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Is there a bubble in the Dutch housing market?

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Abstract

With the increasing prices in the Dutch housing market, the question is raised whether a new bubble is forming. To answer this question, two methods, using data for the Dutch housing market in the period 1985-2020, where actual prices are compared with fundamentals are used to conclude. First, the real price-income ratio and real price-rent ratio are observed and compared with their long-term averages. A bubble is concluded if a ratio deviates with at least ten index points from its long-term average. In the second method, parsimonious- and multivariate regression analyses are performed to predict fitted values that represent fundamental prices whereafter residuals are observed. All methods find results that are in line with the unambiguously proved bubble in the period prior to the 2008 crisis. More recently, the price-income ratio shows significant signs of a bubble since 2017 while the price-rent ratio approaches its long-term average in 2020 and does not imply a bubble. If the increasing trend of the price-rent ratio continues, it could also transcend the bubble threshold soon. In recent years, the residuals of the regression analyses do not show signs of a large deviation of actual prices from their fundamentals until 2019. However, a large increase of the residuals would suggest a bubble arise in 2020 since levels similar to the housing bubble before the crisis are approached. Future research could use regional-, monthly, historical data, and different methods to substantiate the findings.

Keywords: asset bubble, Dutch housing market, regression analysis, ratio method

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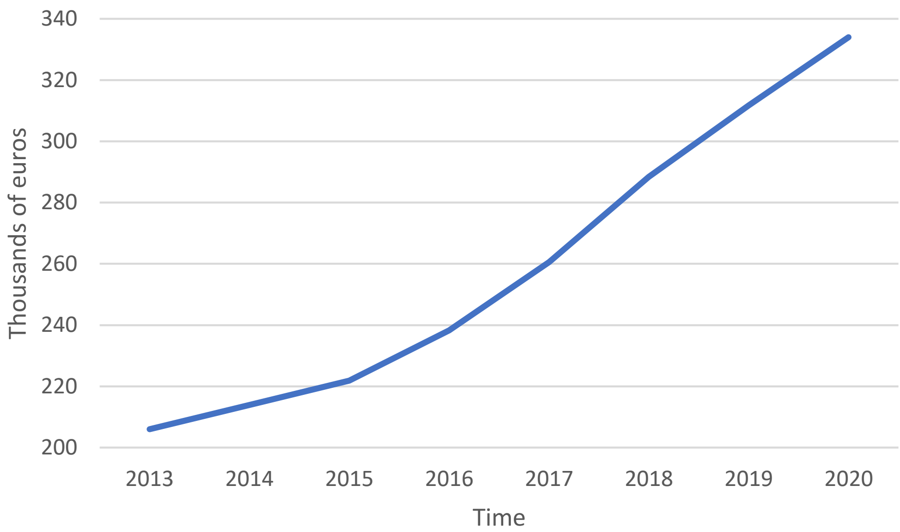
I. Introduction

Buying a house has never been so expensive before. CBS, the central bureau of statistics of the Netherlands, shows a consequent upward trend in housing prices in the Netherlands since 2013, provided in Figure 1 (CBS, 2021d). For starters, it has become more difficult to buy a house. This raises the question of where the price increases come from.



Notes: The average nominal housing prices in the Netherlands between 2013 and 2020. On the y-axis, the average housing price is presented given in thousands of euros. The x-axis represents the year. The data is provided by CBS (2021d).

Figure 1. Dutch average housing prices in the period 2013-2020

Changes in prices could be caused by different factors. Examples of such factors are inflation and mortgage rates. If price changes are caused by changes in fundamentals, price changes are justified and not caused by speculative demand changes (Case and Shiller, 2003). However, if the price increases are caused by speculative demand changes, this could imply the presence of a bubble in the housing market or a bubble to arise in the future. A rapid increase in prices is far from sufficient evidence, to conclude a bubble. If prices are following fundamentals and this causes the prices to increase, there is no bubble. Therefore, further analysis is necessary.

Asset bubbles, where speculative demand changes influence the prices, and real transformations where price changes are caused by fundamental changes could have different consequences. Bubbles are considered to have significant effects on business cycles and the optimal policy response on price changes (Lian, 2016). If housing prices are driven by fundamental changes in demand, monetary policy could be used to stimulate or demotivate the housing prices during the different stages of the cycle (Bernanke and Gertler, 2001; Galí, 2014). However, if the demand changes are caused by certain expectations, the concerning expectations should be adjusted. Monetary policy could be the wrong way to bring the price level to its original level and could even enhance the demand changes. Therefore, to determine the optimal policy response, the causation of the price changes needs to be discovered. A balance needs to be found to simultaneously stabilize the bubble and the aggregate demand (Galí, 2014).

Moreover, Davis and Van Nieuwerburgh (2015) and Piazzesi and Schneider (2016) recognize demand shifts of houses as an important driver of business cycles. Demand shifts driven by fundamental changes, often in line with the business cycle are allowed. However, speculative demand changes could disturb the cycle. So far, little distinction is made between the different factors which could have caused the price increases in the Dutch housing market. Therefore, it is important to fill this macro-economic gap in the academic literature. Then, the price increase could be reasoned, and the right policy could be applied.

If the price increases in the housing market are not investigated, and it is assumed that the recent price changes are justified by fundamental changes, this could have unpleasant consequences. A financial crisis could result from the misjudged price changes since previous literature unambiguously recognizes the collapse of the housing market bubble as one of the core elements for the financial crisis in 2008 to occur (Levitin and Watcher, 2011; Baker, 2008; Acharya and Richardson, 2009). A financial crisis hurt different groups within the Dutch population. Campello et al. (2010) and Chodorow-Reich (2014) emphasize the major global effects of the financial crisis in 2008. Since the bubble in the housing market is recognized as one of the main factors of the crisis, the social relevance of identifying a possible bubble in the Dutch housing market is demonstrated.

Some literature about the Dutch housing market has tried to examine the housing prices and the potential bubble because of price developments. Despite improvements on the Dutch housing market in the form of policies, Boelhouwer and Hoeksta (2009) simultaneously observe shortages in the Dutch housing market. An inefficient asset market could introduce a bubble (Tirole, 1985; Barlevy, 2007). In conjunction with the increasing prices in the market, a bubble is suggested. If so, the prices could make a dramatic turnover soon. Zwitserloot (2020), Keizer (2020), and Kamm (2018) already found evidence for the existence of a bubble in the Dutch housing market in 2008 or in a part of the country. Xu-

Doeve (2010) also finds overvalued houses where prices are higher than fundamentals would expect. Since 2013, prices are increasing again. However, Nijskens and Heeringa (2017) do not find evidence for a bubble yet, despite signals what would suggest one. Since four years have passed and prices continued to increase, further analysis is necessary to investigate the source of the price increase and determine the possible presence of a bubble in the Dutch housing market. With the recognized scientific - and social relevance, the following research question is needed to be answered:

Is there a bubble in the Dutch housing market?

The rest of the paper is divided into four sections. First, the related literature is presented in section II. This section is followed by the data and methodology to determine a potential bubble in the Dutch housing market. Section IV includes the results of this methodology whereafter the main results are summed up in the conclusion.

II. Related literature

Before the possible bubble in the Dutch housing market is analyzed, the related literature is discussed. To become acquainted with the (Dutch) housing market and its potential bubble, various topics and its most important related literature need to be observed. Regarding the subject of this thesis, a lot of academic literature is known. Therefore, the related literature will be divided into different sections. First, assets will be discussed followed by the pricing of assets and its fundamental drivers of the prices. Third, asset bubbles will be explained followed by a close analysis of the housing market. Finally, methods will be given to measure a housing bubble. Most literature related to bubbles consists of an empirical analysis where a possible bubble is examined in a certain place in response to a motive whereat a bubble is suspected.

1. Assets, pricing, and fundamentals

In accounting, an asset is known as a property that represents a certain value. It could either be private- or corporate property. These assets are presented on the left side of the balance sheet and could create economic benefits. Common assets are cash, equipment, inventory, or buildings. Not all assets are tangible. Examples of intangible assets are trademarks and patents (Sveiby, 1997). A patent gives someone the privilege to be the only one producing and selling a certain product, often to stimulate innovation and production. It prohibits others to use, copy or sell it (Boldrin and Levine, 2013). Against the assets, there are liabilities on the right side of the balance sheet which represent the value that is owed to external parties. Together, private asset-liability management could give insights into the value a household represents. To value individual households, real estate is an important factor since this is the highest valued asset under individuals (Kochhar et al., 2011).

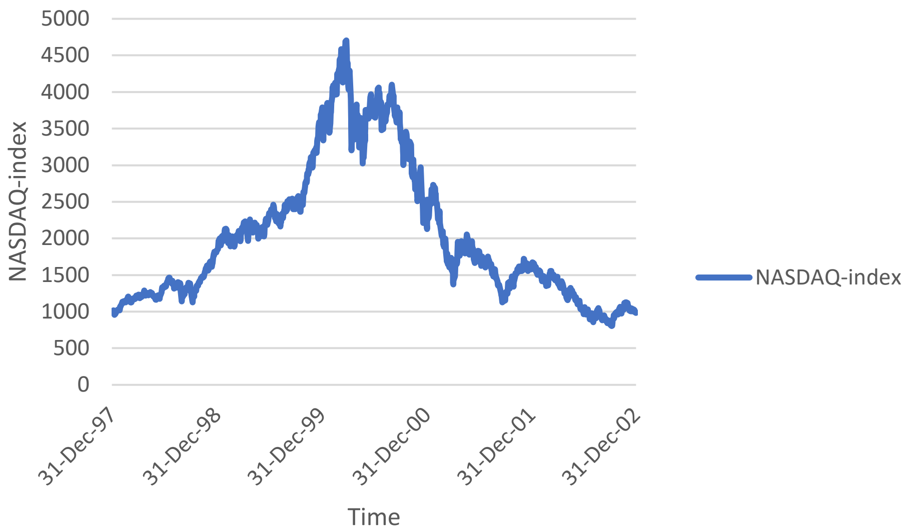
To understand why assets have different prices or returns, different methods are developed. These methods could be divided into two groups: the non-arbitrage models and the consumer-based models (Pereira and da Silveira Bueno, 2008). Both models start with the fundamental price function where the price depends on the return of the asset and the stochastic discount factor. The fundamental value also will become an important factor in assets such as houses. Non-arbitrage models contain the idea where the price of the asset reflects the fundamental value of the asset and corresponds to the fundamental theorem of asset pricing (Delbaen and Schachermayer, 1994). With the absence of arbitrage, no riskless profit could be made. Equilibrium is assumed where the utility of consumers is maximized. With the use of Arrow-Debreu assets in the non-arbitrage models, the prices of any asset in the economy could be found.

In the dynamic consumption-based models, provided by Lucas (1978), the timing of consumption is considered. Uncertainty over time could influence the value consumers give to returns (Duffie, 2010). Individuals could value consumption differently over time. Therefore, someone could be willing to sell for a higher price in one period to an impatient individual who is willing to pay a higher price. Maximizing profits is still available if the lower returns/profits in the first period are compensated by higher ones in the second period. In these dynamic methods, the absence of arbitrage could also be proved (Cochrane, 2009). One of the most used models of asset pricing, corresponding to the consumption-based model, is the capital asset pricing model (CAPM), developed by Sharpe (1964) and Lintner (1965). This method converts the risk of an asset into an estimated expected return.

Since both models use the fundamental function to determine asset prices, the importance of fundamental value is emphasized. Fundamentals are discussed to represent the variables that should drive asset prices (Garber, 2000; Engel and West, 2005). It reflects the expected value of the long-run equilibrium asset price (Rosser, 2013). However, a problem is observed in the difficulty of determining the fundamental value of an asset. Therefore, it could be difficult to distinguish what part of price changes are caused by changes in fundamentals. It is important to examine the effects of price changes that are not caused by fundamentals.

2. Asset bubbles definition

For the term bubble, often used in connection with asset markets, there is no plain definition while it is frequently used. One relatively simple explanation is given by Kindleberger (1978) and Lind (2009). They describe a bubble as a dramatic increase in prices over an extended range of time, followed by an implosion. Based on this definition, an example would be the sharp increase and decrease of the NASDAQ-100 index in the period 1998-2002, presented in Figure 2. This index represents the stock market by using 102 securities of the largest non-financial companies. Other examples of bubbles, based on this definition, are the Tulipmania in the seventeenth century and the share markets of the South Sea Company and the Mississippi Company in the eighteenth century (Barlevy, 2007).



Notes: NASDAQ-100 index in the period 1998-2002 (Nasdaq, 2021). On the y-axis, the price/value of the NASDAQ-100 index could be found. This index represents the stock market by using 102 securities of the largest non-financial companies. The x-axis represents the date.

Figure 2. NASDAQ-100 index in the period 1998-2002

However, most economists argue the insufficiency of this definition. Another definition is given where speculative bubbles refer to a situation where price levels depart from the fundamental value (Stiglitz, 1990; Rosser, 2013). Fundamentals are mentioned to represent the variables that should drive asset prices. Rosser (2013) mentions fundamental value as the long-term equilibrium while random shocks in the short-term are allowed. Stiglitz (1990) observes weakened confidence under economists in the efficiency of resource allocation if the fundamental value does not reflect the actual prices. He mentions expectations as an important factor for asset bubbles. Actual prices will increase if investors believe the future prices will be higher than today's prices whereas these expectations are not based on fundamentals.

Eatwell et al. (1987) and Case and Shiller (2003) also mention expectations play a big role in bubbles. Initial price increases which are supported by fundamental changes could be followed by expectations of further increases. This creates a higher demand and prices for assets. However, this excessive demand mostly consists of speculative investors with the purpose of making a profit instead of using it. Since prices could not increase forever, the prices decrease when demand diminishes because people become aware of the flattened growth curve. The decreasing prices cause the bubble to collapse. The belief where the prices are expected to increase in the future has vanished.

It is likely that one of the causes of a bubble to arise rests in the efficiency of asset markets (Tirole, 1985; Barlevy, 2007). If an economy is characterized by inefficiencies, bubbles could arise to alleviate these. However, this resembles a temporary solution since the collapse of a bubble would aggravate the inefficiency and worsen society. These welfare implications are in line with the effects of a bubble proposed before. A bubble could disturb business cycles and could be a stimulating factor for a financial crisis (Davis and Van Nieuwerburgh, 2015; Piazzesi and Schneider, 2016; Lian, 2016).

A more specific definition of an asset price bubble is given by Siegel (2003). According to him, a positive or negative bubble could be concluded if a realized asset return is more than two standard deviations of the expected asset return. This means that a certain period must go over to draw a conclusion about the realized return. After a certain price drop, a bubble could not be concluded immediately. The following empirical analysis indicates that the rapid price drop in 1987 proves not to be a bubble.

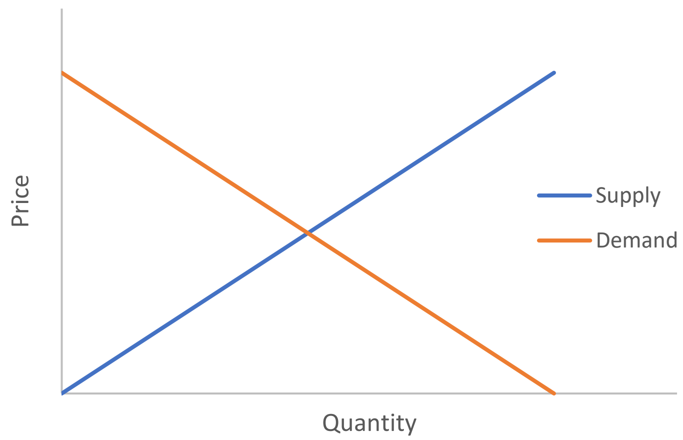
Glaeser et al. (2008) offer a model that concludes areas with a more inelastic supply to show a higher price increase during a housing bubble. Also, bubbles are expected to occur more often and to have a longer duration in this kind of area. Ofek and Richardson (2003) and Hong et al. (2006) examined the lock-up provisions which represented the asset supply. If the provisions expire, an increase in supply along with a price drop as result will cause the bubble to burst. The optimistic behavior of the buyers has disappeared. Another situation where this could happen is mentioned by Tirole (1985) and Weil (1987). They introduce overlapping generations to be an important factor in asset bubbles.

3. The housing market and prices

Real estate is one of the most common and simultaneously the highest evaluated individual assets owned by households (Kochhar et al., 2011). Therefore, the housing market is one of the most important markets in the economy. Prices changes in the housing market have a large welfare effect since the value of households largely depends on their housing price. Therefore, public reactions after a price change are understandable (Kenny, 1998). Goodman and Thibodeau (1998) describe a housing market as a geographic area with constant housing prices and with the availability of purchasing individual housing characteristics. They examine housing market segmentation using hierarchical linear models to identify submarkets in metropolitan areas.

To become acquainted with the housing market, the demand and supply side of the market must be observed. In different areas, the demand and supply are tried to be modeled. Kenny (1999) models the long-run demand in Ireland using housing prices, housing stock, aggregate income, and mortgage interest rates. The related supply could be modeled using the housing prices, construction costs, and mortgage interest rates. Government policy is mentioned as an important factor regarding housing supply (Fingleton, 2008). The supply could increase if government policy is used to stimulate affordability. Since the assumption is made that an increase in supply would also stimulate employment, the increase in supply will go along with an increase in demand. Fingleton (2008) emphasizes the fact that the result of government policy could differ along with areas in the UK. The affordability could also be worsened by the policy.

The primary factor of determining supply and demand is the price of houses. The law of demand implies a negative relationship between price and demand. Simultaneously, the law of supply describes an increase in supply if the price increases and vice versa. This gives a positive relationship between supply and price (Smith, 1937). In Figure 3, the standard demand-supply model of Marshall (2009) is reproduced. Linear relationships between housing prices and quantities of supply and demand are assumed. However, this assumption is unlikely to hold since not only the price influences the quantities. The curves are likely to have different non-linear slopes (Paciorek, 2011). Figure 3 is just to clarify how an equilibrium price and -quantity on a market arrive. Price volatility is likely to affect demand (homeowners and buyers) and the supply with the effect on the construction of new houses (Topel and Rosen, 1988). This is likely to occur in the housing market since housing prices are thoroughly volatile relative to fundamentals (Glaeser et al., 2008).



Notes: The standard Supply-Demand model, assuming a linear relationship between the quantity of supply/demand and prices. The blue increasing line represents the supply where the orange decreasing line the demand represents. On the y-axis, the average house price could be found and on the x-axis the quantity of demand and supply. This is an example of how the housing market could be. The linear assumption is unlikely to hold. The graph shows how the prices of houses could influence the demand and supply and how the equilibrium could arrive. The equilibrium is the point where the demand and supply curves intersect.

*Figure 3***.** Standard Supply-Demand Model

4. Methods to measure a bubble

Asset pricing literature showed the difficulty of confirming a possible bubble on the asset market (e.g., Flood and Hodrick, 1990). As stated, a core element of this difficulty lies in the determining of the fundamental value. However, attempts including some worthwhile haven taken place to measure a bubble. Bourassa et al. (2019) and Keizer (2020) describe and analyze some of these methods. These methods are divided into three groups. An overview is provided in Table 1 in the Appendix.

The first method consists of various ratios where housing prices are compared to incomes or rents. In the second method, different regressions analyses could be performed to prove the presence of a bubble. These first two methods are mostly consistent with the definition of bubbles where the fundamental value of houses must be compared with the actual value (Stiglitz, 1990; Rosser, 2013). If the actual prices do not reflect the fundamental value, a bubble could be concluded. The third and last method observes the growth rate of prices. If the price changes follow a certain pattern in the form of a dramatic increase followed by a sharp decrease, a bubble could be concluded. This method is in line with the definition given by Kindleberger (1978) and Lind (2009).

4.1 Ratio methods

Regarding the first method, various ratios could be analyzed. The most common ratios are price-income and price-rental. Bourassa et al. (2019) also use imputed-actual rent as a ratio. If house buyers are willing to spend more on a house due to certain expectations, the prices of houses in proportion to their incomes could be observed to detect a possible bubble. An increase in the ratio would imply house buyers give up a larger amount of their income to buy a house since prices rise more than incomes. This would suggest a bubble arise. Income growth is a fundamental reason to explain prices to increase. Moreover, equilibrium in the housing market implies that the annual costs of owning a house should not exceed the annual costs of renting a house (Himmelberg et al., 2005). If the price-rent ratio increases significantly, this would suggest the prices of a house are valued higher than the fundamental value since the buying of a house becomes relatively more expensive than renting a house. The price-income – and price-rental ratios are often used to conclude a possible housing bubble including the US, China, the Czech Republic, Israel, and Sweden (Case and Shiller, 2003; Jianglin, 2010; Cadil, 2009; Caspi, 2016; Asal, 2019).

Himmelberg et al. (2005) introduced the imputed-actual rent ratio. The imputed rents (R*) represent the expected user costs (E(u)) per dollar of owning a median house multiplied by the real housing price (P). The annual user costs depending on various variables differ significantly across different regions (Bourassa et al., 2019 and Himmelberg et al., 2005). Himmelberg et al. (2005) did not find evidence of a housing bubble in the US around 2004. Therefore, the robustness of the ratio is questioned. It is difficult to draw a conclusion from the ratio since the effect of a level of the ratio differs across regions. An index of the long-term average is created and set to 100. Regarding all three ratios, a bubble could be concluded if the index exceeds the long-term average with a certain level. This means that the actual value is higher than the fundamental value (Bourassa et al., 2019). This rule is introduced by Bourassa et al. (2019) who argued this threshold to be a strong indicator of the presence of a bubble.

4.2 Regression analyses

The second method to determine whether a bubble is present on a market is to perform various regression analyses. Regarding regression analyses, an ongoing debate is going on what the best model is to determine real housing prices. As described, relevant factors to demand and supply are housing stock, aggregate income, mortgage interest rates, government policy, location, and construction costs (Kenny, 1999; Fingleton, 2008). However, including all factors in a multivariate regression might cause a problem in the form of the explaining factor. The explaining factor is tried to be found instead of the proving of the potential bubble. A variable that could clarify this phenomenon is interest rates. Interest rates are proved to revert in the long term and have contributed to the existence of the US housing bubble (Allen and Carletti, 2010). This creates dissension to take interest rates into account regarding real housing prices. This introduces the parsimonious regression model, a simple model with few predictors but high prediction power. Like the ratio method, a bubble could be concluded if the created index exceeds the long-term average with a certain level.

Price or a ratio where the price is compared with income or rent is mostly used as the dependent variable. To determine the dependent variable, different regression methods could be used. Often, the dependent variable is established by variables that represent supply and demand fundamentals. This method is used by Case and Shiller (2003) and Goodman and Thibodeau (2008) and Wheaton and Nechayev (2008) to find the presence of a housing bubble in the US. Alternative fundamental variables could be used in the form of variables that characterize the arising of a bubble (disequilibrium) and variables that characterize the reversing to the equilibrium. This method also suggests the presence of housing bubbles in Turkey, Australia, and New Zealand (Coskun and Jadevicius, 2017; Abraham and Hendershott, 1994; Bourassa and Hendershott 1995).

Besides, the net present value method is used to determine the fundamental value of houses. It is introduced by Black et al. (2006) and Campbell and Shiller (1988a; 1988b) who estimated the coefficient of expected cash flows (discount factor). For estimating, a vector autoregressive model (VAR) is used. If the prices deviate at a significant level from the computed fundamental value, a bubble could be concluded. With this method, housing bubbles are proved in the US in the early 2000s and in Amsterdam in several periods over a timeframe of 355 years (Campbell et al., 2009; Ambrose et al., 2013).

4.3 Other methods

Time series could also be used in the form of a unit root test. A test is performed to examine the presence of a unit root or to conclude stationarity. The unit root could be interpreted as a sharp unpredictable increase and decrease in pricing. This method is in line with the definition of a bubble presented by Kindleberger (1978). With the presence of a unit root, an asset bubble could be identified (Taipalus, 2006). However, if only prices are observed, the results could be misleading. The price changes could be justified by changes in fundamentals. Using this method, bubbles are identified in Hongkong, the US, the UK, Spain, Germany, and Finland (Taipalus, 2006; Yiu et al., 2013).

A related method to the unit root test presented by Taipalus (2006) and simultaneously the last method to detect a bubble is the exponential growth rate (EGR) method. If the price outgrows a certain exponential threshold, a bubble could be indicated. The threshold represents long-term price development. This method is used by Zhou and Sornette (2006) to prove the US housing bubble in a significant number of states in the early 2000s. However, this method is argued to be insufficient to draw a conclusion about a possible bubble (Bourassa, 2019). Since only housing prices are observed, misleading results could come out. It does not relate to the fundamental value of houses.

III. Data and Methodology

To determine whether a bubble is originating in the Dutch housing market since the ongoing price growth since 2013, different methods will be examined. In the previous chapter, different methods are discussed. However, some methods were unsuited for analyzing a bubble. Regarding the EGR method and the unit root test, the quality is questioned and therefore not used in the analysis. Only price developments are observed and not the corresponding fundamentals that cause the price changes. Therefore, results, where certain price changes are linked to a bubble, could be misleading since these changes could be justified by demand and supply changes. The use of the net present value method is proved to be difficult. Besides, the method requires data where the acquirement is impeded. Therefore, this method is also avoided in the analysis. The imputed-actual rent will be left out since it is difficult to draw a conclusion from this ratio. The effect of a certain level of ratio could differ across regions (Bourassa et al., 2019). Therefore, the ratio is difficult to interpret since a relatively high ratio could have little effect regarding a bubble. The remaining methods for measuring the potential bubble in the Dutch housing market will be discussed.

1. Ratio methods

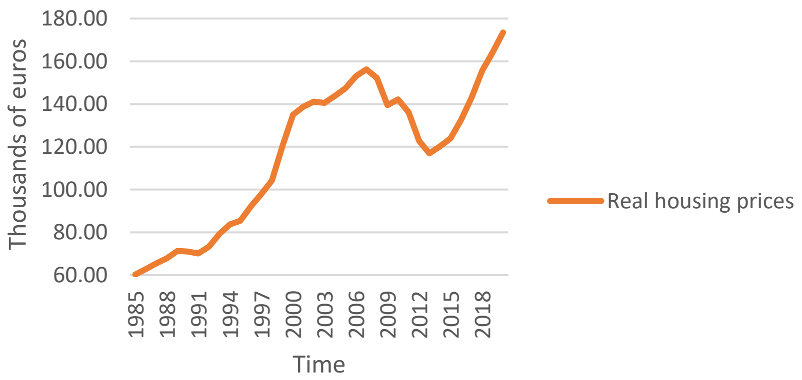
In the first method, different ratios will be analyzed. The ratios that will be analyzed because of their suitableness are price-income and price-rental. Bourassa et al. (2019) consider these two relatively simple methods as the most reliable methods to examine potential bubbles. Respectively the ratios represent real median housing price /real income per capita (P_t/Y_t) and real median housing price/annual median rent (P_t/R_t) at time t. The time-series data that is needed to perform this method, consists of data about the real housing prices, real income per capita, and annual median rent in the period 1985-2020. The descriptive statistics needed for the ratio methods are provided in Table 2.

Table 2. Descriptive Statistics Ratio Methods

Variables (1)	Mean (2)	Standard Deviation (3)	Min (4)	Max (5)
Real housing prices	116.23	34.33	60.30	173.50
Real income per capita	18.64	2.35	13.50	21.90
Rent index	191.45	59.28	100.00	296.73
Price-Income ratio	6.17	1.19	4.30	7.92
Price-Rent ratio	0.61	0.08	0.46	0.76
Number of observations	36	36	36	36

Notes: Descriptive statistics are presented for the Netherlands with respectively the variables, mean, standard deviation, minimum, and maximum in the columns. The real housing prices and the real income per capita are presented in thousands of euros. The rent index with 1985=100 represents the rent and its changes over time. The ratios present the prices divided by respectively the real income per capita and the rent index. The timespan 1985-2020 is observed.

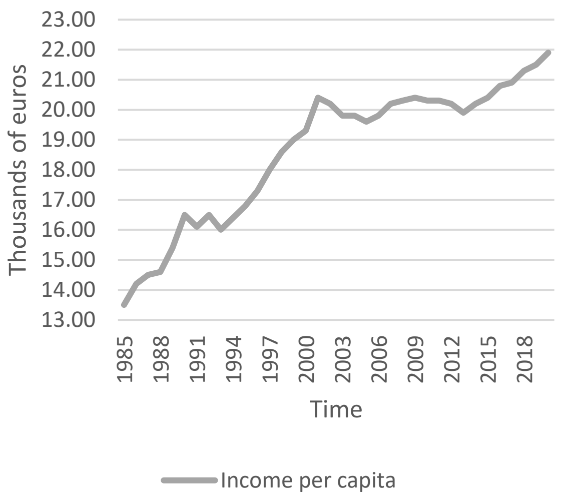
The average annual nominal transaction housing prices for the period 1985-2019 are provided by the Nederlandse Vereniging van Makelaars (NVM, 2020). The average nominal price of 2020 is provided by CBS (2021c). To determine the ratios, real housing prices must be observed. Therefore, the nominal prices are adjusted for inflation rates, which are given by CBS (2021a). An index (with 1985=100) is created to measure total inflation over the years. The real housing price in a certain year is calculated by dividing the nominal price by the deflator. These are presented in Figure 4. The deflator represents the total inflation from 1985 until the corresponding year for which the real price is calculated.



Notes: Annual real housing prices are presented in thousands of euros on the y-axis for time on the x-axis (1985-2020). Data is provided by the NVM (2020) and CBS (2021c).

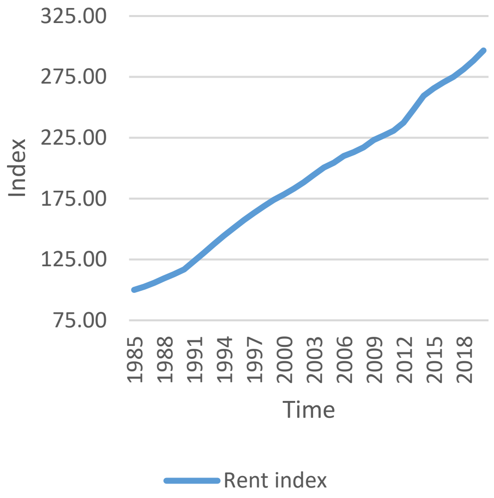
Figure 4. Real housing prices for 1985-2020

To complete the data for the ratios, the fundamental values that are represented by real income per capita and the annual median rent are needed. The real income per capita for the observation period is provided by CBS (2021b). CBS Statline (2020) issued the change of the rents relative to previous years. With this data, an index is created with 1985=100 to be the indicator of rents over time. Figure 5 and Figure 6 present the real income per capita and the rent index over time. With the use of the described data, the two ratio methods could be performed. The ratios at time t could be computed by dividing the real median housing price by real income per capita (P_t/Y_t) and the annual rent index (P_t/R_t).



Notes: the real income per capita in thousands of euros on the y-axis is provided over the time span (x-axis) 1985-2020 (CBS, 2021b).

Figure 5. Real income per capita for 1985-2020



Notes: the computed rent index with 1985=100 is provided (y-axis) to observe rent changes in the period 1985-2020 (CBS Statline, 2020).

Figure 6. Rent index for 1985-2020

A long-term average of the ratios will be determined for the period 1985-2020 and set to 100. The ratios will be observed over time. An index will be created where the ratio in a certain year is divided by the long-term average and multiplied by 100. In contrast to most literature that uses 120 as a threshold, a bubble is expected in the corresponding year if this index exceeds 110. The threshold 110, where the index deviates 10 index points from the long-term average, is introduced by Bourassa et al. (2019). They investigate housing bubbles in six western metropolitan areas in different countries. According to Bourassa et al. (2019), who used ex-post and recursive robustness checks, this deviation would be a significant indicator to determine a bubble. First, they used a threshold of 120 whereafter the threshold was modified respectively down to 10 and up to 30 index points. Robustness checks indicated that for the ratio measures, ex-post analyses scored the highest overall average of sensitivity and specificity when 110 was used as a threshold. This would indicate that the percentage of correctly identifying bubble periods and non-bubble periods would be the highest in the ex-post analysis if the threshold of 110 is used. Since an ex-post analysis is performed, this suggested threshold is used for measuring a potential bubble in the current Dutch housing market. The assumption is made that the robustness of the ex-post methods also applies to the Netherlands. This assumption is substantiated by the observation of the Dutch housing market during the period before 2008 where the unambiguous recognized global housing bubble also showed the deviation of 10 index points from the long-term averages of the ratios (Keizer, 2020).

An increase in the ratios, relative to the long-term average, suggests the prices of a house to be valued higher than the fundamental value since households must give up a larger part of their incomes to buy a house and since the buying of a house becomes relatively more expensive than renting one. However, the accuracy of the long-term average must be interpreted with caution. Bourassa et al. (2019) mention expectations about the relationship between price and income. Theoretical evidence would suggest the possibility where the coefficient of income (and rent) to housing prices could deviate from one in the long-term. In this method, the coefficients of the ratios are assumed to be constant in the long-term. That is why the results that come out should be interpreted with caution.

2. Parsimonious- and multivariate regression analysis

In the second method, various OLS regression analyses will be performed. This method is based on previous literature where bubbles were tried to be identified with regression analysis (Bourassa et al., 2019; Bourassa and Hendershott, 1995; Case and Shiller, 2003; Keizer, 2020). A parsimonious and multivariate regression analysis will be used to predict real prices, based on fundamentals. Fundamental variables are used that are believed to drive housing prices (Kenny, 1999; Fingleton, 2008). As a result, the gradient of fundamental prices could be observed. These fitted values could be compared with the actual prices to determine whether actual prices recently deviated from their fundamentals. The residual represents the part that could not be explained by the regression line and could therefore include variables that do not represent fundamentals. Large residuals would suggest speculative demand changes to be one of the main drivers of actual prices.

The parsimonious regression is considered to be an accurate method. It is a model with few predictors but high prediction power. In contrast to the price-income ratio, the real aggregate income is used which indirectly takes the population into account. This could be reputed as an improvement since Bourassa et al. (2019) mention expectations where the long-term coefficient of income to housing prices could take other values than one.
In the parsimonious regression, the real housing prices will be estimated by:

$$P_t = \beta_0 + \beta_1 * {Y^a}_t + \varepsilon_t \quad (1)$$

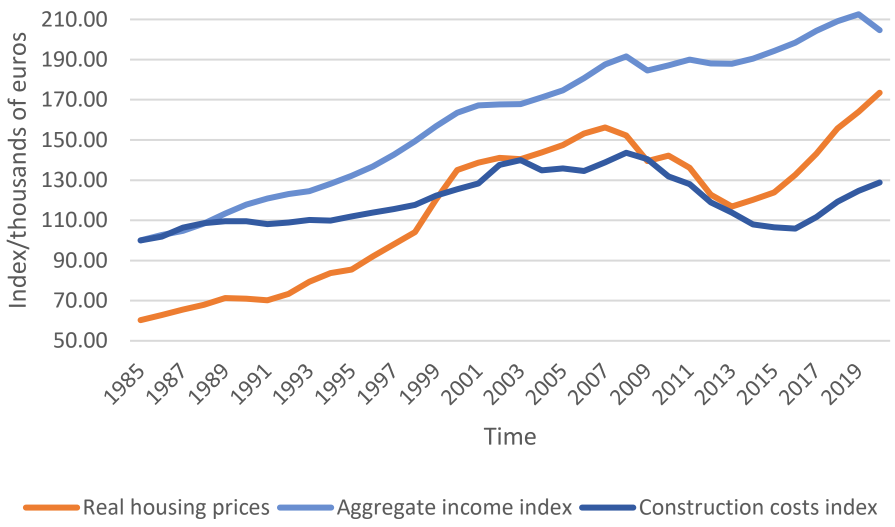
For the multivariate regression analysis, more fundamental variables could come in:

$$P_t = \beta_0 + \beta_1 * {Y^a}_t + \beta_2 * U_t + \beta_3 * M_t + \beta_4 * C_t + \beta_5 * S_t + \varepsilon_t \quad (2)$$

In both regressions, the P_t represents the average real housing price (nominal prices corrected for inflation) at time t. ${Y^a}_t$ represents the aggregate income in the Netherlands. The extra variables in the multivariate regression consist of a proportion of unemployment rates (U), a proportion of real mortgage interest rates (M), real construction costs (C), and a proportion of term spreads between 10-years and 3-months government securities (S). The error term is specified as ε_t. The residual (e) that follows from the estimated regression analysis, represents the part that could not be explained by the regression.

The actual housing prices that are used to determine the residual are the same as in the ratio methods where nominal average housing prices are corrected for inflation (NVM, 2020; CBS, 2021a; CBS, 2021c). The real aggregate income in the Netherlands, where real

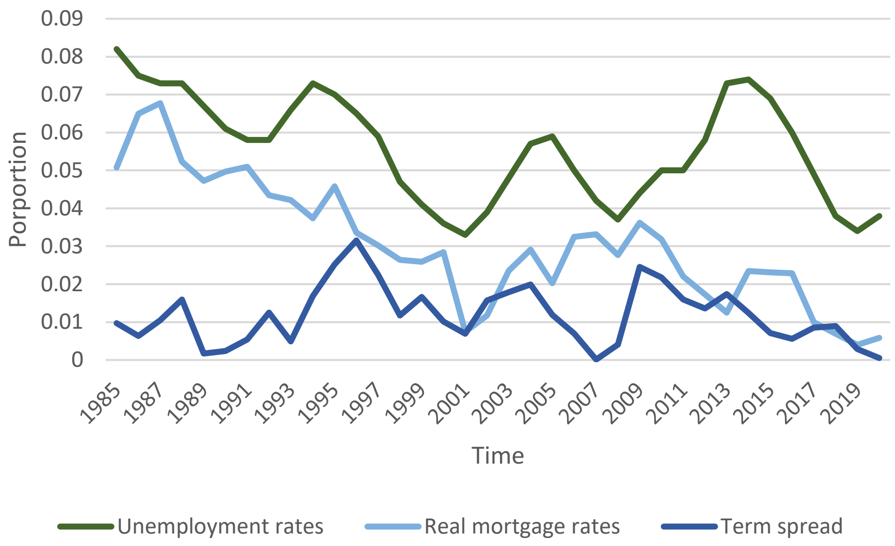
GDP is used as an indicator, is provided by CBS (2021e). The index with 1969=100 is transformed to an index with 1985=100. A construction costs index with 2000=100 is also provided by CBS Statline (2021b). This nominal construction costs index is transformed with 1985=100 and corrected for inflation. The development of these three variables is presented in Figure 7.



Notes: Real housing prices in thousands of euros, real aggregate income index, and construction costs index (both indexes 1985=100) are provided for the period 1985-2000 (NVM, 2020; CBS, 2021a; CBS, 2021c; CBS, 2021e; CBS Statline, 2021b). The real prices are from Figure 4.

Figure 7. The development of real housing prices and the indexes of real aggregate income and real construction costs for 1985-2020.

Daily data about mortgage interest rates were provided by DataStream (2021). The average of each year in the period 1985-2020 is computed and corrected for inflation which resulted in real mortgage rates. The nominal unemployment rates are provided by CBS Statline (2021a). The annual term spread between 10-years and 3-months government bonds is computed by measuring the difference between the short-term interest rates and the long-term interest rates, which were provided by OECD (2021a; 2021b). The development of the three percentages is shown in Figure 8.



Notes: the proportions of unemployment, real mortgage rates, and term spread are provided for the period 1985-2000 (CBS Staline, 2021a; Datastream, 2021; OECD, 2021a; OECD, 2021b).

Figure 8. The development of unemployment rates, real mortgage rates and, the term spread for the Netherlands in 1985-2020.

With the use of regression analyses, the coefficients could be determined. Bourassa et al. (2019) argue to use the variables (and only estimate their coefficients) that first, create the highest adjusted R^2, which measures the goodness-of-fit of the regression, and second, have the right coefficient signs. Aggregate income and construction costs are expected to be positively related to housing prices, while mortgage rates, unemployment rates, and term spread are expected to be negatively related to housing prices.

However, the regressions themselves are not directly capable to find a potential bubble. Therefore, the values of real housing prices must be predicted to compute their fitted values. As a result, fitted values that represent supply and demand fundamentals could be compared with actual prices.

$$e = P_t - \widehat{P}_t \quad (3)$$

From these residuals, the differences between the actual- (P_t) and estimated fundamental prices ($\widehat{P}_t$), a conclusion could be drawn about the potential bubble. If the actual average prices show a significant deviation from the fundamental fitted prices, a bubble is suggested. The descriptive statistics for the regression analyses are provided in Table 3.

Table 3. Descriptive Statistics Regression Analyses

Variables **(1)**	**Mean** **(2)**	**Standard Deviation** **(3)**	**Min** **(4)**	**Max** **(5)**
Real housing prices	116.23	34.33	60.30	173.50
Real aggregate income	160.69	34.92	100.00	212.56
Real construction costs	119.75	12.68	100.00	143.60
Real mortgage rates	3.05	1.63	0.40	6.77
Unemployment rates	5.57	1.40	3.30	8.20
Term spread	1.19	0.76	0.01	3.15
Number of observations	36	36	36	36

Notes: Descriptive statistics are presented with respectively the variables, mean, standard deviation, minimum, and maximum in the columns. The variables whereof descriptive statistics are described for the Netherlands are real housing prices in thousands of euros, aggregate income index and the real construction costs index (both with 1985=100), and the unemployment rates, real mortgage rates, and term spread (difference between short- and long-term interest rates on government securities). The timespan 1985-2020 is observed.

IV. Results

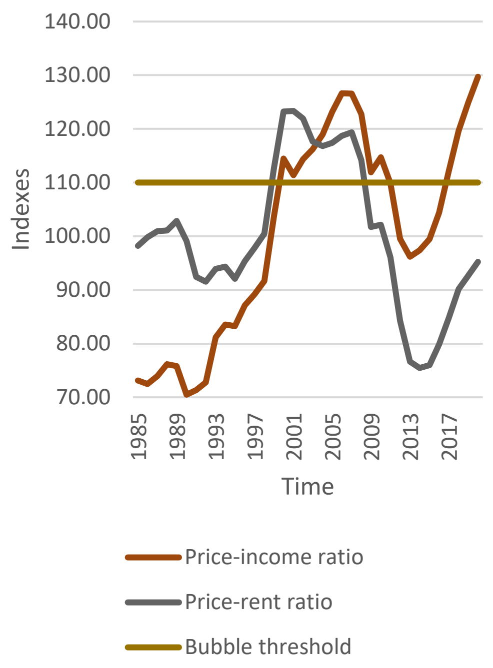
This chapter discusses the results generated from the ratio- and regression analyses to detect a bubble in the Dutch housing market. From the results, a conclusion will be drawn about the potential bubble.

1. Ratio methods

In Figures 9 and 10, the results from the price-income ratio and the price-rental ratio are presented. The index of the real price- real income per capita ratio shows a sharp overall increase from 1985 until 2007 in which the index rises from around 75 to over 125. Since a lot of evidence was already provided about the housing bubble before the credit crisis in 2008, this result does not come as a surprise. The price-income ratio implies the bubble started in 2000 and reached its climax in 2006 and 2007. Hereafter, a sharp decrease is observed until 2013 where the ratio drops to under its long-term average. This could be dedicated to the credit crisis that caused the real prices to drop relatively more than income.

After 2013, a sharp increase is observed again. This implies prices grew harder than incomes in the corresponding period. The price-income ratio suggests an ongoing- and growing bubble that passed the threshold for the first time in 2017. In 2020, the ratio was on a higher level than its top level before the credit crisis. Besides, stagnation does not suggest being put in motion. A possible reason lies in the historic low mortgage interest rates. Borrowing money to buy a house has never been so low before. As a result, the affordability increases to buy a house. Also, the financial capacity of households is suggested to never been higher than today's level. The high capacity is mainly owing to the rapid increase in housing prices since houses are often the biggest assets, owned by a household (NOS, 2021). Households are willing to offer a larger part of their income to buy a house.

However, the price-rent ratio does not show signals that would indicate a bubble in the housing market in recent years, despite an increasing trend that started in 2014. The period in which the ratio show signals for a bubble is 1999-2008, which again, is just before the credit crisis in 2008. The ratio shows a rapid increase from 1995 that resulted in the ratio transcending the bubble threshold in 1999. Until 2008, the presence of a bubble is suggested with its highest point in 2000 and 2001. With the credit crisis, a decreasing trend is deployed until 2013. Afterward, the ratio started to increase. In 2020, the ratio approaches its long-term average. However, this level of the ratio causes a bubble to not be concluded in recent years. This would suggest renting prices to follow the price of buying a house.



Notes: The indexes on the y-axis of the annual Price-income ratio (real average housing price/ real income per capita) and the price-rent ratio (real average housing price/rent index) relative to the long-term are presented over time (x-axis). A bubble is suggested if the index transcends 110.

Figure 9. The development of the price-income ratio and price-rent ratio for 1985-2020

Figure 10. The zoomed-in development of the price-income ratio and price-rent ratio for 2000-2020

2. Parsimonious- and multivariate regression analysis

The actual- and fitted (that represent fundamentals) real housing prices are presented in Figure 11. In Figure 12, the corresponding residuals of the parsimonious- and multivariate OLS regression analyses are presented for the period 1985-2020. The results for both regressions are presented in Table 4. After the coefficients were estimated with the actual housing prices on the left side and various variables on the right side, predictions are made regarding fitted values of the real housing prices to detect bubbles. For the parsimonious regression analysis, the fitted values are determined by using real aggregate income as an independent variable. In the multivariate regression analysis, the independent variables are used that created the highest adjusted R^2. As a result, unemployment is left out. The remaining independent variables that are used are real aggregate income, real construction costs, term spread, and real mortgage rates.

Table 4. Results of the parsimonious- and multivariate regression analysis

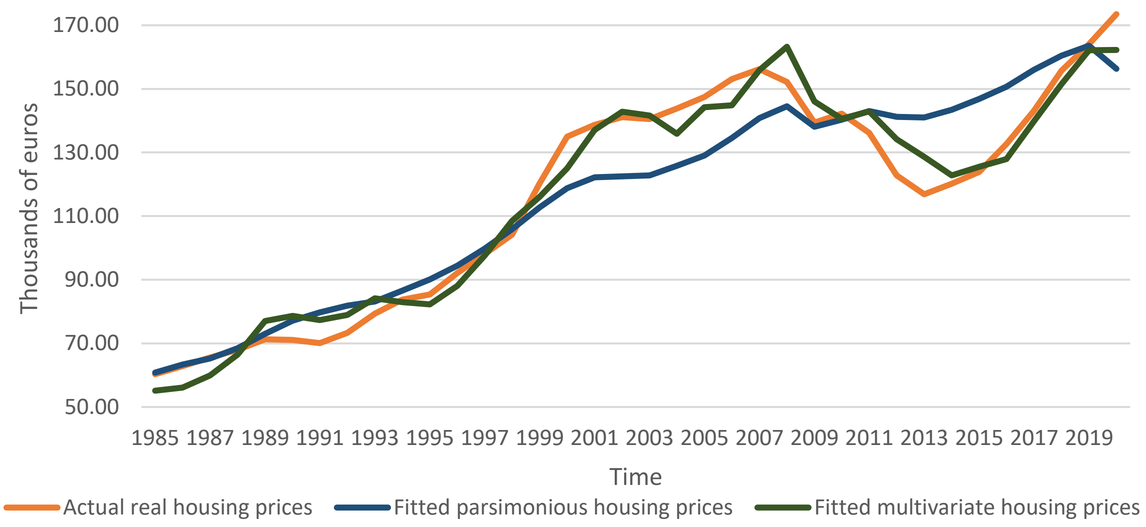
Variables (1)	Real housing price Parsimonious regression (2)	Real housing price Multivariate regression (3)
Constant	- 30.495*** (10.276)	- 92.405*** (16.157)
Real aggregate income	0.913*** (0.063)	0.585*** (0.066)
Real construction costs		1.062*** (0.105)
Real mortgage rates		- 2.675** (1.314)
Term spread		- 3.650** (1.465)
Number of observations	36	36
Adjusted R^2	0.858	0.965

Notes: The sample consists of 36 yearly observations with 1985-2020 as the corresponding period. The dependent variable represents the real housing prices in the Netherlands in thousands of euros. The independent variables that are used to determine the dependent variable are an index of real aggregate income (GDP), an index of real construction costs of houses, the proportion of real mortgage interest rates, and the proportion of term spread (difference between long- and short-term interest rates). For the parsimonious regression, only the real aggregate income is used as an independent variable, while the multivariate regressions used all described independent variables. The standard error is presented between parenthesis while the stars (*) behind the coefficient indicate the significance (*p≤0.10, **p≤0.05, *** p≤0.01).

As expected, the coefficients of construction costs and income are positively related to housing prices while the coefficients of term spread and mortgage rates are negative. In both models, the adjusted R^2 is high which means both models have a high goodness-of-fit. A high adjusted R^2 implies that a high proportion of the dependent variable is accounted for, which is desired to determine fitted values. Reasons for the high adjusted R^2 are not provided by Bourassa et al. (2019). A possible reason could be overfitting the model, in which the model is too complicated for the dataset. Also, trends of the predictor and the dependent variable could play a role. This is assumable since Figure 7 suggests the real aggregate income and real housing prices to follow an increasing trend. Including lagged or differenced variables where time is accounted for could offer a solution.

From the parsimonious regression analysis, the statistically significant variable aggregate income suggests an increase of one index point of aggregate income to result in a 913 euro increase of the real housing prices, ceteris paribus. When more variables are added, the multivariate regression analysis suggests the effect of aggregate income, which is still statistically significantly positive, to decline. One index point increase implies to result in a 585 euro increase of real housing prices in the Netherlands, holding other variables constant. The other coefficients of independent variables are all statistically significantly different from zero. This set of variables, where unemployment is left out, created the highest adjusted R^2. The real construction costs index suggests influencing real housing prices. An increase of one index point regarding construction costs is indicated to increase housing prices by 1,062 euros. The two variables that are suggested to be negatively related to real housing prices are real mortgage rates and the term spread between long- and short-term interest rates on government securities. An increase of the term spread of one percentage point (e.g. from a 2%- to a 3% difference) would suggest the average real housing prices to decrease by 3,650 euros, ceteris paribus. Similarly, a one percentage point increase of the real mortgage rates would influence the average housing prices negatively with 2,675 euros, holding other variables constant.

The regression analyses are not directly capable of finding periods with the potential presence of a bubble. To do so, fitted values are needed to be compared with the actual variables to observe residuals that could not explain price changes based on the main fundamentals of supply and demand of the housing market. As a matter of course, the residuals need to be interpreted carefully since they are predicted using actual prices and a limited set of explaining variables. This could result in the fact that fundamental variables are overexplaining the actual prices, or that not all fundamental variables that drive housing prices are used. Part of the residuals could therefore consist of variables that do not represent speculative demand changes and their corresponding bubble. However, a significant increase of a residual would impose the suggestion that another factor besides fundamentals drives housing prices up or down. The outflowing results regarding fitted values of the parsimonious- and multivariate regression analysis are presented in Figure 11. As expected, since the multivariate has a higher adjusted R^2, the fitted values of the multivariate regression in Figure 11 seem to follow the actual prices more closely than the fitted values of the parsimonious regression.



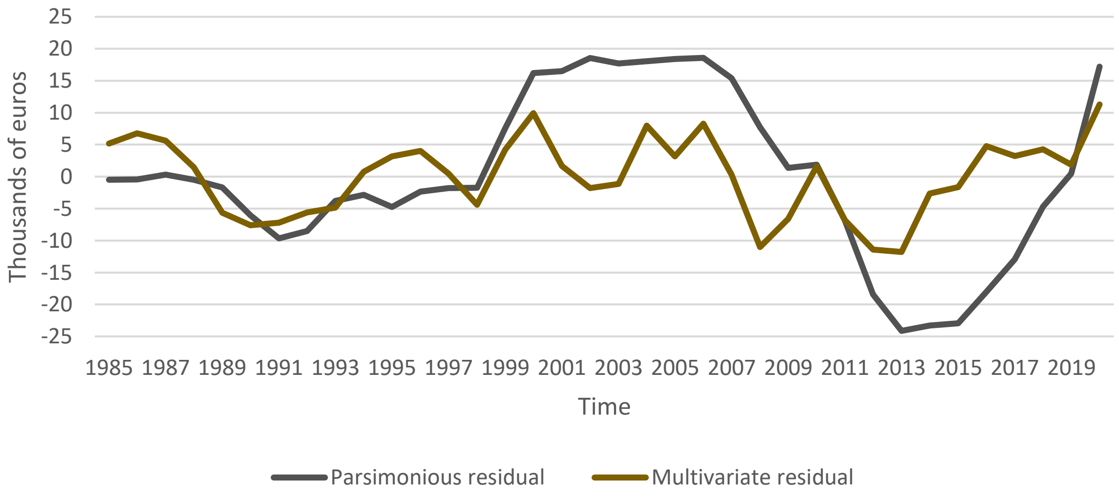
Notes: From the parsimonious- and multivariate regression, fitted values of real Dutch housing prices are generated that represent fundamentals. These, together with the actual housing prices, are presented. On the y-axis, the value of the housing prices could be found in thousands of euros. On the x-axis, the time of the corresponding prices could be found.

Figure 11. Actual- and fitted fundamental Dutch housing prices for 1985-2020

Due to the close similarities between the fitted values of the multivariate regression and the actual values, Figure 11 is hard to interpret. In the first place, this suggests the actual real housing prices to follow equilibrium prices that are formed by supply- and demand fundamentals. However, a closer look at the residuals is necessary and presented in Figure 12. What stands out, is that the fitted values from the parsimonious regression appeared to take another value than the actual value during the housing bubble that initiated the crisis in 2008. The actual prices in that period were almost 19 thousand euros higher than the fundamentals would predict. At least a part of this residual is suggested to be ascribed to the unambiguously proved housing bubble in that period.

In the aftermath of the crisis, actual prices imply to be lower than the fundamental prices. A possible reason for this difference is the confidence that disappeared as a result of the crisis. Besides, the crisis left its traces in other ways that could influence housing prices. The willingness to pay could e.g. experience a negative trend due to a rise in unemployment and uncertainty. Uncertainty contributes to the collapse of a speculative bubble since the buyers of a house do not have trust in increasing prices anymore. The period of the aftermath of the crisis could be considered as a negative bubble if non-fundamental factors drove the actual prices to relatively far under the fitted values. Since the actual prices dropped to almost 25 thousand under the predicted housing prices, it seems likely that speculative demand changes played a big role in this period. A crisis is often characterized as a highly uncertain period with an unknown scenario about the future. For the housing market, this suggests for most people to not be the best timing to buy a house, despite the prices indicate to be relatively low. After this period, the (negative) residual shows an increasing trend. In 2019, the parsimonious residual approached zero what indicates an (almost) equal actual price relative to its corresponding fit.

Since the fitted values of the multivariate regression seem to follow the actual prices more closely, the residuals are smaller. Whether the residuals of both models follow the same pattern could not be concluded. However, like the parsimonious regression, positive residuals are observed just before the crisis and negative ones afterward. The residuals take values higher than eight and lower than minus eleven thousand euros. These are values that are difficult to ignore since a lot of fundamental variables are accounted for. After 2013, the residuals in the multivariate regression increase again and reach zero in 2019. Between 2019 and 2020, the largest increase from the ongoing increase since 2013 is observed. The parsimonious- and multivariate residuals respectively took values of more than 17- and 11 thousand euros. This suggests actual real housing prices do not follow equilibrium prices that are formed by supply- and demand fundamentals.



Notes: From the parsimonious- and multivariate regression, fitted values of real Dutch housing prices are generated and compared with actual Dutch housing prices. On the y-axis, the value of the residuals could be found in thousands of euros where a positive residual implicate that actual housing prices are higher than the estimated fundamental price. The zero line indicates a zero difference between the actual- and predicted fundamental prices. On the x-axis, the years of the corresponding residuals could be found.

Figure 12. Residuals for 1985-2020 from the parsimonious- and multivariate regression

V. Conclusion

With the ongoing sharp increase of real housing prices in the Netherlands since 2013, the question is raised what caused this growth. If the price growth could not be explained by changes in fundamentals, other price-influencing factors play a role. If price changes are fueled by speculative activity, the presence of a bubble is suggested. To answer the question of whether a bubble is forming in the Dutch housing market, two methods are used. First, two ratios are created for which the development of the annual median real housing prices compared to fundamental housing price drivers is observed. These price drivers are represented by real income per capita and rent. If these ratios deviate from their long-term average for at least 10 index points, a bubble is suggested to be present in the Dutch housing market. Afterward, two regression analyses are performed where its fitted values that represent fundamental values are compared with actual prices. If actual prices showed a significant deviation from their corresponding fundamental prices, a bubble was implied.

As expected from previous literature, both ratios transcended the threshold in the period prior to the crisis in 2008. However, more focus is put on recent years. If the period after 2013 is investigated, a large increase of both ratios could be observed. This implies real average housing prices increased more than their corresponding fundamentals. Households must give up a larger part of their incomes to buy a house and the buying of a house has become relatively more expensive than renting one. From 2013, real housing prices increased by almost 50%. Compared to rent and real income per capita, which respectively rose by 20% and 10%, the increase in housing prices is substantial. To determine whether a bubble has formed in the Dutch housing market, the level of both ratios is compared with their long-term average. In 2017, the price-income ratio for the first time transcended the level where a bubble is concluded. A flattening of the curve does not seem to be put in motion. As a result, the price-income ratio reached its all-time high in 2020 with a level of almost 130, which is thirty index points higher than its long-term average. This deviation from its long-term average is larger than the deviation during the housing bubble that introduced the 2008 crisis. Therefore, this may not be passed unnoticed, especially when the increase continues in the future.

For the price-rent ratio, the results distanced themselves from the fact that a bubble could be concluded in the Dutch housing market. Despite an obvious increase from 2013, the ratio did not reach a level where a bubble could be concluded. After the crisis in 2008, the ratio dropped to around 25 index points below its long-term average. The increase from 2013 ensured the ratio to recover and get back to its long-term average. However, if the ratio continues to increase, the probability of transcending the bubble threshold will increase. Along with the price-income ratio, these developments may not be ignored since the consequences of a bubble are considered to be substantial.

To substantiate these results, two regression analyses are performed including a parsimonious- and multivariate regression. Residuals are observed as parts of actual prices that could not be explained by fundamental variables. Similar to the ratio methods, a bubble is suggested in the period before 2008 since actual prices show to be larger than fundamentals would predict. As expected, this difference is larger for the parsimonious regression since it has a lower goodness-of-fit. When more recent years are investigated, actual prices do not imply to be much larger than its corresponding fundamentals until 2019. After 2008, residuals show a decreasing trend where the actual prices are lower than fundamentals would predict. Also similar to the ratio methods, 2013 seems to be the tipping point in which the residuals start to increase again. Until 2019, the average actual prices do not show deviation larger than five thousand euro from the predicted fundamentals. This is considered as a deviation where a bubble could not be concluded since it does not stand out. However, in 2020, the parsimonious- and multivariate residuals increased massively and took values of respectively more than 17- and 11 thousand euros. This suggests actual prices to be significantly higher than its fundamentals. These values are comparable with the period prior to 2008 that is unambiguously considered as a bubble period. As a result, 2020 is suggested and concluded to be a year in which the housing prices take values that match a housing market bubble. Actual average real housing prices are suggested to not follow equilibrium prices that are formed by supply- and demand fundamentals.

Further analysis is necessary to investigate how housing prices will develop in the near future and what the potential consequences of these developments are. Besides, there must be considered whether the forming of a bubble must be countered. For now, there are various signs that suggest the presence of a bubble in the Dutch housing market. More evidence to prove or disprove the forming of a bubble could be found using methods that were left out. Moreover, more focused research could be performed on regions within the country to investigate the difference between regions. Also, monthly data or a longer period of time could be used to substantiate the findings.

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VII. Appendices

1. Tables

Table 1. Overview of methods to measure a bubble

Method (1)	Definition (2)	Related Literature (3)
Ratio methods	Prices could be compared with variables like income and rent (or imputed-actual rent) which represent fundamentals. If the ratios (Price/Income; Price/Rental) transcend the threshold of 120, a bubble is implied.	Bourassa et al. (2019); Case and Shiller (2003); Jianglin (2010); Cadil, (2009); Caspi (2016); Asal (2019); Himmelberg et al. (2005);
Regression Analyses	A statistical technique could be used where a relationship between variables could be analyzed. Below, the different regressions are described. All use the price or a ratio as dependent variable/index. If the index exceeds 120, a bubble is implied.	
Fundamental Variables	To determine the dependent variable, independent variables which characterize demand and supply, or disequilibrium and equilibrium could be used.	Kenny (1999); Fingleton (2008); Allen and Carletti (2010); Case and Shiller (2003); Goodman and Thibodeau (2008); Wheaton and Nechayev (2008); Coskun and Jadevicius, (2017); Abraham and Hendershott (1994); Bourassa and Hendershott (1995)
Net Present Value	The expected cash flows are used to determine the value of houses.	Black et al. (2006); Campbell and Shiller (1988a; 1988b); Campbell et al. (2009); Ambrose et al. (2013)
Unit Root Test	Housing prices or a ratio is tested for a unit root. If a unit root is concluded, prices follow a systematic unpredictable pattern which implies a bubble to be present.	Taipalus (2006); Yiu et al. (2013)
EGR-method	The development of housing prices is observed. If the price growth is higher than the exponential growth rate, a bubble could be concluded.	Zhou and Sornette (2006)

Notes: Different methods to prove the presence of asset bubbles are summed up in the first column. Their definitions and the papers in which they were used are provided in respective columns two and three.

Table 2. Descriptive Statistics Ratio Methods

Variables (1)	Mean (2)	Standard Deviation (3)	Min (4)	Max (5)
Real housing prices	116.23	34.33	60.30	173.50
Real income per capita	18.64	2.35	13.50	21.90
Rent index	191.45	59.28	100.00	296.73
Price-Income ratio	6.17	1.19	4.30	7.92
Price-Rent ratio	0.61	0.08	0.46	0.76
Number of observations	36	36	36	36

Notes: Descriptive statistics are presented for the Netherlands with respectively the variables, mean, standard deviation, minimum, and maximum in the columns. The real housing prices and the real income per capita are presented in thousands of euros. The rent index with 1985=100 represents the rent and its changes over time. The ratios present the prices divided by respectively the real income per capita and the rent index. The timespan 1985-2020 is observed.

Table 3. Descriptive Statistics Regression Analyses

Variables (1)	Mean (2)	Standard Deviation (3)	Min (4)	Max (5)
Real housing prices	116.23	34.33	60.30	173.50
Real aggregate income	160.69	34.92	100.00	212.56
Real construction costs	119.75	12.68	100.00	143.60
Real mortgage rates	3.05	1.63	0.40	6.77
Unemployment rates	5.57	1.40	3.30	8.20
Term spread	1.19	0.76	0.01	3.15
Number of observations	36	36	36	36

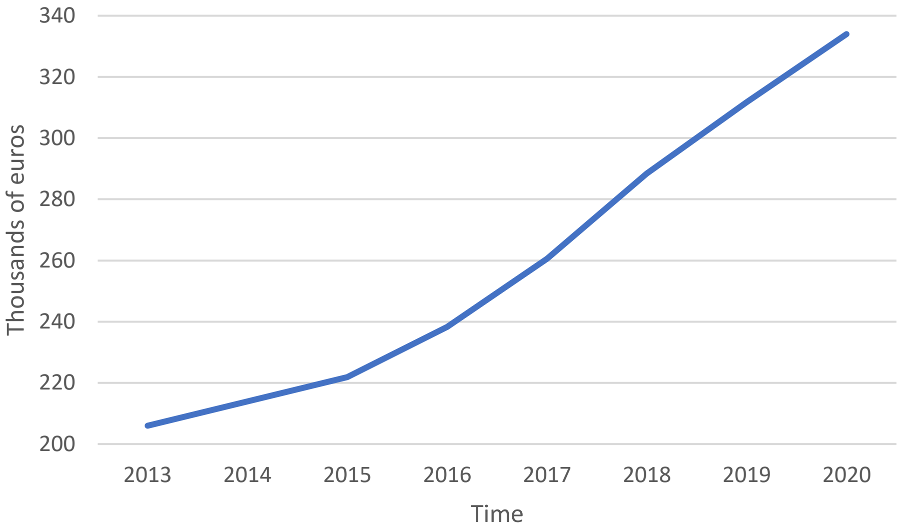
Notes: Descriptive statistics are presented with respectively the variables, mean, standard deviation, minimum, and maximum in the columns. The variables whereof descriptive statistics are described for the Netherlands are real housing prices in thousands of euros, aggregate income index and the real construction costs index (both with 1985=100), and the unemployment rates, real mortgage rates, and term spread (difference between short- and long-term interest rates on government securities). The timespan 1985-2020 is observed.

Table 4. Results of the parsimonious- and multivariate regression analysis

Variables (1)	Real housing price Parsimonious regression (2)	Real housing price Multivariate regression (3)
Constant	- 30.495*** (10.276)	- 92.405*** (16.157)
Real aggregate income	0.913*** (0.063)	0.585*** (0.066)
Real construction costs		1.062*** (0.105)
Real mortgage rates		- 2.675** (1.314)
Term spread		- 3.650** (1.465)
Number of observations	36	36
Adjusted R^2	0.858	0.965

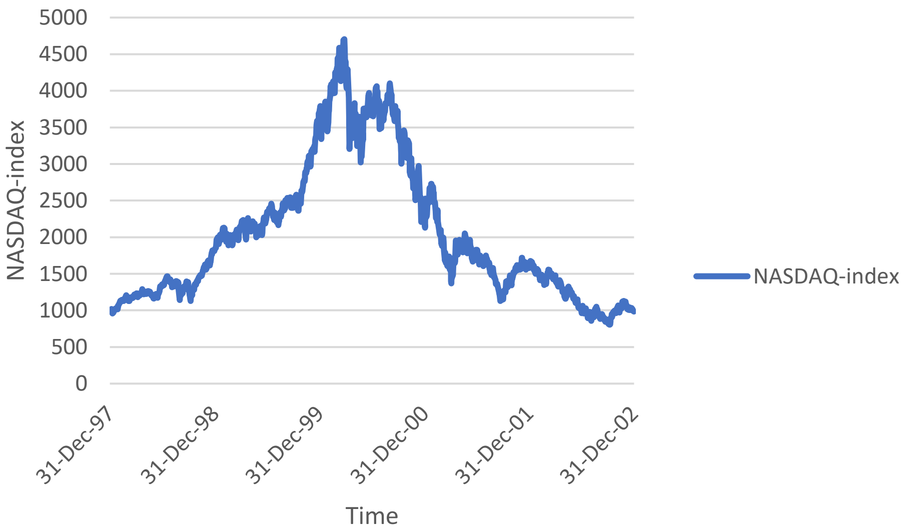
Notes: The sample consists of 36 yearly observations with 1985-2020 as the corresponding period. The dependent variable represents the real housing prices in the Netherlands in thousands of euros. The independent variables that are used to determine the dependent variable are an index of real aggregate income (GDP), an index of real construction costs of houses, the proportion of real mortgage interest rates, and the proportion of term spread (difference between long- and short-term interest rates). For the parsimonious regression, only the real aggregate income is used as an independent variable, while the multivariate regressions used all described independent variables. The standard error is presented between parenthesis while the stars (*) behind the coefficient indicate the significance (*p≤0.10, **p≤0.05, *** p≤0.01).

2. Figures



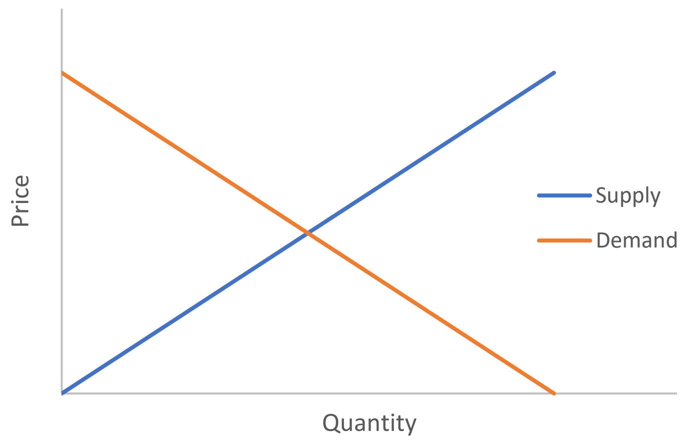
Notes: The average nominal housing prices in the Netherlands between 2013 and 2020. On the y-axis, the average housing price is presented given in thousands of euros. The x-axis represents the year. The data is provided by CBS (2021d).

Figure 1. Dutch average housing prices in the period 2013-2020



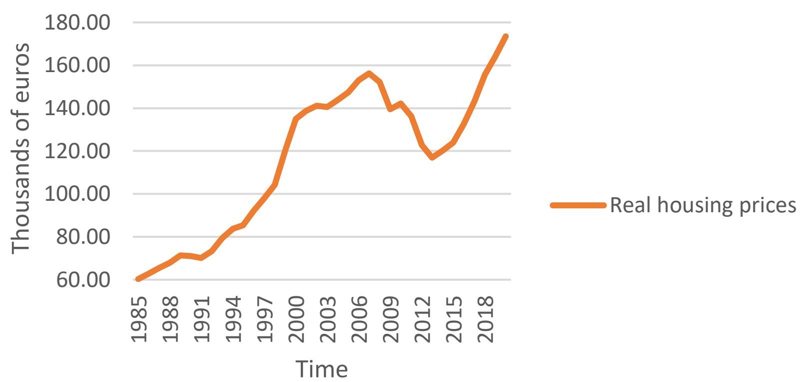
Notes: NASDAQ-100 index in the period 1998-2002 (Nasdaq, 2021). On the y-axis, the price/value of the NASDAQ-100 index could be found. This index represents the stock market by using 102 securities of the largest non-financial companies. The x-axis represents the date.

Figure 2. NASDAQ-100 index in the period 1998-2002



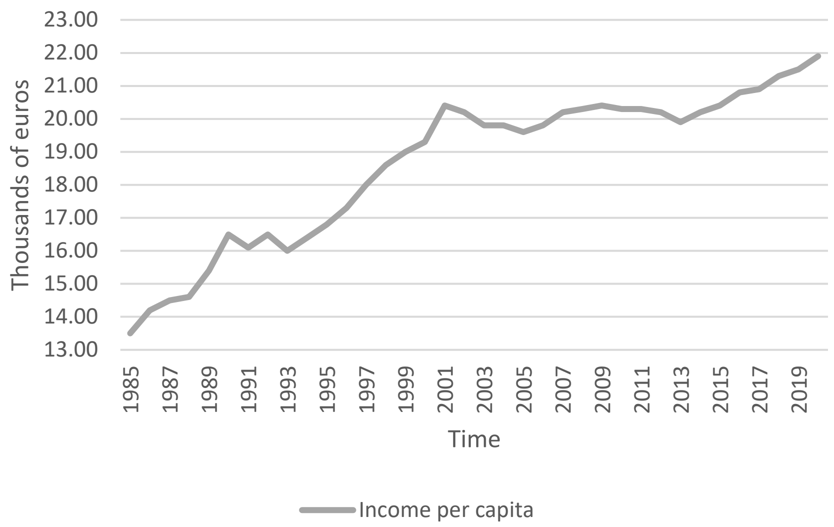
Notes: The standard Supply-Demand model, assuming a linear relationship between the quantity of supply/demand and prices. The blue increasing line represents the supply where the orange decreasing line the demand represents. On the y-axis, the average house price could be found and on the x-axis the quantity of demand and supply. This is an example of how the housing market could be. The linear assumption is unlikely to hold. The graph shows how the prices of houses could influence the demand and supply and how the equilibrium could arrive. The equilibrium is the point where the demand and supply curves intersect.

*Figure 3***.** Standard Supply-Demand Model



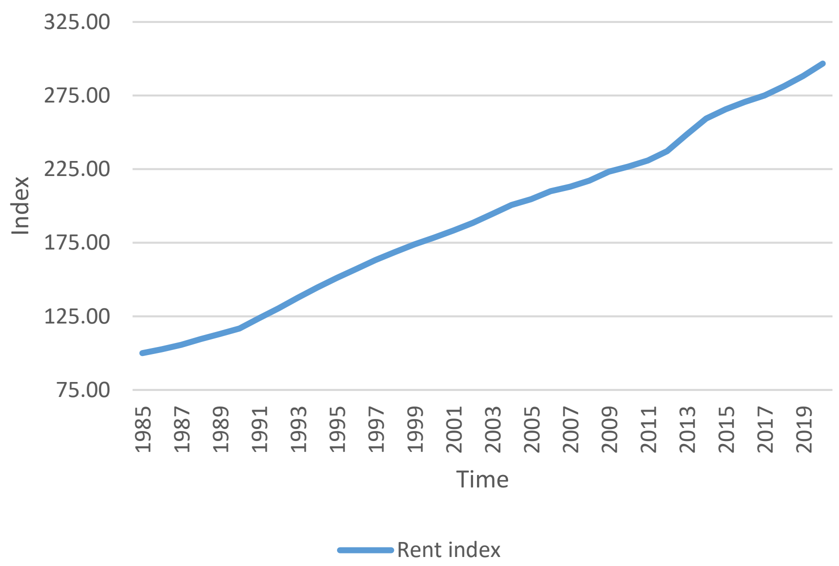
Notes: Annual real housing prices are presented in thousands of euros on the y-axis for time on the x-axis (1985-2020). Data is provided by the NVM (2020) and CBS (2021c).

Figure 4. Real housing prices for 1985-2020



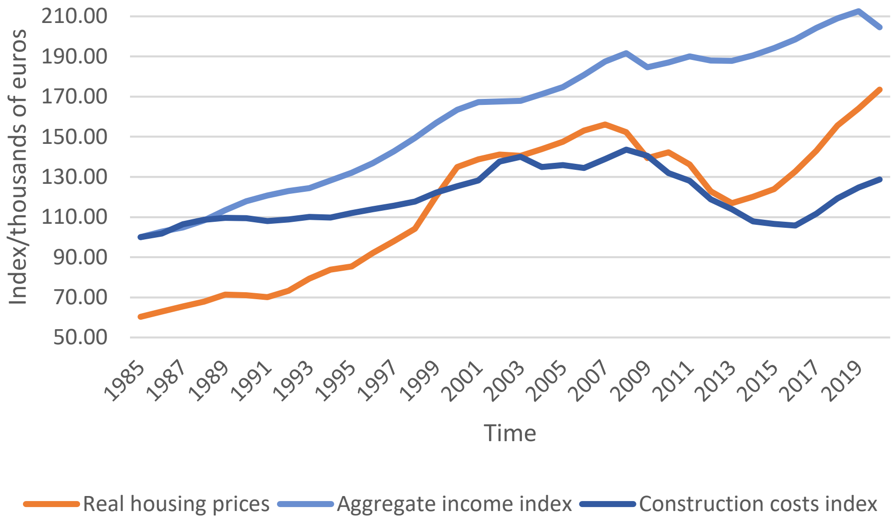
Notes: the real income per capita in thousands of euros on the y-axis is provided over the time span(x-axis) 1985-2020 (CBS, 2021b).

Figure 5. Real income per capita for 1985-2020



Notes: the computed rent index with 1985=100 is provided (y-axis) to observe rent changes in the period 1985-2020 (CBS Statline, 2020).

Figure 6. Rent index for 1985-2020

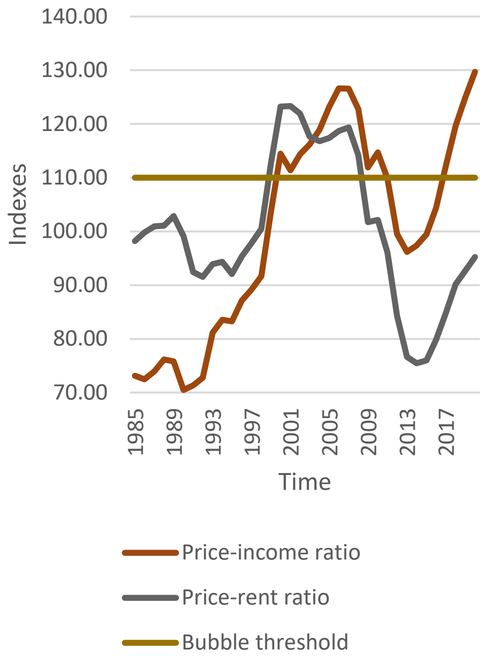


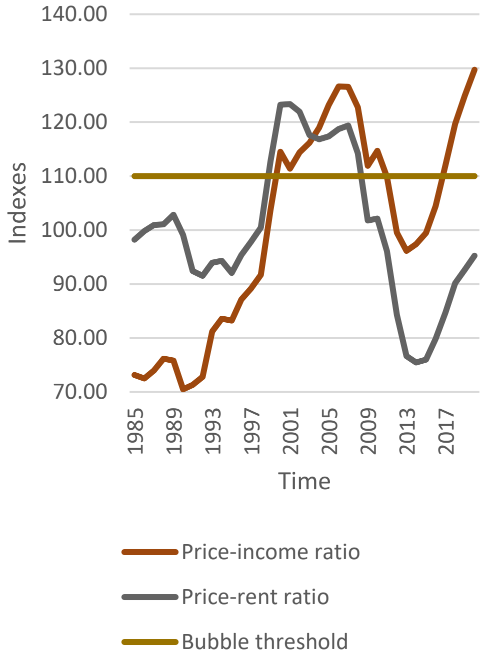
Notes: Real housing prices in thousands of euros, real aggregate income index, and construction costs index (both indexes 1985=100) are provided for the period 1985-2000 (NVM, 2020; CBS, 2021a; CBS, 2021c; CBS, 2021e; CBS Statline, 2021b). The real prices are from Figure 4.

Figure 7. The development of real housing prices and the indexes of real aggregate income and real construction costs for 1985-2020.

Notes: the proportions of unemployment, real mortgage rates, and term spread are provided for the period 1985-2000 (CBS Staline, 2021a; Datastream, 2021; OECD, 2021a; OECD, 2021b).

Figure 8. The development of unemployment rates, real mortgage rates, and term spread for the Netherlands in 1985-2020.

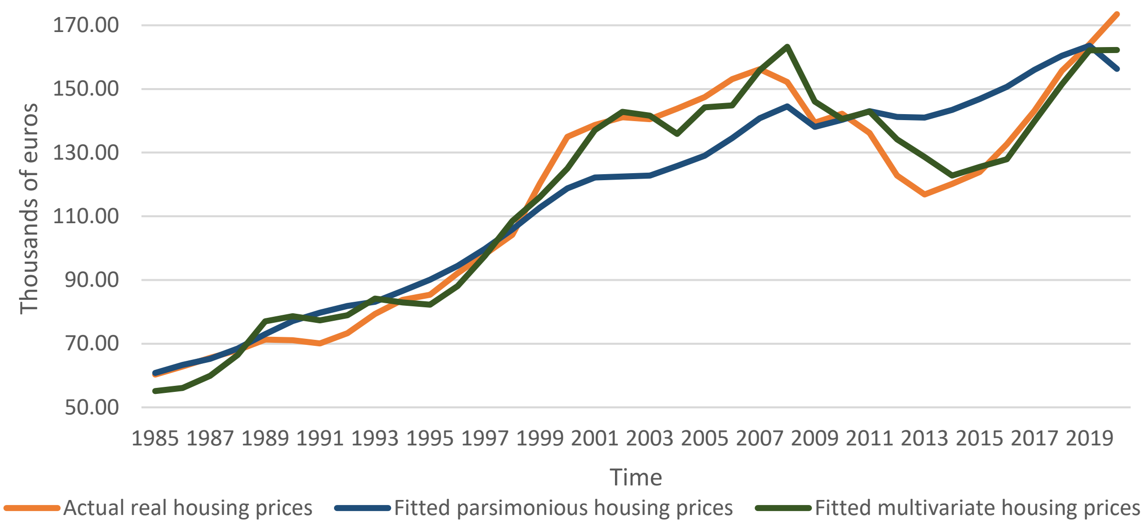




Notes: The indexes on the y-axis of the annual Price-income ratio (real average housing price/ real income per capita) and the price-rent ratio (real average housing price/rent index) relative to the long-term are presented over time (x-axis). A bubble is suggested if the index transcends 110.

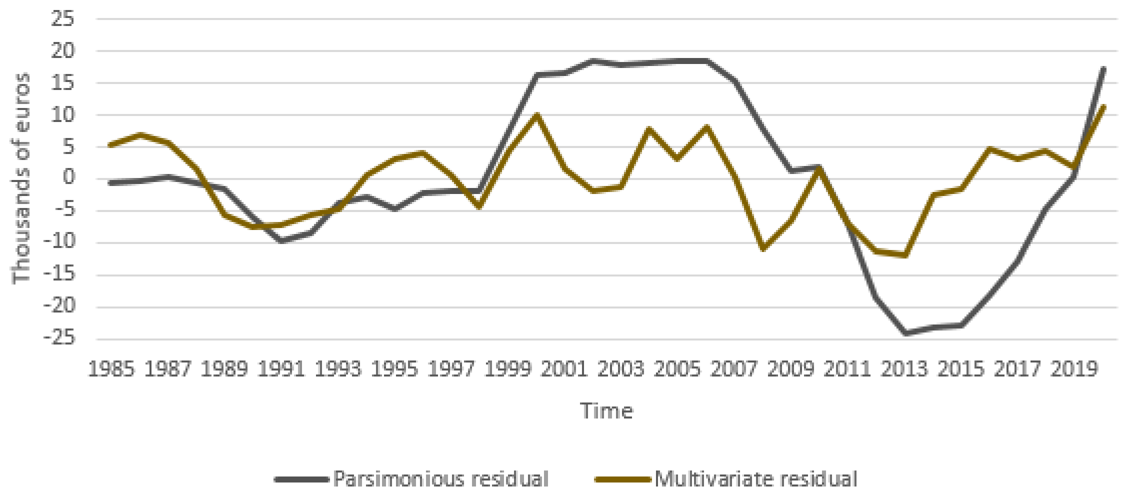
Figure 9. The development of the price-income ratio and price-rent ratio for 1985-2020

Figure 10. The zoomed-in development of the price-income ratio and price-rent ratio for 2000-2020



Notes: From the parsimonious- and multivariate regression, fitted values of real Dutch housing prices are generated that represent fundamentals. These, together with the actual housing prices, are presented. On the y-axis, the value of the housing prices could be found in thousands of euros. On the x-axis, the time of the corresponding prices could be found.

Figure 11. Actual- and fitted fundamental Dutch housing prices for 1985-2020



Notes: From the parsimonious- and multivariate regression, fitted values of real Dutch housing prices are generated and compared with actual Dutch housing prices. On the y-axis, the value of the residuals could be found in thousands of euros where a positive residual implicate that actual housing prices are higher than the estimated fundamental price. The zero line indicates a zero difference between the actual- and predicted fundamental prices. On the x-axis, the years of the corresponding residuals could be found.

Figure 12. Residuals for 1985-2020 from the parsimonious- and multivariate regression

3. Do-file

```
*Ratio method*

*Create ratio*
gen pi_ratio = realprice/incomepercapita
gen pr_ratio = realprice/rent
*Create long term average*
egen lt_average_pi_ratio=mean(pi_ratio)
egen lt_average_pr_ratio=mean(pr_ratio)
*Create index*
gen index_pi_ratio = ((pi_ratio)/(lt_average_pi_ratio)) * 100
gen index_pr_ratio = ((pr_ratio)/(lt_average_pr_ratio)) * 100
*Graph*
twoway (line threshold index_pi_ratio index_pr_ratio year, sort)

*Regression Methods*

*Parsimonious regression*
regress realprice aggregateincomeindex
predict predrealprice_parsi
gen residual_parsi = realprice - predrealprice_parsi
*Multivariate regression*
regress realprice aggincomeindex realconstructionindex realmortgageindex termspread
predict predrealprice_multi
gen residual_multi = realprice - predrealprice_multi
*Graphs*
twoway (line realprice predrealprice_parsi predrealprice_multi year, sort)
twoway (line residual_parsi residual_multi year, sort)
```