The Dutch housing market and the pandemic: A quantitative analysis on the effect of COVID-19 on housing prices in The Netherlands

Dam, Arthur van

The Dutch housing market and the pandemic: A quantitative analysis on the effect of COVID-19 on housing prices in The Netherlands

Arthur van Dam
1949152

Universiteit Leiden
The Netherlands

Supervisor: Max van Lent

January 6, 2023

Words: 13.072

Abstract

The COVID-19 pandemic had an immense economic and social impact. Dutch Gross Domestic Product shrunk with about 3.7 percent in 2020, which was as severe as the credit crisis in 2011. People got sick or died because of the virus, workers were strongly advised to work from their residence and consumption amenities had to close their doors to limit the spread of COVID-19. Although the economy struggled, Dutch housing prices continued to increase during the pandemic. Home preferences did appear affected by COVID-19. As working from home became the norm, households valued residential space more, and thus moved towards non-urban areas where houses have more space. This effect is know as the *Donut-effect*.

The answer to the research question: *To what extent has the COVID-19 pandemic affected housing prices in The Netherlands*? provides statistically significant evidence that COVID-19 has had a positive effect on overall Dutch housing prices. This thesis also provides statistically significant evidence that COVID-19 has likely driven a *Donut-effect* in The Netherlands, where households from the urban, 'Randstad' provinces have moved towards other Dutch provinces outside the 'Randstad' due to COVID-19. Compared to pre-pandemic housing prices, housing prices in the 'Randstad' have decreased with 1.2 to 1.6 percent compared to the non-'Randstad' provinces. The effect is reversed for the non-'Randstad' provinces, where housing prices have increased with 1.2 to 1.6 percent.

Contents

1. Introduction

By the end of 2019, the world was confronted with a new virus: COVID-19 (coronavirus). By March 2020, COVID-19 was categorized as a global pandemic (Qian, Qiu, & Zhang, 2021). In the second week of March 2020, the Dutch government imposed a lockdown to limit social interaction and thus the spread of COVID-19. The implemented lockdowns had both great economic and social effects. Due to the first lockdown in March 2020, the Dutch Gross Domestic Product (GDP) declined with about nine percent and unemployment increased with about two percent in the second quarter of 2020. In overall 2020, Dutch GDP decreased with 3.7 percent, which was as severe as the credit crisis of 2011 (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021). The social impact of COVID-19 was immense. Apart from many people getting sick because of the virus, the imposed lockdowns disrupted day to day life severely, as the Dutch government strongly advised workers to stay at home and consumption amenities to close their doors. The staying at home advise forced employees to work from their residence as much as possible, which increased the working from home rate significantly in The Netherlands (Buitelaar, Bastiaanssen, et al., 2021).

The working from home advise quickly seemed to affect home-owner preferences, as a trend appeared where households in The Netherlands living in urban areas, moved towards non-urban areas as they valued space in and around the house more due to being home more often (FD, 2021), (NOS, 2021a). As the pandemic evolved, so did the scientific literature on the effects of COVID-19 on the housing market. Yang, Xu, Hu, and Cao (2022) do indeed find that residential space is valued more in times of COVID-19. Gamber, Graham, and Yadav (2021) show that in regions with higher working from home rates, demand for and the value of housing increased. Ramani and Bloom (2021) also find supporting evidence that during COVID-19 households indeed moved from urban areas towards suburban areas.

There is little to no scientific evidence on the possible effects of changed home-owner preferences due COVID-19 and how this might affect housing prices. The scientific literature of the effect of pandemics on housing prices itself is relatively scarce. Before the COVID-19 pandemic, there was little to no literature available on the effects of mass disease outbreaks on housing prices. This also has to do with the fact that pandemics (fortunately) do not come across often. Francke and Korevaar (2021) analysed the development of housing prices in Amsterdam during the plague epidemic in the 17th century and the cholera epidemic in Paris in the 19th century. The authors find that due to a decrease in housing demand, caused by death and negative socio-economic sentiment, housing prices and rent prices dropped in both epidemic events. Qian et al. (2021) find a negative relationship of 2.47 percent between increasing COVID-19 cases and housing prices in China. Del Giudice, De Paola, and Del Giudice (2020) also find a negative relationship, in the short-run and the mid-run, between housing prices and COVID-19 in the region of Campania, Italy. Zhao (2020) finds evidence of an opposite effect of COVID-19 on housing prices. Due to low-interest rates, housing demand increased significantly and a clear cut-off before and after the COVID-19 lockdown in March 2020 is noticeable, where housing prices increased significantly more after the March 2020 threshold.

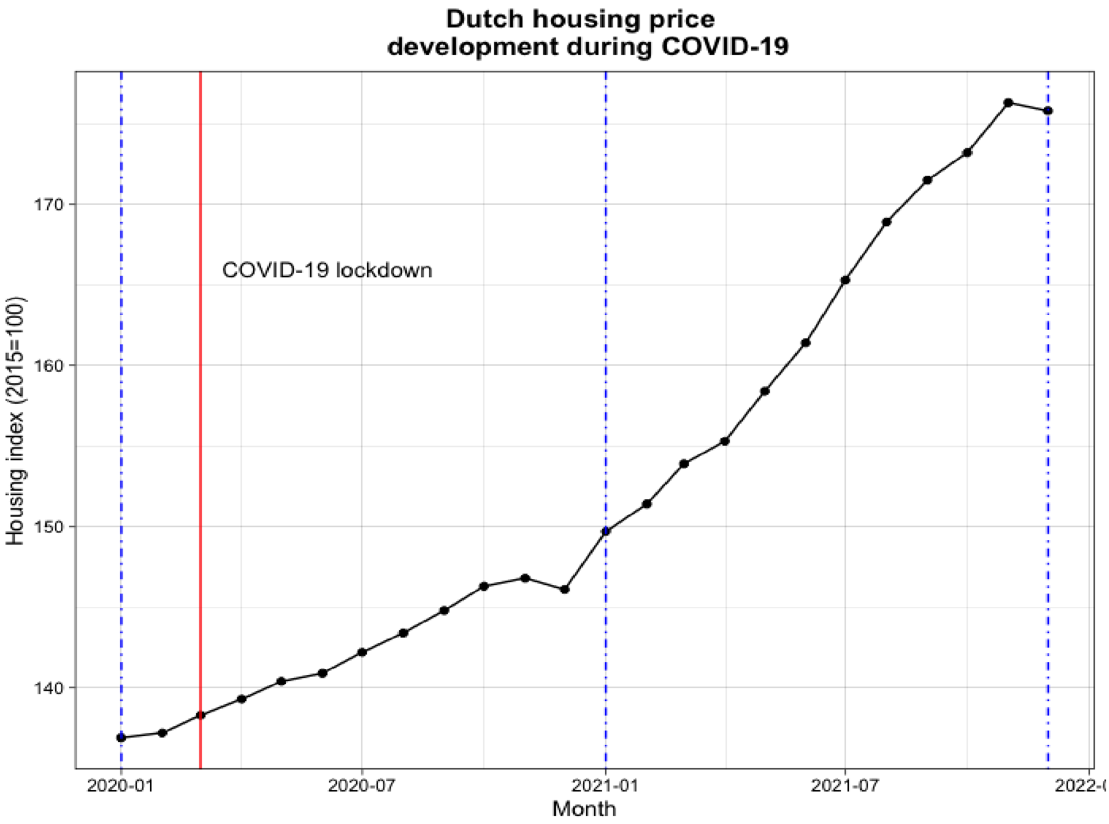

Figure 1.1.: Dutch housing price development: 2020-2021 (Source: CBS)

Taking a look at the development of the housing prices in The Netherlands during COVID-19, which is given by figure 1.1, shows no sign that the pandemic affected housing prices negatively. During 2020, housing prices increased with about fifteen index points. In 2021, housing prices increased even more with about 25 index points. The steady increase during 2020 especially is remarkable as, mentioned before, the Dutch economy shrunk with 3.7 percent during 2020 and scientific literature has shown that housing prices can shrink when the economy struggles (Xu, 2017), (Tripathi, 2019), (Anastasiou, Kapopoulos, & Zekente, 2021). The stable positive development of the Dutch housing price during the pandemic raises the question if COVID-19 might have affected housing prices in The Netherlands positively?

To the best of my knowledge, there is no scientific literature available of an econometric analysis on the effects of COVID-19 on general Dutch housing prices. The Dutch Bureau for Statistics (CBS) and the Dutch Ministry of the Interior and Kingdom Relations have both done analyses on the Dutch housing market and housing prices during COVID-19, but no econometric models or tools were used in both publications (CBS, 2022e) (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021). Rouwendal and Kransberg (2021) used regression analysis on the effects of COVID-19 on housing prices in The Netherlands, but only focused on the city of Maastricht. Also, I couldn't find any scientific literature investigating the trend of Dutch households in urban areas moving towards non-urban areas as preferences for residential space might have changed due to COVID-19. Therefore, this thesis contributes to the academic literature by answering the research question: *To what extent has the COVID-19 pandemic affected housing prices in The Netherlands*? The eventual answer to the research question will include a response on general housing price effects due to COVID-19 and on regional housing price effects in the light of the possible movement from urban to non-urban areas in The Netherlands caused by the pandemic. The answer to the research question also has societal value as policy makers and other stakeholders can use the findings of this thesis to adequately react to future pandemics in the light of housing prices.

In chapter two, the theory on general and COVID-19 housing price drivers is set out. Characteristics of the Dutch housing market will also be discussed after which hypotheses are formulated to be able to answer the research question. In the third chapter, the regression models are described and the dataset will be analyzed. In chapter four, the obtained regression estimates are given, which after interpreting the regression results, will give the answer to the formulated hypotheses. In chapter five, the conclusion of this thesis is given and limitations of this thesis are discussed.

2. Theoretic framework

The theoretic framework explains the underlying drivers of housing price developments. Although this thesis will try to explain the influence of COVID-19 on housing prices, general economic supply and demand drivers cannot be ignored as like most economic products, housing prices are co-determined by supply and demand as well (Girouard, Kennedy, Van Den Noord, & André, 2006). When speaking of housing supply or demand, this is related to the supply and demand of the housing market for home-ownership. The rents market is neglected in this thesis. General housing supply and demand factors of housing prices are determined first. Possible effects of COVID-19 on housing prices are set-out next. Third, Dutch housing market characteristics are described. Finally, based on supply and demand factors, COVID-19 aspects and Dutch housing market characteristics, hypotheses on the behavior of housing prices in relation to COVID-19 are formulated which will be tested and analyzed in chapter four.

2.1. Economic housing price drivers

The supply of housing affects housing prices through the supply elasticity, which is the change in housing supply due to a change in housing prices (S. Wang, Chan, & Xu, 2012). The supply elasticity is an important parameter that explains the housing price equilibrium following a demand shock. When demand for housing increases, this affects the supply side of housing in one of two ways. When the housing supply elasticity is elastic, which is when supply can more easily co-move with demand, the number of housing construction projects will increase. When the supply elasticity is less elastic (inelastic), supply will less easily follow demand and housing construction does not increase following a positive demand shock. The increase in demand is thus absorbed by prices which causes housing prices to increase (Caldera & Johansson, 2013). In regions where housing supply is more elastic, the rise in housing prices after a demand shock is relatively smaller compared to regions where housing supply is more inelastic (Grimes & Aitken, 2006). Glaeser, Gyourko, and Saiz (2008) find that housing prices during the 1980's increased mostly in cities where housing supply is more inelastic. This evidence is supported by Gyourko (2009). The determinants of the elasticity of housing supply are either of economic, regulatory or geographic nature (S. Wang et al., 2012). Macroeconomic variables may influence the cost of housing construction projects (Saiz, 2008). Evidence off geographical and regulatory factors on the supply elasticity is given by Saiz (2010), who finds that areas with inelastic housing supply are constraint by land availability, either due to strict government regulations on building ground or due to steep-sloped terrain which can complicate construction projects. The latter does not seem to be the case for The Netherlands as it is one of the flattest countries in the world (TU Delft, 2011).

The demand side of housing is determined by multiple components, of which the interest rate is one. After the financial crisis, or 'Great Recession', of 2008, the European Central Bank (ECB) lowered interest rates aggressively due to low inflation and worsened economic activity (Gerlach & Lewis, 2014). Already in the 1980's, Schwab (1983) showed that the real interest rate has a significant effect on housing demand, but did not specify the direction of the relationship between the two variables. Recently, Dajcman (2020) found evidence that in the Euro-area, a decrease in the interest rate, hence, the mortgage interest rate, increases the demand for mortgage loans, which puts increasing pressure on housing prices. Results from Gamber et al. (2021) show that low mortgage interest rates explained about a third of the rise in housing prices in 2020. The mortgage interest rate thus seemed to have played a crucial role in explaining housing price development. Keeping interest rates too low in the long-run can be risky, as it may drive housing prices up significantly and form housing bubbles (Taylor, 2007). The ECB has continued to maintain low interest rates from 2008 up to 2021 onwards, with COVID-19 putting extra pressure on keeping interest rates as low as they are (Andrade, Galí, Le Bihan, & Matheron, 2021).

One other factor that can influence housing demand is population growth. When the population, and especially the number of households, grows, it can impact housing demand positively (Mulder, 2006). One important side-note on the relationship between population growth and housing demand, is that the effect of a growing population is likely to be significant in the short-run (Al-Masum & Lee, 2019). Although Kohler, Van Der Merwe, et al. (2015) argue that there is a positive relationship between population growth and housing demand in the long-run, there is no statistical significant evidence provided that supports their claim. Al-Masum and Lee (2019) researched the same relationship between housing demand and population growth. The authors do find a positive relationship between the two variables in the long-run, but the effect is statistically insignificant. An explanation for the short-run effect of population growth on housing prices can be given by using a simple supply and demand framework. An increase in demand for housing through positive population growth in the short-run, can drive housing prices up in the short-run as the supply side takes time to adjust to the demand shock (Cochrane & Poot, 2021), (Mulder, 2006). In the long-run, the supply side will follow the demand side of housing and form a new housing price equilibrium (Mulder, 2006). Immigration is an example of a sudden increase in population. Cochrane and Poot (2021) find that an one percent increase in immigration can raise housing prices by two to three percent by analyzing migration shocks in eight Western economies. Moallemi and Melser (2020) also show positive effects on housing prices due to a positive shock in immigration. The demographic and economic characteristics of the immigrants play an important role in how housing demand will develop following an increase in immigration, as immigrants with lower education and/or income levels are less likely to obtain a mortgage and thus are less qualified to buy a home (Moallemi & Melser, 2020).

A third component of housing demand is economic/consumer confidence. Dong, Hui, and Yi (2021) find evidence that higher economic sentiment can have a positive effect on buying a home. Higher economic confidence also contributes to higher housing investments and motivates to buy a second house. Similar evidence is found by Abildgren, Hansen, and Kuchler (2018), who also show that positive economic confidence can have an upward pressure on housing prices. Highly confident or overoptimistic buyers on the housing market can even lead to housing price booms as happened in the middle of the 1980's and 2000's in Denmark. Rouwendal and Longhi (2008) find evidence that positive consumer confidence affected the sharp rise in housing prices between 1999 and 2000 in The Netherlands. The authors find no existence of an endogenous relationship where housing prices affects consumer confidence. When the economy struggles, consumer confidence can decrease which could affect housing prices negatively through lower housing demand (Xu, 2017).

Other drivers that are argued to increase housing prices are fundamental macroeconomic variables which include inflation, employment rate, (household) income and GDP growth. Anari and Kolari (2002) and Tsatsaronis and Zhu (2004) find positive effects of inflation on housing prices. One explanation for the positive relationship between housing prices and inflation is given by Leombroni, Piazzesi, Schneider, and Rogers (2020), who find a shift in portfolio assets from equity to housing as this is more profitable in times of high inflation. Agnew and Lyons (2018) show existence of a positive relationship of employment on housing prices. Housing prices rise with about two percent after one to two years when 1000 new jobs have been created. Irandoust (2019) finds a negative relationship using cross-country analyses of unemployment on housing prices, which is in line with the findings of Agnew and Lyons (2018), as the effect is reversed due to the use of the unemployment statistic instead of the employment statistic. During COVID-19, unemployment rates rose slightly in The Netherlands, reaching its peak in August 2020. From September 2020 onwards, unemployment rates started to decline to pre-pandemic levels (CBS, 2021). The evidence of the effect of (household) income on housing prices is more precarious. Al-Masum and Lee (2019) and Määttänen and Terviö (2014) find positive effects of income on housing prices, yet Gallin (2006) finds a negative effect. One possible answer for the different effects of income on housing prices is given by Xu (2017), who does obtain a positive relationship between income and housing prices, as higher income increases demand for housing. But, when housing prices are too high, this can result in buying pressure which could omit the upward effect of income on housing demand. The relation between GDP on housing prices is also given by Xu (2017), who explains that positive GDP growth affects the value of buildings and incentivizes housing investments positively, which increases housing prices. During COVID-19, Dutch GDP declined from the first quarter of 2020 until the first quarter of 2021. Since the second quarter of 2021, Dutch GDP has recovered fast with steady growth rates during the remainder of 2021 (CBS, 2022b).

2.2. COVID-19 housing price drivers

The literature on the effects of pandemics on housing prices is scarce, as pandemics are not a very reoccurring phenomenon. The currently available literature on the effects of COVID-19 on housing prices give some valuable insights. Looking at macro-effects, Qian et al. (2021) find a general negative effect of increasing COVID-19 cases on housing prices of 2.47 percent in China. The effect can hold for three months while the size of the effect increases as time goes on. Conflicting evidence is found by Zhao (2020), who shows that overall, housing prices in the US increased between March and August 2020 due to monetary easing, which positively affected housing demand through lower mortgage interest rates. Zhao (2020) also argues that there is a clear break starting from March 2020 onwards (which is when COVID-19 hit the US), when housing prices increased more severely compared to pre-March 2020. Explanations for this structural break are a 'fear of missing out' effect or a switch in the behavior of households due to COVID-19.

The results from Qian et al. (2021) and Zhao (2020) do not give a clear answer of how COVID-19 affects housing prices as the evidence is conflicting. Micro-focused literature on the effect of COVID-19 on housing prices allows to decompose the general findings.

The results from B. Wang (2022) show that the introduction to COVID-19 reduced demand in the short-run, therefore housing prices decreased between March and May 2020. From June 2020 onwards, housing prices stabilized and started increasing again starting in July 2020. The stabilization and rise in housing prices is stronger for higher valued homes compared to lower valued homes. Gamber et al. (2021) show that the increase in housing valuation during COVID-19 can partially be explained by working from home policies. Governments all around the world advised workers to work from home as much as possible to limit social interactions and thus COVID-19 infections (Buitelaar et al., 2021). This resulted in households spending more time at home. Difference-in-Difference regression outcomes show that regions with higher working from home rates experienced a significantly higher increase in housing prices compared to regions with lower working from home rates. The increase in housing prices works through higher demand and higher valuation for housing in regions with higher working from home rates, as these households spend more time at home (Gamber et al., 2021). The time spending at home rate in The Netherlands also increased compared to pre-pandemic levels, as the Dutch government strongly advised workers to work from their residency as much as possible. Figure 2.1 shows that the staying at the home rate increased severely compared to the pre-pandemic baseline[1]. Buitelaar et al. (2021) find that due to the working from home advise, the number of workers in The Netherlands that worked from home increased with five percent in the fourth quarter of 2020. The valuation for housing increased as well, but no effect of increasing housing prices is mentioned.

Furthermore, COVID-19 appears to have ignited a move away from high population dense/urban areas towards less population dense areas/non-urban areas. D'Lima, Lopez, and Pradhan (2022) show that during COVID-19, housing prices in population dense areas decreased with 1.4 percent, whilst housing prices in less population dense areas increased with 1.5 percent due to a change in housing preferences. Ramani and Bloom (2021) also find evidence for this *'Donut-effect'*, where households and entrepreneurs within population dense cities move towards more spacious suburban parts of the city where the population density is lower. Evidence from Yang et al. (2022) invokes that during COVID-19, homeowners valued spacious homes more, but does not show if this increases housing prices in regions with more spacious homes. S. Liu and Su (2021) show existence of similar effects where households move from population dense areas to less dense areas. The authors give three arguments for the drop in housing demand and housing prices in densely populated areas. First, dense areas tend to be relatively closer

[1]The dashed line indicates absence of data

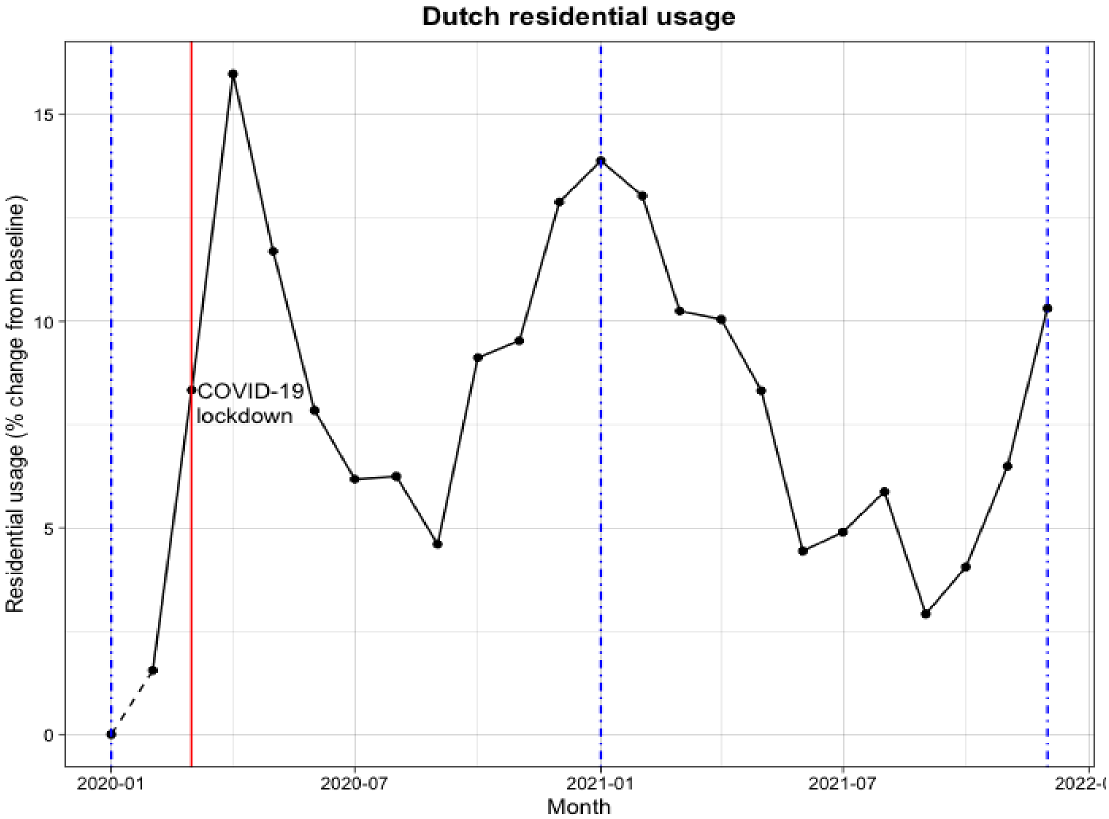

Figure 2.1.: Dutch residential use (Source: Google Mobility Data)

to job amenities compared to less dense populated areas. Working from home policy measures decreased the need for workers to live closer to their job. Working from home policies that were implemented to limit COVID-19 infections thus lower demand for living in population dense areas. For The Netherlands, no statistical significant evidence is found that COVID-19 stimulated a move away from population dense areas towards less population dense areas, although articles on the move from urban to non-urban areas due to COVID-19 appeared early 2021 (FD, 2021), (NOS, 2021a). Buitelaar et al. (2021) do find a positive trend of moving towards non-urban areas in The Netherlands, but argue that this was already an ongoing, long-term trend which can be explained by the high prices in urban regions and is thus not caused by COVID-19 and working from home policies. Second, consumption amenities are more abundant in population dense areas. Due to COVID-19 lockdowns, these amenities were often closed. Therefore, the value of living close to consumption amenities decreases, which would lower the demand for housing in population dense areas. Finally, housing supply elasticities in population dense areas are often lower, therefore increasing housing prices when demand increases (Saiz, 2008). If demand for living in dense areas decreases, housing supply elasticities could increase, which could lower housing prices. One additional possibility for higher demand for housing in less population dense areas is that COVID-19 spreads more easily in regions with a higher population density (Coşkun, Yıldırım, & Gündüz, 2021). Moving towards towards less population dense regions could therefore lower the risk of being infected with COVID-19.

2.2.1. Risk-aversion

Apart from changing housing demand preferences, COVID-19 also affected risk-aversion behavior of individuals. Goossens and Knoef (2022) show that increasing COVID-19 hospitalizations in The Netherlands positively affect risk-aversion, time consistency and patience in the long-term. The effects are more severe at the beginning of the pandemic, starting in March 2020, relative to December 2020, as the pandemic was completely new in March 2020. Therefore, uncertainty at the beginning of the pandemic was higher. Interestingly, during the experiment, the authors found that when the amount of patients with COVID-19 in hospitals increased, investors held on to assets longer that experienced (financial) gains during the time-period of increasing COVID-19 hospitalizations. The driving force behind this finding is to create a financial buffer for the uncertain future. Translating this effect to the housing market, holding on to assets, like housing, longer than usual, could lead onto decreasing housing supply, as home-owners are less likely to sell their property when the value of their home increases to build a financial buffer for the future. On the other hand, individuals are also more risk-averse during during COVID-19 pandemic. This lowers the willingness to pay, therefore possibly lowering demand. How housing prices will behave therefore depends on the strength of the effects of the willingness to pay (demand) and holding on to assets (supply). If during uncertain periods, the decrease in demand is stronger relative to supply, prices could decrease. If the effect of home-owners holding on to their asset (house) longer dominates over the demand effect, prices could increase. Goossens and Knoef (2022) also show that individuals saved more due to higher risk-aversion and long-term patience caused by COVID-19. The Dutch National Bank (DNB) confirms that, especially in 2020, households have increased their savings during COVID-19 compared to the pre-pandemic years (De Nederlandsche Bank, 2022). The increased savings could have an upward pressure on housing prices, as Zeng, Zhang, Wang, and Zeng (2019) show that increasing household savings can increase housing prices.

2.3. Dutch housing market

Since 1970, housing prices in The Netherlands increased relatively steady, with two short periods of housing value decline at the end of the 1970's and around 2008. Over 50 years, no other good in the Dutch economy grew as strong as housing prices. The Dutch housing market also showed no evidence of any cyclical development (Deelen et al., 2020). Figure 2.2 plots the average Dutch housing price between 1995 and 2021. Apart from a period of five years from 2008 until 2013, Dutch housing prices have been rising continuously since 1995. In 26 years, the average housing price in The Netherlands increased from about €100.000 to about €400.000, almost quadrupling its value.

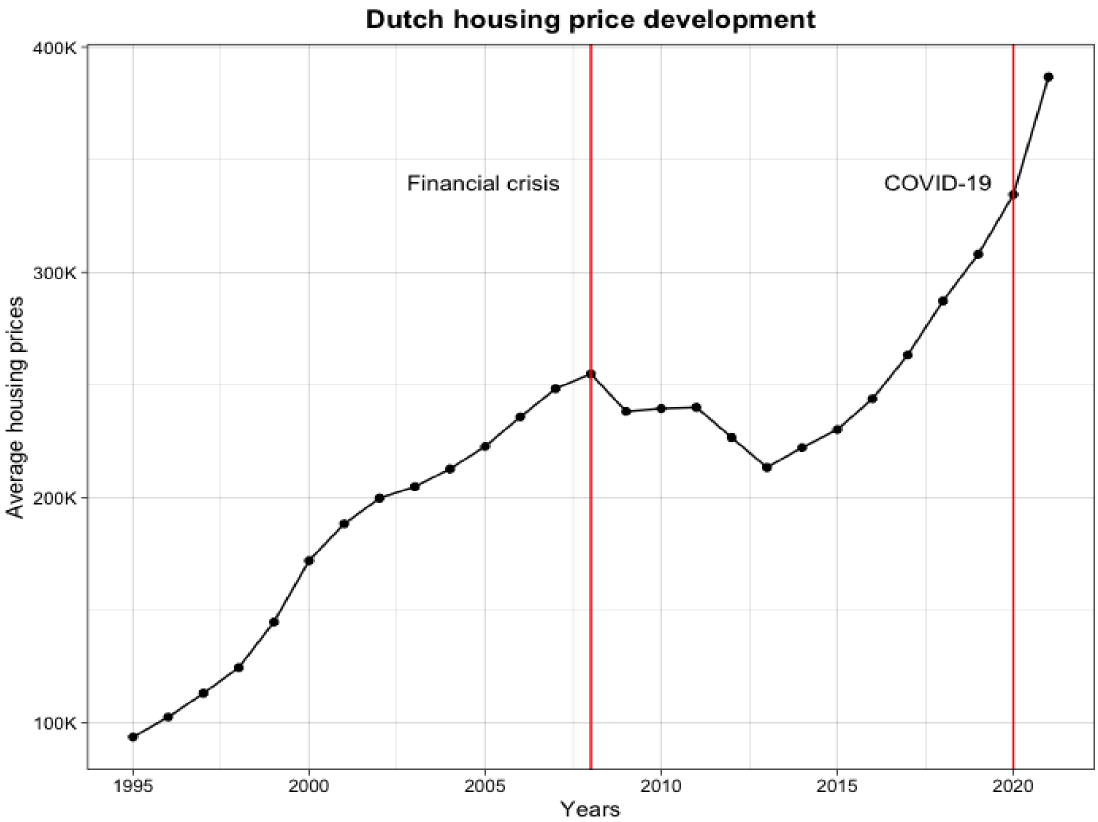

Figure 2.2.: Dutch housing price development: 1995-2021 (Source: CBS)

Analyzing the supply side of housing in The Netherlands, some findings stand out. Sánchez and Johansson (2011) show that The Netherlands has one of lowest housing supply elasticities in the world. Therefore, an increase in housing demand will likely not result in more housing construction projects, but will increase prices instead (Rouwendal, van der Straaten, & Vermeulen, 2007). The supply of housing in The Netherlands was worsened by the financial crisis of 2008. Housing construction output stayed relatively stable right after 2008, but starting from 2013, housing output mitigated until around 2018, when housing construction increased slightly afterwards (Boelhouwer, 2020). This decrease in housing supply can be partially explained by the reaction of the supply elasticity to the drop in housing prices right after the Great Recession (Deelen et al., 2020). Because of the fall in housing prices, housing construction capacity was negatively affected. As a result, when demand for housing increased, the supply side of housing couldn't absorb the demand shock as quickly, as housing construction capacity, and therefore the supply elasticity, was diminished. Hence, this short-term effect of a decreased housing supply elasticity can have long-term supply effects on the Dutch housing market, especially since The Netherlands already has a very low housing supply elasticity (Buitelaar, 2019) (Sánchez & Johansson, 2011). Supply of housing in The Netherlands is also limited due to scarce available land for housing construction purposes and on account of rigid and long governmental processes for attaining the permits for such land. These complications lead to a longer period until new houses can be build (Deelen et al., 2020). More recently, the issuing of housing construction permits has been limited due to the fact that the Dutch government wants to reduce nitrogen emissions and housing construction cites emit nitrogen (Bürmann, 2022). Partially due to the described supply issues, the housing shortage in The Netherlands reached 4.2 percent of the total housing stock in 2020 (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2021).

On the demand side, the Dutch government stimulates home-ownership through different policies. The Netherlands maintains a generous tax system as home-owners can deduct their mortgage interest from their taxes. This is called the mortgage tax deduction (hypotheekrenteaftrek) (Boelhouwer, 2017). The mortgage tax deduction allows home-owners to deduct their mortgage interest payments from their income taxes, thus owning a house becomes more affordable and therefore stimulates housing demand as buying a house becomes cheaper (Wigger, 2021). To stimulate the housing market right after the financial crisis of 2008, the Dutch government enlarged the tax-free wealth transfer of €50.000 to €100.000, which eases the housing market entry for first-time buyers as parents can partially fund the mortgage on a tax-free basis with a wealth transfer up to €100.000 (Wigger, 2021). This is tax-free transfer of wealth with the goal of buying a house is called the 'jubelton'. The tax-free wealth transfer limit stayed at €100.000 for over a decade. In 2024, the tax-free wealth transfer is planned to be cancelled (Rijksoverheid, 2022c).

The Netherlands has a relatively small private rents market (Deelen et al., 2020). On the other hand, the social housing rents market in The Netherlands is one of the largest in Europe (Nijskens et al., 2017), but limitations like a maximum income force households above the income threshold towards the smaller, private rents market (Rijksoverheid, 2022a) (Deelen et al., 2020). The rents in the private market in The Netherlands are high, especially in the larger cities. Therefore, renting in the private market is often sub-optimal compared to buying a house. This forces households towards home-ownership, therefore increasing housing demand (Nijskens et al., 2017). Explained by Dajcman (2020), lower mortgage interest rates can increase housing demand. The euro-zone experienced record low interest rate over the last few years. The DNB confirms, that also in The Netherlands, low interest rates have pushed the demand for mortgages up as costs for borrowing money is low. Therefore pushing housing prices up (De Nederlandsche Bank, 2021). Finally, The Netherlands experienced a demand shock in housing due to immigration. This immigration shock increased the housing shortage with 3.2 percent in 2018 (Boelhouwer, 2020).

2.3.1. Areal differences

The combination of supply and demand complications described in section 2.3, resulted in Dutch housing prices increasing fast, with more than twice the amount the European real-estate average price since 2013 (Wigger, 2021). Figure 2.2 confirms the rapid rise of average Dutch housing prices, with in an increase of almost €200.000 between 2013 and 2021. However, housing price developments may not behave similar across all twelve Dutch provinces. Klarl (2018) finds evidence for differentiating housing price development in The Netherlands between 'Randstad' and 'Non-Randstad' regions[2], suggesting that the Dutch housing market is very localized. Findings from the DNB shows that especially in the urban, 'Randstad' provinces, housing prices increased faster relative to the non-urban areas due to higher demand. Mainly young people between eighteen and 29 move to urban areas, therefore naturally boosting population growth in the same urban area they live in through new births (Nijskens et al., 2017). One other explanation for differentiating housing prices between 'Randstad' and 'Non-Randstad' provinces is that the land for construction purposes around the 'Randstad' provinces is relatively scarce (Hilber & Vermeulen, 2016). The possibility to increase the housing supply is therefore limited, which decreases the supply elasticity (Saiz, 2010). Following Glaeser et al. (2008), increased demand in urban areas with a lower housing supply elasticity will lead to increasing housing prices within those same urban regions.

[2]The 'Randstad' area is an agglomeration of the three provinces Noord-Holland, Utrecht and Zuid-Holland, which is where the biggest Dutch cities are located (CBS, 2022a)

Table 2.1.: Averages of population density, housing price and living space (Source: CBS)

Province	Population density (per km^2)	Housing price €	Living space (m^2)
Drenthe	183	185.496	137
Flevoland	258	192.682	126
Friesland	191	170.946	136
Gelderland	399	226.773	130
Groningen	246	160.933	129
Limburg	523	186.150	137
Noord-Brabant	494	233.026	131
Noord-Holland	995	260.742	101
Overijssel	335	192.773	128
Utrecht	863	260.787	115
Zeeland	212	176.480	122
Zuid-Holland	1246	212.587	104

Table 2.1 shows the average population density per km^2 and the average housing price per Dutch province over the period 1995 to 2021. The average living space per m^2 is given over the period 2015-2021. The 'Randstad' provinces have the highest population density of all twelve Dutch provinces. On average, the highest housing price can be found in Utrecht, followed by Noord-Brabant, Gelderland, Zuid-Holland and Noord-Holland. Drenthe has, on average, the lowest population density. The lowest average housing price can be found in Groningen, which could partially be explained by the occurring earthquakes in the Groningen province caused by natural-gas extraction procedures (De Kam, 2016). The 'Randstad' provinces have the least spacious homes in The Netherlands. Housing prices however are relatively high. The most spacious homes can be found in Drenthe, Limburg and Friesland where prices are lower compared to the 'Randstad' provinces. On average, individuals could buy a more spacious home in Drenthe, Limburg or Friesland for about €64.000 less compared to the average housing price of the three 'Randstad' provinces.

2.3.2. Property transfer tax

During the pandemic, the Dutch government implemented a change to the property transfer tax (overdrachtsbelasting). By 2021, the property transfer tax increased from two to eight percent for investors who already owned one house or more. First time buyers on the other hand were exempted from the property transfer tax to give them a better competitive position on the housing market. The implementation of this change in the property transfer tax resulted in an increase of finished transactions at the notary in December 2020, due to investors wanting to escape the increase in the property transfer tax before the beginning of 2021 and a decrease of transaction of first time buyers in December 2020. By January 2021, the number of transactions at the notary of first time buyers doubled compared to January 2020 (NOS, 2021b). If the change in the property transfer tax had a significant effect on housing prices is unknown. To the best of my knowledge, there is no literature available on the effect of the increase of the property transfer tax on housing prices. Figure 1.1 does show a small increase in housing prices from December 2020 unto January 2021. Still, it is not possible to dedicate this increase to the adjustment in the property transfer tax. The change in the property transfer tax is worth mentioning as this gives a full overview of changing housing price dynamics in times of COVID-19.

2.4. Hypotheses

The described theory provides the framework for formulating hypotheses that can later be tested in chapter 4. The first hypothesis will test if during COVID-19, housing prices in The Netherlands have increased significantly more compared to pre-pandemic housing price levels. The described evidence shows reason to believe so. Due to COVID-19, the Dutch government strongly advised workers to work from home as much as possible to limit the spread of coronavirus (Buitelaar et al., 2021). This resulted in higher staying at and working from home rates compared to pre-pandemic levels, which is confirmed by figure 2.1. Results from Gamber et al. (2021) show that regions with higher working from home rates have higher housing price increases and higher demand for housing, suggesting that working from home policies have increased housing prices during COVID-19. The pandemic might also have affected housing prices through changing risk-aversion preferences, as individuals tend to keep on to assets longer that experienced (financial) gains during COVID-19, which would lower the supply of housing and therefore increase housing prices if demand is kept constant (Goossens & Knoef, 2022). On the other hand, the willingness-to-pay during the pandemic decreased through higher risk-aversion and long-term patience. This would lower the demand for housing as individuals are more keen to postpone their decision to buy a house. One side effect of a lower willingness-to-pay is that net savings increased during the pandemic and higher household savings can put an upward pressure on housing prices (De Nederlandsche Bank, 2022), (Zeng et al., 2019).

Apart from COVID-19 influences, macro-economic variables also might have played an important role. This will later be controlled for in the analysis. The interest rate in the EU has been kept low for over a decade and COVID-19 increased the pressure too keep the interest rates low (Andrade et al., 2021). Lower mortgage interest rates reduce mortgage costs and therefore stimulate housing demand (Dajcman, 2020). If interest rates are kept at a minimum for too long, interest rates could facilitate housing price booms (Taylor, 2007). In 2020, mortgage interest rates explained about a third of housing price increases (Gamber et al., 2021). The Dutch government increases housing demand further through home-ownership policy incentives like the mortgage tax-deduction and tax free wealth transfer (Wigger, 2021) (Boelhouwer, 2017). In a country with one of the lowest housing supply elasticities in the world, these policy measures are likely to have increased demand and thus put an upward pressure on housing prices in The Netherlands (Sánchez & Johansson, 2011).

Combining COVID-19 effects with macro-economic influences and Dutch housing market characteristics on housing prices, the first hypothesis states that housing prices in The Netherlands have increased during COVID-19 compared to pre-pandemic levels. This is in line with findings from Zhao (2020), who shows that housing prices during COVID-19 have increased significantly more compared to the pre-coronavirus period. The first hypothesis is thus formulated as:

H0: COVID-19 has no effect on housing prices in The Netherlands.
H1: COVID-19 has an increasing effect on housing prices in The Netherlands.

The second and third hypothesis test whether the *Donut-effect* is dominant in The Netherlands, where there is lower demand for housing in population dense/urban areas and higher demand for housing in less population dense/non-urban areas. The 'Randstad' area, containing the provinces Noord-Holland, Utrecht and Zuid-Holland, can be defined as urban as these provinces contain the biggest main cities and have the highest population density which can be derived from table 2.1 (CBS, 2022a). The movement from the 'Randstad' provinces to other provinces in The Netherlands could be driven by multiple factors. Due to COVID-19, the Dutch government issued workers to work from home as much as possible (Buitelaar et al., 2021). Figure 2.1 shows an increasing rate of staying at and working from home. Working from home increased the need for more living space (Yang et al., 2022). At least in The Netherlands, the urban ('Randstad') provinces have the least spacious homes with the highest population density and highest prices per square meter (see table 2.1). This could motivate households to move to more spacious, cheaper houses in the periphery. Other motives for this *Donut-effect* is that working from home policies demotivate to live closer to work, which is often the case in urban areas, and therefore the value of living close to work diminishes. The same argument goes for living close to consumption amenities in urban areas. These consumption amenities were often closed due to COVID-19 lockdows, which could lower the value of living close to these amenities (S. Liu & Su, 2021). Both argument could incentivize households to move away from the 'Randstad' region towards the other less population dense provinces outside the 'Randstad'. One additional motive could be that COVID-19 spreads easier in population dense areas. Moving towards less populated provinces could thus lower the risk of being infected with COVID-19 (Coşkun et al., 2021).

Buitelaar et al. (2021) acknowledge that households in The Netherlands have been moving away from the 'Randstad' towards different provinces in The Netherlands, but argue that COVID-19 has not influenced this movement and could rather be explained by high housing prices in the 'Randstad' area. This is not in line with other evidence found by S. Liu and Su (2021) and Ramani and Bloom (2021). The statement from Buitelaar et al. (2021) is used as the null hypothesis. Using a supply and demand model where households move away from the 'Randstad' to other provinces, thus increasing housing supply in the 'Randstad', the alternative hypothesis for hypothesis two states that COVID-19 has a negative effect on housing prices in the 'Randstad':

H0: COVID-19 has no effect on 'Randstad' housing prices.
H1: COVID-19 has a negative effect on 'Randstad' housing prices.

On the other hand, higher housing demand in other, non-'Randstad' provinces, due to a move away from the population dense 'Randstad' region, should increase housing prices. Therefore, hypothesis three is stated as:

H0: COVID-19 has no effect on non-'Randstad' housing prices.
H1: COVID-19 has a positive effect on non-'Randstad' housing prices.

3. Methodology

The hypotheses formulated in chapter 2.4 will be tested through quantitative data-analysis using a regression discontinuity design (RDD). To test whether the null hypotheses can be rejected, I use three different models, all using a RDD. The first model tests whether housing prices in The Netherlands have increased in times of COVID-19, relative to pre-COVID-19 periods. The second and third model test whether COVID-19 has decreased housing prices in 'Randstad' provinces and if the value of homes have increased in non-'Randstad' provinces.

3.1. COVID-19 timeline

To be able to set up the regression models, the timeline of the COVID-19 pandemic in The Netherlands has to be established first. The Dutch government has summarized the most important COVID-19 related events (Rijksoverheid, 2022b). This can be used to define the period of time for the thesis's research design. The first wave of COVID-19 hit The Netherlands around the end of February 2020. By March 15, The Dutch government had imposed many lockdown measures like closing schools, offices, cafe's and cancelled big events. Towards the summer of 2020, COVID-19 infections and hospitalizations decreased, which resulted in the Dutch government opening up society, still with some COVID-19 mitigation policies maintaining in place. By the end of 2020, the second wave of COVID-19 infections hit The Netherlands. In October 2020, The government of The Netherlands implemented the second lockdown of the year. This lockdown stayed in tact until around May/June 2021, when most of the COVID-19 lockdown policies were lifted. By December 2021, COVID-19 infections increased again, which led the Dutch government to impose another lockdown. This lockdown didn't last as long as the second lockdown. In January 2022, some of the lockdown policies were already abolished. By March 2022, almost all of the lockdown policy measures were lifted. During the time of writing this thesis, no other lockdown or social limitation policies have been implemented by the Dutch government since (Rijksoverheid, 2022b).

3.2. Treatment period

The described time frame in section 3.1 can be used to set up the bandwidth of the research design. COVID-19 seemed to be dominantly present within the Dutch society since the last two weeks of March 2020 to December 2021 onwards, as lockdown measures where implemented during this time frame. Starting from January 2022, the last COVID-19 lockdown measures where slowly terminated until there were no lockdown related policies left (Rijksoverheid, 2022b).

To implement a RDD, a threshold needs to be set for when treatment is applied. RDD analyses the effect of treatment versus no-treatment (Imbens & Lemieux, 2008). In the case of this thesis, the treatment effect is COVID-19 on Dutch housing prices versus the control group of Dutch housing prices with no COVID-19. Using the COVID-19 time frame, the cut-off for the treatment effect will be set at April 2020, as COVID-19 was spread all over The Netherlands and lockdown policies were in full effect by then (Rijksoverheid, 2022b). Therefore, from April 2020 onwards, COVID-19 is determined as the start of the treatment effect. Using March 2020 as the threshold for treatment would give biased effects, as during the first half of March, no major interventions were implemented by the Dutch government to limit the spread of coronavirus and therefore society might not have fully reacted to COVID-19. The threshold for the control group is set at December 2019. This means that the first three months or first quarter of 2020 is neglected for the control group. Motivation for this decision is related to the argument why not to choose March 2020 as the cut-off for treatment. During January and February, COVID-19 infections around the world rose and gained more media attention. This enabled individuals to react to COVID-19 in whatever way. The first official worldwide COVID-19 infection was discovered in Wuhan in China in December 2019 (Y.-C. Liu, Kuo, & Shih, 2020). The first official COVID-19 infection in The Netherlands was recorded in February 2020 and by March 2020, COVID-19 was defined as a global pandemic (Rijksoverheid, 2022b) (S. Liu & Su, 2021). It seems unlikely that in December 2019, Dutch housing prices already reacted significantly to the discovery of COVID-19. Therefore, December 2019 or the fourth quarter of 2019 can be used as the threshold for the control group. The end of the treatment period is set at December 2021 or the fourth quarter of 2021. This has two reasons. First, a lockdown was implemented in December 2021. By January 2022, the Dutch government started gradually lifting lockdown policy measures until there weren't any left in March/April 2022, which makes it harder to determine when the treatment of COVID-19 ended (Rijksoverheid, 2022b). Second, data availability has to be taken into account. For the model of hypothesis one, monthly data is used. This allows for specifically choosing April 2020 as the start of the treatment period and December 2021 as the end of the treatment period. For the model of hypothesis two and three, which analyses if a *Donut-effect* is present in The Netherlands, quarterly data is used as there is unfortunately not enough monthly provincial data available. As quarterly data is used, the treatment period will be set at quarter two of 2020 until quarter four of 2021. Using quarter one of 2022 in the treatment period could give biased estimates as COVID-19 lockdown policies were slowly abolished during the first quarter of 2022 (Rijksoverheid, 2022b).

3.3. Regression models

Figure 3.1 shows the development of the Dutch housing price index (in natural logs) over time, before and after treatment of COVID-19. The increase of the Dutch housing price index, before and after the treatment, is surprisingly linear. Hence, it seems there is no need to implement a polynomial model. Figure 3.1 also shows a noticeable difference between the coefficients of the control and treatment period. The coefficient of the treatment period seems positively steeper compared to the control period. This supports the hypothesis that COVID-19 might have had a positive effect on Dutch housing prices, but no causal relation can be derived from this finding yet.

The first RDD model tests whether COVID-19 had an uplifting effect on overall Dutch housing prices. The mathematical formulation of the model to test hypothesis one is given by equation 1.

$$lnY = \alpha + \beta X + \rho D + \gamma lnA + \epsilon \tag{1}$$

lnY gives the outcome of the dependent variable; Dutch housing prices in natural logs. α gives the constant housing price if all variables would be zero. β gives the coefficient for the running variable X, which is COVID-19. ρ is the coefficient for the dummy variable D, which will measure the possible difference in outcomes at the threshold. The value of D is given by:

$$D = \left\{1\, if\ X \geq April\, 2020 \text{ and } 0\, if\ X \leq December\, 2019\right\}$$

γ is the coefficient for a set of control variables of lnA. An overview of all control variables in this model is given in table 3.1. ϵ measures the error term of the model. The outcome of the RDD model gives an average treatment effect (ATE) of COVID-19 on housing prices. The ATE gives a relative effect of how housing prices during the

Figure 3.1.: Control and treatment comparison on housing index: 2015-2021 (Source: CBS)

treatment period (COVID-19) reacted in comparison to housing prices in the control period (pre-COVID-19).

The second model tests for declining housing prices in the 'Randstad' provinces. Model three tests for opposite housing price effects in the non-'Randstad' provinces. The mathematical formulation of the model to test hypothesis two is given by equation 2:

$$lnY_i = \alpha_i + \beta X_i + \rho D_i + \gamma lnA_i + \epsilon_i \tag{2}$$

In this model, the housing price for each individual province will be analysed. lnY_i gives the outcome of the housing price of in natural logs for each province i. α gives the constant housing price for each province i if all variables would be zero. β gives the coefficient for the COVID-19 running variable X for every individual province i. ρ is the coefficient for the dummy variable D_i, which will measure the possible difference in outcomes at the threshold for each province for each province i. γ is the coefficient for a set of control variables lnA_i for each province i. ϵ_i measures the error term for each province i.

In the third model, 'Randstad' and non-'Randstad provinces are pooled to check for relative effects between the two areas. The mathematical formulation of the model to test hypothesis three is given by equation 3:

$$lnY = \alpha + \beta X + \rho D + \theta U + \gamma lnA + \epsilon \quad (3)$$

Equation 3 is very similar to equation 2, but there are some small differences. lnY_i now measures the housing price in natural logs for either urban or non-urban areas. This depends on the coefficient θ for dummy variable U. The value of U depends on the hypothesis. For hypothesis two:

$$U = \Big\{1\, if\; urban \text{ and } 0\, if\; non-urban\Big\}$$

For hypothesis three:

$$U = \Big\{1\, if\; non-urban \text{ and } 0\, if\; urban\Big\}$$

The outcome of the regression model gives an ATE of housing prices during COVID-19 (treatment) compared to housing prices before COVID-19 (control), relative to either 'Randstad' or non-'Randstad' provinces depending on the value of dummy variable U.

3.4. Data

Table 3.1 shows the variables used in the RDD models. After testing for multicollinearity through a variance inflation test (VIF), CPI and the mortgage interest rate have a VIF score ≥ 10, which is an indicator that these variables are highly correlated with other control variables. A VIF score ≥ 5 does give some concerns regarding multicollinearity, but here, a critical value of ≥ 10 is applied (Menard, 2002). Including CPI and the mortgage interest could bias the outcome of the models as they both have a VIF value of ≥ 10 (Akinwande, Dikko, Samson, et al., 2015). Figure A.1 in the appendix shows that especially the mortgage interest rate is highly inflated. In the analysis, this will be controlled for by removing the mortgage interest rate as a control variable. The VIF values for the control variables without the mortgage interest rate are given by figure A.2 in the appendix, which shows that all control variables now have a VIF value < 5.

Table 3.1.: Descriptive Statistics (2015-2021)

Variable	**Function**	**Source**	**Monthly**	**Quarterly**
Housing index (2015 = 100)	Dependent	CBS	Y	Y
Average housing price (€)	Dependent	CBS	Y	Y
Housing stock	Control	CBS	Y	Y
New build dwellings	Control	CBS	Y	Y
Population growth	Control	CBS	Y	N
Mortgage interest rate (>5 years)	Control	ECB	Y	Y
Net savings	Control	DNB	Y	N
CPI (all products)	Control	OECD	Y	Y
Consumer confidence (Index)	Control	OECD	Y	Y
Unemployment rate (% of labour force)	Control	OECD	Y	N
GDP (% change from previous year)	Control	FRED	Y	Y

All control variables are squared and then transformed into natural logs. This allows for an easier interpretation of the regression output, as an one percentage increase in the control variable changes the dependent variable with a certain percentage. The dependent variable, housing prices in The Netherlands, is measured by the housing index and by the average housing price. An advantage of using the housing index as the dependent variable over the average housing price, is that the housing index is less dependent on market buying decisions. For example, if in a certain year, only houses above the average price would be sold, housing prices would seem to increase, which may not essentially be the case. The selection of control variables is based on the findings in the theoretic framework. On the demand side, population growth, mortgage interest rate, GDP, CPI, net savings, consumer confidence and the unemployment rate are used. New build dwellings and the housing stock are used as a proxy for the supply side of housing.

Apart from using control variables in real-time, lagged variables will also be included as controls to capture delayed effects. The dependent variables will also be lagged and included as a control variable as Cohen and Karpaviciute (2017) find evidence that the housing price in the previous period has a significant effect on the housing price in the next period. Using quarterly data, the dependent and control variables will be lagged with one period. This is equal to three months. Therefore, when using monthly data, variables will be lagged with a maximum of three months.

The variables population growth, net savings and unemployment rate will not be included as controls in the second and third model on regional housing prices due to data availability, as quarterly data is used here. For consumer confidence, national measures are included as regional values. Hence, the underlying assumption is that consumer confidence is equal over all twelve Dutch provinces. National Dutch GDP measures are also included as regional values, under the assumption that all provinces react equally to national GDP in relation to housing prices. For the unemployment rate this assumption is less likely to hold as the values of the variable seems to differentiate for the twelve provinces (CBS, 2022d). The same goes for population growth, due to higher inflow of younger people in urban areas compared to non-urban areas, which naturally stimulates new births in urban areas more relative to non-urban areas (Nijskens et al., 2017).

Table 3.2.: Skewness and kurtosis values

Variable	**Skewness**	**Kurtosis**	**p-value**
Housing index (2015 = 100)	0.38	2.19	0.13
Average housing price (€)	0.33	2.14	0.19
Housing stock	-0.89	4.06	0.00
New build dwellings	-0.25	2.80	0.33
Population growth	-1.05	4.34	0.00
Mortgage interest rate (>5 years)	-0.15	1.99	0.56
Net savings	-0.84	3.89	0.00
CPI (all products)	0.49	2.22	0.06
Consumer confidence (Index)	-0.80	3.05	0.00
Unemployment rate (% of labour force)	0.36	1.82	0.15
GDP (% change previous year)	0.26	2.26	0.30

3.4.1. Skewness & Kurtosis

To test for skewness and kurtosis of the data, a D'Agostino-Pearson test is used. The D'Agostino-Pearson test can detect if the data is statistically significantly different from a normal distribution (D'agostino, Belanger, & D'Agostino Jr, 1990). When data is skewed, it deviates from the normal distribution. Data can either be negatively (left) skewed or positively (right) skewed. Kurtosis tells whether the distribution has heavy or light distribution tails and a sharp or flat peak (DeCarlo, 1997). The null hypothesis of the D'Agostino-Pearson test states that the data is normally distributed. If the null hypothesis can be rejected, the data is not normally distributed. The null hypothesis can be rejected when the p-value ≤ 0.05. Table 3.2 shows that four out of eleven variables have a skeweness and are thus not normally distributed. This could influence the calculation of the confidence intervals of the regression model and therefore the regression coefficient outcomes. A graphical overview of the distribution of the variables is given by figure A.3 which can be found in the appendix.

3.4.2. Heteroscedasticity

With heteroscedasticity, the residual variance is not equal over the full range of the model and the variance of the residuals increases over time. The Breusch-Pagan test can control if heteroscedasticity is present within the data. The null hypothesis states that there is no heteroscedasticity, but can be rejected when the p-value ≤ 0.05. If this is the case, the residuals are heteroscedastic. Executing the Breusch-Pagan gives a p-value of 0.53. Therefore, the null hypothesis cannot be rejected which indicates that there is no heteroscedasticity present within the dataset.

4. Analysis

The output of the RDD models will play a central role in the analysis, as the obtained estimates of the RDD models provide evidence whether the null hypothesis of the formulated hypotheses can be rejected. To get a feel for the data, table 4.1 shows the descriptive statistics of the used variables within the time-frame of 2015 until 2021. Looking at the used dependent variables, the average of the housing index shows a value of 125.5, which means that on average, housing values have increased between 2015 and 2021. The maximum housing index value measured within the dataset is 176.3, which shows that housing values in The Netherlands have increased a lot. The average housing price over 2015 to 2021 is €292,956. The average deviation of the mean (standard deviation) is quite large for the average housing price.

Table 4.1.: Descriptive Statistics (2015-2021)

Statistic	**N**	**N**	**St. Dev.**	**Min**	**Max**
Housing Index (2015=100)	84	125.5	21.2	98.4	176.3
Average housing price (€)	84	292,956	52,168	216,678	408,987
Housing stock	84	5,447	2,010	−1,875	9,956
New build dwellings	84	5,304	1,405	2,418	9,055
Population growth	84	8,213	6,751	−4,605	30,507
Mortgage interest rate (>5 years)	84	3.2	0.5	2.3	4.3
Net savings	84	773.6	2,177	−4,574	9,405
CPI (all products)	84	104.2	3.7	98.2	114.0
Consumer confidence (Index)	84	100.6	0.84	98.2	101.6
Unemployment rate (% of labour force)	84	5.6	1.3	3.7	8.3
GDP (% change from previous year)	84	−0.2	2.8	−9.7	7.1

An interesting control variable to analyse is the mortgage interest rate. The average mortgage interest rate between 2015 and 2021 was 3.2 percent. The lowest level of interest rate measured is 2.3 percent. The highest level is 4.3 percent. Consumer confidence has stayed fairly level as the low standard deviation of 0.84 shows. The average unemployment rate is 5.6 percent, with the lowest level of unemployment measured being 3.7 percent and the maximum being 8.3 percent. Overall, GDP shows a small average decline, with quite a large variation between minimum and maximum values, as the minimum value is -9.7 percent and the maximum value being 7.1 percent, which is a difference of 16.8 percent points.

4.1. Regression results

The first regression results will establish whether the null hypothesis of hypothesis one can be rejected, which states that COVID-19 has no effect on housing prices in The Netherlands. If the null hypothesis can be rejected through obtaining statistical significant regression results (which is when the p-value is ≤ 0.05), the alternative hypothesis can be accepted where COVID-19 has a positive effect on overall Dutch housing prices. Table 4.2 and 4.3 show the regression output for hypothesis one. Table 4.2 gives the ATE for the period 2015-2021, where the development of housing prices during COVID-19 (treatment) is relative to the period 2015-2019 (control). In the first model (column one and four) no control variables are used and can thus be used as a baseline. The estimates are highly significant and find an increase in housing prices of about 60 to 64 percent[1] compared to pre-COVID-19 housing prices.

Table 4.2.: Overall Dutch housing price effects (2015-2021)

	Dependent variable:					
	Housing index (ln)			Average housing price (ln)		
	(1)	(2)	(3)	(4)	(5)	(6)
ATE	0.606***	0.191***	0.284***	0.641***	0.263***	0.402***
	(0.050)	(0.035)	(0.030)	(0.053)	(0.053)	(0.044)
Constant	9.472***	−11.040***	−15.680***	24.970***	5.471	−1.457
	(0.025)	(3.456)	(3.589)	(0.027)	(5.131)	(5.334)
Controls	N	Y	P	N	Y	P
Observations	81	81	81	81	81	81
R^2	0.654	0.994	0.993	0.653	0.989	0.986
Adjusted R^2	0.649	0.993	0.992	0.649	0.987	0.984
Note:				*p<0.1; **p<0.05; ***p<0.01		

[1] As logs are used, regression coefficients can be multiplied by 100%.

As controls are not included, it is incorrect to interpret the findings of model one as causal. The second model, which is represented by column two and five, include all control variables in the dataset. The coefficients are statistically significant, but the strength of the effect weakens comparing the coefficients of model two to the coefficients to model one. The coefficients of model two find a relative increase in housing prices of about nineteen to 26 percent due to COVID-19. The adjusted R^2 of the second model is fairly high with a value of 0.993 and 0.987, which shows that the model explains 99.3 to 98.7 percent of the dependent variables. The estimates of the third model are given by column three and six. Here, the mortgage interest rate is left out as a control variable, as Gamber et al. (2021) provide evidence that the mortgage interest rate explained about one third of the rise in housing prices during 2020 and therefore seems an important factor of explaining housing price developments. Omitting the mortgage interest rate in model three also controls for the fact that the mortgage interest rate is highly inflated as the VIF test in the methodology showed. Leaving the mortgage interest rate out of the regression could therefore give less inflated estimates. In model three, and in future models, the letter P represents the partial use of control variables. In this case, the mortgage interest rate is thus omitted. The coefficients of model three show statistical significant effects for both dependent variables. On average, housing prices during COVID-19 increased between 28 and 40 percent when leaving out the mortgage interest rate. The adjusted R^2 of the third model becomes slightly smaller compared to the second model, but the difference is negligible. Extracting the coefficients of the second model from the coefficients of the third model gives a rough estimates of the average effect of the mortgage interest rate on housing prices. On the housing index, the mortgage interest rate is responsible for an increase in housing value of about nine percent compared to pre-COVID-19 housing values. Under the average housing price, the mortgage interest rate is responsible for about seventeen percent in housing price increases. Overall, the estimates under the average housing price are higher compared to the housing index. As explained in the methodology, the housing index is a less biased estimate. Lags were intentionally added to set up a fourth regression model, but didn't enhance the adjusted R^2 or general fit of the other variables. Therefore, the fourth model with lagged variables is therefore neglected here.

Although table 4.2 shows promising results, the null hypothesis cannot be rejected yet, as the period used before the cut-off (control) is larger than the period after the cut-off (treatment). In table 4.3, the period before and after the cut-off is equal, with a range of 21 months. The estimates of the first model show an average rise in housing prices, compared to pre-pandemic housing prices, of about 36 to 39 percent. Adding control variables in model two, shows no statistical significant effect of COVID-19 on housing prices under the housing index. Using the average housing price as the dependent variable, a statistical significant effect is found where the average housing price during COVID-19 has increased with about 30 percent relative to pre-pandemic housing prices in The Netherlands. The adjusted R^2 of model two is relatively high with values of 98.7 and 96.2 percent. Excluding the mortgage interest rate in model three gives statistical significant effects for both dependent variables. This implicates that the mortgage interest rate plays a vital role in explaining the rise in housing prices. Under model three, COVID-19 has increased housing prices with about 22 to 46 percent. Also here, the intention was to add a fourth model with lagged values, but didn't enhance the adjusted R^2 or general fit of the other variables. Hence, the fourth model with lagged variables is also neglected here. Comparing the overall findings of table 4.3 with table 4.2, one can notice that the effects in table 4.3 are less strong, indicating that the use of a larger control period can increase the treatment effect of COVID-19 on housing prices.

Table 4.3.: Overall Dutch housing price effects (21m-21m)

	Dependent variable:					
	Housing index (ln)			Average housing price (ln)		
	(1)	(2)	(3)	(4)	(5)	(6)
ATE	0.367***	0.085	0.218***	0.389***	0.295***	0.462***
	(0.038)	(0.051)	(0.054)	(0.039)	(0.094)	(0.087)
Constant	9.712***	−6.573	−26.836***	25.222***	18.466	−6.853
	(0.027)	(6.197)	(5.529)	(0.028)	(11.368)	(8.979)
Controls	N	Y	P	N	Y	P
Observations	42	42	42	42	42	42
R^2	0.701	0.990	0.984	0.714	0.971	0.962
Adjusted R^2	0.693	0.987	0.980	0.706	0.962	0.951
Note:				*p<0.1; **p<0.05; ***p<0.01		

Using the regression coefficients of table 4.2 and 4.3 gives motivation for whether the null hypothesis of hypothesis one can be rejected or not. Overall, the tables show positive, statistical significant effects of COVID-19 on housing prices. Therefore, the null hypothesis can be rejected and the alternative hypothesis can be accepted which states that COVID-19 has an increasing effect on housing prices in The Netherlands. This is line with the evidence of Zhao (2020), who finds a structural break in housing price development before and during COVID-19, where housing prices have increased significantly more during the pandemic. One important side note has to be made on the subject of the mortgage interest rate. Controlling for the mortgage interest rate in model two of table 4.3 first and omitting the mortgage interest rate in model three under the housing index shows that the mortgage interest rates also plays a significant part in explaining the rise in housing prices in the treatment period.

A driver for the rise in housing prices is the working from home advise. As Gamber et al. (2021) show, regions with higher working from home rates show a higher demand for and higher value of housing, which positively affects housing prices within those same regions. One other COVID-19 related factor for increasing housing prices is that homeowners held onto their homes longer. Goossens and Knoef (2022) find evidence that individuals held on to assets longer which experienced gains during COVID-19, with the purpose to build up a financial buffer to absorb possible future risk. This could've lowered the supply of housing in The Netherlands and with housing demand positively stimulated by the low mortgage interest rate and generous Dutch housing market policy schemes, housing prices in The Netherlands have likely increased during the COVID-19 pandemic.

Next, the effect of COVID-19 on local housing prices will be analyzed. Table 4.4 shows regression coefficients for each of the twelve Dutch provinces. Here, four models are used to analyze the provincial effects of COVID-19 on housing prices. The first model uses no control variables and is used as a baseline. Controls are added in model two. In model three, partial controls are used by omitting the mortgage interest rate as a control variable. In the fourth model, lagged variables are added. The full data range of 2015 until 2021 is used here. For the province of Drenthe, COVID-19 seemed to have increased housing prices significantly. For both dependent variables, positive and statistical significant effects are found across all four models. Under the housing index, housing prices seemed to have increased with about ten to fourteen percent. Under the average housing price, housing prices in Drenthe have increased between 22 and 24 percent due to COVID-19. Housing prices in Flevoland seemed to be unaffected by COVID-19, finding no to weak significant effects. The same goes for Friesland and Gelderland where small to none significant effects are found. The coefficients on the Groningen province suggest that COVID-19 has had a positive and significant effect on housing prices there. Under the housing index, housing prices increased between around ten to fifteen percent on average. Under the average housing price, prices of homes in Groningen increased with an average of around eighteen to 23 percent. In Limburg, COVID-19 has had a more moderate, but positive and slightly significant effect on housing prices, increasing housing prices with seven to eleven or ten to fifteen percent depending on the dependent variable. In Noord-Brabant, housing prices seemed to have increased significantly due to COVID-19, but omitting the mortgage interest rate in model three and comparing the coefficient to the coefficient in model two suggests that the increase in housing prices in Noord-Brabant is also partially driven by the mortgage interest rate. Under the housing index, negative housing price effects are found in model two and three for Noord-Holland, providing evidence that housing prices have declined in urban ('Randstad') areas during COVID-19. Though, the effects are not statistically significant, like most coefficients for Noord-Holland, inclining that COVID-19 had no statisitcally significant effect on housing prices within that province. The coefficients for Overijssel show some statistical significant results, suggesting that under the housing index, housing prices have increased between thirteen and fourteen percent due to COVID-19. In Utrecht, hardly any significant effects are found, which implicates that COVID-19 had no effect on housing prices there. Under the housing index, the coefficients for Zeeland show that COVID-19 had an increasing effect on housing prices, varying between thirteen and fifteen percent. Under the average housing price, no statistical significant effects are found. For Zuid-Holland, it is the other way round. Under the housing index, statistical significant effects are found only in model four. Using the average housing price, model two and four give statistical significant effects, indicating that COVID-19 has increased the average housing price between fifteen and 22 percent.

Table 4.4.: Provincial housing price development (2015Q1-2021Q4)

	Dependent variable:							
	Housing index (ln)				Average housing price (ln)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Drenthe	0.619***	0.139**	0.144**	0.106**	0.633***	0.247***	0.244***	0.229**
	(0.077)	(0.062)	(0.060)	(0.039)	(0.075)	(0.061)	(0.059)	(0.084)
Flevoland	0.741***	0.080	0.117	0.127**	0.747***	0.120*	0.183*	0.116
	(0.104)	(0.060)	(0.074)	(0.021)	(0.108)	(0.060)	(0.098)	(0.070)
Friesland	0.596***	0.085	0.075	0.067	0.619***	0.095*	0.080	0.090
	(0.081)	(0.052)	(0.059)	(0.038)	(0.081)	(0.049)	(0.067)	(0.065)
Gelderland	0.606***	0.087	0.094	0.072**	0.657***	0.113*	0.124	0.142**
	(0.083)	(0.061)	(0.068)	(0.024)	(0.087)	(0.054)	(0.075	(0.056)
Groningen	0.642***	0.148**	0.137**	0.106**	0.633***	0.202***	0.179**	0.228**
	(0.079)	(0.058)	(0.061)	(0.044)	(0.082)	(0.069)	(0.085)	(0.090)
Limburg	0.552***	0.113**	0.101*	0.076**	0.572***	0.111**	0.098*	0.156**
	(0.073)	(0.043)	(0.052)	(0.033)	(0.079)	(0.045)	0.261**	(0.065)
Noord-Brabant	0.554***	0.101*	0.172***	0.060**	0.615***	0.128*	0.261**	0.217**
	(0.075)	(0.053)	(0.060)	(0.026)	(0.086)	(0.070)	(0.093)	(0.097)
Noord-Holland	0.633***	−0.040	−0.047	0.042	0.659***	0.016	0.008	0.077
	(0.108)	(0.054)	(0.125)	(0.033)	(0.116)	(0.078)	(0.162)	(0.082)
Overijssel	0.583***	0.132**	0.141*	0.056	0.613***	0.096	0.114	0.190**
	(0.075)	(0.059)	(0.070)	(0.041)	(0.085)	(0.061)	(0.102)	(0.083)
Utrecht	0.619***	0.009	0.005	0.064**	0.666***	0.050	0.044	0.077
	(0.094)	(0.055)	(0.090)	(0.029)	(0.107)	(0.069)	(0.126)	(0.057)
Zeeland	0.543***	0.151**	0.150**	0.130**	0.534***	0.013	0.015	0.058
	(0.063)	(0.069)	(0.069)	(0.044)	(0.074	(0.079))	(0.079)	(0.121)
Zuid-Holland	0.627***	0.038	0.057	0.044**	0.694***	0.149**	0.169*	0.220***
	(0.095)	(0.044)	(0.085)	(0.017)	(0.101)	(0.059)	(0.095)	(0.054)
Controls	N	Y	P	Y	N	Y	P	Y
Lags (t_{-1})	N	N	N	Y	N	N	N	Y
Observations (per province)	27	27	27	26	27	27	27	26

Note: *p<0.1; **p<0.05; ***p<0.01

Overall, the effect of COVID-19 on housing prices is the strongest in Drenthe and Groningen and to some extent in Noord-Brabant and Zeeland. These findings provide some evidence that housing prices outside the 'Randstad' have increased due to COVID-19, but no causal relations can be drawn from these findings yet.

Table 4.5.: Pooled Randstad province results (2015Q1-2021Q4)

	Dependent variable:			
	Housing index (ln)			
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	0.100***	0.123***	0.083***	0.111***
	(0.029)	(0.046)	(0.011)	(0.027)
Constant	9.422***	10.026***	17.446**	−103.170***
	(0.015)	(0.023)	(6.779)	(35.927)
Controls	N	N	Y	Y
Lags (t_{-1})	N	N	N	N
Observations	240	84	240	84
R^2	0.047	0.079	0.925	0.818
Adjusted R^2	0.043	0.068	0.923	0.801
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	0.078***	0.113***	0.010***	−0.008
	(0.013)	(0.027)	(0.003)	(0.005)
Constant	−42.838***	−49.728***	−1.475	−141.050***
	(4.742)	(5.420)	(2.423)	(27.658)
Controls	P	P	Y	Y
Lags (t_{-1})	N	N	P	P
Observations	240	84	228	84
R^2	0.887	0.813	0.994	0.994
Adjusted R^2	0.884	0.798	0.994	0.994
Note:				*p<0.1; **p<0.05; ***p<0.01

Pooling 'Randstad' and non-'Randstad' provinces gives relative price effects which allows for easier estimation if housing prices in the 'Randstad' have decreased and if housing prices in non-'Randstad' provinces have increased. The answer to these hypotheses are given by tables 4.5, 4.6 and 4.7, who show regression coefficients for the pooled 'Randstad' and non-'Randstad' provinces in the pre-pandemic period (control) and during the COVID-19 period (treatment). The results in table 4.5 show estimates over the first quarter of 2015 until the fourth quarter of 2021 for the 'Randstad' provinces. Every one of four blocks represents a model, where treatment and control estimates are provided separately.

Table 4.6.: Pooled Randstad province results (2018Q2-2021Q4)

	Dependent variable:			
	Housing index (ln)			
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	0.164***	0.123***	0.127***	0.111***
	(0.024)	(0.046)	(0.020)	(0.027)
Constant	9.629***	10.026***	15.208	−103.170***
	(0.012)	(0.023)	(15.230)	(35.927)
Controls	N	N	Y	Y
Lags (t_{-1})	N	N	N	N
Observations	84	84	84	84
R^2	0.360	0.079	0.729	0.818
Adjusted R^2	0.353	0.068	0.704	0.801
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	0.125***	0.113***	0.001	−0.008
	(0.020)	(0.027)	(0.005)	(0.005)
Constant	10.998	−49.728***	−52.786***	−141.050***
	(14.816)	(5.420)	(16.486)	(27.658)
Controls	P	P	Y	Y
Lags (t_{-1})	N	N	P	P
Observations	84	84	84	84
R^2	0.724	0.813	0.990	0.995
Adjusted R^2	0.703	0.798	0.	0.994
Note:				*p<0.1; **p<0.05; ***p<0.01

Model one functions as a baseline model where no control variables are used. Model two gives significant effects for both the control and treatment period. The same goes for model three, where the mortgage interest rate is omitted as a control variable. Including partial lags[2] gives significant effects for the control period, but insignificant effects for the treatment period. The treatment effect is found by extracting the control coefficient from the treatment coefficient. Overall, extracting the control coefficients from the treatment coefficients gives positive housing price results. In model two, housing prices increased with about three percent in 'Randstad' provinces due to COVID-19. In model three, this is about four percent.

Table 4.5 does not provide sufficient evidence yet to answer hypothesis two, as the control period uses more quarterly observations compared to the treatment period. In table 4.6, the period before and after the cut-off is equal, with a range of seven quarters. The first model functions as a baseline where no control variables are used. In model two, where controls are added, the regression coefficients are statistically significant. The same goes for model three where the mortgage interest rate is omitted as a control variable. In model four, lags are used. Here, the ATE becomes insignificant. Extracting the control coefficients from the treatment coefficients in model two and three shows that housing prices in the three 'Randstad' provinces have decreased with about 1.2 to 1.6 percent depending on the model. Given the statistical significant evidence estimates, the null hypothesis of hypothesis two can be rejected. Therefore, the alternative hypothesis can be accepted which states that housing prices in the 'Randstad' have decreased due to COVID-19.

Table 4.7 gives regression results for the other, non-'Randstad' provinces. The data range exists of both seven quarters before and and after the cut-off. Taking a closer look at the given estimates, one can notice that the effects are equal to the 'Randstad' estimates in table 4.6, but negative. This makes sense, as the effects between the 'Randstad' and non-'Randstad' areas are relative. Using dummies for Randstad' and non-'Randstad' provinces thus gives the same estimates as the effects are relative to each other, but positive effects for the 'Randstad and negative effects for the non-'Randstad' provinces.

For the non-'Randstad' provinces, positive effects of COVID-19 on housing prices are found. Extracting the control coefficients from the treatment coefficients in model two and three give positive effects, as extracting a negative number gives a positive number. For model two and three, housing prices in non-'Randstad' provinces have increased with 1.2 to 1.6 percent depending on the model, which is how much housing prices in

[2] lagged variables of inflation and GDP are omitted due to multicollinearity issues.

the 'Randstad' provinces have been decreased with. The results from table 4.7 allows to reject the null hypothesis of hypothesis three, which states that there is no effect of COVID-19 on housing prices. The alternative hypothesis can be accepted where COVID-19 has a positive effect on housing prices in non-'Randstad' provinces.

Table 4.7.: Pooled non-Randstad results (2018Q2-2021Q4)

	Dependent variable:			
	Housing index (ln)			
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (non-Randstad)	-0.164^{***}	-0.123^{***}	-0.127^{***}	-0.111^{***}
	(0.024)	(0.046)	(0.020)	(0.027)
Constant	9.793^{***}	10.148^{***}	15.335	-103.059^{***}
	(0.021)	(0.040)	(15.229)	(35.928)
Controls	N	N	Y	Y
Lags (t_{-1})	N	N	N	N
Observations	84	84	84	84
R^2	0.360	0.079	0.729	0.818
Adjusted R^2	0.353	0.068	0.704	0.801
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (non-Randstad)	-0.125^{***}	-0.113^{***}	-0.001	0.008
	(0.020)	(0.027)	(0.005)	(0.005)
Constant	11.122	-49.615^{***}	-52.786^{***}	-141.058^{***}
	(14.815)	(5.420)	(16.486)	(27.658)
Controls	P	P	Y	Y
Lags (t_{-1})	N	N	P	P
Observations	84	84	84	84
R^2	0.724	0.813	0.991	0.995
Adjusted R^2	0.703	0.798	0.990	0.994
Note:				*p<0.1; **p<0.05; ***p<0.01

Rejecting the null hypotheses of hypothesis two and three provides evidence of existence of a *Donut-effect*. The rise in housing prices for non-'Randstad' provinces relative to the 'Randstad' indicates that demand for housing in the non-'Randstad' regions was higher during COVID-19 compared to the urban, 'Randstad' provinces. However, the rise in housing prices in the non-'Randstad' provinces do not explicitly show a move of

'Randstad' households towards the non-'Randstad' provinces. Another possible explanation for the rise in housing prices in the non-'Randstad' provinces is that first-time buyers shifted their focus from the 'Randstad' towards the non-'Randstad' provinces, which would also increase housing prices in the non-'Randstad' regions due to higher demand. If this is the case, a *Donut-effect* is not present, but the focus of demand just shifted. To obtain a stronger argument for the existence of the *Donut-effect* in The Netherlands, tables A.1 and A.2 in the appendix show the regression output of the number of houses sold for 'Randstad' and non-'Randstad' provinces. The model is equal to the model used in tables 4.6 and 4.7, although the dependent variable is now the number of houses sold and the housing index is added as a control variable. The regression estimates of tables A.1 and A.2 show that relative to the 'Randstad', about fifteen to twenty percent more houses have been sold in non-'Randstad' provinces in times of COVID-19, depending on which model is used. The estimates are all statistically significant. The increased number of homes sold in non-'Randstad' provinces provide additional evidence for the existence of the *Donut-effect*, as demand for housing in non-'Randstad' regions is clearly higher, relative to the Randstad' provinces. The provided estimates on housing prices and number of houses sold is also backed by findings from the CBS, who show proof of a move away from the 'Randstad' to other Dutch provinces (CBS, 2022c).

The pooled regression estimates on the housing index and the number of houses sold provide thus statistically significant evidence for the existence of a *Donut-effect* in The Netherlands. COVID-19 has thus triggered a move away from the 'Randstad' to other Dutch provinces. One driving factor for the *Donut-effect* is the working from home advise. Often in urban areas, workers live closer to their job. The working from home advise diminished the need for living close to work, thus the demand for living in the urban, 'Randstad' area. A second driver of the move away from the 'Randstad' area is that consumption amenities are more abundant and closer in urban areas. Due to COVID-19 lockdowns, these consumption amenities were often closed, which would lower the value of living close to them. Therefore, demand for living in urban regions can decrease. A third factor is related to the working from home advise (S. Liu & Su, 2021). As the working from home rate increased, the value for home space increased as well (Yang et al., 2022). In The Netherlands, more spacious homes can overall be found outside the 'Randstad' provinces against, often, a lower price, which could also motivate a move away from the 'Randstad'. One final possibility for the existence of the *Donut-effect* is that COVID-19 spreads more easily in population dense areas (Coşkun et al., 2021). A move towards the non-'Randstad' provinces, where the population density is lower, could therefore more easily prohibit a COVID-19 infection.

4.2. Robustness checks

Robustness checks test whether the outcomes of regression models are reliable. For the models used in this thesis, a model variation check is done to examine the robustness of the regression estimates in section 4.1. A model variation test checks the reliability of the regression outcomes through implementing small changes in the model set-up. Adding or removing a small amount of variables is an example of such a small change. Thus omitting the mortgage interest rate variable in the used models is a robustness check. Overall, discarding the mortgage interest in the models as a control variable gives higher or more significant regression coefficient estimates compared to including the mortgage interest rate in the control variable set. Yet, including the mortgage interest rate still gives statistical significant effects in almost every model, although the effect is less strong. This shows that the mortgage interest rate is an important predictor of explaining housing prices in The Netherlands, as is explained by by Gamber et al. (2021) who find that the mortgage interest rate explained about a third of the rise in housing prices in 2020.

One other possibility for checking the robustness of the models is through a change in the cut-off of the control period. As explained earlier, the cut-off for the control period is set at the end of 2019 as including the first quarter of 2020 may include biased effects as individuals may have already reacted to the rise in COVID-19 infections and thus might have impacted housing prices in this period. As another robustness check, the first quarter of 2020 is added to the control period to test if the regression outcomes of the models change. The threshold for treatment remains at April 2020 until December 2021. The period until March 2020 is now the control period. Tables A.3 and A.4 in the appendix show the outcomes for the general Dutch price effect model where the control threshold is set until March 2020. Comparing these outcomes with the model where the control cut-off is set at December 2019, no major changes are found. The robustness model shows less strong coefficients compared to the standard model, but the estimates are all significant apart from the model in column 5, which can be explained by adding the mortgage interest rate and other control variables. The robustness estimates for the pooled 'Randstad' and non-'Randstad' provinces are given by tables A.5, A.6 and A.7 in the appendix. Similar to the outcomes in tables 4.6 and 4.7, the robustness model shows that housing prices in the 'Randstad' have decreased between two and 2.2 percent and housing prices in the non-'Randstad' provinces have increased with two to 2.2 percent due to COVID-19. The direction of the robustness model is thus equal to the standard model, although the effect of the robustness model is stronger. The outcomes of the robustness model are also statistically significant.

Adding the first quarter of 2020 to the control period does not show large differences in regression estimates compared to the used models in section 4.1, where the cut-off for the control period is set at December 2019. The outcomes of the robustness models are statistically significant and the effects have the same direction. This indicates that the regression estimates in chapter 4.1 are thus likely to be robust.

5. Conclusion

In December 2019, the world was confronted with a new virus: COVID-19. By March 2020, COVID-19 had evolved into a global pandemic. COVID-19 had serious implications on everyday life. Apart from many people getting sick because of the virus, workers were strongly advised to work from home and many consumption amenities were closed. Literature on the effect of pandemics on housing prices is scarce as pandemics do not come across often. To the best of my knowledge, there is no literature available on the effects of COVID-19 on Dutch housing prices where econometric models are used. By answering the research question: *To what extent has the COVID-19 pandemic affected housing prices in The Netherlands*? this thesis contributes to the scarce scientific literature of the effects of COVID-19 on housing prices. The answer to the research question also has societal value as policy makers and other stakeholders can use the findings of this thesis to adequately react to future pandemics in the light of housing prices.

Looking at overall effects, this thesis provides statistically significant evidence that housing prices in The Netherlands have increased due to COVID-19. This finding is in line with the results from Zhao (2020), who speaks of a structural break in housing price development, where housing prices during COVID-19 increased significantly faster compared to the pre-pandemic period. One likely driver for this increase in housing prices is the working from home advise, as regions with higher working from home rates show higher demand for housing which translates into higher housing prices (Gamber et al., 2021). One other possible explanation is that home-owners held onto their homes longer due to COVID-19. Goossens and Knoef (2022) find evidence that individuals held on to assets longer which experienced gains during COVID-19, with the purpose to build up a financial buffer to absorb possible future risk. This could've lowered the supply of housing in The Netherlands and with housing demand positively stimulated by the low mortgage interest rate and generous Dutch housing market policy schemes, housing prices in The Netherlands have likely increased during the COVID-19 pandemic. One important remark on the mortgage interest rate has to be made. The regression model on the overall Dutch housing price finds strong evidence that the mortgage interest rate has had a severe impact on the development on housing prices in The Netherlands as well. However, the evidence for the COVID-19 effects on housing prices is strong, but the mortgage interest cannot be ruled out of the equation of explaining Dutch housing price development during COVID-19.

The pooled regression outcomes also give statistically significant evidence that COVID-19 is a driver of the *Donut-effect* on the Dutch housing market, which is when households move from urban/population dense areas to non-urban/less population dense areas. In the case of The Netherlands, the three 'Randstad' provinces, Noord-Holland, Utrecht and Zuid-Holland are defined as urban. When pooling 'Randstad' and non-'Randstad' provinces, I find that non-'Randstad' housing prices have increased with 1.2 to 1.6 percent relative to housing prices in the 'Randstad' provinces. Housing prices in the 'Randstad' have decreased with 1.2 to 1.6 percent relative to non-'Randstad' housing prices. The rise in housing prices in the non-'Randstad' provinces suggests that demand for housing in these provinces has increased compared to the 'Randstad' provinces, which inclines that households have moved away from the 'Randstad' towards other provinces. The additional regression on number of houses sold provides extra statistically significant evidence that between fifteen to twenty percent more houses have been sold in non-'Randstad' provinces relative to the 'Randstad', which clearly indicates that demand for homes non-'Randstad' regions is higher during COVID-19, which is evidence for the existence of the *Donut-effect* in The Netherlands. Proof from the CBS backs this claim (CBS, 2022c).

A driver for the rise in housing prices in non-'Randstad' provinces is the working from home advise. As workers were not asked to work from the office anymore, the need to live closer to work diminished, which is often the case in urban areas. One other explanation is that in urban areas, consumption amenities are more abundant and closer compared to non-urban areas. These consumption amenities were often closed during COVID-19 due to lockdowns, thus could the value to live closer to these consumption amenities have diminished, therefore also the value of living in an urban area (S. Liu & Su, 2021). Third, housing prices in the non-'Randstad' provinces are on average lower and houses are more spacious. As working from home became the norm during COVID-19, individuals valued residential space more during the pandemic (Yang et al., 2022). Owning a less expensive home that is also more spacious could therefore stimulate a move away from the 'Randstad'. One final explanation for higher housing prices in non-'Randstad' provinces is that COVID-19 spreads more easily in regions where the population density is higher (Coşkun et al., 2021). As non-'Randstad' provinces have a lower population density than the 'Randstad' provinces, individuals might want to move towards the non-'Randstad' provinces to prohibit a possible COVID-19 infection.

5.1. Discussion

The results of this thesis imply that COVID-19 has had a significant effect on housing prices in The Netherlands. Overall, housing prices have on average increased due to the pandemic and COVID-19 has driven a *Donut-effect*, where households from the 'Randstad' have moved to other provinces, as the rise in housing prices in non-'Randstad' provinces inclines. Almost all results are statistically significant and the robustness checks do not indicate that the estimates are not robust. Still, this thesis has some limitations that may affect the validity of the results. The property-transfer tax could've had an effect on housing prices, as first-time-buyers were exempted from the property-transfer tax at the start of 2021 and existing home owners had to pay more taxes when buying an additional house. In the used models, the change in the property-transfer tax could not be controlled for, which could harm the validity of the estimates if the property-transfer tax does indeed have an effect on housing prices. Such absence of a control variable that could explain the dependent variable is defined as the omitted variable bias, which could always be a problem in regression analyses. The high adjusted R^2's of the used models, which explains how much the control variables explain the dependent variable, do not indicate that an omitted variable bias is present, but it cannot be ruled out with absolute certainty.

Another limitation of this thesis is the use of data. For the effect of COVID-19 on regional housing prices, quarterly data is used as monthly data wasn't overly abundant for the twelve Dutch provinces. The use of quarterly data instead of monthly data lowers the amount of observations, which could possibly influence the outcomes. The use of monthly data would increase the amount of observations and thus the fit and validity of the regional housing price model. However, the obtained estimates do show strong statistically significant effects with high adjusted R^2's, thus the models regarding regional housing prices seem valid and robust. One other remark regarding the data, is that four out of eleven variables have a skewness, which could influence the calculation of the confidence intervals and therefore the regression outcomes. Another data limitation is the use of the mortgage interest rate, which has a very high VIF value and could thus bias the outcome of the models due to multicollinearity.

One last point of discussion is also related to mortgage interest rate. In the model on the effects of COVID-19 on general Dutch housing prices, it seems that the mortgage interest rate has played a significant role in explaining housing prices in The Netherlands. In column two of table 4.3, the effect is insignificant when adding control variables. After omitting the mortgage interest rate in column three, the effect becomes statistically significant, which indicates a significant role of the mortgage interest rate on housing prices during COVID-19. Still, I assume that COVID-19 has had a significant effect on the overall housing prices in The Netherlands based on the obtained results under the average housing price under column two in table 4.3 and as all estimates in table 4.2 are statistically significant, including the model that includes the mortgage interest rate.

References

Abildgren, K., Hansen, N. L., & Kuchler, A. (2018). Overoptimism and house price bubbles. *Journal of Macroeconomics*, *56*, 1–14.

Agnew, K., & Lyons, R. C. (2018). The impact of employment on housing prices: Detailed evidence from fdi in ireland. *Regional Science and Urban Economics*, *70*, 174–189.

Akinwande, M. O., Dikko, H. G., Samson, A., et al. (2015). Variance inflation factor: as a condition for the inclusion of suppressor variable (s) in regression analysis. *Open Journal of Statistics*, *5*(07), 754.

Al-Masum, M. A., & Lee, C. L. (2019). Modelling housing prices and market fundamentals: evidence from the sydney housing market. *International Journal of Housing Markets and Analysis*.

Anari, A., & Kolari, J. (2002). House prices and inflation. *Real Estate Economics*, *30*(1), 67–84.

Anastasiou, D., Kapopoulos, P., & Zekente, K.-M. (2021, 09). Sentimental shocks and house prices. *The Journal of Real Estate Finance and Economics*, *Forthcoming*. doi: 10.1007/s11146-021-09871-z

Andrade, P., Galí, J., Le Bihan, H., & Matheron, J. (2021). Should the ecb adjust its strategy in the face of a lower r? *Journal of Economic Dynamics and Control*, *132*, 104207.

Boelhouwer, P. (2017). The role of government and financial institutions during a housing market crisis: A case study of the netherlands. *International Journal of Housing Policy*, *17*(4), 591–602.

Boelhouwer, P. (2020). The housing market in the netherlands as a driver for social inequalities: proposals for reform. *International Journal of Housing Policy*, *20*(3), 447–456.

Buitelaar, E. (2019). Versnelling van de woningbouw: van korte-naar langetermijnperspectief. *Real Estate Research Quarterly*, *2*, 5–11.

Buitelaar, E., Bastiaanssen, J., et al. (2021). Thuiswerken en de gevolgen voor wonen, werken en mobiliteit: Op zoek naar trends, trendbreuken en kansen als gevolg van corona.

Bürmann, S. (2022). *Woningbouw in de knel na nieuwe stikstofuitspraak rechter.* https://nos.nl/artikel/2426648-woningbouw-in-de-knel-na-nieuwe-stikstofuitspraak-rechter. (Online; accessed 27-November-2022)

Caldera, A., & Johansson, Å. (2013). The price responsiveness of housing supply in oecd countries. *Journal of Housing Economics*, *22*(3), 231–249.

CBS. (2021). *Werkloosheid gedaald tot niveau van voor coronacrisis.* https://www.cbs.nl/nl-nl/nieuws/2021/46/werkloosheid-gedaald-tot-niveau-van-voor-coronacrisis. (Online; accessed 15-december-2022)

CBS. (2022a). *De Randstad.* https://www.cbs.nl/nl-nl/nieuws/2022/32/trek-uit-de-randstad-blijft-toenemen/de-randstad. (Online; accessed 28-November-2022)

CBS. (2022b). *Economie krimpt in derde kwartaal 2022 met 0,2 procent.* https://www.cbs.nl/nl-nl/nieuws/2022/46/economie-krimpt-in-derde-kwartaal-2022-met-0-2-procent#:~:text=Bbp%203%2C1%20procent%20groter,droegen%20bij%20aan%20deze%20groei. (Online; accessed 19-december-2022)

CBS. (2022c). *Meer verhuizingen naar regio's buiten de Randstad.* https://www.cbs.nl/nl-nl/nieuws/2021/08/meer-verhuizingen-naar-regio-s-buiten-de-randstad. (Online; accessed 5-January-2023)

CBS. (2022d). *Werkloosheid naar regio.* https://www.cbs.nl/nl-nl/visualisaties/dashboard-arbeidsmarkt/werklozen/werkloosheid-naar-regio. (Online; accessed 8-december-2022)

CBS. (2022e). *Woningmarkt in coronatijd.* https://www.cbs.nl/nl-nl/visualisaties/welvaart-in-coronatijd/woningmarkt#:~:text=D%20prijzen%20van%20bestaande%20koopwoningen,om%20daarna%20weer%20te%20versnellen. (Online; accessed 15-November-2022)

Cochrane, W., & Poot, J. (2021). Effects of immigration on local housing markets. *The economic geography of cross-border migration*, 269–292.

Cohen, V., & Karpaviciute, L. (2017). The analysis of the determinants of housing prices. *Independent journal of management & production*, *8*(1), 49–63.

Coşkun, H., Yıldırım, N., & Gündüz, S. (2021). The spread of covid-19 virus through population density and wind in turkey cities. *Science of the Total Environment*, *751*, 141663.

D'agostino, R. B., Belanger, A., & D'Agostino Jr, R. B. (1990). A suggestion for using powerful and informative tests of normality. *The American Statistician*, *44*(4), 316–321.

Dajcman, S. (2020). Demand for residential mortgage loans and house prices in the euro area. *Economics & Sociology*, *13*(1), 40–51.

De Nederlandsche Bank. (2021). *De woningmarkt.* https://www.dnb.nl/actuele-economische-vraagstukken/woningmarkt/. (Online; accessed 28-November-2022)

De Nederlandsche Bank. (2022). *Huishoudens spaarden in 2021 minder dan in eerste coronajaar.* https://www.dnb.nl/nieuws-statistiek/statistisch-nieuwsbericht-2022/huishoudens-spaarden-in-2021-minder-dan-in-eerste-coronajaar/. (Online; accessed 4-december-2022)

DeCarlo, L. T. (1997). On the meaning and use of kurtosis. *Psychological methods*, *2*(3), 292.

Deelen, A., van der Wiel, K., Olsen, J., van der Drift, R., Zhang, L., & Vogt, B. (2020). Beweging op de woningmarkt: prijzen en volumes. *CPB Notitie*.

De Kam, G. (2016). Waardedaling van woningen door aardbevingen in de provincie groningen. *URSI report*, *352*, 14.

Del Giudice, V., De Paola, P., & Del Giudice, F. P. (2020). Covid-19 infects real estate markets: Short and mid-run effects on housing prices in campania region (italy). *Social sciences*, *9*(7), 114.

D'Lima, W., Lopez, L. A., & Pradhan, A. (2022). Covid-19 and housing market effects: Evidence from us shutdown orders. *Real Estate Economics*, *50*(2), 303–339.

Dong, Z., Hui, E., & Yi, D. (2021). Housing market sentiment and homeownership. *Journal of Housing and the Built Environment*, *36*(1), 29–46.

FD. (2021). *Trek uit Randstad neemt verder toe door corona en hoge huizenprijzen.* https://fd.nl/economie-politiek/1374952/trek-uit-de-randstad-neemt-verder-toe-door-corona-en-stijgende-huizenprijzen-qea3caLNK7VF. (Online; accessed 5-January-2023)

Francke, M., & Korevaar, M. (2021). Housing markets in a pandemic: Evidence from historical outbreaks. *Journal of Urban Economics*, *123*, 103333.

Gallin, J. (2006). The long-run relationship between house prices and income: evidence from local housing markets. *Real Estate Economics*, *34*(3), 417–438.

Gamber, W., Graham, J., & Yadav, A. (2021). Stuck at home: Housing demand during the covid-19 pandemic.

Gerlach, S., & Lewis, J. (2014). Zero lower bound, ecb interest rate policy and the financial crisis. *Empirical Economics*, *46*(3), 865–886.

Girouard, N., Kennedy, M., Van Den Noord, P., & André, C. (2006). Recent house price developments: the role of fundamentals.

Glaeser, E. L., Gyourko, J., & Saiz, A. (2008). Housing supply and housing bubbles. *Journal of urban Economics*, *64*(2), 198–217.

Goossens, J., & Knoef, M. (2022). Covid-19 crisis: Are preferences and trading behavior affected during extreme events?

Grimes, A., & Aitken, A. (2006). Housing supply and price adjustment.

Gyourko, J. (2009). Housing supply. *Annu. Rev. Econ.*, *1*(1), 295–318.

Hilber, C. A., & Vermeulen, W. (2016). The impact of supply constraints on house prices in england. *The Economic Journal*, *126*(591), 358–405.

Imbens, G. W., & Lemieux, T. (2008). Regression discontinuity designs: A guide to practice. *Journal of econometrics*, *142*(2), 615–635.

Irandoust, M. (2019). House prices and unemployment: an empirical analysis of causality. *International Journal of Housing Markets and Analysis*.

Klarl, T. (2018). Housing is local: Applying a dynamic unobserved factor model for the dutch housing market. *Economics Letters*, *170*, 79–84.

Kohler, M., Van Der Merwe, M., et al. (2015). Long-run trends in housing price growth—bulletin–september quarter 2015. *Bulletin*(September).

Leombroni, M., Piazzesi, M., Schneider, M., & Rogers, C. (2020). *Inflation and the price of real assets* (Tech. Rep.). National Bureau of Economic Research.

Liu, S., & Su, Y. (2021). The impact of the covid-19 pandemic on the demand for density: Evidence from the us housing market. *Economics letters*, *207*, 110010.

Liu, Y.-C., Kuo, R.-L., & Shih, S.-R. (2020). Covid-19: The first documented coronavirus pandemic in history. *Biomedical journal*, *43*(4), 328–333.

Määttänen, N., & Terviö, M. (2014). Income distribution and housing prices: An assignment model approach. *Journal of Economic Theory*, *151*, 381–410.

Menard, S. (2002). *Applied logistic regression analysis* (No. 106). Sage.

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2021). *Staat van de Woningmarkt.* `https://open.overheid.nl/repository/ronl-8f2e6b2e-33c8-40cd-952c-3f8749b65a8c/1/pdf/Staat%20van%20de%20Woningmarkt%202021.pdf`. (Online; accessed 10-November-2022)

Moallemi, M., & Melser, D. (2020). The impact of immigration on housing prices in australia. *Papers in Regional Science*, *99*(3), 773–786.

Mulder, C. H. (2006). Population and housing: a two-sided relationship. *Demographic research*, *15*, 401–412.

Nijskens, R., et al. (2017). The housing market in major dutch cities.

NOS. (2021a). *Aantal verhuizingen uit de Randstad blijft toenemen.* `https://nos.nl/`

artikel/2370024-aantal-verhuizingen-uit-de-randstad-blijft-toenemen. (Online; accessed 5-January-2023)

NOS. (2021b). *Grote impact van corona op de huizenmarkt: meer huizen verkocht en hogere prijzen.* https://nos.nl/artikel/2374022-grote-impact-van-corona-op-de-huizenmarkt-meer-huizen-verkocht-en-hogere-prijzen. (Online; accessed 16-december-2022)

Qian, X., Qiu, S., & Zhang, G. (2021). The impact of covid-19 on housing price: Evidence from china. *Finance Research Letters*, *43*, 101944.

Ramani, A., & Bloom, N. (2021). *The donut effect of covid-19 on cities* (Tech. Rep.). National Bureau of Economic Research.

Rijksoverheid. (2022a). *Betere verdeling van betaalbare huurwoningen.* https://www.rijksoverheid.nl/onderwerpen/huurwoning-zoeken/maatregelen-tegen-woningnood/betere-verdeling-van-betaalbare-huurwoningen#:~:text=De%20inkomensgrens%20daarvoor%20(%E2%82%AC%2040.024,%E2%82%AC%2044.196%20(prijspeil%202021). (Online; accessed 28-November-2022)

Rijksoverheid. (2022b). *Coronavirus tijdlijn.* https://www.rijksoverheid.nl/onderwerpen/coronavirus-tijdlijn. (Online; accessed 5-december-2022)

Rijksoverheid. (2022c). *Plannen kabinet voor schenkingsvrijstelling eigen woning.* https://www.rijksoverheid.nl/onderwerpen/belastingplan/vermogen-en-wonen/schenkingsvrijstelling-eigen-woning. (Online; accessed 28-November-2022)

Rouwendal, J., & Kransberg, S. (2021). De impact van covid-19 op de huizenprijzen in maastricht. *Real Estate Research Quarterly*, *20*(4), 1–11.

Rouwendal, J., & Longhi, S. (2008). The effect of consumers' expectations in a booming housing market: space-time patterns in the netherlands, 1999–2000. *Housing Studies*, *23*(2), 291–317.

Rouwendal, J., van der Straaten, J., & Vermeulen, W. (2007). Economische analyse van ruimtelijke-ordeningsbeleid. *Kwartaalschrift Economie*, *4*, 57–75.

Saiz, A. (2008). On local housing supply elasticity. *Available at SSRN 1193422*.

Saiz, A. (2010). The geographic determinants of housing supply. *The Quarterly Journal of Economics*, *125*(3), 1253–1296.

Sánchez, A. C., & Johansson, Å. (2011). The price responsiveness of housing supply in oecd countries.

Schwab, R. M. (1983). Real and nominal interest rates and the demand for housing. *Journal of Urban Economics*, *13*(2), 181–195.

Taylor, J. B. (2007). *Housing and monetary policy* (Tech. Rep.). National Bureau of

Economic Research.

Tripathi, S. (2019). Macroeconomic determinants of housing prices: a cross country level analysis.

Tsatsaronis, K., & Zhu, H. (2004). What drives housing price dynamics: cross-country evidence. *BIS Quarterly Review, March*.

TU Delft. (2011). *A flat country in 3D.* `https://www.delta.tudelft.nl/article/flat-country-3d#`. (Online; accessed 9-december-2022)

Wang, B. (2022). Housing market volatility under covid-19: Diverging response of demand in luxury and low-end housing markets. *Land Use Policy*, *119*, 106191.

Wang, S., Chan, S. H., & Xu, B. (2012). The estimation and determinants of the price elasticity of housing supply: Evidence from china. *Journal of Real Estate Research*, *34*(3), 311–344.

Wigger, A. (2021). Housing as a site of accumulation in amsterdam and the creation of surplus populations. *Geoforum*, *126*, 451–460.

Xu, T. (2017). The relationship between interest rates, income, gdp growth and house prices. *Research in Economics and Management*, *2*(1), 30–37.

Yang, J., Xu, J., Hu, T., & Cao, J. (2022). Satisfaction and demands of indoor space in the high-density residential areas in the covid-19 era. *Buildings*, *12*(5), 660.

Zeng, S., Zhang, X., Wang, X., & Zeng, G. (2019). Population aging, household savings and asset prices: A study based on urban commercial housing prices. *Sustainability*, *11*(11), 3194.

Zhao, Y. (2020). Us housing market during covid-19: aggregate and distributional evidence. *Available at SSRN 3744679*.

A. Appendix

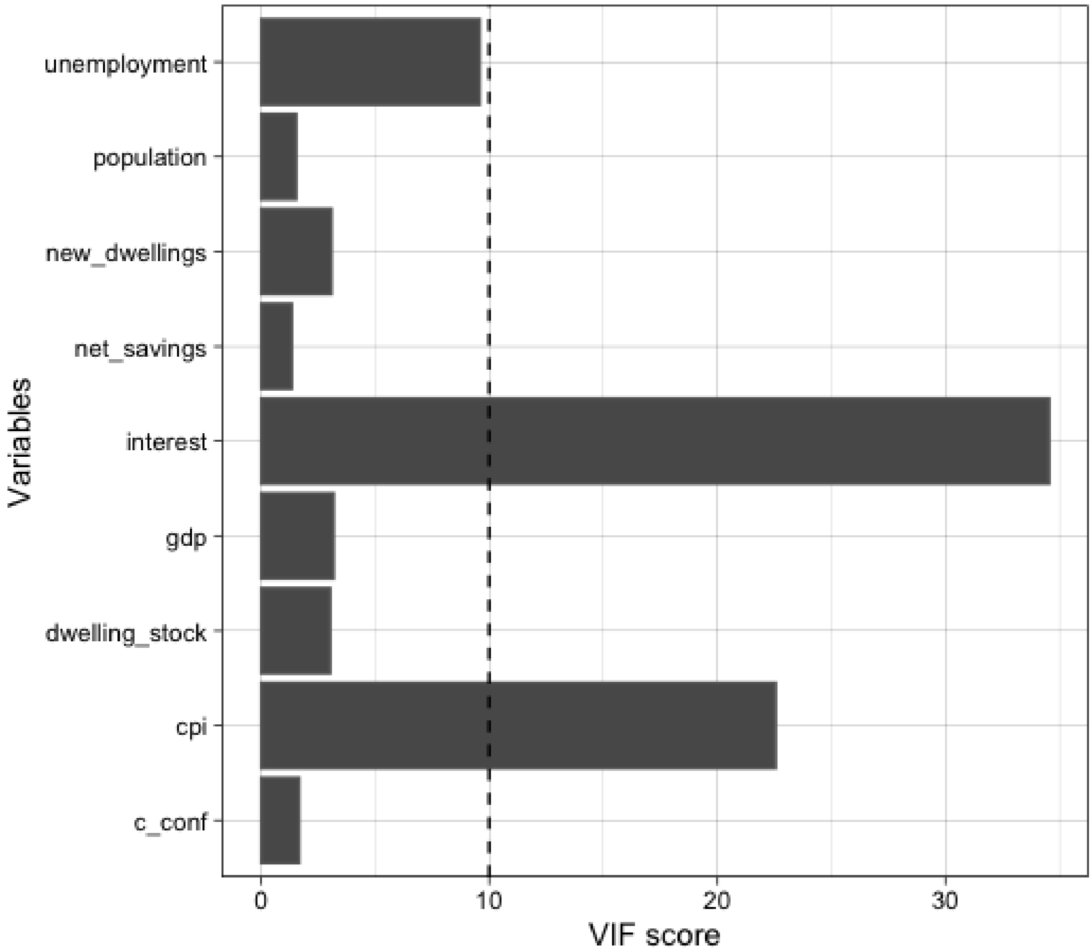

Figure A.1.: VIF scores before variable elimination

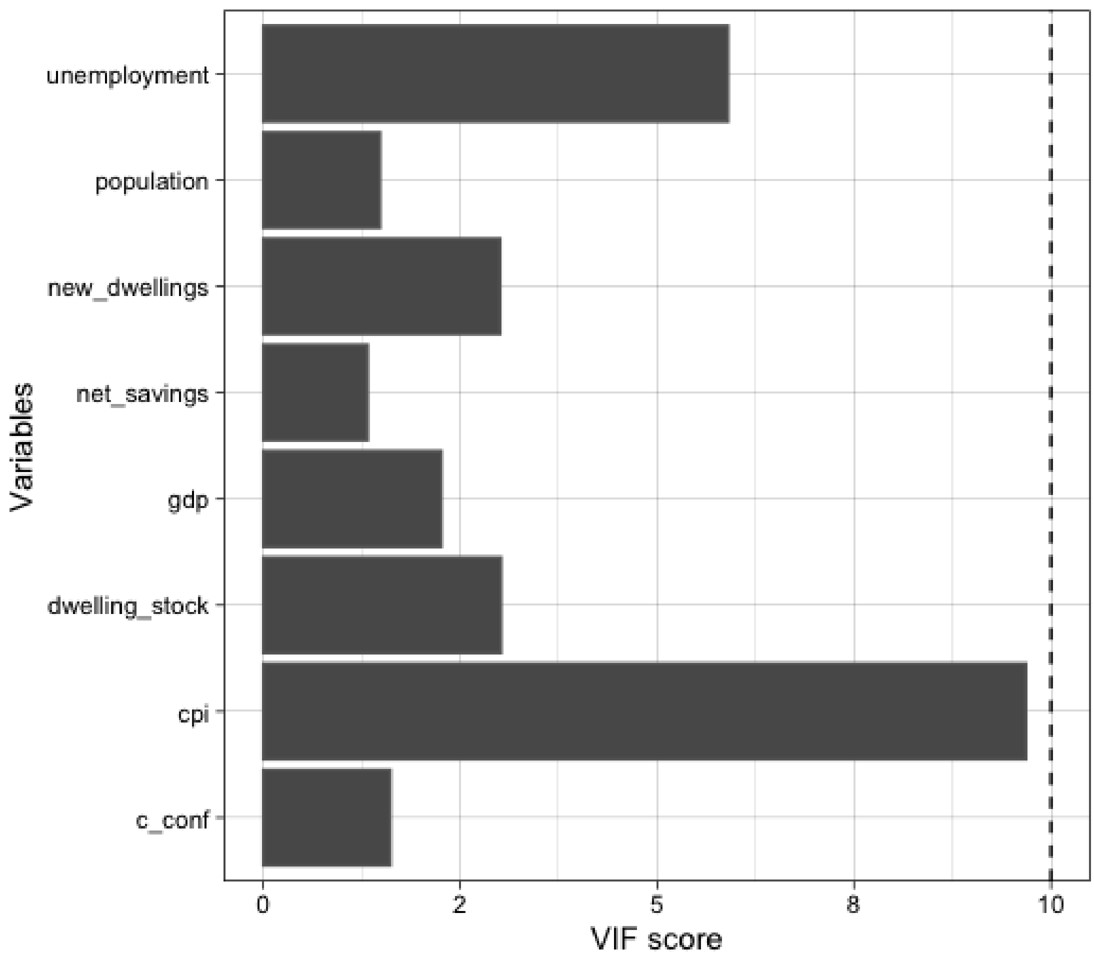

Figure A.2.: VIF scores after variable elimination

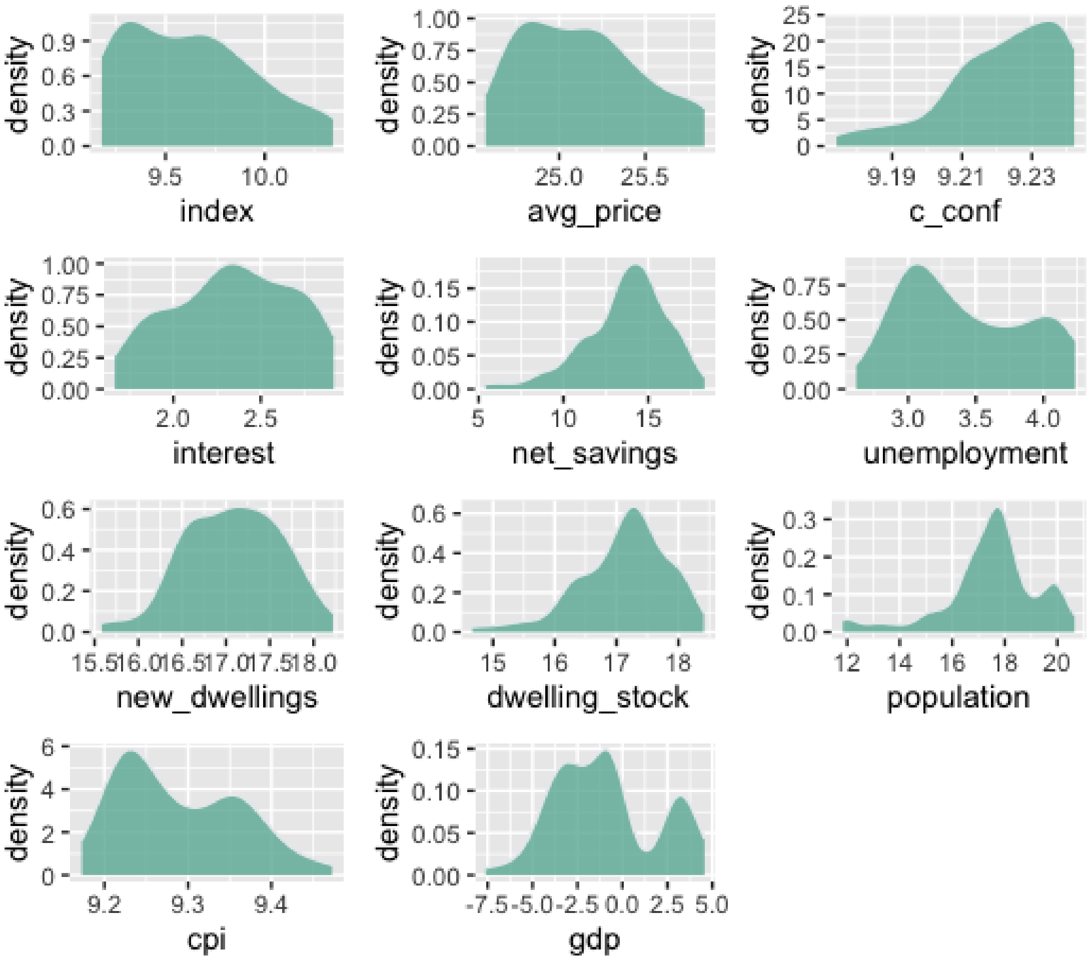

Figure A.3.: Variable distribution

Table A.1.: Houses sold Randstad (2018Q2-2021Q4)

	Dependent variable:			
	Houses sold (ln)			
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	2.000***	2.028***	0.796***	0.638***
	(0.288)	(0.294)	(0.196)	(0.177)
Constant	15.858***	15.957***	−29.469	−476.919**
	(0.144)	(0.147)	(120.151)	(222.192)
Controls	N	N	Y	Y
Lags (t_{-1})	N	N	N	N
Observations	84	84	84	84
R^2	0.371	0.368	0.887	0.894
Adjusted R^2	0.363	0.360	0.875	0.883

	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	0.807***	0.625***	0.783***	0.587***
	(0.193)	(0.179)	(0.197)	(0.187)
Constant	−16.960	−107.345**	−615.182	−1,592.885*
	(115.662)	(46.252)	(692.235)	(955.917)
Controls	P	P	Y	Y
Lags (t_{-1})	N	N	P	P
Observations	84	84	84	84
R^2	0.887	0.890	0.889	0.891
Adjusted R^2	0.876	0.880	0.874	0.876

Note: *p<0.1; **p<0.05; ***p<0.01

Table A.2.: Houses sold non-Randstad (2018Q2-2021Q4)

	Dependent variable:			
	Houses sold (ln)			
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (non-Randstad)	-2.000^{***}	-2.028^{***}	-0.796^{***}	-0.638^{***}
	(0.288)	(0.294)	(0.196)	(0.177)
Constant	17.858^{***}	17.986^{***}	-28.674	-476.281^{**}
	(0.249)	(0.254)	(120.160)	(222.174)
Controls	N	N	Y	Y
Lags (t_{-1})	N	N	N	N
Observations	84	84	84	84
R^2	0.371	0.368	0.887	0.894
Adjusted R^2	0.363	0.360	0.875	0.883
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (non-Randstad)	-0.807^{***}	-0.625^{***}	-0.783^{***}	-0.587^{***}
	(0.193)	(0.179)	(0.197)	(0.187)
Constant	-16.153	-106.720^{**}	-614.398	$-1,592.298$
	(115.663)	(46.200)	(692.250)	(955.945)
Controls	P	P	Y	Y
Lags (t_{-1})	N	N	P	P
Observations	84	84	84	84
R^2	0.887	0.890	0.889	0.891
Adjusted R^2	0.876	0.880	0.874	0.876
Note:				*p<0.1; **p<0.05; ***p<0.01

Table A.3.: Robustness check (2015-2021)

	Dependent variable:					
	Housing index (ln)			Average housing price (ln)		
	(1)	(2)	(3)	(4)	(5)	(6)
ATE	0.589***	0.159***	0.248***	0.621***	0.166***	0.312***
	(0.052)	(0.030)	(0.027)	(0.055)	(0.049)	(0.043)
Constant	9.490***	−10.038***	−15.196***	24.990***	8.301	−0.240
	(0.026)	(3.427)	(3.666)	(0.027)	(5.456)	(5.890)
Controls	N	Y	P	N	Y	P
Observations	84	84	84	84	84	84
R^2	0.614	0.994	0.992	0.610	0.986	0.982
Adjusted R^2	0.609	0.993	0.991	0.605	0.985	0.980
Note:				*p<0.1; **p<0.05; ***p<0.01		

Table A.4.: Robustness check (21m-21m)

	Dependent variable:					
	Housing index (ln)			Average housing price (ln)		
	(1)	(2)	(3)	(4)	(5)	(6)
ATE	0.332***	0.077**	0.146***	0.351***	0.075	0.215**
	(0.038)	(0.035)	(0.041)	(0.040)	(0.072)	(0.084)
Constant	9.747***	−7.456	−30.340***	25.260***	32.259**	−13.800
	(0.027)	(6.452)	(5.490)	(0.028)	(13.232)	(11.172)
Controls	N	Y	P	N	Y	P
Observations	42	42	42	42	42	42
R^2	0.660	0.989	0.981	0.663	0.959	0.931
Adjusted R^2	0.651	0.986	0.976	0.655	0.946	0.911
Note:				*p<0.1; **p<0.05; ***p<0.01		

Table A.5.: Robustness check pooled Randstad (2015Q1-2021Q4)

	Dependent variable:			
	Housing index (ln)			
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	0.103***	0.123***	0.087***	0.111***
	(0.030)	(0.046)	(0.010)	(0.027)
Constant	9.438***	10.026***	19.644***	−103.170***
	(0.015)	(0.023)	(6.703)	(35.927)
Controls	N	N	Y	Y
Lags (t_{-1})	N	N	N	N
Observations	252	84	252	84
R^2	0.044	0.079	0.931	0.818
Adjusted R^2	0.040	0.068	0.929	0.801

	Dependent variable:			
	Housing index			
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	0.082***	0.113***	0.010***	−0.007
	(0.013)	(0.027)	(0.003)	(0.005)
Constant	−40.433***	−49.728***	−1.257	−152.934***
	(4.587)	(5.420)	(2.416)	(27.228)
Controls	P	P	Y	Y
Lags (t_{-1})	N	N	P	P
Observations	252	84	240	84
R^2	0.897	0.813	0.995	0.995
Adjusted R^2	0.895	0.798	0.995	0.994

Note: *p<0.1; **p<0.05; ***p<0.01

Table A.6.: Robustness check pooled Randstad (2018Q3-2021Q4)

	Dependent variable:			
	Housing index (ln)			
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	0.162***	0.123***	0.133***	0.111***
	(0.024)	(0.046)	(0.021)	(0.027)
Constant	9.666***	10.026***	−9.333	−103.170***
	(0.015)	(0.023)	(6.703)	(35.927)
Controls	N	N	Y	Y
Lags (t_{-1})	N	N	N	N
Observations	84	84	84	84
R^2	0.358	0.079	0.708	0.818
Adjusted R^2	0.351	0.068	0.681	0.801
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (Randstad)	0.133***	0.113***	0.0004	−0.007
	(0.020)	(0.027)	(0.005)	(0.005)
Constant	−21.386	−49.728***	−57.385***	−152.934***
	(19.305)	(5.420)	(9.299)	(27.228)
Controls	P	P	Y	Y
Lags (t_{-1})	N	N	P	P
Observations	84	84	84	84
R^2	0.706	0.813	0.991	0.995
Adjusted R^2	0.684	0.798	0.990	0.994
Note:			*p<0.1; **p<0.05; ***p<0.01	

Table A.7.: Robustness check pooled non-Randstad (2018Q3-2021Q4)

	Dependent variable:			
	Housing index (ln)			
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (non-Randstad)	−0.162***	−0.123***	−0.133***	−0.111***
	(0.024)	(0.046)	(0.021)	(0.027)
Constant	9.827***	10.148***	−9.199	−103.059***
	(0.021)	(0.040)	(28.479)	(35.928)
Controls	N	N	Y	Y
Lags (t_{-1})	N	N	N	N
Observations	84	84	84	84
R^2	0.358	0.079	0.708	0.818
Adjusted R^2	0.351	0.068	0.681	0.801
	(Control)	(Treatment)	(Control)	(Treatment)
ATE (non-Randstad)	−0.133***	−0.113***	−0.0004	0.007
	(0.020)	(0.027)	(0.005)	(0.005)
Constant	−21.254	−49.615***	−57.385***	−152.941***
	(19.304)	(5.420)	(9.300)	(27.229)
Controls	P	P	Y	Y
Lags (t_{-1})	N	N	P	P
Observations	84	84	84	84
R^2	0.706	0.813	0.991	0.995
Adjusted R^2	0.684	0.798	0.990	0.994
Note:			*p<0.1; **p<0.05; ***p<0.01	