et al., 2021). Businesses active in the technology sector were hit the latest and least severely. This can be explained by the increased demand for web-based entertainment and distraction options due the lockdown measures.

Gormsen and Koijen (2020) investigated the stock market's reaction to the Covid-19 outbreak with a focus on risk pricing. They find that stock market's pricing included the risk of a severe and persistent economic contraction in March 2020. However, investors revised that view later in 2020. Furthermore, the response of financial markets to Covid-19 is related to previous financial crises, rather than previous pandemics (Izzeldin et al., 2021). Reflecting the ambiguity in the initial response and adoption of lockdown measures, of all G7 countries, the UK and US were affected the most and had the highest heterogeneity in business sectors' response. With respect to bond markets, Covid-19 related government interventions substantially reduce local sovereign bond volatility, and thereby stabilize international sovereign bond markets, where the effect is mainly driven by economic support policies (Zaremba et al., 2021).

Compared to previous infectious disease outbreaks, Covid-19 impacted financial markets severely (Baker et al., 2020). This includes the Spanish Flu that killed around 2 percent of the world's population. Looking back up to 1900, there are no contemporaneous newspapers that attribute a large daily market move induced by pandemic-related developments (Baker et al., 2020). Furthermore, Baker et al. found that government restrictions on commercial activity and voluntary social distancing are the main reasons the US stock market was impacted more severely by Covid-19 than previous pandemics. Thereby, the restrictions on commercial activity are more stringent in response to Covid-19, broader in scope and longer in duration, compared to policies of other infectious disease outbreaks. The effect is strengthened by the service-oriented economy structure of the US nowadays.

2.1.3. Covid-19 and real estate

Real estate, as an alternative asset class, produces powerful portfolio diversification providing a large range of investors with attractive risk-adjusted returns (Geltner et al., 2014). Due to diversification benefits, real estate investments can be used as a hedge against the volatility of the stock market. Furthermore, real estate investment returns are tied to the trends and behaviors of its surrounding local market (Nuredini, 2020). When separating commercial real estate with residential real estate, there is an important difference between the two with respect to market players and transactions. In the commercial real estate market, transactions are made by professional investors, while in the residential market also consumers are active (Geltner et al., 2014).

Using a Supply-Demand Gap metric, van Dijk et al. (2020) show substantial drops in liquidity across all commercial real estate markets in the US through April 2020. The drops in liquidity substantially exceeded the drops during the first months of the Global Financial Crisis. The reaction of commercial real estate is in contrast with the response of financial markets, as the response of financial markets to Covid-19 is more related to previous financial crisis (Izzeldin et al., 2021). Work from home policies have proved the effectiveness of such a corporate work structure. This raises uncertainty regarding the demand levels for office space in the future, and hence overall rental levels for office space. Additionally, working from home orders have caused commercial office occupancy rates to plummet (Ramani & Bloom, 2021). Hence, prices of commercial offices fell in more crowded areas. For both direct and indirect real estate, price decreases tend to be significant for commercial real estate (Hoesli & Malle, 2021; Ling et al., 2021). However, various property types have been affected differently. As stocks in those sectors were impacted the most as well, hospitality and retail commercial real estate sectors have been affected the most by the Covid-19 outbreak (Hoesli & Malle, 2021; Izzeldin et al., 2021). Residential and logistic commercial real estate sectors have been more resilient (Hoesli & Malle, 2021). Another important takeaway is that larger portfolio allocations by real estate investment trusts cause a larger response to local information shocks. Home markets of investors were also more sensitive to local information shocks (Ling et al., 2021).

2.1.4. Historical outbreaks and housing markets

Francke and Korevaar (2021) studied the effect of the 17th-century plague in Amsterdam and the 19th-century Cholera in Paris on urban housing markets. They show large declines in house prices during the beginning of these pandemics and in heavily affected areas. However, the negative price developments were only short-lived as both cities quickly reverted to their initial price levels. The short-lived price reductions seem similar to the effect of Covid-19 on financial markets where markets were only negatively affected in the short-term (Feng & Li, 2021). Francke and Korevaar (2021) found that an important reason for the short-lived price reductions, was that quickly increasing migration compensated for the high mortality levels during the pandemics. The results suggest that large cities like Paris and Amsterdam are resilient to major shocks following from the disease outbreaks. The results can be used today to evaluate the current Covid-19 pandemic in a sense that the historic pandemics caused a large number of deaths, cities were growing due to substantial migration, and cities included large buy-to-let markets. This is related to current urban city characteristics. However, current cities are different from those in the 17th and 19th-century, especially with respect to living conditions and hygiene. Thereby, governments now provide financial support to citizens and companies and introduce policies that aim to limit the spread of the virus. Hence, Francke and Korevaar (2021) conclude that the results might be most representative for cities in currently developing countries.

2.1.5. Covid-19 and housing markets

Although the Covid-19 pandemic is very recent, a few studies have been published on the effects of Covid-19 on the housing market. Wang (2021) tried to explain how Covid-19 affects house prices in the US. Using a difference-in-difference framework, Wang found that areas that rely more on face-to-face interactions (like tourism and aviation) suffer from the largest loss in property values. This conclusion is also supported by the research of Duca et al. (2021). A similar effect is seen in financial markets where consumer services sectors were hit severely due to the Covid-19 outbreak (Izzeldin et al., 2021). Although evidence does not suggest that changes in house prices are related to stay-home orders from employers and government, stronger housing market fundamentals and better amenities seem associated with larger house price growth due to Covid-19. However, developments in house prices, demand, and supply since April 2020 are similar across urban, suburban, and rural areas in the US (Zhao, 2020).

Gupta et al. (2021) focused on house price and rent developments in the US metropolitan areas during the Covid-19 pandemic. They found that the pandemic caused house price and rent declines in city centers, and price and rent increases away from the center, thereby flattening the bid-rent curve in most US metropolitan areas. This is consistent with the finding of Ramani & Bloom (2021), though inconsistent with the findings of Zhao (2020). Demand for housing is shifting from the more densely populated urban centers to the more spacious suburbs (Ramani & Bloom, 2021). Also, Gupta et al. (2021) and Ramani & Bloom (2021) found that the flattening effect of the bid-rent curve is larger when working from home is more prevalent, housing markets are more regulated, and supply is less elastic, which is the case in the Netherlands.

In the Netherlands, migration between the Randstad and intermediary or periphery areas has changed over the years. Generally, young people move to more urban areas due to study and career opportunities and move out of urban areas to larger houses and a more attractive living area after realizing the social increase (Fielding, 1992). This cycle is also seen in the Netherlands (CBS, 2021). However, during the Covid-19 pandemic, more relocations of households outside the Randstad are taking place (CBS, 2021). CBS found an increasing positive migration balance between the intermediary zone and the Randstad for 2015 – 2020. Yet, the migration balance between the periphery and the Randstad seems to have changed since 2019 and experienced a significant growth during 2020 (CBS, 2021). Although there is an increasing trend of moving to areas outside of the Randstad since 2015, the Covid-19 pandemic seems to have strengthened that trend, especially among people in the age of thirty to fifty (CBS, 2021).

From a monetary point of view, cutting interest rates in response to the uncertainty caused by Covid-19 seems to influence house prices. Research by Zhao (2020) indicates that monetary easing has accelerated faster than any period towards the Great Financial Crisis. In response to lower mortgage interest rates, Zhao found a structural break in the increase in housing demand since March 2020. From March 2020, housing demand has increased much faster than before. This indicates the phenomenon of "fear of missing out or Covid-induced fundamental changes in household behavior" (Zhao, 2020).

Nanda et al. (2021) discusses the preference change for some of the hedonic physical attributes due to Covid-19. They divided the different preferences into work-related considerations and recreational aspects. For work-related considerations, preference changes may occur in total space and connectivity. An additional room of usable workspace might be preferrable to accommodate for stay-home orders. Thereby, extra storage space can be useful when more working from home is expected (Nanda et al., 2021). Recreational considerations consist of a private room for all people in the household. This can be translated into extra demand for additional rooms as also discussed in the work-related considerations. As we spend more time at home, a private garden or balcony may be in higher demand. Due to the large fraction of time spend at home, energy consumption will increase compared to pre-Covid years. This may imply that houses with superior energy-efficient features, such as proper insulation, may become an important consideration for housing choice (Nanda et al., 2021).

2.1.6. *Real estate valuation*

There are multiple methods to explain real estate prices. One of the most classical methods to analyze real estate prices is the bid-rent theory by Alonso (1964). This theory describes the price setting for different locations. In other words, it describes the outcome of the land use and the resulting price by considering the perspectives of landowners and bidders. This theory is widely used to explain real estate prices (Alonso, 1964). The bid-rent curve works best with monocentric city models.

Another method to explain real estate prices is using the four-quadrant model developed by DiPasquale and Wheaton (1992), which distinguishes between short-run and long-run. The four quadrants represent four binary relationships that together link the space market, asset market, and the development industry. When looking at the short run, which is applicable to the exogenous shock this paper is dealing with, the housing market is treated as a housing stock market (de Vries & Boelhouwer, 2005). In this case, developments of new buildings react poorly to demand incentives and supply surplus does not exist (DiPasquale & Wheaton, 1992; Francke et al., 2009). In this situation, interest rates, disposable income, and borrowing capacity of consumers are the most relevant factors influencing house price developments. When taking the short-run part of the four-quadrant model alone, it functions as an affordability model where the focus is on the relationship between house prices and several demand factors like price/income ratio or mortgage-payments/income ratio (Francke et al., 2009).

Multiple studies have been performed on the house price equilibrium. In Dutch house price studies, it is assumed that the short-run relations between the development of house prices and its explanatory variables are constant (van der Windt et al., 2015). However, on an international level, evidence shows that differences in this relationship can occur during several exogenous shocks (Nneji et al., 2013). Thereby, Hall et al. (1997) conclude, using an error-correction model, that house prices do not always return to their equilibrium.

As housing is a multidimensional good with both consumption and investment demand motivations, a hedonic price model is required to reflect the consumption motivation (Nanda et al., 2021). Houses reflect unique bundles of physical/structural characteristics such as size, building period, number of rooms, and garden (Nanda, 2019). Rosen (1974) introduced the theoretical basis of hedonic price modelling to explore how these product characteristics matter in determining transaction prices of houses. It is derived from Lancaster's (1966) consumer behavior theory, that assert that it is not the good itself that creates utility, but its individual characteristics (Rosen, 1974). Ekeland et al. (2004) adjusted the traditional hedonic price model. They argue that the willingness to pay is a non-linear function of a household's characteristics and housing attributes. According to Droës and Koster (2019), the non-linearity provides information that rules out collinearity between an endogenously chosen characteristic and its marginal willingness to pay. This "enables identification of structural parameters in a single market, given the assumption that marginal utility is additive" (Ekeland et al., 2004).

2.2. Hypothesis

Important literature for determining the hypotheses are the assessment of migration balances in the Netherlands by CBS (2021), the international findings on transaction prices during the Covid-19 outbreak (Gupta et al., 2021; Wang, 2021; Duca et al., 2021; Ramani & Bloom, 2021), and the discussion about changes in housing preferences (Nanda et al., 2021).

Based on the flattening of the bid-price curve during the Covid-19 outbreak in the US (Gupta et al., 2021), and the shift of demand for housing from the more densely populated urban centers to the more spacious suburbs during the Covid-19 outbreak (Ramani & Bloom, 2021), hypothesis (1) expects a flattening of the bid-price curve in the Netherlands. Based on the same reasoning, hypothesis (2) expects positive relative price developments for less urban areas, and negative relative price developments for more urban areas during the lockdown period in the Netherlands. Hypothesis (3) expects increased demand in the intermediary and periphery zones (higher migration balance between the intermediary/periphery and the Randstad (CBS, 2021)) to decrease prices in the Randstad and increase prices in the periphery and intermediary zone during the lockdown period in the Netherlands. Additionally, in hypothesis (4), I expect bigger houses, houses with a (larger) garden, and non-apartment house types to experience positive relative price developments during the lockdown period in the Netherlands. I partially base this hypothesis on the fact that more people work from home due to stay-home orders by the government. By working from home, people experience burdens of smaller houses and/or no outdoor space. This hypothesis is supported by the housing preferences discussion by Nanda et al. (2021). Hypothesis (5) expects houses which are better insulated to have a positive relative price growth during the lockdown period as, due to the large fraction of time spend at home, energy consumption will increase compared to pre-Covid years (Nanda et al., 2021). This results in the following hypotheses:

(1) The bid-price curve flattens during the lockdown period in the Netherlands.
(2) Transaction prices in less urban areas are positively impacted by the lockdown compared to more urban areas in the Netherlands.
(3) Intermediary and periphery zones experience positive price developments compared to the Randstad since the lockdown is introduced in the Netherlands.
(4) Bigger houses, houses with a garden, and non-apartment house types are positively impacted by the lockdown in the Netherlands.
(5) Houses with more types of insulation experience positive price developments since the lockdown is introduced in the Netherlands.

3. Data

This paper uses transaction-based microdata of houses in the Netherlands. The data is provided by the Dutch Association of Real Estate Brokers and Real Estate Experts (NVM), which is the largest real estate broker organization in the Netherlands. Although the dataset is very large, the dataset is not fully representative for all transactions in the Netherlands as 65.7%[1] of all transactions are covered in the dataset over the sample period (May 1st, 2017 – May 18th, 2021). This is a similar percentage used in other literature on housing markets in the Netherlands (van Dijk & Francke, 2015; Dröes & Koster, 2016). May 18th, 2021, is the last observation in the dataset.

The NVM dataset includes sale price, date of sale, urbanity, and other house-specific characteristics. House-specific characteristics include, among others, size in square meters, number of rooms, building period, garden size in square meters, and variables that indicate the presence of a parking lot, insulation levels and maintenance levels. Transaction data is on the individual level and anonymized on ZIP code level[2]. The data is merged with a Corop-region linking-table classified by The Dutch National Bureau of Statistics to identify "Randstad, intermediary and periphery" levels.

I exclude transactions with a transaction price below €50,000, number of rooms above 15, transaction price per square meter above €40,000 or below €1,000, size in square meters below $10m^2$, or parcel bigger than $5{,}000m^2$ to remove outliers. Thereby, I trim the data on the (0, 99.9) level for transaction price, parcel, and size in square meters. I do this to improve the quality of the dataset by excluding unrealistic transactions or transactions that include data-entry errors.

Maintenance is defined as the average maintenance for inside and outside maintenance and is classified in buckets (0 to 9). When the maintenance score is missing, the NVM assumes that the maintenance is average (equal to 6). This is a reasonable assumption as 73.61% is categorized as good maintenance. Macro area is defined based on the definition of the Dutch National Bureau of Statistics where the Netherlands is divided into three separate macro-regions. The three different macro-regions are based on the number of jobs that could be reached within a 50 kilometers radius in 2017. The area of which most of the jobs (more than 1,700,000) are reachable within a 50 kilometers radius consists of Utrecht, Zuid-Holland, and the southern part of Noord-Holland. The G4 (biggest four cities in the Netherlands) are also within this area. This area is defined as the Randstad. The middle area is named the intermediary zone and consists of Flevoland, Noord-Brabant, Gelderland (minus the Achterhoek), and the middle part of Noord-Holland. In the intermediary zone, 800,000 to 1,700,000 jobs are available within a 50 kilometers radius. The area with the least jobs available within a radius of 50 kilometers is defined as the periphery. This area includes less than 800,000 jobs within the radius and consists of Groningen, Friesland, Drenthe, Zeeland, Limburg, a large part of Overijssel, de Achterhoek, and the northern part of Noord-Holland.

[1] According to the Dutch National Bureau of Statistics, 946,821 transactions were closed in the period from March 2017 until March 2021. The NVM dataset that is used consists of 622,314 transactions.
[2] i.e., 9999 XX

Table 1 reports the descriptive statistics for all observations within the sample period. The sample includes 622,314 individual transactions. Table 2 reports the tabulation table of the categorical variables degree of urbanization, building period, macro area, insulation, maintenance, and house type.

Table 1 - Descriptive Statistics Continuous Variables

	(1)	(2)	(3)	(4)
VARIABLES	Mean	SD	Min	Max
Transaction Price	327,549.571	193,757.009	50,000.000	2,200,000.000
Price per square meter	2,686.531	1,204.496	1,000.000	38,500.000
House size (m^2)	124.465	49.310	10.000	1,111.000
Garden size (m^2)	66.093	100.405	0.000	998.000
Parking	0.410	0.492	0.000	1.000

Notes: Descriptive statistics of the main dataset over the sample period May 1st, 2017 – May 18th, 2021. Transaction price is the price paid at the sale of the house in euros. Price per square meter is defined as transaction price / house size (m^2) in euros. House size is defined as total floor area in m^2. Garden size is defined as total size of the garden in m^2. Parking is a dummy variable that equals 1 when there is personal parking availability.

As shown in Table 1, the transaction price varies between €50,000 and €2,200,000 with an average of €327,550. The minimum is due to excluding transactions below €50,000 as described above. Transaction prices vary over time. For the sample period, the average monthly price index for transaction prices is shown in Figure 1. From May 1st, 2017, to May 18th, 2021, the average price index rose 54%. The graph shows an almost linear growth from 2016 to 2020 after an increased growth during the second half of 2020 and the beginning of 2021. The average house comprises a total house size of 124 m^2 with a minimum capped at 10 m^2 and a maximum of 1,111 m^2. The price per square meter varies between €1,000 (capped) and €38,500 with an average of €2,687. The average garden size including apartments is 66 m^2. However, when excluding apartments, the average garden size equals 88 m^2. 41% of the transacted houses have personal parking availability. Parking availability comprises of an outside parking spot, a garage, or a carport.

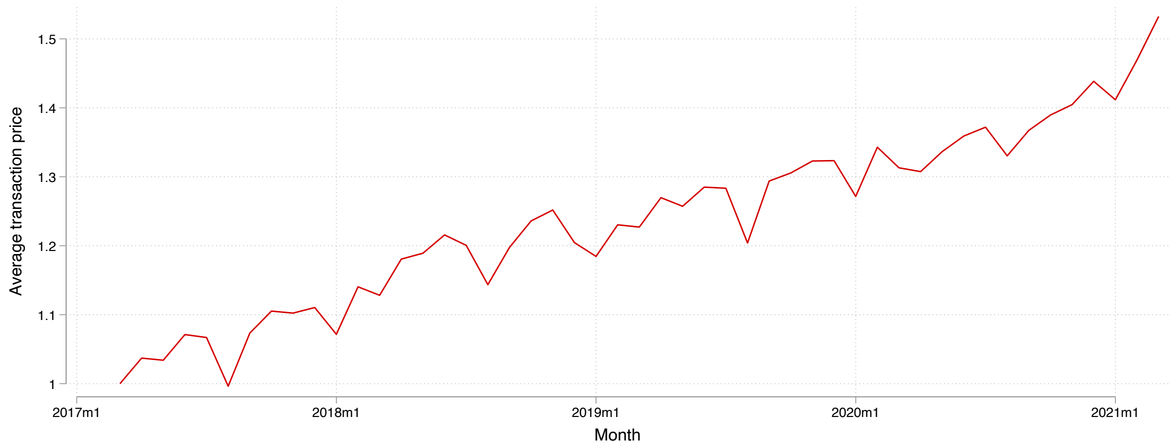

Figure 1: Average price index per month for transaction prices during the sample period May 1st, 2017 – May 18th, 2021

The sample is categorized in five different levels of urbanity based on address density. The degree of urbanization is defined as very urban (2,500 addresses per km^2), highly urban (1,500 – 2,500 addresses per km^2), moderately urban (1,000 – 1,500 addresses per km^2), little urban (500 – 1,000 addresses per km^2), and not urban (less than 500 addresses per km^2). As shown in Table 2, the sample has more urban transactions than non-urban transactions. 46.17% of the transactions are based in very urban and highly urban areas compared to 33.87% in little urban and not urban areas. 19.96% are from moderately urban areas. This distribution is as expected, as more urban areas of course include more houses to be transacted. The same distribution pattern is seen for macro areas. More than half of all transactions have one type of insulation or five or more/fully insulated. The maintenance score, which is the average between inside and outside maintenance inspected by the broker, is concentrated at good maintenance. More than half of all transactions are terraced houses or apartments.

Table 2 - Categorical variables

VARIABLES	(1) Frequency	(2) Percent	(3) Cumulative
Degree of urbanization			
Very urban	132,855	21.35%	21.35%
Highly urban	154,479	24.82%	46.17%
Moderately urban	124,213	19.96%	66.13%
Little urban	117,137	18.82%	84.95%
Not urban	93,630	15.05%	100.00%
Building period			
1500 - 1905	33,613	5.40%	5.40%
1906 - 1930	65,566	10.54%	15.94%
1931 - 1944	43,852	7.05%	22.98%
1945 - 1959	47,960	7.71%	30.69%
1960 - 1970	90,142	14.48%	45.18%
1971 - 1980	98,965	15.90%	61.08%
1981 - 1990	78,571	12.63%	73.70%

1991 - 2000	82,173	13.20%	86.91%
> 2001	81,472	13.09%	100.00%
Macro area			
Randstad	262,628	42.20%	42.20%
Intermediary	199,289	32.02%	74.23%
Periphery	160,397	25.77%	100.00%
Insulation			
No insulation	81,650	13.12%	13.12%
1 type	175,331	28.17%	41.29%
2 types	89,910	14.45%	55.74%
3 types	76,013	12.21%	67.96%
4 types	74,591	11.99%	79.94%
5 or more / fully insulated	124,819	20.06%	100.00%
Maintenance			
Very poor maintenance	715	0.11%	0.11%
Very poor to poor maintenance	861	0.14%	0.25%
Poor maintenance	3,786	0.61%	0.86%
Poor to average maintenance	5,378	0.86%	1.73%
Average maintenance	28,032	4.50%	6.23%
Average to good maintenance	52,496	8.44%	14.67%
Good maintenance	458,093	73.61%	88.28%
Good to excellent maintenance	40,038	6.43%	94.71%
Excellent maintenance	32,915	5.29%	100.00%
House type			
Terraced house	171,134	27.50%	27.50%
Corner house	71,976	11.57%	39.07%
Semi-detached house	112,716	18.11%	57.18%
Detached house	98,535	15.83%	73.01%
Apartment	167,953	26.99%	100.00%

Notes: Descriptive statistics for the categorical variables. The sample includes all individual transaction during the period of May 1st, 2017, to May 18th, 2021. Degree of urbanization is based on address density per km^2. Macro area is defined based on Dutch National Bureau of Statistics grouping. Maintenance represents the average maintenance score of inside and outside maintenance.

4. Methodology

4.1. Bid-price curve

Following the study by Gupta et al. (2021), the empirical analysis starts with analyzing the effect on transaction prices and its gradient, using the bid-price curve framework by Alonso (1964) and applying it to the Netherlands. The bid-price curve theory is based on a monocentric city model. The model is therefore limited in its application on the Dutch housing market as this market is characterized by polycentric city regions and different urban areas that are interconnected. Despite its limitations, the bid-price curve in my research has the purpose to show whether an effect at the level of the city core including suburban areas can already be seen. Another goal of applying this model is to help with the interpretation of the results of the difference-in-difference methodology. I use a standard bid-price curve plot with a cross-sectional relationship between transaction prices per square meter and the (defined) distance to the city center.

The distance to the city center is defined in kilometers. The city center is determined based on intuition and center definition by the municipalities. Most of the city centers are retail shopping districts. Table 3 shows the cities used for the bid-price analysis and their respective city centers and the coordinates of those city centers. The NVM dataset includes coordinates of the Rijksdriehoeksmeting coordinates system. X and Y coordinates are in meters.

Table 3 - City center definitions

(1) Classification	(2) City	(3) City center	(4) Coordinates (X, Y)	(5) Radius (km)
G4	Amsterdam	Damplein	121350, 487347	10
G4	Utrecht	Domkerk	136850, 455871	10
G4	The Haque	Binnenhof	81297, 455098	6.5
G4	Rotterdam	Town hall	92552, 437536	8
G40	Groningen	Grote Markt	233851, 581991	10
G40	Eindhoven	Central Station	161531, 383756	10
G40	Den Bosch	Markt	149229, 411144	10

Notes: City center definitions used for the bid-price curve analysis. Coordinates are from the Rijksdriehoeksmeting coordinate system.

Subsequently, the distance to the city center can be defined using the Euclidean distance theory. Distance is defined as:

$$d_i(x,y) = \frac{\sqrt{\left(x_i - x_{city}\right)^2 + \left(y_i - y_{city}\right)^2}}{1{,}000} \qquad (1)$$

Where, d_i is the distance between transaction i and its respective city center. The distance is derived from the city center's coordinates x_{city} and y_{city}, and the location coordinates x_i and y_i of transaction i. The radius is set at 10 kilometers. However, for The Haque and Rotterdam, the radius is set at 6.5 and 8 kilometers respectively. The Haque is set at 6.5 kilometers because it would otherwise include Wassenaar, which is a very exclusive and high-end area. Consequently, this would sabotage the bid-price curve. Rotterdam is set at 8 kilometers so that transactions from Delft are not included in the analysis.

Subsequently, the lockdown period is compared with the year earlier. The lockdown period starts on the 21st of March 2020 and ends on the 18th of March 2021, which is the last data observation.

The other period is from March 21st, 2019, to March 21st, 2020. The start of the lockdown period is set at the 21st of March 2020 as this is the day where the "intelligent" lockdown was introduced in the Netherlands.

4.2. Difference-in-difference

The main analysis of this paper analyzes the impact of several (spatial) housing preferences on transaction prices during Covid-19. First, a Hedonic Price Model is constructed to allow for property heterogeneity affecting transaction prices. However, reverse causality and omitted variable bias are two endogeneity problems that may threaten identification in most empirical studies (Hang et al., 2020). Reverse causality is not likely to be an issue in this study as the outbreak of Covid-19 is unexpected. On the other hand, omitted variable bias may result in inconsistent estimates.

To minimize the omitted variable bias, I use a relatively new difference-in-difference framework based on the empirical framework by Hassink et al. (2020), Hang et al. (2020) and Wang (2021). For a panel of individual transactions, I apply a difference-in-difference specification by interacting the 0-1 indicator for the lockdown period (which is set to one for the period March 21st, 2020, to March 18th, 2021, and the period March 21st, 2018, to March 18th, 2019) with the 0-1 indicator for the treatment group (which is set to one for the period March 18th, 2019, to March 18th, 2021). The model calculates the difference between the treatment house prices after the lockdown and the control house prices after the lockdown. At the same time, the model calculates the difference between the treatment house prices before the lockdown and control house prices before the lockdown. Subsequently, the two differences are subtracted to yield the net effect of the lockdown relative to before. To answer the research questions, I estimate a heterogeneous difference-in-difference model by complementing the model with a triple interaction between lockdown, treatment, and a variable of interest. This is a special form of the traditional difference-in-difference framework, as the control group is the same group in a different period. The traditional difference-in-difference framework has to be adjusted because the Covid-19 measures impacted all transactions in the Netherlands during the lockdown period which makes it impossible to find a corresponding control group. By adding monthly fixed effects, I control for price variations and nation-wide month-specific shocks over time between the treatment and control group. Figure 2 visualizes the difference-in-difference framework using a timeline.

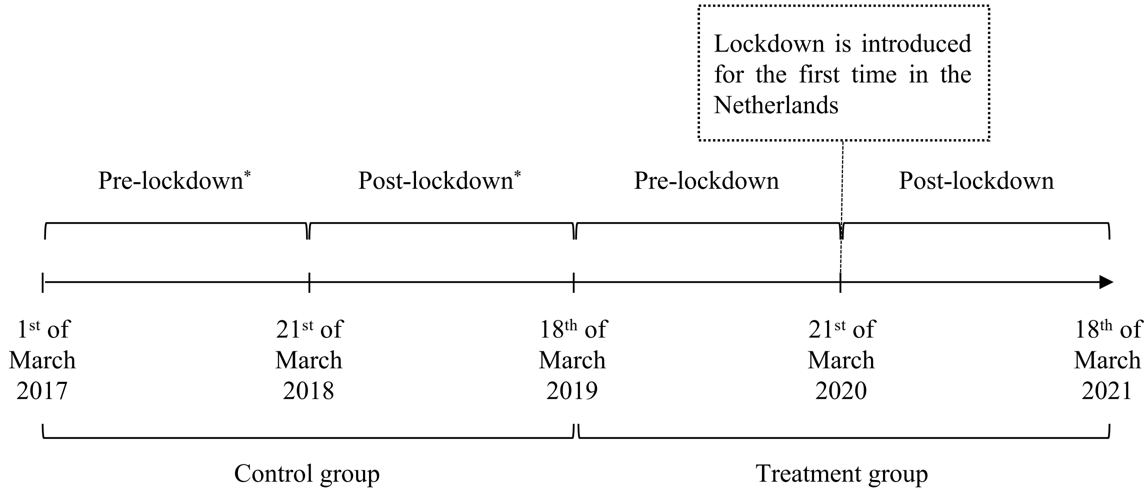

Figure 2: Difference-in-difference framework. * Pre-lockdown and post-lockdown periods are compared in both the control and treatment group through the LO_t dummy variable in Equation 3. Although there was no lockdown during the control group period, I have named the two periods pre-lockdown and post-lockdown to show that the same periods of the year are compared both in the control and treatment group.

For the difference-in-difference framework, I use a hedonic price model to allow for property heterogeneity. This hedonic price model is inspired by the hedonic price model used by van Dijk & Francke (2015). The hedonic price model specification is:

$$log(P_i) = \beta_0 + \beta_1\, log(HSize_i) + \beta_2 TUIN_i + \beta_3 HType_i + \beta_4 Insul_i + \beta_5 BPeriod_i + \beta_6 Maint_i + \beta_7 Parking_i + \varepsilon_i \quad \{i \in 1, \dots, N\} \tag{2}$$

For which P_i is the outcome variable that is transaction price for transaction i in month t. $HSize_i$ is the log of the house size in m^2. $TUIN_i$ is a categorical variable that is equal to 0 if there is no garden at all, 1 when the garden has a size up to 100 m^2, 2 when the garden has a size between 100 and 200 m^2, and 3 if the garden size is bigger than 200 m^2 for transaction i. $HType_i$ is a categorical variable that indicates the house type of transaction i. A distinction is made between terraced houses, corner houses, semi-detached houses, detached houses, and apartments. $Insul_i$ is a categorical variable that indicates the number of different types of insulation of transaction i. $BPeriod_i$ indicates the building period of transaction i. $Maint_i$ shows the average maintenance score between inside and outside maintenance of transaction i. $Parking_i$ is a categorical variable that specifies the kind of parking availability of transaction i.

Following this hedonic price model specification, the difference-in-difference framework is:

$$\log(P_{i,t}) = \eta_0 + \beta LO_t + \gamma TR_t + \delta LO_t * TR_t + \varphi TR_t * E_i + \omega LO_t * E_i + \theta LO_t * TR_t * E_i + \zeta' X_i + \lambda_t + \alpha_i + \varepsilon_i \quad (3)$$
$$\{i \in 1, \dots, N; t \in 1, \dots, 49\}$$

Where, LO_t is a dummy variable that equals 1 when the transaction took place in the period May 21st, 2020, to May 18th, 2021, and the period May 21st, 2018, to May 18th, 2019, to indicate the lockdown period. TR_t is a dummy variable that equals 1 when the transaction took place in the period May 18th, 2019, to May 18th, 2021, to indicate the treatment group. E_i is the variable of interest to answer the research questions. The variable of interest changes over the different models used. For example, the variable of interest is the degree of urbanization for the model that tests the impact of Covid-19 on prices in different urban areas. When interacting the lockdown and treatment dummies with the variable of interest, the effect of Covid-19 can be isolated. Here, θ is the difference-in-difference estimator and represents the causal effect of the Covid-19 outbreak on the impact of housing characteristics on transaction prices. When the sign of the difference-in-difference estimator is positive, it indicates that the specific variable of interest positively impacts the transaction price during the lockdown period and vice versa. The variables of interest include degree of urbanization, macro area, log house size, garden size, house type, and insulation. Separate regressions will be used to estimate the effect on the different variables of interest. $' X_i$ is a vector of control variables that include log house size, garden size, house type, building period, maintenance, types of insulation, and parking availability. The vector of control variables differs across the different regressions to ensure that the variable of interest is not multicollinear with the control variables, and that the variable of interest is not included twice in the regression. Hedonic variables do not influence the lockdown measures taken by the government. Therefore, I do not interact the control variables with the difference-in-difference interaction terms as I do not expect heterogeneous effects of the control variables on the treatment variable. λ_t represents monthly fixed effects to control for month-specific nation-wide shocks and price variations over time. α_i represents neighborhood fixed effects, which accounts for time-invariant heterogeneous spatial characteristics except from degree of urbanization. ε_i is the error term of the model. I cluster the standard errors by neighborhood to account for spatial correlation of the error term.

5. Results

5.1. Descriptive analysis

To answer the research question, I start with showing descriptive evidence of price changes in the transaction price index. During the sample period different degrees of price increases are seen in Figure 1. To create a better understanding of price developments with respect to different special preferences, a split in degree of urbanization is shown in Figure 3. The transaction price index experienced lower growth for the less urban areas between mid 2018 and the start of 2020, while more urban areas continue their growth approximately. During the lockdown period (as of 21st of March 2020), the five different urban areas converge. Less urban areas experience a higher growth relative to more urban areas. An explanation could be that less urban areas become more popular and therefore experience higher price growth than more urban areas.

Figure 3: Monthly price index by degree of urbanization for the total sample period May 1st, 2017 – May 18th, 2021.

The same pattern is seen in Figure 4 for different types of houses. Apartments experience no real trend change during the lockdown period. However, detached houses experience rapid price increases during the lockdown period resulting in a convergence with the other house types.

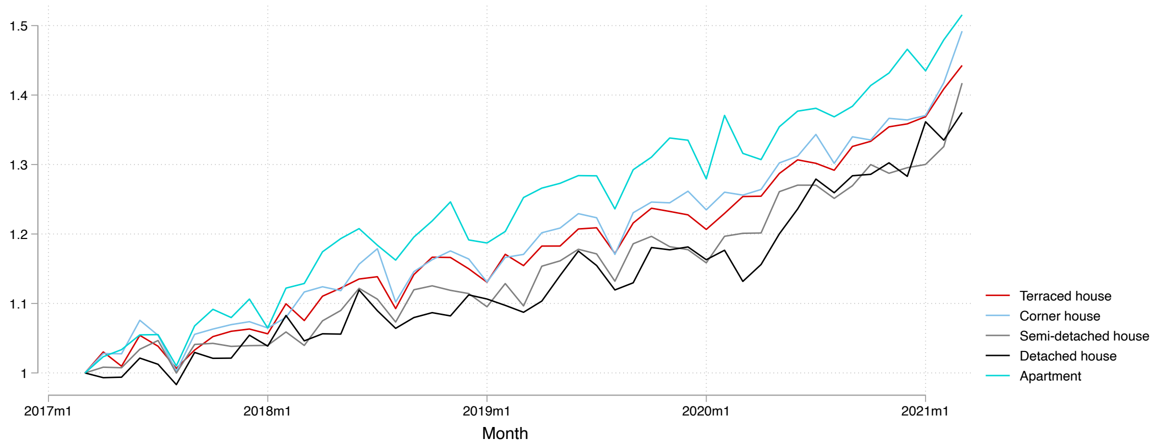

Figure 4: Monthly price index by house type for the total sample period May 1st, 2017 – May 18th, 2021.

5.2. Bid-price curve

It seems that areas with a lower degree of urbanization experience higher price growth during the lockdown period. However, as degree of urbanization is measured on ZIP code level, within a city, different degrees of urbanization are present. For example, Amsterdam encompasses all five degrees of urbanization. To analyze the effect within the bigger cities, a bid-price curve is applied to analyze the price effect with respect to distance to the city center.

Figure 5 to Figure 8 show the cross-sectional relationship in the G4 cities between the log of the transaction price per m^2 and distance to the city center. The dots indicate individual transactions for the period of May 21st, 2019 – May 18th, 2021. Red dots specify transactions after the lockdown is introduced (21st of March 2020 – 18th of March 2021). Blue dots specify transactions before the lockdown is introduced (21st of March 2019 – 21st of March 2020).

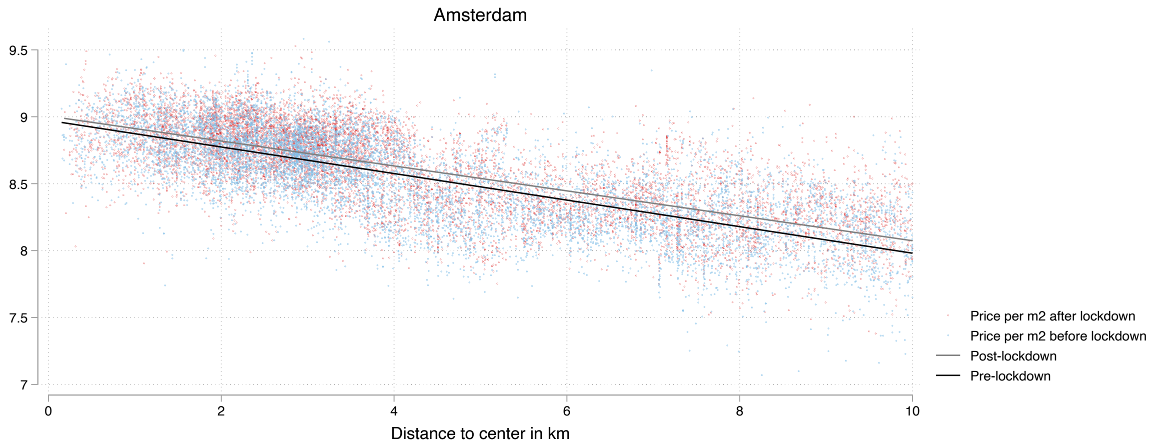

Figure 5: Bid-price curve for Amsterdam with a radius of 10 km. The plot shows the cross-sectional relationship between the log of the transaction price per m^2 and the distance to the city center. The city center is defined as Dam Square. The red dots show the individual transaction prices per m^2 after the lockdown was announced (21st of March 2020 – 18th of March 2021). The blue dots show the individual transaction prices per m^2 for the period before the lockdown was announced (21st of March 2019 – 21st of March 2020). For both periods, the linear relationship is shown.

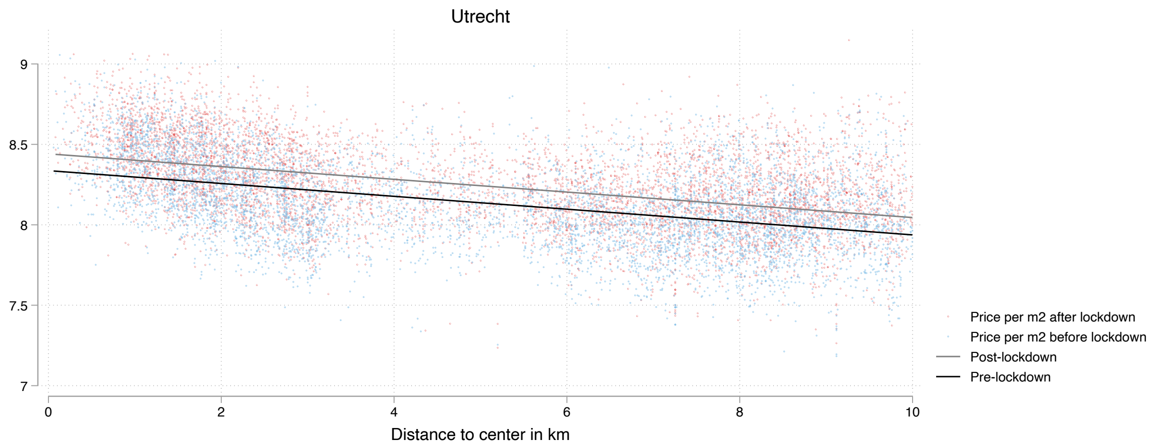

Figure 6: Bid-price curve for Utrecht with a radius of 10 km. The plot shows the cross-sectional relationship between the log of the individual transaction prices per m^2 and the distance to the city center. The city center is defined as Domkerk. The red dots show the individual transaction prices per m^2 after the lockdown was announced (21st of March 2020 – 18th of March 2021). The blue dots show the transaction price per m^2 for the period before the lockdown was announced (21st of March 2019 – 21st of March 2020). For both periods, the linear relationship is shown.

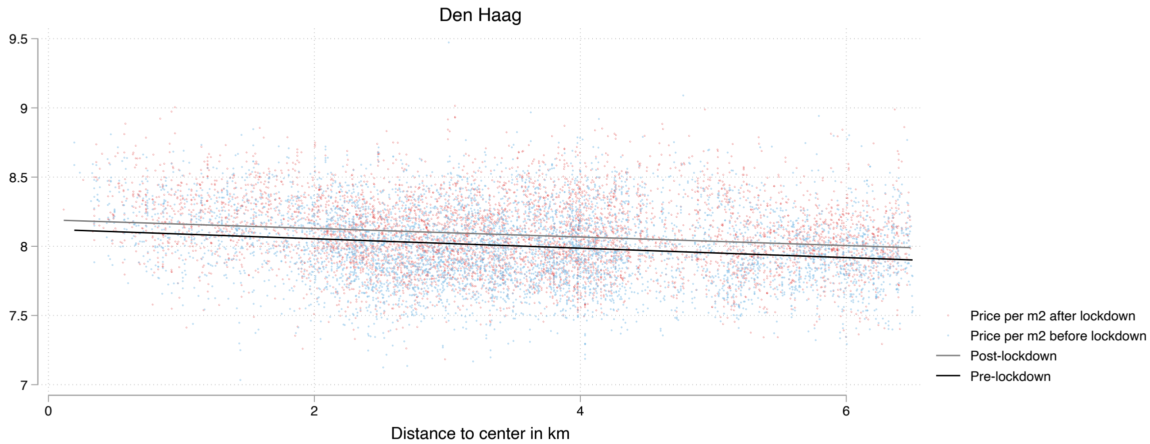

Figure 7: Bid-price curve for The Haque with a radius of 6.5 km. The radius is decreased because otherwise the very expensive neighborhood Wassenaar would be included, making the bid-price curve unrealistic. The plot shows the cross-sectional relationship between the log of the individual transaction prices per m^2 and the distance to the city center. The city center is defined as Binnenhof. The red dots show the individual transaction prices per m^2 after the lockdown was announced (21st of March 2020 – 18th of March 2021). The blue dots show the transaction price per m^2 for the period before the lockdown was announced (21st of March 2019 – 21st of March 2020). For both periods, the linear relationship is shown.

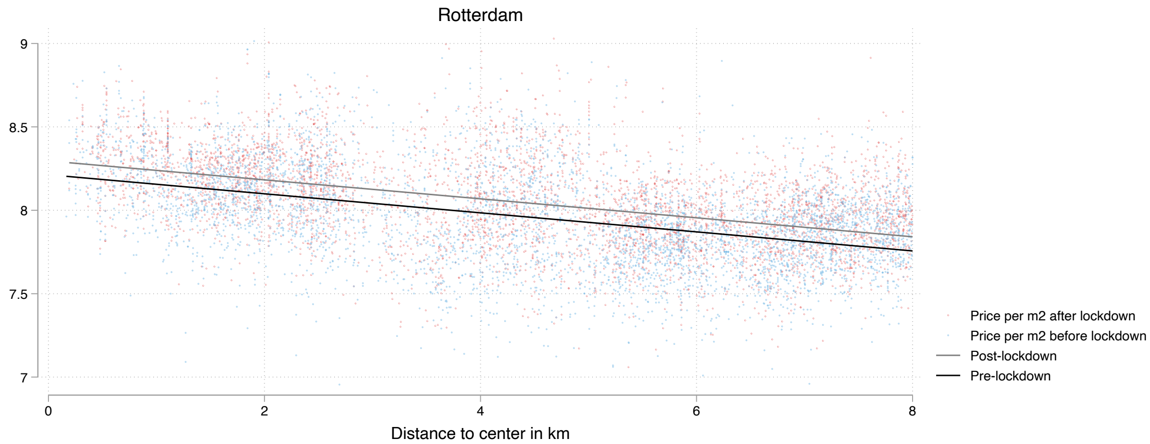

Figure 8: Bid-price curve for Rotterdam with a radius of 8 km. The radius is decreased because otherwise the radius would intervene with Delft, making the bid-price curve not useful. The plot shows the cross-sectional relationship between the log of the individual transaction prices per m^2 and the distance to the city center. The city center is defined as Grote Markt. The red dots show the individual transaction prices per m^2 after the lockdown was announced (21st of March 2020 – 18th of March 2021). The blue dots show the transaction price per m^2 for the period before the lockdown was announced (21st of March 2019 – 21st of March 2020). For both periods, the linear relationship is shown.

Although the bid-price curve theory is based on a monocentric city model, the bid-price curve for the Dutch cities shown in figures 5 to 8 and appendix figures A1 to A3 show the traditional declining bid-price curve. For all the G4 cities, a price increase is seen between the two periods. Following hypothesis (1), public debate, and the flattened curve in the US (Gupta et al., 2021), one would expect that the curve flattens making the suburban areas (further away from the city center) more expensive. Yet, the curve only flattens in Amsterdam. Remarkably, transaction prices per square meter in The Haque are almost uniformly distributed over distance, making the bid-price curve nearly flat in both periods.

The same pattern is seen for smaller cities. Appendix figures A1 to A3 show the bid-price curves for smaller cities in the Netherlands (Groningen, Eindhoven, and Den Bosch). For the smaller cities, no flattening effect is present in the slope of the curve. In fact, for Eindhoven and Den Bosch, the curve even steepens, meaning that prices closer to the city center have increased faster than away from the city center. Therefore, I must reject hypothesis (1) stating that the bid-price curve flattens during the lockdown period. Furthermore, prices have increased between the two periods for all cities.

5.3. Difference-in-difference

For the main analysis, a difference-in-difference framework using a triple difference estimator is exploited to analyze potential drivers of the changing price gradient. Table 4 shows the empirical results illustrating the effect of the lockdown period on transaction prices for the triple difference interactions. The first model is focused on the changes in the effect of degree of urbanization on transaction prices. The results in column (1) come from a simplistic difference-in-difference model where only the interaction terms are included. Column (2) shows the same model with neighborhood fixed effects and month fixed effects included, to control for time-invariant neighborhood specific characteristics, besides degree of urbanization and month-specific price variations. Colum (3) complements the model by adding hedonic control variables to allow for property heterogeneity. The results from column (3) come from the regression following Equation (3). The coefficients of the control variables and other interaction terms can be found in appendix Table A1.

Column (3) shows that house prices in very urban and highly urban areas are significantly negatively affected by the lockdown period compared to moderately urban areas. The results are significant at the 1% level. Furthermore, not urban areas are significantly positively affected by the lockdown period compared to moderately urban areas (significant at the 1% level). Especially very urban areas are affected severely by the lockdown with a negative price change of 4.4% compared to moderately urban areas. The effect of the lockdown period on prices in little urban areas seem to be somewhat more moderate and are significantly positive at the 5% level. Not urban areas benefited the most from the lockdown with a positive price impact of 1.9% compared to moderately urban areas. Looking at the results of the difference-in-difference hedonic price model framework, it seems that house prices have increased faster for less urban areas compared to moderately urban areas during the lockdown period. In addition, more urban areas that experienced high price growth in recent years, seem to have encountered smaller price growth compared to moderately urban areas during the lockdown period. The results confirm the findings in the descriptive analysis of the price index. In Figure 3, prices of different urban areas converge during the lockdown period. With the difference-in-difference framework I can confirm that the results I found in the descriptive analysis are indeed significant.

Table 4 - Regression degree of urbanization

	(1)	(2)	(3)
VARIABLES	Log price	Log price	Log price
Very urban * Lockdown * Treatment	-0.059***	-0.066***	-0.044***
	(0.009)	(0.008)	(0.005)
Highly urban * Lockdown * Treatment	-0.014*	-0.025***	-0.012***
	(0.008)	(0.006)	(0.003)
Little urban * Lockdown * Treatment	0.018**	0.008	0.007**
	(0.008)	(0.007)	(0.003)
Not urban * Lockdown * Treatment	0.038***	0.025***	0.019***
	(0.010)	(0.008)	(0.004)
Observations	622,314	622,278	622,278
R-squared	0.058	0.396	0.862
Adjusted R-squared	0.058	0.394	0.861
Neighborhood fixed effects	No	Yes	Yes
Time fixed effects	No	Yes	Yes
Control variables	No	No	Yes

Notes: Regression output that looks at the impact of the Covid-19 lockdown period on house prices using a difference-in-difference hedonic price model specification. The sample includes all individual transaction during the period of May 1st, 2017, to May 18th, 2021. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to moderately urban areas. Control variables are included to allow for property heterogeneity and include log house size, garden size, house type, building period, maintenance, types of insulation, and parking availability. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level and are in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Figure 9 shows a forest plot to visualize the results of column (3) in Table 4. Confidence intervals for the 90%, 95% and 99% are included. From Figure 9, one can see more clearly the positive price impact of the lockdown period for more urban areas and negative price impact for less urban areas compared to moderately urban areas. As the confidence intervals overlap for little urban and not urban areas, I can conclude that there is no significant difference between the two. The results confirm hypothesis (2), as prices in more urban areas experience negative price developments and price in less urban areas experience positive price developments during the lockdown in the Netherlands.

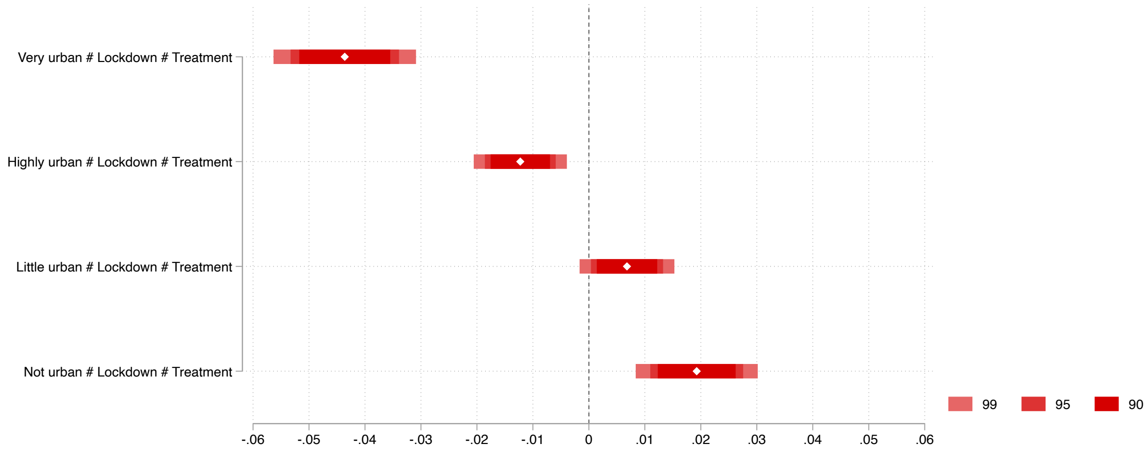

Figure 9: Forest plot of difference-in-difference model, with the logarithm of transaction price as dependent variable and as variable of interest the different degrees of urbanization. The horizontal axis shows the percentage change for transaction prices. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to moderately urban areas. Control variables are included to allow for property heterogeneity and include log house size, garden size, house type, building period, maintenance, types of insulation, and parking availability. Neighborhood fixed effects are included. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level.

Additionally, the increased migration balance between intermediary/periphery zones and the Randstad in the results of CBS (2021) give reason to analyze the price changes between macro areas during the lockdown period. Figure 10 shows a forest plot of the difference-in-difference coefficients for the macro areas. The full regression table is included in appendix Table A2. Figure 10 and Table A2 show that transaction prices in the Randstad are negatively impacted by the lockdown with -3.5% compared to the intermediary zone. Furthermore, Figure 10 shows that prices in the periphery have experienced positive price impact of 1.2% by the lockdown compared to the intermediary zone. Both coefficients are significant at the 1% level. The findings are in line with expectations as the Randstad has relatively more urbanized areas compared to the intermediary and periphery zone. The results of Figure 10 and Table A2 confirm hypothesis (3).

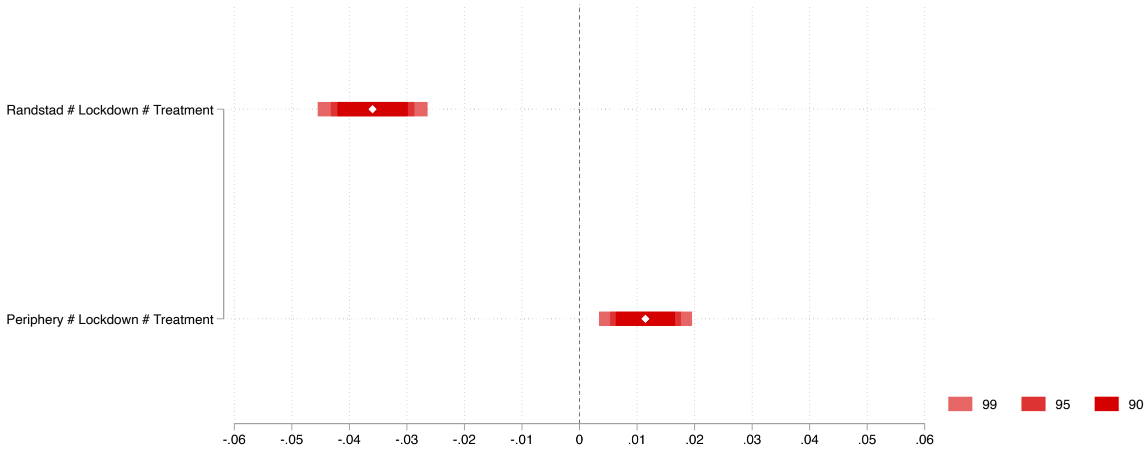

Figure 10: Forest plot of difference-in-difference model, with the logarithm of transaction price as dependent variable and as variable of interest the different macro areas. The horizontal axis shows the percentage change for transaction prices. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to the intermediary zone. Control variables are included to allow for property heterogeneity and include log house size, garden size, house type, building period, maintenance, types of insulation, and parking availability. Neighborhood fixed effects are included. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level.

5.4. Extensions

In addition to the main analysis, I analyze how several housing characteristics relate to house pricing during the lockdown period. To check hypothesis (4) and (5), the same difference-in-difference specification is used as described in Equation (3). Figure 11 focuses on the impact of house size on prices by the lockdown. Through a stepwise logarithmic house size variable, the effect of the lockdown on transaction prices is shown for different house sizes. For the step-function, three different variables are created. The first variable includes the house size in square meters for houses up to 100 m^2. The second variable includes the house size in m^2 for houses between 100 m^2 and 200 m^2. The third variable includes the house size in m^2 for houses bigger than 200 m^2. I do this to allow for the law of diminishing returns as the house gets bigger. From Figure 11 and Table A3 one can see that prices for all house sizes are positively affected by the lockdown at the 1% level. However, although there is a positive effect for house size in general, there is no significant difference between the total house size as all confidence intervals overlap. According to the law of diminishing returns, one would expect larger house sizes to experience lower price additions for every extra square meter when the total house size gets larger. This effect is not present in the results shown in Figure 11. Hence, it seems that houses with a larger house size are positively affected by the lockdown.

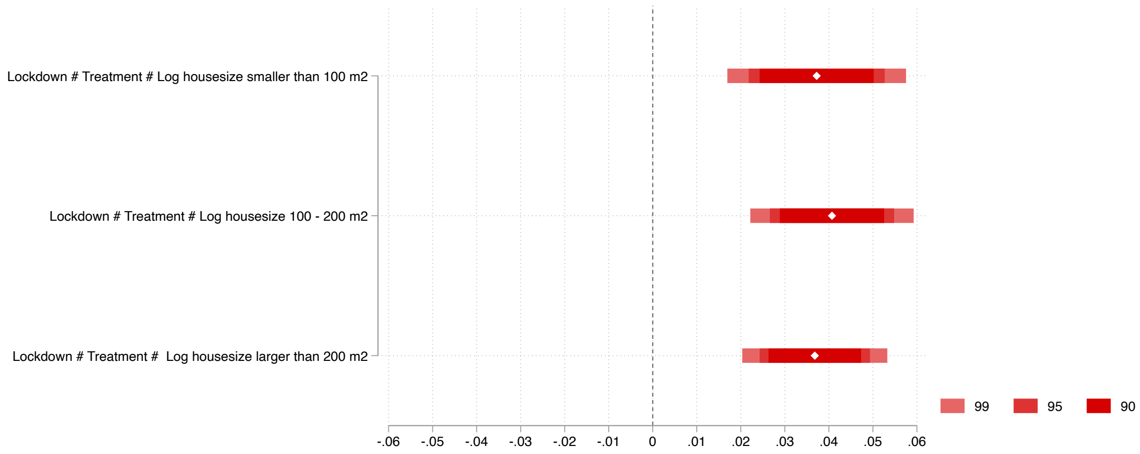

Figure 11: Forest plot of difference-in-difference model, with the logarithm of transaction price as dependent variable and as variables of interest a step function of the logarithm of the house size. The first variable includes the house size in m2 for houses up to 100 m2. The second variable includes the house size in m2 for houses between 100 m2 and 200 m2. The third variable includes the house size in m2 for houses bigger than 200 m2. The horizontal axis shows the percentage change for transaction prices. The specification is described in the methodology section under difference-in-difference. Control variables are included to allow for property heterogeneity and include garden size, building period, maintenance, types of insulation, and parking availability. Neighborhood fixed effects are included. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level.

To continue analyzing hypothesis (4), I look at the impact of the lockdown on prices of different house types. According to previous results and literature, it is expected that apartments, which are usually smaller houses without outdoor space, are negatively impacted by the lockdown. Figure 12 and Table A4 show the results for the difference-in-difference specification with house types as variable of interest. For almost all house types, the effect is very moderate. The lockdown affected prices of semi-detached and detached houses only moderately with a small positive price increase compared to terraced houses (significant at the 5% level). Corner houses are not impacted at all by the lockdown compared to terraced houses. However, apartments are impacted very significantly by the lockdown. Prices of apartments are negatively affected by the lockdown with 5.2% compared to terraced houses.

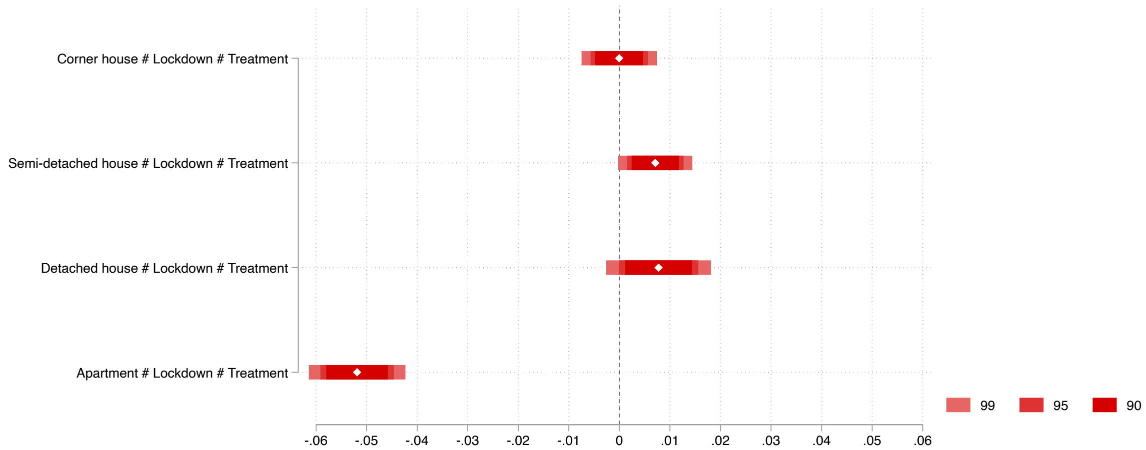

Figure 12: Forest plot of difference-in-difference model, with the logarithm of transaction price as dependent variable and as variable of interest the different house types. The horizontal axis shows the percentage change for transaction prices. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to terraced houses. Control variables are included to allow for property heterogeneity and include log house size, garden size, building period, maintenance, types of insulation, and parking availability. Neighborhood fixed effects are included. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level.

The same specification is used for garden sizes. Four dummy variables equal 1 if the garden size falls within the intervals. The three coefficients seen in Figure 13 and Table A5 are compared to houses with a garden smaller than 100 m^2. The results show that prices of houses without a garden are negatively impacted by the lockdown with 3.6% compared to houses with a garden up to 100 m^2. Prices for houses with larger gardens (both 100 – 200 m^2 and gardens larger than 200 m^2) are positively impacted by the lockdown period compared to houses with gardens up to 100 m^2. This confirms the expectation that people are looking for more outdoor space during the lockdown period.

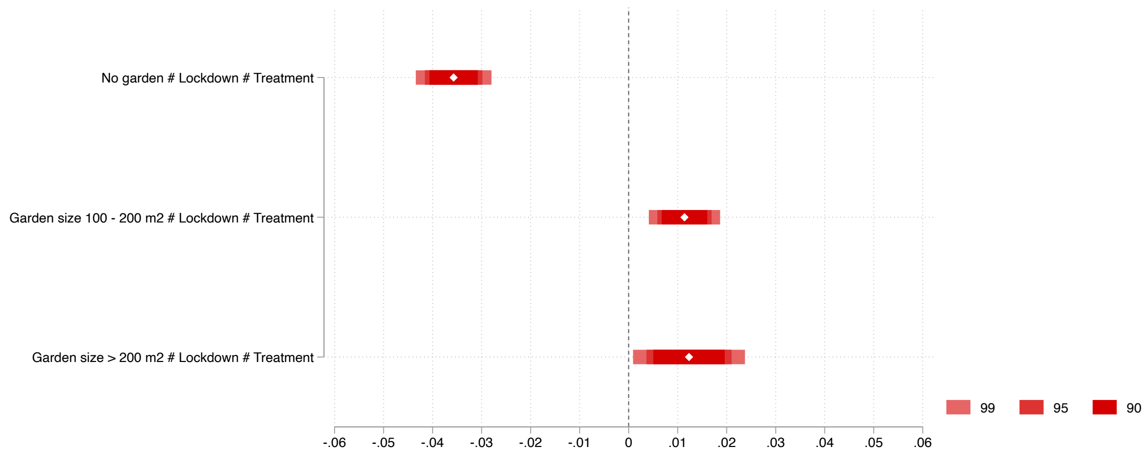

Figure 13: Forest plot of difference-in-difference model with as dependent variable the logarithm of transaction price and as variable of interest the different garden dummies. The horizontal axis shows the percentage change for transaction prices. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to houses with a garden size smaller than 100 m^2. Control variables are included to allow for property heterogeneity and include log house size, house type, building period, maintenance, types of insulation, and parking availability. Neighborhood fixed effects are included. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level.

The results from the models shown in figures 11, 12 and 13 and tables A3, A4, and A5 confirm hypothesis (4). To analyze the last hypothesis, the framework from Equation (3) is used to determine the effect of the lockdown on house prices with different types of insulation. The results in Figure 14 and Table A6 show that prices of houses with two, three, and four types of insulation are impacted positively by the lockdown compared to houses with only one type of insulation. Transaction prices of houses with no insulation and houses which are fully insulated seem not to be impacted by the lockdown compared to houses with only one type of insulation. The fact that there is no effect for houses that are fully insulated compared to houses that have only one type of insulation is remarkable and against expectations set in the literature by Nanda et al. *(2021)*. Hypothesis (5) is therefore only partially confirmed, as this is true for houses with up to four types of insulation.

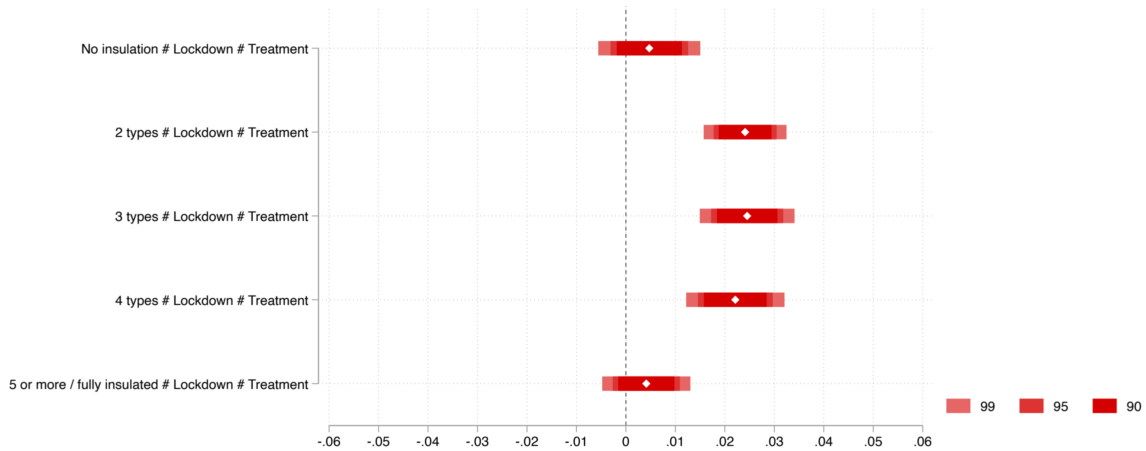

Figure 14: Forest plot of difference-in-difference model with as dependent variable the logarithm of transaction price and as variable of interest the number of different types of insulation. The horizontal axis shows the percentage change for transaction prices. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to houses with only one type of insulation. Control variables are included to allow for property heterogeneity and include log house size, house type, building period, maintenance, types of insulation, and parking availability. Neighborhood fixed effects are included. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level.

6. Robustness

The results in Section (5) show that prices in more urban areas are negatively impacted by the lockdown period. In addition, the Randstad experienced negative price developments during the lockdown period compared to the intermediary and periphery zones. As can be seen from the additional analysis, prices of houses with housing characteristics that suit larger houses in less urban areas (bigger house size, outdoor space, non-apartment house types) are positively impacted by the lockdown. Although the empirical strategy allows us to isolate a possible price effect from time-dependent variables, this does not mean that the Covid pandemic (and with it the growth in working from home and changing living preferences) are really the cause of the price movements. In this section, I perform a couple of robustness checks to develop a causal understanding of the lockdown period.

6.1. *First-look robustness checks*

One concern is the introduction of the new transfer tax system since January 2021. During the first months of 2021, a sharp increase in young home buyers (< 35 years old) occurred, resulting in a 40% increase in the number of transactions in January 2021 compared to January 2020 (de Groot et al., 2021). The new transfer tax system includes an exemption from transfer tax for home buyers up to the age of 35 and increases the transfer tax from 2% to 8% for investors. As of April 2021, the house may not be more expensive than €400,000 to be able to apply for this tax treatment. The tax shock may have an impact on the results outlined in Section (5). There are two possible effects of the changing tax system on the results. (1) The more urban areas see an increased demand from young home buyers as younger home buyers traditionally prefer urban areas over non-urban areas. (2) As of April 2021, less urban areas see an increased demand from young home buyers as the transaction price needs to be smaller than €400,000, making it hard to find houses below that price tag in more urban areas. Table A7 shows the regression results when the period of the new tax system introduction is excluded (May 1st, 2017, to December 31st, 2020). I find no significant change in the difference-in-difference estimators showing that the results are not influenced by the newly introduced transfer tax system.

Another concern with respect to the results in different degrees of urbanization and macro areas is the decreasing availability of houses in the very and highly urban areas and the Randstad. In the past, transaction prices of more expensive detached houses in less urban areas experienced lower growth compared to apartments in the more urban areas. An explanation for this effect was the less tight housing market conditions for less urban areas according to de Vries (2021) in his column in ESB. Unfortunately, the dataset used in this research paper does not have access to demand and supply data of the Dutch housing market. However, the number of transactions per month can be assessed to see if there is an effect between different degrees of urbanization that could explain the regression results. Figure 15 shows the number of houses sold over the sample period by degree of urbanization. The figure shows a relatively stable number of transactions per month for all degrees of urbanization. I can therefore conclude that the results I found are not influenced by the number of available transactions in the different urban areas.

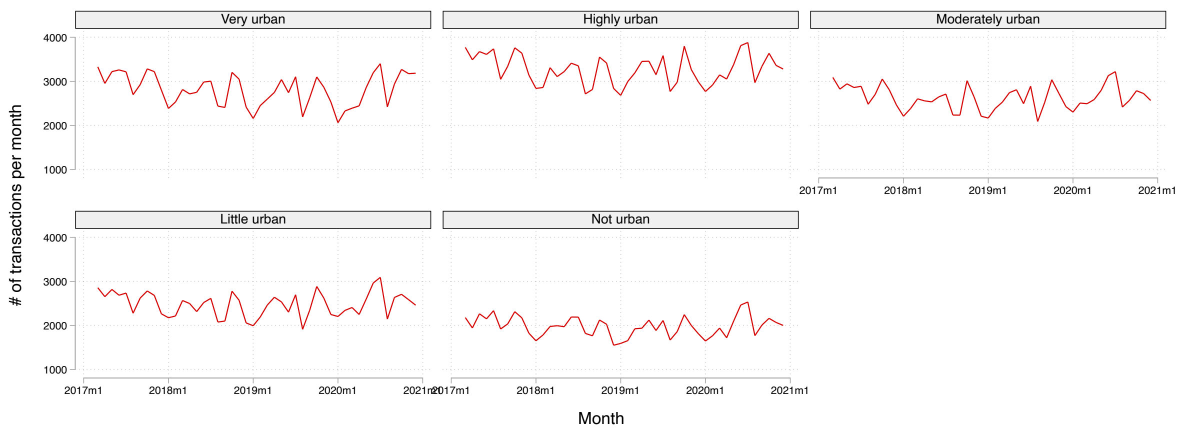

Figure 15: Number of transactions in the dataset per month by degree of urbanization.

6.2. Affordability

Prices have increased over the year for all urban areas as can be seen in Figure 3. When looking at price developments for absolute prices in Figure 16, a big difference can be seen in prices between urban and non-urban areas. The price difference between very urban and not urban areas is around €60,000 over 2019. Mid 2020, the average house in a not urban area was €350,000 while the average house in very urban areas was over €400,000. There is a possibility that the results found in Section (5) are not a Covid-19 effect, but an affordability issue between different degrees of urbanization.

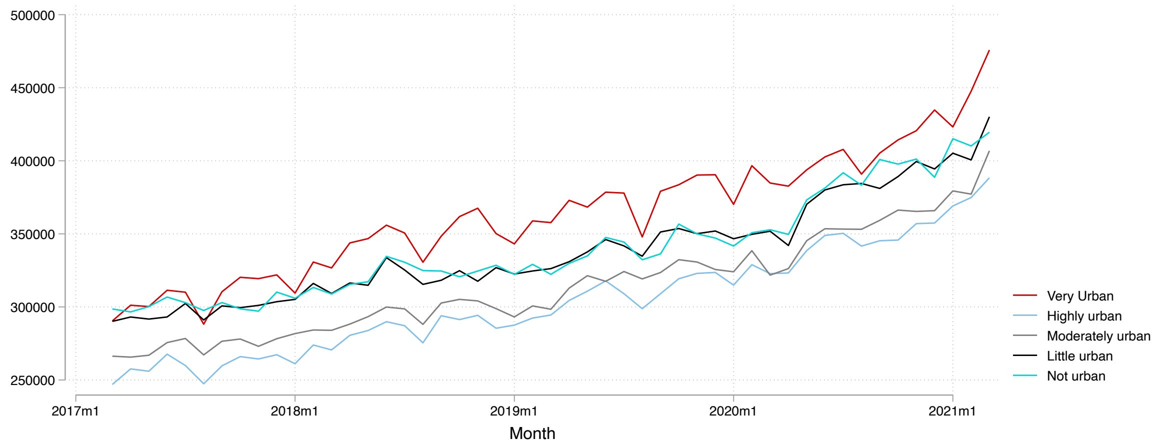

Figure 16: Mean transaction prices per month by degree of urbanization.

Running the same difference-in-difference specification in Equation (3) on a subsample of transactions smaller than €400,000, I find the same results as described in Section (5) with respect to different degrees of urbanization. The results are shown in Figure 17. For a subsample of transactions with a value between €400,000 and €1,000,000 only very urban areas are significantly negatively affected by the lockdown. For transaction prices above €1,000,000, there is no effect at all with respect to different degrees of urbanization. The results indicate an affordability issue as more urban areas are more expensive than less urban areas. This is confirmed by the findings that only for a subsample of transactions below €400,000, the effects are significant.

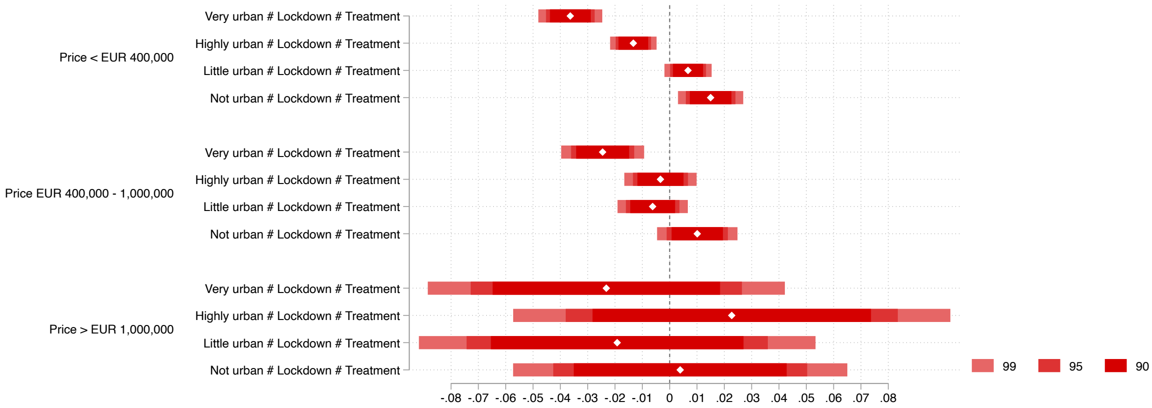

Figure 17: Forest plot of difference-in-difference model with as dependent variable the logarithm of transaction price and as variable of interest the different degrees of urbanization. The model is applied to three different subsamples categorized by transaction value: < €400,000, €400,000 - €1,000,000, and > €1,000,000. The horizontal axis shows the percentage change for transaction prices. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to moderately urban areas. Control variables are included to allow for property heterogeneity and include log house size, garden size, house type, building period, maintenance, types of insulation, and parking availability. Neighborhood fixed effects are included. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level.

6.3. Existing deurbanization trend

Another important issue is the historical trend in the Dutch housing market. As of the beginning of the 21st century, a trend of increased demand for urban housing emerged prior to the turn of the century and peaked in 2013 (de Vries, 2021). Since 2013, the trend reversed to more demand found outside of the urban environment (de Vries, 2021; CBS, 2021). To test whether this is the case, I perform the same difference-in-difference framework as described in the methodology section. However, it is applied to the situation one year earlier so that the sample period consists of May 1st, 2016, to May 18th, 2020. For this period, the Covid-19 outbreak and its corresponding lockdown is excluded from the sample. Table A8 shows the regression results for this model. The coefficient signs are the same for the model over the earlier sample period. It can therefore be concluded that the trend of deurbanization already started before the Covid-19 outbreak. This is an important finding as it contradicts a causal relationship between the lockdown period and price decreases (increases) in more (less) urban areas. I find the same results for the difference-in-difference model for the three macro areas and the different housing characteristics. Although there is possibly no causal relationship between the lockdown period and price developments for different (spatial) housing characteristics, the existing trend of deurbanization seems to have continued during the Covid-19 outbreak as the difference-in-difference estimators are still significant for the main models.

6.4. Macro areas

When performing the main model with a sample period of May 1st, 2017, to May 18th, 2021, on different subsamples, the different effects of degree of urbanization can be evaluated by macro area. To do this, I create three different subsamples for each macro area: Randstad, intermediary zone, and periphery. Figure 18 shows a forest plot of the results for the different subsamples. The results show that the effect of the lockdown is strongest in the Randstad area. The effect for all degrees of urbanization in the intermediary zone and periphery are less significant or not significant at all. This implies that demand for houses in less urbanized areas is increasing within the Randstad itself, but the effect is not as strong in other macro areas. The results suggest a trend of deurbanization, but not interregional migration.

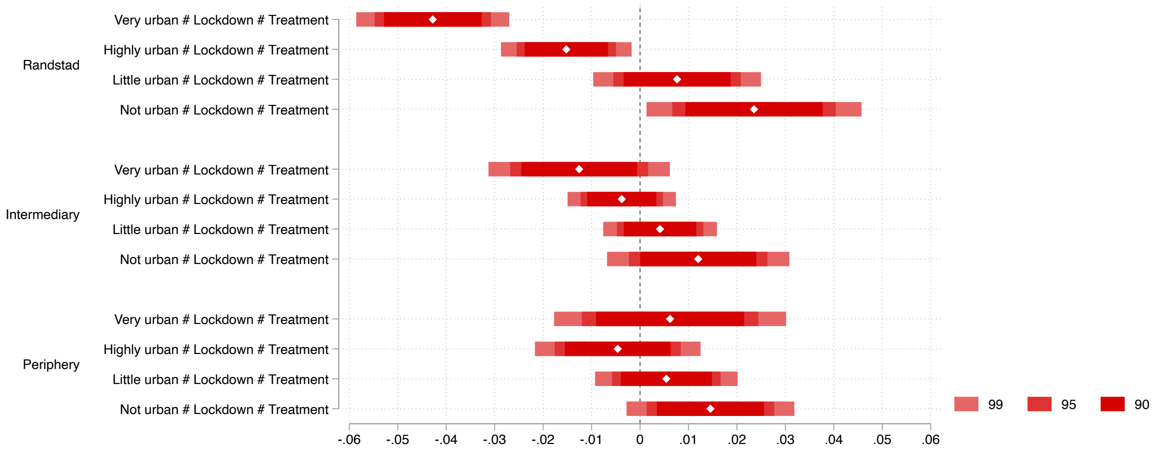

Figure 18: Forest plot of difference-in-difference model with as dependent variable the logarithm of transaction price and as variable of interest the different degrees of urbanization. The model is applied to three different subsamples: Randstad, intermediary, and periphery. The horizontal axis shows the percentage change for transaction prices. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to moderately urban areas. Control variables are included to allow for property heterogeneity and include log house size, garden size, house type, building period, maintenance, types of insulation, and parking availability. Neighborhood fixed effects are included. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level.

7. Conclusion

7.1. Conclusion

This paper investigates the effect of the lockdown on prices for different (spatial) housing characteristics. I start this paper by analyzing the effect descriptively using price indices created from the transaction dataset used. I see prices for different degrees of urbanization converge during the lockdown period. Additionally, detached houses experience large price increases during the lockdown period. This implies that demand for less urban areas and its corresponding house types is increasing during this period. Subsequently, a bid-price curve is created for the G4 cities as well as Groningen, Eindhoven, and Den Bosch. The results show that only the bid-price curve in Amsterdam has flattened during the lockdown compared to the pre-lockdown period, indicating that prices in the suburbs of Amsterdam have increased more than prices closer to the city center. To test whether there is a causal relationship between house prices and the lockdown, a relatively new modified difference-in-difference hedonic price model framework is used. The results of this model show that more urban areas are negatively impacted by the lockdown. Less urbanized areas are positively impacted by the lockdown.

Thereby, larger houses, houses with outdoor space, non-apartment house types, and houses with more types of insulation are positively impacted by the lockdown.

From a set of robustness checks, however, the findings suggest that there is not necessarily a causal relationship between the price developments and the lockdown. The results following the robustness checks show that the trend of deurbanization has started before the Covid-19 outbreak already. Yet, the Covid-19 outbreak seems to have continued this trend. All urban areas experience price increases as can be seen from Figure 3. However, from my research, I find a 4.4% and 1.2% lower price growth in prices for very urban and urban areas compared to moderately urban areas during the lockdown period respectively. Putting this number into perspective, the numbers are very similar to previous years. From my analysis using a sample period one year earlier excluding the Covid-19 outbreak, I find that very urban and urban areas lack 5.1% and 1.5% in price growth compared to moderately areas respectively. The Covid-19 outbreak has therefore not caused an acceleration of the existing deurbanization trend. However, there is still a significant difference in price developments between the different degrees of urbanization. Translating the numbers into economic interpretation, during the lockdown period, very urban areas lacked around €18,000 in value growth (4.4% of an average selling price of €410,000 in 2020 for very urban areas). This is a significant price difference.

When performing the same analysis on a set of subsamples, the results show that the price impact by the lockdown is especially significant in the Randstad area. This complies partially with the results of the bid-price curve and the flattening curve in Amsterdam as well as the results shown by Gupta et al (2021) in the US. In the US, bid-price curves flattened for almost all metropolitan statistical areas during the Covid-19 outbreak. A plausible explanation for the different effect in the Netherlands is that the Netherlands is characterized by its polycentric city model and interconnected urban areas, while the bid-price curve assumes a monocentric city model. My results show that the expectations by Nanda et al. (2021) of more demand for several housing characteristics due to Covid-19 are partially true. Although there is more demand for the house-specific characteristics Nanda et al. described, there is not necessarily a causal effect of Covid-19. The same effect is found for a sample period one year earlier excluding the Covid-19 outbreak.

Probably the most important finding is the affordability issue of houses in urbanized areas. From the analysis of different subsamples based on transaction prices, only for a subsample of transactions below €400,000 the effects with respect to different degrees of urbanization are significant. My results indicate an affordability issue for houses in more urbanized areas in the lower segment. My findings are supported by the findings of de Groot and Smit (2021). They found that only 12% of the people that are currently living in the urban cities have the desire to move away to a less urban area. The reason why other people still leave urban cities is that they are unable to find an affordable house within the urban city for the next step in their housing cycle (de Groot & Smit, 2021). It is therefore not the case that the urban cities lose popularity under home buyers, but that people are forced to move outside of the urban cities due to affordability issues. It seems that the price ceiling is (almost) reached for affordable houses in the urban cities.

7.2. Discussion

The results of my research show that there is not necessarily a causal effect of Covid-19 on the price developments in the Dutch housing market. A very likely explanation for this is the large disequilibrium in the Dutch housing market. Because of the huge demand in the Dutch housing market compared to the supply side, the effect of Covid-19 might be limited. Even though demand for some specific types of houses or areas may have dropped due to the Covid-19 outbreak, the demand is still extremely high, softening the effect of the Covid-19 outbreak on the Dutch housing market. If this is the case, no Covid-19 effect can be seen from the data.

The results following the robustness checks comply with the statements of Buitelaar (2021) in his opinion paper. Data from CBS shows that the popularity of urban cities (in this case Amsterdam) has not changed over the short-term based on both migration data and qualitative interview data (Buitelaar, 2021). Therefore, it is incorrect to state that urban areas will lose their popularity in the long-term. Firstly, when looking from a historical perspective, outbreaks in the 17th and 19th century in Amsterdam and Paris respectively show only short-lived price reductions whereafter prices returned to their initial price trend within one to two years after the end of the outbreak (Francke & Korevaar, 2021). Francke and Korevaar (2021) attributed the absence of any long-term effects on house prices to the resilience of urban cities to major shocks. Francke and Korevaar (2021) pointed out that the Covid-19 outbreak is expected to impact the housing market less severely than the historical outbreaks. My results show that this statement is true as there is no pure causal relationship found between house prices and Covid-19. This can be attributed to the introduction of policies that aim to limit the spread of the virus as well as improved living conditions and hygiene compared to the past. Additionally, the provision of financial support by governments to their citizens and companies during Covid-19 softens the impact of the outbreak.

Secondly, the population in Utrecht doubled in the second half of the 19th century even though Utrecht was hit by multiple severe Cholera outbreaks at the same time (Buitelaar, 2021). Finally, as Buitelaar also mentioned in his opinion paper, the urban cities offer much more than employment opportunities. It is also a place, especially for younger people, to socialize and make use of all amenities that the urban city has to offer. Less urban areas lack these amenities and socialization opportunities. Covid-19 is unlikely to also change those benefits of the urban cities after the lockdown measures are lifted.

It will be interesting to see whether remote working is really going to be implemented by many employers. It may be one of the motivations to continue the trend of deurbanization in the future. When the implementation of remote working does not go as well as expected, it can have major consequences for the decision-making process where people will settle. If that is the case, it is possible that people feel attracted to the urban cities again for its large employment opportunities and will cause increasing urbanization.

Another future possibility is that the deurbanization trend is continued for many years. From the results of my robustness checks, I already found that a major concern is the affordability of houses in the urban areas causing home seekers for houses up to €400,000 to avoid urbanized areas. If the price gap between the different kind of urban areas stays large, I would expect that the periphery and less urban areas will experience increased demand, contributing to the trend of deurbanization. This effect is enhanced by the ability to work from home as it removes the need to live close to work.

The results have important implications for policy makers in the Dutch housing market as existing trends have continued during the Covid-19 outbreak. It is important for policymakers to understand the current trends in the housing market and to act on them. One major concern for policy makers should be the affordability of highly urbanized areas, as my results show that affordability in urbanized areas causes people to move away from those areas. For a well-functioning city, it is important that people from all backgrounds and social classes have the opportunity to live there. Consequently, policy makers should focus on creating affordable housing in urban areas. The only way to solve this problem is to build more affordable houses in the urbanized areas. This needs to be a key focus point in the mission to build more houses to bring the housing market back to its demand supply equilibrium.

One limitation of my research is the lack of rental data. As shown in the study by Gupta et al. (2021), the rental sector is more sensitive to shocks caused by the lockdown as it is more elastic. I expect that a short-term Covid-19 effect can be found in the rental data as expats stayed away during the lockdown and therefore have not been part of the demand side for housing. Investor activity data can be added to see whether decreasing demand in the rental sector translates into lower house prices due to the lack of investor demand. Additionally, the bottom of the labor market has been mainly affected by Covid-19 as most of those jobs rely on face-to-face interactions like restaurants or travel agencies. Many of the participants in this specific part of the labor market are (social) tenants. This part of the society is not included in the dataset that is used for this study. Further research could include rental data to analyze the effect of Covid-19 on this specific group of people.

Another limitation of this study is that the difference-in-difference model used, lacks controls on unobservable ZIP code characteristics that might affect the net effect of the lockdown on house prices. For example, the model does not include the dominant working sector of a neighborhood. This can impact the results. If neighborhoods rely predominantly on sectors that require physical work, the lockdown has a more limiting effect on that neighborhood than neighborhoods that include more knowledge workers. This study can be extended with micro household data to control for these selection effects.

Also, as the lockdown measures are still in place, the long-term effects cannot be estimated using the data that is available. Extensions of this study can analyze the long-term effects of the Covid-19 outbreak using a sample that includes the period after Covid-19 when available. This will show whether the effects I found will hold in the long-term. It is especially interesting to see whether companies keep allowing their employees to work from home and how that impacts the Dutch housing market.

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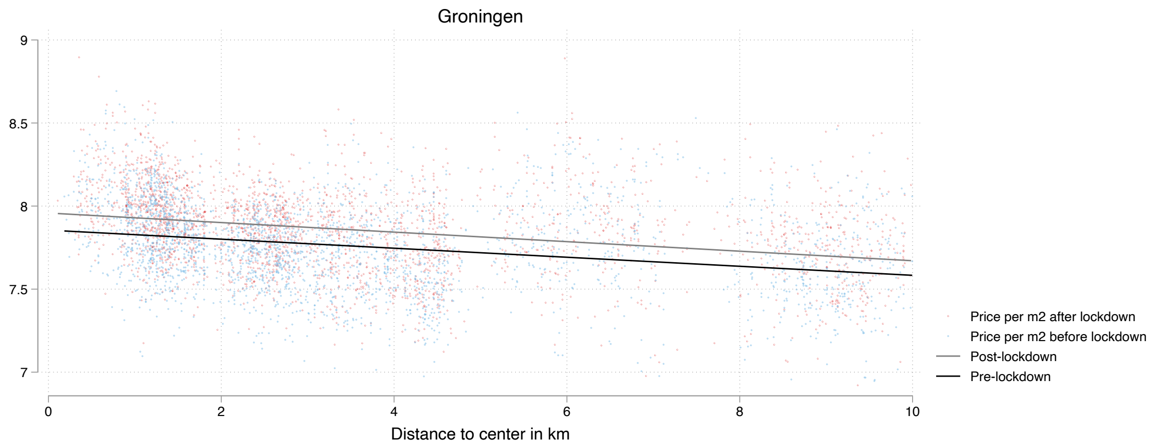
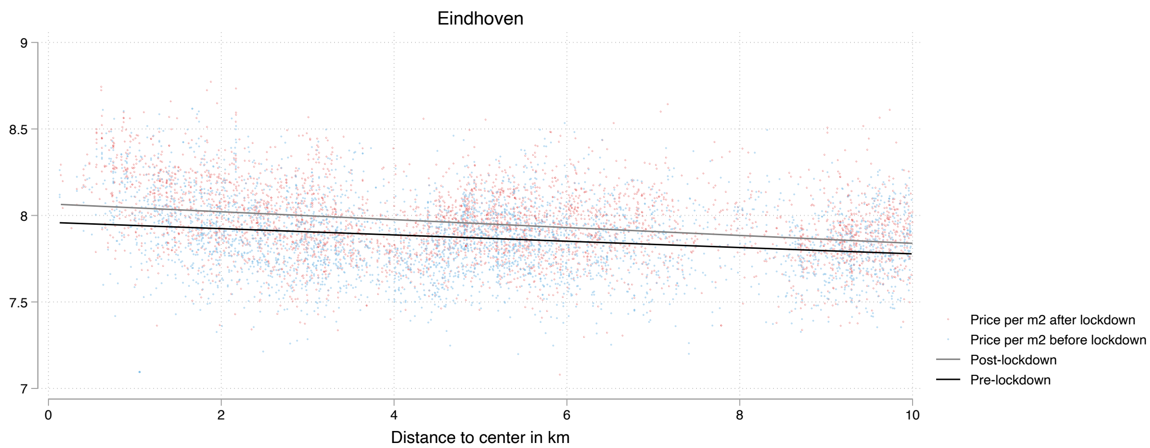
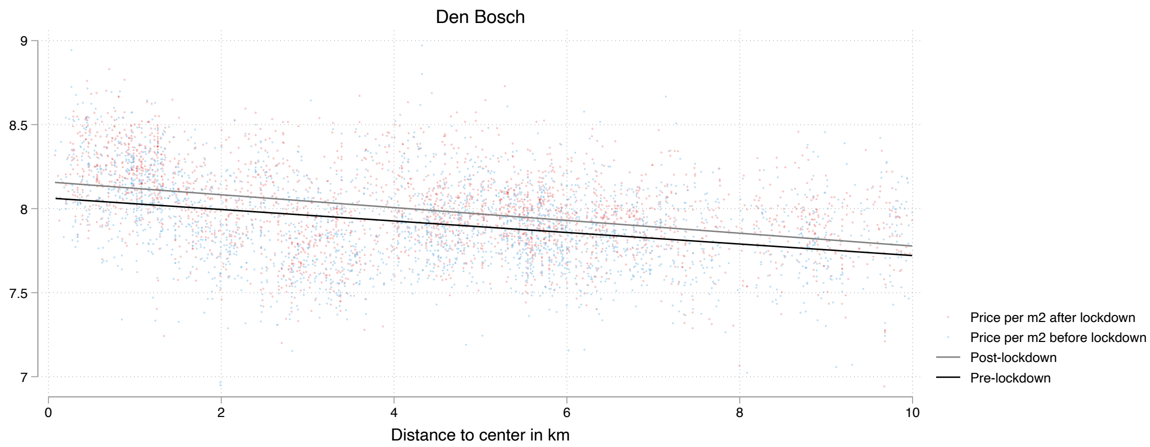
9. Appendix



Appendix figure A1: This plot shows the bid-price curve for Groningen with a radius of 10 km. The plot shows the cross-sectional relationship between the log of the individual transaction prices per m^2 and the distance to the city center. The city center is defined as Grote Markt. The red dots show the individual transaction prices per m^2 after the lockdown was announced (21st of March 2020 – 18th of March 2021). The blue dots show the transaction price per m^2 for the period before the lockdown was announced (21st of March 2019 – 21st of March 2020). For both periods, the linear relationship is shown.



Appendix figure A2: This plot shows the bid-price curve for Eindhoven with a radius of 10 km. The plot shows the cross-sectional relationship between the log of the individual transaction prices per m^2 and the distance to the city center. The city center is defined as Eindhoven Central Station. The red dots show the individual transaction prices per m^2 after the lockdown was announced (21st of March 2020 – 18th of March 2021). The blue dots show the transaction price per m^2 for the period before the lockdown was announced (21st of March 2019 – 21st of March 2020). For both periods, the linear relationship is shown.



Appendix figure A3: This plot shows the bid-price curve for Den Bosch with a radius of 10 km. The plot shows the cross-sectional relationship between the log of the individual transaction prices per m^2 and the distance to the city center. The city center is defined as Markt. The red dots show the individual transaction prices per m^2 after the lockdown was announced (21st of March 2020 – 18th of March 2021). The blue dots show the transaction price per m^2 for the period before the lockdown was announced (21st of March 2019 – 21st of March 2020). For both periods, the linear relationship is shown.

Table A1 - Regression degree of urbanization

	(1)	(2)	(3)
VARIABLES	Log price	Log price	Log price
Lockdown	0.089***	0.004	-0.006
	(0.004)	(0.008)	(0.004)
Treatment	0.176***	0.055	-0.023
	(0.004)	(0.034)	(0.017)
Lockdown * Treatment	0.001	-0.013	0.008*
	(0.006)	(0.010)	(0.005)
Very urban	0.058	-0.175***	-0.005
	(0.047)	(0.030)	(0.016)
Highly urban	-0.062***	-0.104***	-0.009
	(0.019)	(0.013)	(0.006)
Little urban	0.084***	0.144***	0.020***
	(0.018)	(0.014)	(0.007)
Not urban	0.081***	0.304***	0.017*
	(0.018)	(0.018)	(0.009)
Very urban * Lockdown	0.056***	0.052***	0.033***
	(0.008)	(0.006)	(0.004)
Highly urban * Lockdown	0.020***	0.024***	0.015***
	(0.006)	(0.005)	(0.002)
Little urban * Lockdown	-0.011*	-0.008*	-0.009***
	(0.006)	(0.005)	(0.002)
Not urban * Lockdown	-0.022***	-0.013**	-0.018***
	(0.006)	(0.005)	(0.003)
Very urban * Treatment	0.060***	0.047***	0.034***
	(0.010)	(0.008)	(0.006)
Highly urban * Treatment	0.028***	0.029***	0.021***
	(0.006)	(0.005)	(0.003)

Little urban * Treatment	-0.025***	-0.022***	-0.014***
	(0.006)	(0.005)	(0.003)
Not urban * Treatment	-0.053***	-0.045***	-0.031***
	(0.007)	(0.006)	(0.003)
Very urban * Lockdown * Treatment	-0.059***	-0.066***	-0.044***
	(0.009)	(0.008)	(0.005)
Highly urban * Lockdown * Treatment	-0.014*	-0.025***	-0.012***
	(0.008)	(0.006)	(0.003)
Little urban * Lockdown * Treatment	0.018**	0.008	0.007**
	(0.008)	(0.007)	(0.003)
Not urban * Lockdown * Treatment	0.038***	0.025***	0.019***
	(0.010)	(0.008)	(0.004)
Log house size (m2)			0.701***
			(0.009)
No garden			0.037***
			(0.004)
Garden size 101 m2 - 200 m2			0.039***
			(0.002)
Garden size > 200 m2			0.090***
			(0.003)
Corner house			0.022***
			(0.001)
Semi-detached house			0.097***
			(0.003)
Detached house			0.256***
			(0.005)
Apartment			-0.093***
			(0.006)
No insulation			0.018***
			(0.002)
2 types of insulation			0.031***
			(0.001)
3 types of insulation			0.041***
			(0.001)
4 types of insulation			0.048***
			(0.002)
5 or more / fully insulated			0.055***
			(0.002)
Building period 1500 - 1905			0.127***
			(0.007)
Building period 1906 - 1930			0.095***
			(0.007)
Building period 1931 - 1944			0.117***
			(0.007)
Building period 1945 - 1959			0.047***
			(0.005)
Building period 1971 - 1980			0.012***
			(0.003)
Building period 1981 - 1990			0.056***

			(0.004)
Building period 1991 - 2000			0.115***
			(0.005)
Building period > 2001			0.137***
			(0.006)
Very poor maintenance			-0.286***
			(0.012)
Very poor to poor maintenance			-0.222***
			(0.009)
Poor maintenance			-0.184***
			(0.005)
Poor to average maintenance			-0.166***
			(0.003)
Average maintenance			-0.125***
			(0.002)
Average to good maintenance			-0.086***
			(0.001)
Good to excellent maintenance			0.071***
			(0.001)
Excellent maintenance			0.103***
			(0.002)
Parking			0.081***
			(0.002)
Observations	622,314	622,278	622,278
R-squared	0.058	0.396	0.862
Adjusted R-squared	0.058	0.394	0.861
Neighborhood fixed effects	No	Yes	Yes
Time fixed effects	No	Yes	Yes

Notes: This table looks at the impact of the Covid-19 lockdown period on house prices using a difference-in-difference hedonic price model specification. The sample includes all individual transaction during the period of May 1st, 2017, to May 18th, 2021. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to moderately urban areas. Control variables are included to allow for property heterogeneity. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level and are in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A2 - Regression macro areas

VARIABLES	(1) Log price	(2) Log price	(3) Log price
Lockdown	0.093***	0.009	-0.005
	(0.003)	(0.008)	(0.004)
Treatment	0.181***	0.066*	-0.025
	(0.004)	(0.036)	(0.017)
Lockdown * Treatment	0.006	-0.014	0.011**
	(0.005)	(0.009)	(0.005)
Randstad	0.134***	Omitted	Omitted
	(0.026)	-	-
Periphery	-0.183***	-0.238***	-0.291***
	(0.014)	(0.005)	(0.006)
Randstad * Lockdown	0.033***	0.028***	0.023***
	(0.005)	(0.004)	(0.003)
Periphery * Lockdown	-0.019***	-0.014***	-0.015***
	(0.005)	(0.004)	(0.002)
Randstad * Treatment	0.027***	0.021***	0.026***
	(0.007)	(0.006)	(0.004)
Periphery * Treatment	-0.035***	-0.024***	-0.017***
	(0.006)	(0.005)	(0.003)
Randstad * Lockdown * Treatment	-0.040***	-0.041***	-0.035***
	(0.007)	(0.006)	(0.004)
Periphery * Lockdown * Treatment	0.013**	0.014**	0.012***
	(0.007)	(0.006)	(0.003)
Log house size (m2)			0.702***
			(0.009)
No garden			0.037***
			(0.004)
Garden size 101 m2 - 200 m2			0.039***
			(0.002)
Garden size > 200 m2			0.090***
			(0.003)
Corner house			0.022***
			(0.001)
Semi-detached house			0.097***
			(0.003)
Detached house			0.255***
			(0.005)
Apartment			-0.093***
			(0.006)
No insulation			0.018***
			(0.002)
2 types of insulation			0.031***
			(0.001)
3 types of insulation			0.041***
			(0.001)
4 types of insulation			0.048***

			(0.002)
5 or more / fully insulated			0.055***
			(0.002)
Building period 1500 - 1905			0.127***
			(0.007)
Building period 1906 - 1930			0.095***
			(0.007)
Building period 1931 - 1944			0.117***
			(0.007)
Building period 1945 - 1959			0.047***
			(0.005)
Building period 1971 - 1980			0.011***
			(0.003)
Building period 1981 - 1990			0.055***
			(0.004)
Building period 1991 - 2000			0.115***
			(0.005)
Building period > 2001			0.137***
			(0.006)
Very poor maintenance			-0.286***
			(0.012)
Very poor to poor maintenance			-0.222***
			(0.009)
Poor maintenance			-0.184***
			(0.005)
Poor to average maintenance			-0.166***
			(0.003)
Average maintenance			-0.125***
			(0.002)
Average to good maintenance			-0.086***
			(0.001)
Good to excellent maintenance			0.070***
			(0.001)
Excellent maintenance			0.103***
			(0.002)
Parking			0.082***
			(0.002)
Observations	622,314	622,278	622,278
R-squared	0.132	0.384	0.862
Adjusted R-squared	0.132	0.381	0.861
Neighborhood fixed effects	No	Yes	Yes
Time fixed effects	No	Yes	Yes

Notes: This table looks at the impact of the Covid-19 lockdown period on house prices using a difference-in-difference hedonic price model specification. The sample includes all individual transaction during the period of May 1st, 2017, to May 18th, 2021. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to the intermediary zone. Control variables are included in model (3) to allow for property heterogeneity. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level and are in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A3 - Regression house size

VARIABLES	(1) Log price	(2) Log price	(3) Log price
Lockdown	0.335***	0.241***	0.230***
	(0.054)	(0.030)	(0.026)
Treatment	0.583***	0.336***	0.331***
	(0.051)	(0.040)	(0.037)
Lockdown * Treatment	-0.100	-0.164***	-0.190***
	(0.067)	(0.039)	(0.035)
Log housesize smaller than 100 m2	0.795***	0.950***	0.819***
	(0.046)	(0.012)	(0.008)
Log housesize smaller than 100 m2 * Lockdown	-0.051***	-0.049***	-0.047***
	(0.012)	(0.007)	(0.006)
Log housesize smaller than 100 m2 * Treatment	-0.088***	-0.067***	-0.073***
	(0.011)	(0.007)	(0.007)
Log housesize smaller than 100 m2 * Lockdown * Treat.	0.021	0.032***	0.038***
	(0.015)	(0.009)	(0.008)
Log housesize 100 - 200 m2	0.796***	0.953***	0.825***
	(0.044)	(0.011)	(0.008)
Log housesize 100 - 200 m2 * Lockdown	-0.053***	-0.051***	-0.049***
	(0.011)	(0.006)	(0.005)
Log housesize 100 - 200 m2 * Treatment	-0.092***	-0.072***	-0.077***
	(0.010)	(0.007)	(0.007)
Log housesize 100 - 200 m2 * Lockdown * Treatment	0.023*	0.036***	0.041***
	(0.014)	(0.008)	(0.007)
Log housesize larger than 200 m2	0.838***	0.965***	0.833***
	(0.039)	(0.010)	(0.007)
Log housesize larger than 200 m2 * Lockdown	-0.052***	-0.048***	-0.046***
	(0.010)	(0.005)	(0.005)
Log housesize larger than 200 m2 * Treatment	-0.089***	-0.068***	-0.073***
	(0.009)	(0.006)	(0.006)
Log housesize larger than 200 m2 * Lockdown * Treat.	0.021*	0.032***	0.037***
	(0.012)	(0.007)	(0.006)
No garden			0.042***
			(0.005)
Garden size 101 m2 - 200 m2			0.063***
			(0.002)
Garden size > 200 m2			0.148***
			(0.003)
No insulation			0.024***
			(0.002)
2 types of insulation			0.035***
			(0.002)
3 types of insulation			0.049***
			(0.002)
4 types of insulation			0.062***
			(0.002)
5 or more / fully insulated			0.062***

			(0.002)
Building period 1500 - 1905			0.153***
			(0.007)
Building period 1906 - 1930			0.138***
			(0.007)
Building period 1931 - 1944			0.153***
			(0.007)
Building period 1945 - 1959			0.068***
			(0.005)
Building period 1971 - 1980			-0.000
			(0.003)
Building period 1981 - 1990			0.051***
			(0.004)
Building period 1991 - 2000			0.110***
			(0.004)
Building period > 2001			0.108***
			(0.005)
Very poor maintenance			-0.230***
			(0.013)
Very poor to poor maintenance			-0.191***
			(0.010)
Poor maintenance			-0.156***
			(0.005)
Poor to average maintenance			-0.150***
			(0.004)
Average maintenance			-0.112***
			(0.002)
Average to good maintenance			-0.082***
			(0.001)
Good to excellent maintenance			0.070***
			(0.001)
Excellent maintenance			0.104***
			(0.002)
Parking			0.117***
			(0.002)
Observations	622,314	622,278	622,278
R-squared	0.438	0.793	0.842
Adjusted R-squared	0.438	0.792	0.841
Neighborhood fixed effects	No	Yes	Yes
Time fixed effects	No	Yes	Yes

Notes: This table looks at the impact of the Covid-19 lockdown period on house prices using a difference-in-difference hedonic price model specification. The sample includes all individual transaction during the period of May 1st, 2017, to May 18th, 2021. The specification is described in the methodology section under difference-in-difference. Control variables are included in model (3) to allow for property heterogeneity. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level and are in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A4 - Regression house type

VARIABLES	(1) Log price	(2) Log price	(3) Log price
Lockdown	0.093***	0.001	-0.002
	(0.003)	(0.006)	(0.003)
Treatment	0.167***	0.037	-0.018
	(0.003)	(0.027)	(0.016)
Lockdown * Treatment	0.009**	0.003	0.011***
	(0.004)	(0.007)	(0.004)
Corner house	0.043***	0.081***	0.028***
	(0.006)	(0.003)	(0.002)
Semi-detached house	0.195***	0.328***	0.118***
	(0.012)	(0.005)	(0.003)
Detached house	0.444***	0.663***	0.280***
	(0.015)	(0.006)	(0.005)
Apartment	-0.100***	-0.305***	-0.118***
	(0.035)	(0.010)	(0.008)
Corner house * Lockdown	-0.000	-0.001	-0.006***
	(0.005)	(0.003)	(0.002)
Semi-detached house * Lockdown	-0.019***	-0.011***	-0.017***
	(0.005)	(0.003)	(0.002)
Detached house * Lockdown	-0.034***	-0.021***	-0.020***
	(0.006)	(0.004)	(0.003)
Apartment * Lockdown	0.051***	0.045***	0.034***
	(0.005)	(0.004)	(0.003)
Corner house * Treatment	0.002	0.000	-0.006***
	(0.005)	(0.003)	(0.002)
Semi-detached house * Treatment	-0.027***	-0.025***	-0.030***
	(0.005)	(0.003)	(0.002)
Detached house * Treatment	-0.044***	-0.037***	-0.036***
	(0.006)	(0.005)	(0.003)
Apartment * Treatment	0.081***	0.065***	0.045***
	(0.006)	(0.005)	(0.004)
Corner house * Lockdown * Treatment	-0.007	-0.005	0.000
	(0.007)	(0.004)	(0.003)
Semi-detached house * Lockdown * Treatment	0.006	0.002	0.007**
	(0.007)	(0.004)	(0.003)
Detached house * Lockdown * Treatment	0.028***	0.017**	0.008**
	(0.009)	(0.006)	(0.004)
Apartment * Lockdown * Treatment	-0.058***	-0.066***	-0.052***
	(0.007)	(0.006)	(0.004)
Log house size (m2)			0.701***
			(0.009)
No garden			0.037***
			(0.004)
Garden size 101 m2 - 200 m2			0.039***
			(0.002)
Garden size > 200 m2			0.090***

			(0.003)
No insulation			0.018***
			(0.002)
2 types of insulation			0.030***
			(0.001)
3 types of insulation			0.041***
			(0.001)
4 types of insulation			0.048***
			(0.002)
5 or more / fully insulated			0.055***
			(0.002)
Building period 1500 - 1905			0.127***
			(0.007)
Building period 1906 - 1930			0.095***
			(0.007)
Building period 1931 - 1944			0.117***
			(0.007)
Building period 1945 - 1959			0.047***
			(0.005)
Building period 1971 - 1980			0.011***
			(0.003)
Building period 1981 - 1990			0.055***
			(0.004)
Building period 1991 - 2000			0.115***
			(0.005)
Building period > 2001			0.137***
			(0.006)
Very poor maintenance			-0.287***
			(0.012)
Very poor to poor maintenance			-0.221***
			(0.009)
Poor maintenance			-0.184***
			(0.005)
Poor to average maintenance			-0.166***
			(0.003)
Average maintenance			-0.125***
			(0.002)
Average to good maintenance			-0.086***
			(0.001)
Good to excellent maintenance			0.071***
			(0.001)
Excellent maintenance			0.103***
			(0.002)
Parking			0.081***
			(0.002)
Observations	622,314	622,278	622,278
R-squared	0.154	0.613	0.862
Adjusted R-squared	0.154	0.612	0.861

Neighborhood fixed effects	No	Yes	Yes
Time fixed effects	No	Yes	Yes

Notes: This table looks at the impact of the Covid-19 lockdown period on house prices using a difference-in-difference hedonic price model specification. The sample includes all individual transaction during the period of May 1st, 2017, to May 18th, 2021. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to terraced houses. Control variables are included in model (3) to allow for property heterogeneity. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level and are in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A5 - Regression garden

VARIABLES	(1) Log price	(2) Log price	(3) Log price
Lockdown	0.091***	0.003	-0.004
	(0.003)	(0.007)	(0.003)
Treatment	0.171***	0.023	-0.022
	(0.003)	(0.033)	(0.016)
Lockdown * Treatment	0.007**	-0.008	0.010**
	(0.003)	(0.009)	(0.004)
No garden	0.007	-0.035***	0.021***
	(0.017)	(0.012)	(0.004)
Garden size 101 m2 - 200 m2	0.176***	0.212***	0.054***
	(0.010)	(0.005)	(0.002)
Garden size > 200 m2	0.385***	0.422***	0.109***
	(0.015)	(0.008)	(0.004)
No garden * Lockdown	0.036***	0.034***	0.022***
	(0.005)	(0.004)	(0.002)
Garden size 101 m2 - 200 m2 * Lockdown	-0.018***	-0.015***	-0.014***
	(0.005)	(0.004)	(0.002)
Garden size > 200 m2 * Lockdown	-0.030***	-0.022***	-0.015***
	(0.008)	(0.006)	(0.003)
No garden * Treatment	0.050***	0.050***	0.027***
	(0.006)	(0.005)	(0.003)
Garden size 101 m2 - 200 m2 * Treatment	-0.032***	-0.025***	-0.022***
	(0.005)	(0.004)	(0.002)
Garden size > 200 m2 * Treatment	-0.044***	-0.035***	-0.030***
	(0.007)	(0.006)	(0.003)
No garden * Treatment * Treatment	-0.044***	-0.049***	-0.036***
	(0.007)	(0.006)	(0.003)
Garden size 101 m2 - 200 m2 * Lockdown * Treatment	0.021***	0.011**	0.011***
	(0.007)	(0.005)	(0.003)
Garden size > 200 m2 * Lockdown * Treatment	0.035***	0.023***	0.012***
	(0.011)	(0.008)	(0.004)
Log house size (m2)			0.701***
			(0.009)
Corner house			0.022***
			(0.001)
Semi-detached house			0.097***
			(0.003)
Detached house			0.255***
			(0.005)
Apartment			-0.092***
			(0.006)

No insulation			0.018***
			(0.002)
2 types of insulation			0.031***
			(0.001)
3 types of insulation			0.041***
			(0.001)
4 types of insulation			0.048***
			(0.002)
5 or more / fully insulated			0.055***
			(0.002)
Building period 1500 - 1905			0.127***
			(0.007)
Building period 1906 - 1930			0.095***
			(0.007)
Building period 1931 - 1944			0.117***
			(0.007)
Building period 1945 - 1959			0.047***
			(0.005)
Building period 1971 - 1980			0.011***
			(0.003)
Building period 1981 - 1990			0.055***
			(0.004)
Building period 1991 - 2000			0.115***
			(0.005)
Building period > 2001			0.137***
			(0.006)
Very poor maintenance			-0.287***
			(0.012)
Very poor to poor maintenance			-0.222***
			(0.009)
Poor maintenance			-0.184***
			(0.005)
Poor to average maintenance			-0.167***
			(0.003)
Average maintenance			-0.125***
			(0.002)
Average to good maintenance			-0.086***
			(0.001)
Good to excellent maintenance			0.070***
			(0.001)
Excellent maintenance			0.103***
			(0.002)
Parking			0.082***
			(0.002)
Observations	622,314	622,278	622,278
R-squared	0.081	0.430	0.862
Adjusted R-squared	0.0812	0.428	0.861
Neighborhood fixed effects	No	Yes	Yes
Time fixed effects	No	Yes	Yes

Notes: This table looks at the impact of the Covid-19 lockdown period on house prices using a difference-in-difference hedonic price model specification. The sample includes all individual transaction during the period of May 1st, 2017, to May 18th, 2021. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to houses with a garden size smaller than 100 m^2. Control variables are included in model (3) to allow for property heterogeneity. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level and are in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A6 - Regression insulation

VARIABLES	(1) Log price	(2) Log price	(3) Log price
Lockdown	0.112***	0.032***	0.012***
	(0.004)	(0.008)	(0.004)
Treatment	0.199***	0.062*	-0.003
	(0.005)	(0.033)	(0.017)
Lockdown * Treatment	-0.014**	-0.038***	-0.010**
	(0.006)	(0.009)	(0.005)
No insulation	0.115***	0.094***	0.026***
	(0.013)	(0.007)	(0.003)
2 types of insulation	0.112***	0.156***	0.046***
	(0.014)	(0.006)	(0.003)
3 types of insulation	0.129***	0.204***	0.058***
	(0.017)	(0.006)	(0.003)
4 types of insulation	0.199***	0.284***	0.067***
	(0.019)	(0.007)	(0.002)
5 or more / fully insulated	0.281***	0.315***	0.067***
	(0.018)	(0.008)	(0.003)
No insulation * Lockdown	-0.016**	-0.022***	-0.008***
	(0.007)	(0.005)	(0.003)
2 types of insulation * Lockdown	-0.024***	-0.032***	-0.019***
	(0.006)	(0.005)	(0.002)
3 types of insulation * Lockdown	-0.019***	-0.026***	-0.020***
	(0.006)	(0.005)	(0.003)
4 types of insulation * Lockdown	-0.015**	-0.026***	-0.021***
	(0.006)	(0.005)	(0.003)
5 or more / fully insulated * Lockdown	-0.011*	-0.017***	-0.011***
	(0.006)	(0.004)	(0.003)
No insulation * Treatment	-0.032***	-0.031***	-0.012***
	(0.008)	(0.007)	(0.004)
2 types of insulation * Treatment	-0.036***	-0.036***	-0.025***
	(0.007)	(0.005)	(0.003)
3 types of insulation * Treatment	-0.030***	-0.031***	-0.027***
	(0.007)	(0.005)	(0.003)
4 types of insulation * Treatment	-0.023***	-0.032***	-0.029***
	(0.007)	(0.005)	(0.003)
5 or more / fully insulated * Treatment	-0.015**	-0.021***	-0.015***
	(0.007)	(0.005)	(0.003)
No insulation * Lockdown * Treatment	0.002	0.018**	0.005
	(0.011)	(0.007)	(0.004)
2 types of insulation * Lockdown * Treatment	0.033***	0.035***	0.024***
	(0.008)	(0.006)	(0.003)
3 types of insulation * Lockdown * Treatment	0.027***	0.031***	0.024***
	(0.009)	(0.007)	(0.004)

4 types of insulation * Lockdown * Treatment	0.005	0.024***	0.021***
	(0.009)	(0.007)	(0.004)
5 or more / fully insulated * Lockdown * Treatment	-0.004	0.007	0.004
	(0.008)	(0.006)	(0.003)
Log house size (m2)			0.702***
			(0.009)
No garden			0.036***
			(0.004)
Garden size 101 m2 - 200 m2			0.039***
			(0.002)
Garden size > 200 m2			0.090***
			(0.003)
Corner house			0.022***
			(0.001)
Semi-detached house			0.097***
			(0.003)
Detached house			0.255***
			(0.005)
Apartment			-0.093***
			(0.006)
Building period 1500 - 1905			0.127***
			(0.007)
Building period 1906 - 1930			0.095***
			(0.007)
Building period 1931 - 1944			0.117***
			(0.007)
Building period 1945 - 1959			0.047***
			(0.005)
Building period 1971 - 1980			0.011***
			(0.003)
Building period 1981 - 1990			0.055***
			(0.004)
Building period 1991 - 2000			0.115***
			(0.005)
Building period > 2001			0.137***
			(0.006)
Very poor maintenance			-0.287***
			(0.012)
Very poor to poor maintenance			-0.223***
			(0.009)
Poor maintenance			-0.185***
			(0.005)
Poor to average maintenance			-0.167***
			(0.003)
Average maintenance			-0.125***
			(0.002)
Average to good maintenance			-0.086***
			(0.001)
Good to excellent maintenance			0.071***

			(0.001)
Excellent maintenance			0.103***
			(0.002)
Parking			0.082***
			(0.002)
Observations	622,314	622,278	622,278
R-squared	0.083	0.428	0.861
Adjusted R-squared	0.0833	0.426	0.861
Neighborhood fixed effects	No	Yes	Yes
Time fixed effects	No	Yes	Yes

Notes: This table looks at the impact of the Covid-19 lockdown period on house prices using a difference-in-difference hedonic price model specification. The sample includes all individual transaction during the period of May 1st, 2017, to May 18th, 2021. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to houses with only one type of insulation. Control variables are included in model (3) to allow for property heterogeneity. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level and are in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A7 - Regression degree of urbanization (without tax system renewal)

	(1)	(2)	(3)
VARIABLES	Log price	Log price	Log price
Lockdown	0.087***	0.004	-0.006
	(0.004)	(0.008)	(0.004)
Treatment	0.176***	Omitted	Omitted
	(0.004)	-	-
Lockdown * Treatment	-0.004	-0.013	0.008*
	(0.006)	(0.010)	(0.005)
Very Urban	0.058	-0.175***	-0.004
	(0.047)	(0.030)	(0.016)
Highly urban	-0.062***	-0.104***	-0.008
	(0.019)	(0.013)	(0.006)
Little urban	0.084***	0.144***	0.019***
	(0.018)	(0.014)	(0.007)
Not urban	0.081***	0.303***	0.016*
	(0.018)	(0.018)	(0.009)
Very Urban * Lockdown	0.055***	0.052***	0.033***
	(0.008)	(0.006)	(0.004)
Highly urban * Lockdown	0.020***	0.025***	0.015***
	(0.006)	(0.005)	(0.002)
Little urban * Lockdown	-0.011*	-0.008	-0.009***
	(0.006)	(0.005)	(0.002)
Not urban * Lockdown	-0.022***	-0.013**	-0.018***
	(0.006)	(0.005)	(0.003)
Very Urban * Treatment	0.060***	0.047***	0.034***
	(0.010)	(0.008)	(0.006)
Highly urban * Treatment	0.028***	0.029***	0.021***
	(0.006)	(0.005)	(0.003)
Little urban * Treatment	-0.025***	-0.022***	-0.014***
	(0.006)	(0.005)	(0.003)

Not urban * Treatment	-0.053***	-0.045***	-0.031***
	(0.007)	(0.006)	(0.003)
Very Urban * Lockdown * Treatment	-0.058***	-0.067***	-0.043***
	(0.009)	(0.008)	(0.005)
Highly urban * Lockdown * Treatment	-0.015*	-0.025***	-0.013***
	(0.008)	(0.006)	(0.003)
Little urban * Lockdown * Treatment	0.019**	0.008	0.006*
	(0.008)	(0.007)	(0.003)
Not urban * Lockdown * Treatment	0.037***	0.024***	0.019***
	(0.010)	(0.008)	(0.004)
Log house size (m2)			0.702***
			(0.009)
No garden			0.037***
			(0.004)
Garden size 100 - 200 m2			0.039***
			(0.002)
Garden size > 200 m2			0.090***
			(0.003)
Corner house			0.022***
			(0.001)
Semi-detached house			0.098***
			(0.003)
Detached house			0.256***
			(0.005)
Apartment			-0.093***
			(0.006)
No insulation			0.018***
			(0.002)
2 types of insulation			0.030***
			(0.001)
3 types of insulation			0.042***
			(0.001)
4 types of insulation			0.048***
			(0.002)
5 or more / fully insulated			0.055***
			(0.002)
Building period 1500 - 1905			0.127***
			(0.007)
Building period 1906 - 1930			0.095***
			(0.007)
Building period 1931 - 1944			0.117***
			(0.007)
Building period 1945 - 1959			0.047***
			(0.005)
Building period 1971 - 1980			0.012***
			(0.003)
Building period 1981 - 1990			0.055***
			(0.004)
Building period 1991 - 2000			0.115***

			(0.005)
Building period > 2001			0.138***
			(0.006)
Very poor maintenance			-0.285***
			(0.012)
Very poor to poor maintenance			-0.222***
			(0.009)
Poor maintenance			-0.184***
			(0.005)
Poor to average maintenance			-0.166***
			(0.003)
Average maintenance			-0.125***
			(0.002)
Average to good maintenance			-0.086***
			(0.001)
Good to excellent maintenance			0.070***
			(0.001)
Excellent maintenance			0.102***
			(0.002)
Parking			0.081***
			(0.002)
Observations	606,326	606,289	606,289
R-squared	0.056	0.395	0.862
Adjusted R-squared	0.0557	0.392	0.861
Neighborhood fixed effects	No	Yes	Yes
Time fixed effects	No	Yes	Yes

Notes: This table looks at the impact of the Covid-19 lockdown period on house prices using a difference-in-difference hedonic price model specification. The sample includes all individual transaction during the period of May 1st, 2017, to December 31st, 2021. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to moderately urban areas. Control variables are included to allow for property heterogeneity. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level and are in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Table A8 - Regression degree of urbanization (2016-2020)

VARIABLES	(1) Log price	(2) Log price	(3) Log price
Lockdown	0.069***	-0.005	-0.011***
	(0.005)	(0.007)	(0.004)
Treatment	0.148***	0.006	-0.035**
	(0.006)	(0.036)	(0.016)
Lockdown * Treatment	0.012*	0.012	0.013***
	(0.006)	(0.009)	(0.004)
Very Urban	-0.006	-0.217***	-0.034*
	(0.048)	(0.032)	(0.017)
Highly urban	-0.092***	-0.119***	-0.017***
	(0.018)	(0.013)	(0.006)
Little urban	0.084***	0.143***	0.019**
	(0.016)	(0.015)	(0.009)
Not urban	0.092***	0.316***	0.026***

	(0.017)	(0.018)	(0.009)
Very Urban * Lockdown	0.069***	0.061***	0.051***
	(0.009)	(0.006)	(0.005)
Highly urban * Lockdown	0.033***	0.025***	0.020***
	(0.006)	(0.005)	(0.003)
Little urban * Lockdown	-0.000	-0.005	-0.009***
	(0.006)	(0.005)	(0.003)
Not urban * Lockdown	-0.012*	-0.015***	-0.023***
	(0.007)	(0.006)	(0.003)
Very Urban * Treatment	0.119***	0.107***	0.080***
	(0.011)	(0.008)	(0.006)
Highly urban * Treatment	0.051***	0.048***	0.033***
	(0.007)	(0.006)	(0.004)
Little urban * Treatment	-0.011	-0.011*	-0.016***
	(0.007)	(0.006)	(0.004)
Not urban * Treatment	-0.034***	-0.027***	-0.038***
	(0.008)	(0.006)	(0.004)
Very Urban * Lockdown * Treatment	-0.069***	-0.068***	-0.051***
	(0.012)	(0.008)	(0.005)
Highly urban * Lockdown * Treatment	-0.028***	-0.022***	-0.015***
	(0.009)	(0.007)	(0.004)
Little urban * Lockdown * Treatment	-0.015*	-0.010	0.004
	(0.009)	(0.007)	(0.003)
Not urban * Lockdown * Treatment	-0.019**	-0.016**	0.013***
	(0.010)	(0.008)	(0.004)
Log house size (m2)			0.723***
			(0.009)
No garden			0.033***
			(0.004)
Garden size 101 - 200 m2			0.038***
			(0.002)
Garden size > 200 m2			0.085***
			(0.003)
Corner house			0.024***
			(0.001)
Semi-detached house			0.099***
			(0.003)
Detached house			0.257***
			(0.005)
Apartment			-0.100***
			(0.006)
No insulation			0.018***
			(0.002)
2 types of insulation			0.031***
			(0.001)
3 types of insulation			0.041***
			(0.001)
4 types of insulation			0.046***
			(0.002)

5 or more / fully insulated			0.051***
			(0.002)
Building period 1500 - 1905			0.136***
			(0.007)
Building period 1906 - 1930			0.101***
			(0.007)
Building period 1931 - 1944			0.124***
			(0.008)
Building period 1945 - 1959			0.050***
			(0.005)
Building period 1971 - 1980			0.013***
			(0.003)
Building period 1981 - 1990			0.060***
			(0.004)
Building period 1991 - 2000			0.123***
			(0.005)
Building period > 2001			0.150***
			(0.006)
Very poor maintenance			-0.279***
			(0.013)
Very poor to poor maintenance			-0.229***
			(0.009)
Poor maintenance			-0.182***
			(0.005)
Poor to average maintenance			-0.162***
			(0.004)
Average maintenance			-0.126***
			(0.002)
Average to good maintenance			-0.088***
			(0.002)
Good to excellent maintenance			0.068***
			(0.001)
Excellent maintenance			0.098***
			(0.002)
Parking			0.084***
			(0.002)
Observations	646,909	646,880	646,880
R-squared	0.053	0.386	0.863
Adjusted R-squared	0.0525	0.383	0.863
Neighborhood fixed effects	No	Yes	Yes
Time fixed effects	No	Yes	Yes

Notes: This table looks at the impact of the Covid-19 lockdown period on house prices using a difference-in-difference hedonic price model specification. The sample includes all individual transaction during the period of May 1st, 2016, to May 18th, 2020. The specification is described in the methodology section under difference-in-difference. The coefficients show the different price developments compared to moderately urban areas. Control variables are included to allow for property heterogeneity. Time fixed effects are on a monthly level. Constants were not included in the regression. Standard errors are clustered at the neighborhood level and are in parentheses: *** p<0.01, ** p<0.05, * p<0.1.