MEASURING HOUSING BUBBLES:
A CASE STUDY ON AMSTERDAM

Abstract:

This research aims to identify which existing bubble detection method are able to identify a housing bubble in Amsterdam. To answer this question a sequential triangulation mixed methods approach is used to better understand housing bubbles and the drivers of housing bubbles. By using existing quantitative methods to identify a housing bubble in Amsterdam and a qualitative approach to pinpoint the drivers of a housing bubble, it became clear that the price-income ratio is the most suitable bubble detection method for Amsterdam. Besides identifying the most suitable bubble detection methods, the research also investigates if there was a housing bubble in Amsterdam between 2005 and 2015. The quantitative analysis shows that a housing bubble in Amsterdam appeared in 2008, but based on the qualitative analysis, the answer is not definitive. The results of this research have important policy implications in terms of how to detect bubble formation in Amsterdam.

Keywords: Housing, bubble, overvaluation, price-income ratio, price-rent ratio.

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1. Introduction

1.1. Motivation

Western countries experienced a rapid increase of house prices in the early 2000s. This partly caused the great financial crisis, or GFC, which started in 2008 (Garber, 2016). The GFC affected Dutch society, as can be seen in Figures 1 and 2. Unemployment increased, while the gross domestic product per capita decreased. The affected firms had to cut tech and capital spending and employment . Additionally, these firms had to spend more cash and draw more heavily on lines of credit for fear that banks would restrict access in the future and sell more assets to fund their operations. Finally, firms had to pass over attractive investment opportunities because they were unable to borrow from external funds.

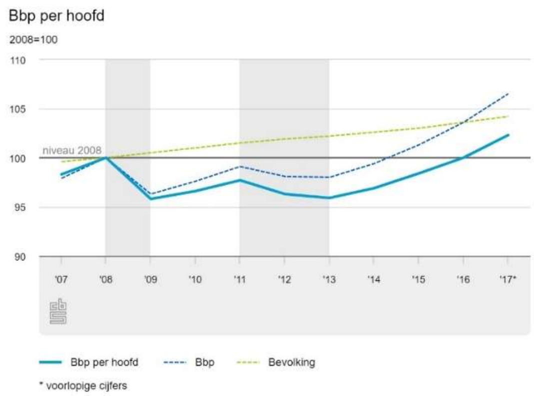


Figure 1: GDP per capita in the Netherlands (CBS, 2018).

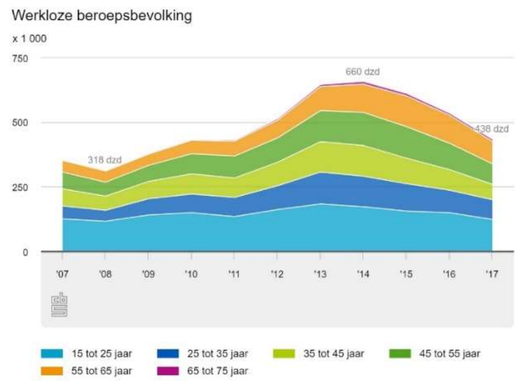


Figure 2: Unemployment in the Netherlands (CBS, 2018).

In recent years, again a rapid price increase can be seen in the Amsterdam housing market. Since 2013, house prices have increased by 60% (AD, 2018). This rapid increase in housing prices is called a housing bubble. According to Stiglitz (1990), bubbles exist when prices grow more rapidly than fundamental variables such as rent and income, in the remainder of the thesis it is referred to as fundamentals. When a housing bubble bursts, it can cause the housing market to collapse, as happened during the GFC. Because of the resulting drop in GDP per capita and the increase of unemployment, house prices can drop even further. A drop in GDP per capita and an increase in unemployment decrease the average amount potential house buyers can borrow for their mortgages. As a result, house prices decrease to a value under the value of outstanding mortgages. This means homeowners cannot quickly sell their house, causing immobility and foreclosures. Therefore, a collapse of the housing market strongly affects society. Insights into housing bubbles in the Amsterdam housing market provide policymakers the opportunity to anticipate on future housing bubbles and prevent a sudden decrease in housing prices.

1.2 Literature review

There is a large stream of academic literature on housing bubbles (Abraham and Hendershott, 1996; Bourassa et al., 2016; Glaeser et al., 2014; Himmelburg et al., 2005; Liu et al., 2017; Teng et al., 2017; Zhou and Sornette, 2006). Most of this literature is written after a housing bubble in a specific place took place (Liu et al., 2017). An important topic is which methods can be used to detect a bubble. In general, three methods exist to identify bubbles (Abraham and Hendershott, 1996, Glaeser et al., 2014, Himmelburg et al., 2005, Zhou and Sornette, 2006). One is analysing various ratios of the fundamentals compared to house prices or rents. The second is a regression analysis that includes models based on housing supply and demand or the present value. The third is drawn from physics and focusses on the rate of growth of prices. Bourassa et al. (2016) researched all these alternatives for detecting housing bubbles before the event of a bubble, to identify which method is the most suitable for bubble detection.

Ambrose et al. (2013) researched housing bubbles in the Amsterdam housing market between 1650 and 2005. They found evidence for several crises and housing bubbles during this period. This thesis continues the work of Ambrose et al. (2013) on the Amsterdam housing market by studying the period between 2005 and 2015. Even though the aforementioned methods for detecting housing bubbles have proven themselves, there is little published literature on the suitability for these methods tested for Amsterdam. Apart from this quantitative approach, this thesis also contributes to the literature by applying a qualitative perspective. Experts in the field of real estate are interviewed to learn about their experience in the Amsterdam housing market and how they identify housing bubbles. Therefore, this thesis also aims to show which method accurately represents the detection of housing bubbles in the Amsterdam housing market as experienced by the real estate experts.

1.3 Research aim

The aim of the research is to review existing housing bubble detection methods and examine if there was a housing bubble in Amsterdam between 2005 and 2015. The situation in the Amsterdam housing market, where prices grew and declined rapidly between 2005 and 2015 (NVM, 2018), is relevant for a study on housing bubbles. This research is conducted using a subsequentially triangulation mixed methods approach.

The central research question and corresponding sub-questions for this thesis are:
'*Which housing bubble detection methods are available to identify a housing bubble with application for Amsterdam?*'

1. *How are housing bubbles measured in the academic literature?*
2. *In what manner can existing detection methods identify a housing bubble in Amsterdam between 2005 and 2015?*
3. *Did real estate experts notice a housing bubble in the housing market between 2005 and 2015, and which variables do they hold responsible for a housing bubble?*

The first sub-question is theoretical. First, the phenomenon '*housing bubble*' is defined using a literature review on housing bubbles. A clear distinction is created between methods using fundamentals and methods using other variables.

The second sub-question is answered using the methods discussed in the first sub-question. Data from various sources is used to answer this question. Second, an overview of methods is used to identify housing bubbles.

The final sub-question is answered using interviews with real estate professionals. Using an exploraroty interview technique the interviewees are asked to share their experiences with the Amsterdam housing market throughout their real estate career and in particular if they ever thought that Amsterdam houses were overvalued. Further explanation on the structure of the interviews is given in Chapter 5.
The research questions are visualised in a conceptual model in Figure 3.

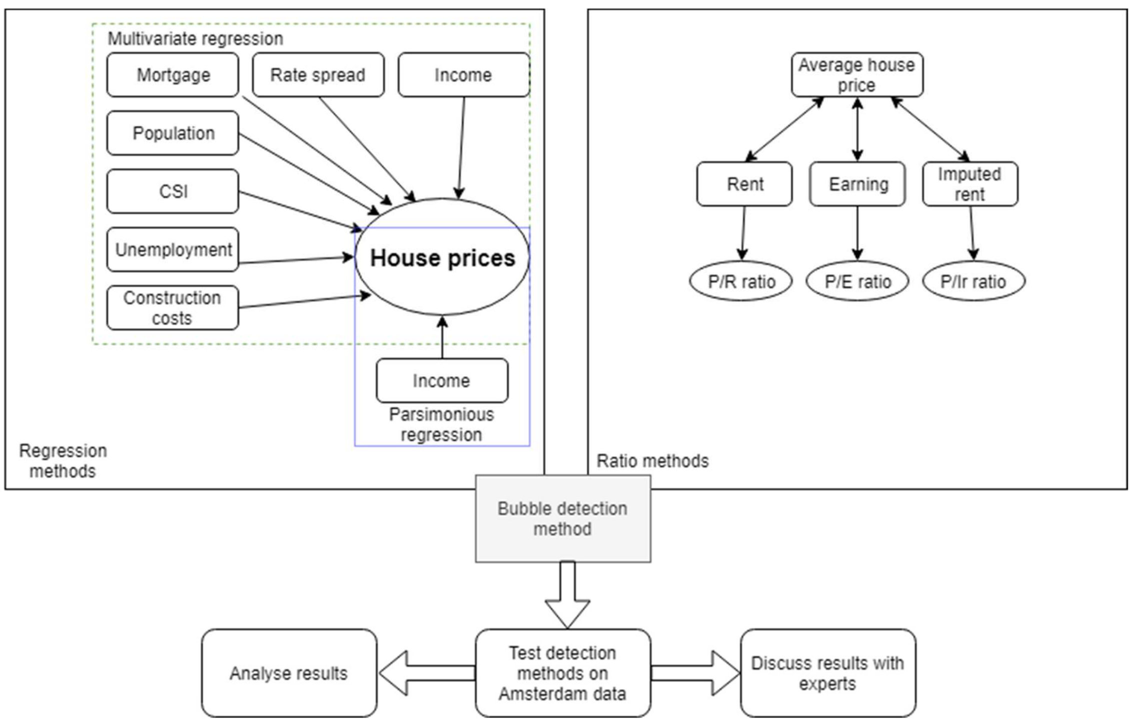


Figure 3: Conceptual model

1.4 Outline

After the introduction in Chapter 1, Chapter 2 presents the theoretical framework and discusses theories concerning housing bubbles and the methods used to detect housing bubbles. Because the results of the quantitative analysis inform the execution of the qualitative analysis, the analyses are presented separately. Chapter 3 describes the quantitative data and explains the methodology. Chapter 4 describes the results of the quantitative data analysis. Chapter 5 presents the qualitative design and descriptive statistics. The results of the qualitative analysis are presented in Chapter 6. The thesis ends with a conclusion, discussion and recommendations for further research in Chapter 7.

2. Theory

This chapter contains two sections. The first defines the term 'housing bubble'. The second discusses the methods used to detect a housing bubble.

2.1 Housing bubble

Case and Shiller (2003) argue that the term *'housing bubble'* did not have much value before 2002. The word '*bubble'* was hardly used in the press and was only used shortly after the stock market crash of 1987. The press mostly used the term '*housing boom'*, possibly because *'boom'* has a less negative sound than *'bubble'*. The definition of a housing bubble is debated in the literature, but the generally accepted definition is '*a bubble refers to house price levels that depart markedly from fundamental values'* (Stiglitz, 1990). Lind (2009) defines a bubble as a dramatic increase in prices followed by rapid fall in prices. In addition to these definitions, Black et al. (2006) state that there are three main characterisations of bubbles in the literature: momentum, explosive and intrinsic.

According to De Long et al. (1990), a momentum bubble is driven only by price and is against rationality of the marketplace. Agents buy when the price increases and sell when the price decreases, and momentum occurs when prices rise and when they are expected to continue to rise. Since a momentum bubble consists of the impulse of acquiring or selling an asset based on a previous price dynamic, this type of bubble is treated as an irrational price movement (Black et al., 2006). This is in accordance with Case et al. (1996), who argue that a housing bubble begins when homebuyers believe that a house they previously thought was too expensive becomes a safe investment due to future price increases.

Contrary to momentum bubbles, explosive and intrinsic bubbles are considered rational. Rational bubbles can be characterised as housing bubbles that deviate from fundamental factors. Black et al. (2006) define an explosive rational bubble as prices that deviate from fundamentals due to factors extraneous to asset value. These are non-fundamental factors that cannot be explained by economic trends. In addition, Diba and Grosmann (1988) state that the explosive bubbles in stock prices cannot be negative, because of the implication that explosive bubbles have conditional expectations. One of these implications is that given free disposal, stockholders cannot rationally expect a stock price to decrease without bound, so the stock price cannot become negative at a finite future date. The same line of reasoning can be applied for housing bubbles. However, Farlow (2004) argues that a zero price floor puts a limit on how far prices can fall, but real payoffs in debt-backed housing can still go below zero. For example, the UK experienced negative equity in the 1990s.

Froot and Obstfeld (1989) introduce intrinsic bubbles in their article *Intrinsic bubbles: The case of stock prices.* In contrast with explosive bubbles, exogenous fundamental factors are the main drivers of the price dynamics of intrinsic bubbles. These factors are fundamental, because they are based on trends in the economy, like rent. This makes the intrinsic bubbles rational (Black et al., 2006, Froot and Obstfeld, 1989, Nneji et al., 2013). Further evidence is provided by Ma and Kanas (2004), who state that intrinsic bubbles closely capture the overreaction of stock prices to alteration in dividends. Although the literature mostly provides insights on stock market bubbles, Black et al. (2006) argue that house price bubbles are mainly a combination of momentum and intrinsic bubbles. The authors state that intrinsic bubbles play an important role in determining actual house prices. However, price dynamics impact these actual house prices in periods of strong deviation from the fundamental value. These price dynamics are driven by momentum behaviour.

2.2 Methods of detecting a housing bubble

Bourassa et al. (2016) distinguish three methods used to identify bubbles. The first is the analysis of different ratios that compare house prices to rent or income. In the literature, the following ratios are mostly used for bubble detection:

- price–income
- price–rent
- imputed rent–price
- rent–price
- imputed rent–actual rent
- imputed rent–income

Case and Shiller (2003) used the price-income ratio and compared this with a long-term average. If the long-term average is exceeded by more than 20%, the authors suspected a housing bubble. Using this method for 1985–2002 showed multiple bubbles in the late 1980s and early 1990s in Los Angeles, San Francisco and Boston. Ambrose et al. (2013) used the rent-price ratio for Amsterdam for 1650–2005. They found several housing bubbles and crises during this period. The authors indicated that the price-rent ratio is the most effective ratio for detecting multiple housing bubbles over a long period of time. Himmelberg et al. (2005) focussed on the imputed-rent to price ratio. Imputed-rent is the cost of home ownership. The authors argue that the imputed-rent to price ratio differs significantly per region, mainly due to tax differences. Therefore, it is hard to interpret the ratio, because a high ratio may be alarming for one region and typical for another region (Bourassa et al., 2016).

The second method uses regression analyses, including models based on housing supply and demand theory, asset pricing concepts or cointegration and unit root tests (Black et al., 2006, Oikarinen, 2009, Yiu et al., 2013). Black et al. (2006) identified deviations from actual house prices using the fundamental value of disposable income. They used the vector autoregressive (VAR) model introduced by Campbell and Shiller (1987). VAR is a stochastic process model used to capture the linear interdependencies among multiple time series. Black et al. (2006) used this VAR model to exclude the existence of an explosive rational bubble, because non fundamental factors are the driving force of deviations from fundamental factors. They argue that intrinsic bubbles can be important in determining actual house prices. However, this effect seems stronger in periods of strong deviation from fundamental value. Oikarinen (2009) used timeseries data to examine the relationship between housing prices and household borrowing. By running a vector error correction model (VECM), which is a restricted VAR model, the interaction between housing prices and household borrowing could be established. The analysis of Oikarinen (2009) suggests that there is a strong two-way interaction between housing prices and housing loan stock.

Yiu et al. (2013) used the PSY method, designed by Phillips, Shi and Yu (2011). This test can identify multiple bubbles in a time series, which other tests could not. Using this test, Yiu et al. (2013) revealed multiple bubbles in the Hong Kong property market. The method detected bubbles in the mass segment and in the luxury segment in 1997. A shortcoming of the various methods that use regression analysis is that these methods are comprehensive and thus time consuming. Besides, these methods require a considerable amount of data to be able to use them. The ratio methods and regression methods mentioned are all in line with the theory of Stiglitz (1990) mentioned in Section 2.1.

The third method, known as the exponential growth rate (EGR), focusses on the rate of growth in prices and was used by Zhou and Sornette (2006). They found housing bubbles between 1993–2005 in 22 U.S. states. EGR corresponds with the housing bubble definition by Lind (2009).

After reviewing the previous methods, Bourassa et al. (2016) argue that there is no consensus in the literature on how to measure actual house value and the discrepancy between house values. There is, however, some consensus on the concept of a house price bubble, namely the definitions by Stiglitz (1990) and Lind (2009). The authors used 30 years of quarterly data to determine the long-term average of the six metropolitan areas used for the study. The methods tested were compared with the present value method, which Bourassa et al. (2016) regard the most suitable ex post bubble detection method. The authors observed when the discrepancy exceeds 20% from the long-term average (ratios), equilibrium (regression) or log-linear trend (EGR). The authors use price–rent, price–income and imputed–actual rent ratios, because they are the main variables used in the literature for house bubble detection. Using regression methods to identify housing bubbles raises questions regarding model specification, estimation techniques and interpretation of results. One issue is the specification of housing supply and demand models and the choice of parsimony and a larger set of variables. An issue with a fully specified model is that it can explain too much about the formation of the bubbles instead of just the long-term equilibrium price levels, therefore it can be comprehensive in understanding the method. Both multivariate and parsimonious models are estimated (Bourassa, 2016). They state that the EGR approach is by definition unsustainable. Using this method, a bubble is defined if prices increase at a faster rate than exponential growth would be diagnosed whenever the price curves upwards, departing from a straight line. The authors state that the price-rent ratio performed best in four of the six metropolitan areas in which they applied this method, and had the best overall result. The least effective methods were the multivariate regression and the EGR. All the above described methods are summarized in table 1.

The expectation for the central research question is based on the research done by Bourassa et al. (2016). The authors argue that the price-rent ratio and the price-income ratio are suitable methods to effectively measure a housing bubble. The expectation is therefore: *the price-rent ratio and the price-income ratio are suitable bubble detection methods to identify a housing bubble in Amsterdam.* This expectation will be investigated using various methods as described by Bourassa et al. (2016), and the results will be compared with the experiences of the real estate experts.

Table 1: Overview of detection methods.

Method	Definition	Calculation method	Source
Ratio method	A ratio where the average increase of a variable is set against the annual increase of house prices.	Pmt/Yt, create a long term average (average of the ratio over long period of time), make an index (divide the average price-variable ratio by the long-term average multiply with 100). If index is above 120 a housing bubble is detected.	Case and Shiller (2003), Ambrose et al. (2013), Himmelberg et al. (2005), Bourassa et al (2016).
Regression method	The are multiple regression methods that are available for housing bubble detection. The method described uses an OLS model to predict house prices and detect a bubble using an index.	The regression is created using various variables to predict house prices. This prediction is set against the actual average of house prices. With the regression outcome an index is created, with a 100 as average.If index is above 120 a housing bubble is detected	Bourassa and Hendershott (1995), Abraham and Hendershott (1996), Bourassa et al. (2001), Case and Shiller (2003), Goodman and Thibodeau (2008), and Wheaton, Nechayev (2008), Bourassa et al (2016).
EGR	The exponential growth rate (EGR), focusses on the rate of growth in house prices.	p(t) = A + B(tc − t) m + C(tc − t) m cos [ω log(tc − t) − φ] . If this model proves that house prices grow fasten then exponential growth, a housing bubble is detected.	Zhou and Sornette (2006)

3. Quantitative data and methodology

This chapter describes what data were used for each method, how the data are modified and how the data are used.

3.1 Ratio methods

This method requires data about real house prices and real income from 2005–2015. Data are collected on transaction prices from Nederlandse Vereniging voor Makelaars NVM (2019) in Amsterdam and the peripheries of Amsterdam for 2005–2015 and from the Dutch central bureau of statistics (CBS, 2018) on index figures of housing prices for 1995–2005 to compute a long-term average. The NVM dataset contains 276,857 observations and 81 variables, but only data on the city of Amsterdam and the variables transaction price, square metres and date of transaction are used for this study. Therefore 101,958 observations are removed from the dataset. The information in the dataset showed some observations with a negative transaction price of -1. These 67,716 observations are considered as missing values and are also removed. The dataset still showed improbable transaction prices; to solve this all observations with transaction prices below €65,000 and above €20,000,000 and square metre prices above €13,000 are also removed from the dataset. The dataset is expanded with the variables yearly average transaction price and average transaction price per square metre, which are calculated with the cleaned dataset. The descriptive statistics of the NVM data are given in Table 2. With the cleaned dataset the aggregate house prices for each year in 2005 – 2015 are calculated. Because there is no data available on the average house prices for 1995 – 2004 index figures from CBS (2018) are used for computing the average house prices for this period.

The data on income are taken from CBS and the Amsterdam bureau for research, information and statistics (OIS). CBS provided the data on income from 2005–2014 (CBS, 2016) and OIS provided data for 2015 (OIS, 2015). Data on income and index figures for 1995–2004 are not available. To calculate the data on earnings, index figures on the collective labour agreement (CAO) are used (CBS, 2015). The data described above is sufficient to use the price-income ratio method.

The price-income ratios are stated as *Pmt/Yt* and as *Pat/Yt. Pmt* is the average house transaction price per square metre at time t, *Pat* is the average transaction price at time t and *Yt* is the real aggregate income at time t. These ratios are compared with the long-term average, which is calculated by calculating the average price-income ratio for 1995–2015. Further explanation of the calculation can be found in table 1.

To perform the price-rent ratio, Amsterdam data on actual transaction prices for 2005–2015 are needed. For the same period, Amsterdam data on rent prices is needed. For an accurate representation of a housing bubble a real estate cycle should be measured, data on rent and house prices since at least 1995 is needed to calculate a credible long-term average.

The data on average rental prices are collected from two sources. The CBS (2016) database provided the average rental increase and Pararius provided data on average rental price per square metre. The Pararius data are provided by NOS (2014). To determine the average rental price per square metre in Amsterdam, both datasets are merged. To generate the long-term average, the data on transaction price are expanded as described before. Since there is no data on the average square metre price, the data on average transaction prices per square metre are expanded by dividing the average transaction price by the average square metres in the dataset. The data on rental prices are expanded by taking the average rental increase per year and calculating the new average rental prices for 1995–2004. With the data described above, the price-rent ratio method can be performed.

The price-rent ratio is measured by *Pmt/Rmt, Pmt* is taken from the NVM (2019) data described above and *Rmt* is the average rent per square metre at time t. The data are compared with the long-term average. The price-rent ratio was created in the same manner as the price-income ratio: the average transaction price divided by the average rent. Also, a long-term average was established by taking the mean of the average transaction price for each year from 1995–2015. Further explanation of the calculation can be found in table 1.

The measurement of the imputed rent ratio is comparable with the previous discussed ratios. *Pmt/IR*, where *Pmt* is again the average transaction price and *IR* is the imputed rent. The required data for performing this method are the same transaction price data discussed before and data on imputed rent for 2005–2015. Imputed rent is the user cost of home ownership; these data were taken from CBS. Unfortunately, the data are not complete, since the CBS reports on imputed rent every three years, starting in 2009. Therefore, the price-imputed rent ratio could not be conducted. The descriptive statistics on the different ratios can be found in Table 3

Table 2: Descriptive statistics NVM data

Variables	Mean	sd	min	max
Transaction price	312,025	226,827	65,000	4.500e+06
Average transaction price per year	312,025	48,723	255,834	438,431
Average transaction price per year per m2	3,572	527.4	2,820	4,875
Observations	101,000	101,000	101,000	101,000

Table 3: Descriptive statistics ratios and regressions

	Mean	sd	min	max
Average income	26,061	4,318	19,736	33,500
Average rent	16.29	2.237	12.21	19.91
Price income ratio m2	0.102	0.0188	0.0592	0.122
Price income ratio average	8.868	1.666	5.163	10.82
Price rent ratio m2	163.0	33.67	95.66	211.3
Price rent ratio average	14,181	2,907	8,346	18,301
Log price	12.317	.357	11.532	12.684
Log income	10.155	.168	9.89	10.419
Unemployment rate	6.424	1.544	3.7	8.9
Real mortgage rate	3.603	.894	1.907	5.52
Interest rate spread	1.529	.9	.01	3.53
Log construction costs	4.743	.152	4.501	4.94
Observations	21	21	21	21

The data used for the long-term average could be inaccurate, so the results should be interpreted with caution. Since real house price data and index figures on house price data are merged, the data for 1995–2004 does not represent the actual aggregate house prices for this period in Amsterdam.

3.2 Regression analyses

A regression analysis is a complicated approach to detect housing bubbles that is used to identify long-term relationships among variables. The regression models used for detecting housing bubbles are based on the supply and demand for housing, as can be seen in the work of Bourassa and Hendershott (1995), Abraham and Hendershott (1996), Bourassa et al. (2001), Case and Shiller (2003), Goodman and Thibodeau (2008), and Wheaton and Nechayev (2008). The multivariate model places real house transaction prices on the left-hand side and a range of variables used in the aforementioned literature on the right-hand side. The variables considered are real aggregate income, unemployment rates, real mortgage rates, real construction costs, and rate spreads between 10-year and 3-month government securities.

For each of the variables, data are needed for 1995–2015. The data from NVM (2019) are used to calculate the average transaction prices, and an index was used to calculate the prices for 1995–2004. The aggregate income are the same data used for the price-income ratio. Data on unemployment are merged data from CBS and other sources (CBS, 2000, CBS, 2001, CBS, 2018). Real construction costs (CBS 2019) and consumer sentiment index (CBS, 2017) are directly unmodified data from CBS. The real mortgage rate is constructed from data from De Nederlandsche Bank DNB (2019) and CBS (2016) for 2005–2015. Data from DNB are used for average mortgage rates and data from CBS were used for inflation, so the real mortgage rate could be constructed by adjusting the average mortgage rate for inflation. The data on 1995–2004 are from a report of Netherlands bureau for economic policy analysis (CPB, 2013) in combination with data on inflation from CBS (2016). The rate spread is calculated using data from CBS (2015) combined with data from CBS (2016) and Organisation for Economic Cooperation and Development (OECD) (2019); the short-term rate minus the long-term rate are the different rate spreads calculated for each year.

For the parsimonious model, the same method is used. The variable used as a regressor of price is the natural logarithm of real aggregate income. The descriptive statistics on the regression models are shown in Table 3.

As mentioned earlier five different variables are used for performing this method:

$$P = \beta\_0 + \beta\_1(income) + \beta\_2(Interst\ rate\ spreads) + \beta\_3(unemployment) + \beta\_4(mortgage) + \beta\_5(construction\ costs) + \varepsilon$$

where p is the natural logarithm of the average house price, $\beta 1$ is natural logarithm of income, and $\beta 5$ is the natural logarithm of the construction cost index. For every year, the predicted natural logarithm of price is indexed against the natural logarithm of the long-term average of the real house prices. For the regression analysis, first the data on average transaction price, the average income and the construction cost are transformed by calculating their natural logarithm. With these transformed variables, the multivariate regression and the parsimonious regression are executed. With the regression analysis, the values for multivariate regression and for the parsimonious regression can be predicted, and these values are needed for the bubble detection method. A long-term average is calculated by taking the mean of the natural logarithm of the average transaction price. Further explanation of the calculation can be found in table 1.

The results should be interpreted with caution, as this regression used a low number of observations. According to Harrel (2015), however, the number of observations is sufficient for interpreting the results.

3.3 Other methods

The literature discusses other housing bubble detection methods: the present value method and the EGR approach. These methods are not used in this thesis. The present value method is difficult to use and requires specific data that could not be obtained. The literature proves that the EGR method is unsuitable and unreliable for detecting housing bubbles (Bourassa et al. 2016). The authors argue that the EGR approach lacks quality from a theoretical perspective. Since house price bubbles are not measured using fundamentals, it could lead to incorrect bubbles signs.

4. Quantitative results

This chapter shows the results for the different bubble detection methods. First the price-income ratio and the price-rent ratio are discussed, followed by the regression methods.

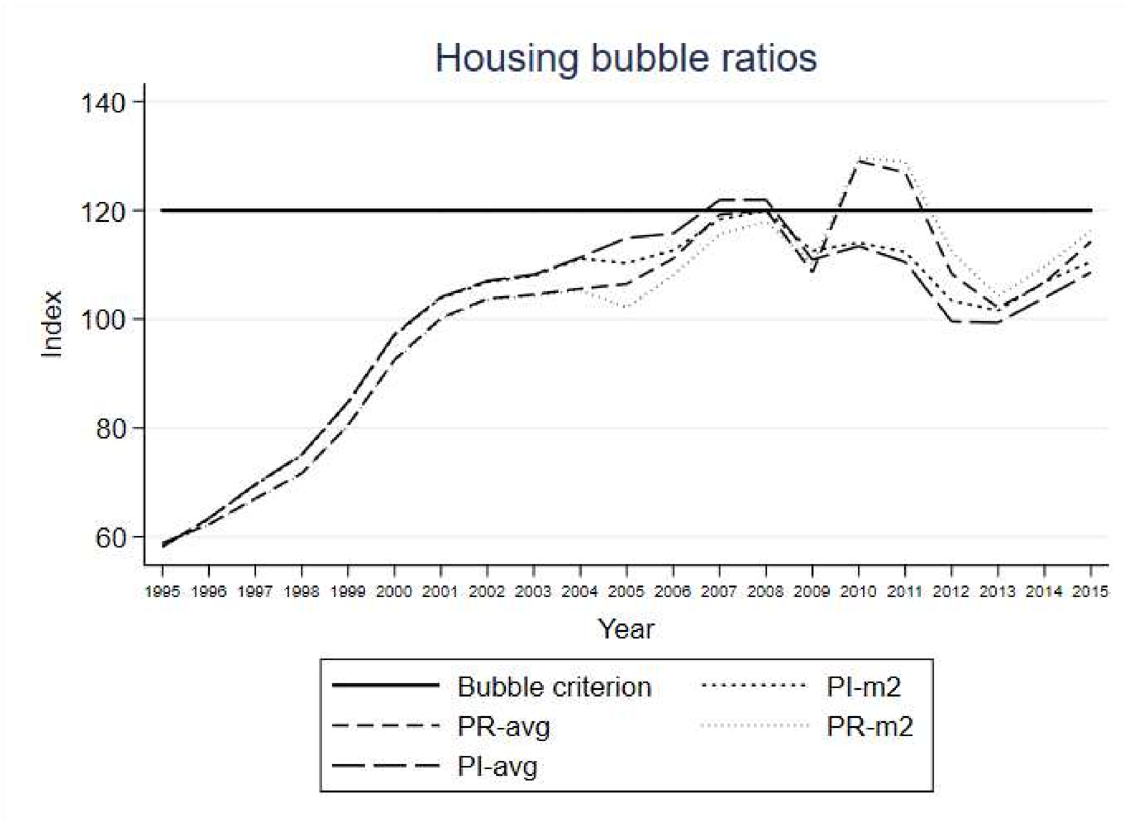
4.1 Ratio methods

Figure 4 presents the results for the three measured ratios, and the index indicates the deviation from the long-term average (100). The price income ratio using the average transaction price (PI-avg) shows a housing bubble movement beginning in 2006 and ending in 2008, when the ratio starts to decline. There is a small recovery between 2009 and 2010, but the decline continues until 2013. In 2012 and 2013, the PI-avg stays at the same level just beneath the long-term average. From 2013 onwards, the ratio starts to increase.

The price income ratio using data per square metre (PI-m2) shows a similar pattern as PI-avg. From 2005 to 2008, the ratio is below the ratio of average transaction prices, indicating a bubble only in 2008. Halfway through 2008, PI-m2 exceeds PI-avg. The movement of both ratios remains similar, but the decline is less strong than PI-avg. It shows a minimum of approximately 102 in 2013, just above the long-term average. The longer period of bubble detection by PI-avg can be explained by a relatively stronger increase in house prices than house prices per square metre. This indicates that mostly larger homes were sold in this period. The difference between PI-avg and PI-m2 in 2012-2013, where average house prices increased while the price per square metre declined, is also interesting. This can be seen in Figure 4, PI-avg flattens out while PI-m2 continues to decline.

The price-rent ratio for the average transaction price (PR-avg) detects two housing bubble periods. The first is at the end of 2007. The second is between 2009 and 2013, so just after the GFC. Similar to the earlier discussed ratios, PR-avg shows an increase from 2005 to 2008 and a decline until 2009. While PI-avg and PI-m2 show a small increase, PR-avg shows a large increase, resulting in a second bubble period starting halfway through 2009 and ending in 2011, when a rapid decline is started. This decline ends in 2013, where the lowest value for the ratio is measured. After this decline, a period of strong increase starts again.

The price-rent ratio using data of average transaction price per square metre (PR-m2) shows a similar movement as PR-avg. From 2005 to 2008, the PR-m2 is below PR-avg, but from 2008 onwards it is above PR-avg. Unlike PR-avg, PR-m2 does not show a housing bubble in 2008. It does detect a housing bubble for 2009–2011, which lasts slightly longer than the bubble detected by PR-avg. Interestingly, the decline that starts in 2009 is less strong than the decline shown for PR-avg. The recovery after the decline starts at the same moment as the recovery of PR-avg. The failure of bubble detection in 2007 and 2008 can be explained by the same relative difference in average transaction price and transaction per square metre as discussed before. Because price per square metre corrects the price difference for high transactions. The longer and stronger bubble period for PR-m2 starting in 2010 is a result of the difference between average house price decline and price per square metre decline in 2011 and 2012, because both variables have decreasing values, the ratio increases.



Note: This graph shows the different ratio indexes as explained in Chapter 3. PI-m2 is the price-income ratio using data per square metre, PR-m2 is the price-rent ratio using data per square metre, PR-avg is the price-rent ratio using average housing transaction price data and PI-avg is the price-income ratio using average housing transaction price data. The index shows the long-term average at 100, so if the ratio line is above 120, a bubble is detected.

Figure 4: Bubble detection ratio methods

4.2 Regressions analyses

Table 3 contains the results of the OLS regression for the multivariate model and the parsimonious model. Both regression models were tested for autocorrelation using a Durbin Watson test, which indicated that there is positive autocorrelation, but not in an alarming way. The R-squared for both models is high, indicating that most of the variation between the variables is explained by the model and that the model has a good fit. All the variables in both models are significant to varying degrees. It is interesting that in the multivariate model income has a negative relation with house price changes, while in the literature the relationship tends to be positive. A possible explanation for the negative relationship is the Amsterdam housing market, which is dominated by investors who buy up houses. These investors drive up house prices, making it difficult for regular house buyers to buy houses.

The coefficient real mortgage rate is positively related to Amsterdam house price changes. The positive relationship between average aggregate income and house price changes is in line with findings in the literature. The positive relationship between construction costs and house prices changes is also in line with the literature. The positive relationship between the real mortgage rate and housing prices, however, is not in line with literature, but this can be explained by the declining real mortgage rate due to dropping interest rates in the dataset. The negative relationship between the unemployment rate and interest rate spread is in line with the literature.

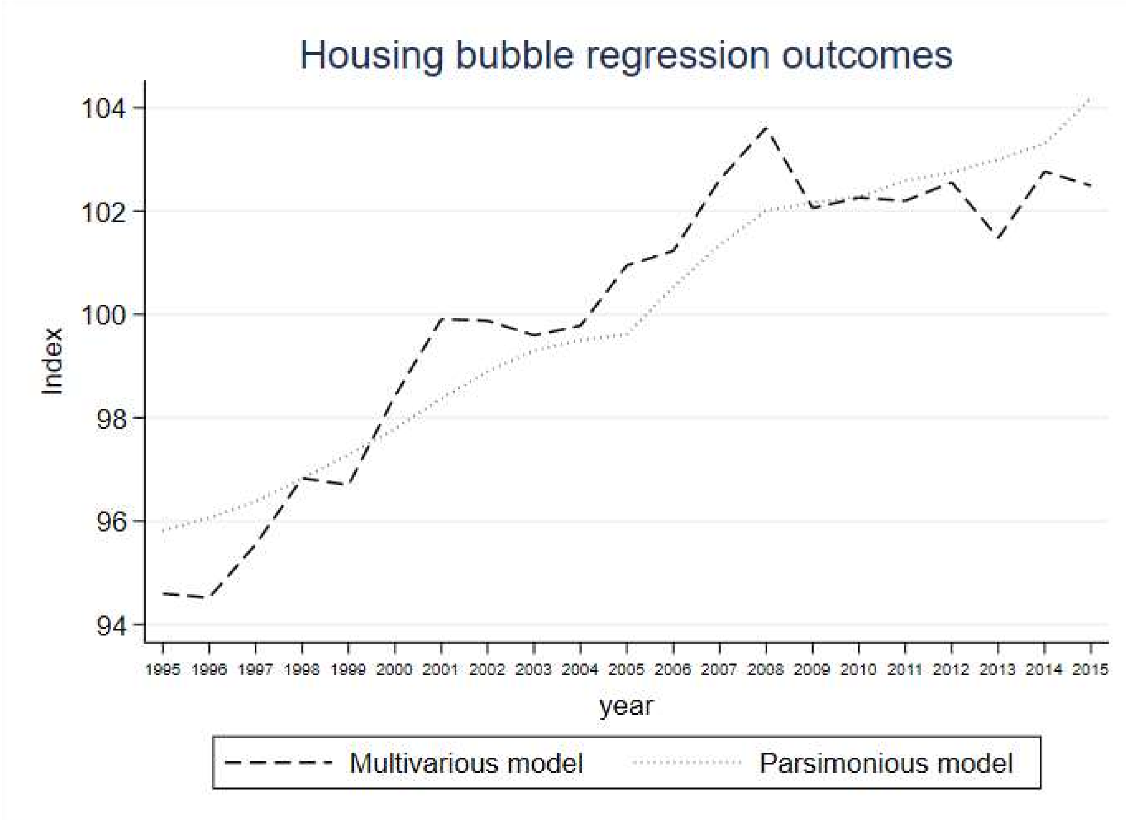
An issue with a specified regression model is that it explains more which factors are involved in the formation of bubbles than the long-term equilibrium price models. The regression model itself is not capable of detecting a housing bubble, but the predicted values generated using the regression model can be used to detect a housing bubble.

Table 3: Results of multivariate model and parsimonious model

VARIABLES	(1) Multivariate model Log price	(2) Parsimonious model Log price
Log income	-4.015***	1.947***
	(1.181)	(0.197)
Unemployment rate	-0.0360**	
	(0.0158)	
Real mortgage rate	0.0593*	
	(0.0318)	
Log construction	6.757***	
	(1.365)	
Interest rate spread	-0.0771**	
	(0.0291)	
Constant	21.18***	-7.450***
	(5.628)	(1.999)
Observations	21	21
R-squared	0.962	0.837

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results of the regressions models are shown in Figure 5. The figure shows that both regression models do not show a bubble in 2005–2015.



Note: This graph shows the regression indexes as explained in Chapter 3. The multivariate model is the index generated with the dependent variable natural logarithm of average transaction price and multiple independent variables (natural logarithm of income, unemployment rates, real mortgage rates, natural logarithm of construction costs and rate spreads between 10-year and 3-month government securities). The parsimonious model uses the natural logarithm of price as the dependent variable and the natural logarithm of income as the independent variable. The index shows the long-term average at 100. So if the ratio line is above 120 a bubble is detected.

Figure 5: Results of the bubble detection regression methods

5. Qualitative data and methods

This chapter provides a qualitative analysis of the conducted interviews. Firstly, it describes how the contact with the interviewees was made and the interview guide is exemplified. In the second part of the chapter, the descriptive statistics of the interviews are presented. The chapter ends with an analysis of the results gathered from the interviews.

5.1 Qualitative design

As mentioned in Chapter 1, a sequential triangulation mixed method approach is used. The quantitative results are shown during the interview, therefore the interviews are conducted after finishing the quantitative analysis. Before making contact with possible interviewees, a draft of the interview guide is made. The interview guide contains an introduction to explain the terms of the interview and questions to help the interviewer perform a semi-structured interview; the standard interview guide can be found in the appendix IV. Because the interviewees all have different experiences and a different role in the real estate market a semi-structured interview is conducted. A semi structured interview gives the interviewees the opportunity to fully share their experiences with the Amsterdam real estate market and their insights on variables that influence housing bubbles. The questions specified in the interview guide sought the interviewee's professional perspective on housing bubbles and are used to ascertain the experiences of the interviewee regarding the Amsterdam housing market. The interview guide is designed to split the interview into three different phases. These different phases are used to conduct an exploratory interview. In the first phase of the interview the interviewees are asked to share their knowledge on which variables influence housing prices and housing bubbles. During the second phase the interviewees are invited to share their experiences of the Amsterdam housing market between 2005 and 2015. In the third phase, the interviewees are presented with the results from Chapter 4 and are asked which method described in the graphs best resembles their experiences with housing bubbles in Amsterdam.

After completing the standard interview guide, different profiles for possible interviewees are made. For a concise overview of the Amsterdam housing market multiple real estate professionals are interviewed. It is mandatory that the interviewee is a real estate professional and that the interviewee has experience in the Amsterdam housing market. Other desirable qualities are extensive knowledge on housing bubbles and more than 10 years of professional experience. To obtain a broad perspective on the Amsterdam housing market in this research, it is preferable that the interviewees work in different sectors of the Amsterdam real estate market. The contact with the different interviewees was via e-mail or was set up using the network of the interviewer. The interviewees are listed in Table 4, because of privacy reasons the names of the interviewees are not mentioned. For each interview the standard interview guide is customized for the interviewee in order to get relevant information about the expertise of the interviewee. All interviews were held face-to-face, in Dutch, at the office of the interviewee.

Table 4: List of interviewees.

Interviewee	Profession	Experience	Date of interview
1	Broker/Investor	37 years	01-11-2019
2	Market Analyst	3 years	20-11-2019
3	Researcher	11 years	27-11-2019
4	Capital Markets	10 years	29-11-2019
5	Valuation & Advisory	11 years	12-12-2019

5.2 Descriptive statistics qualitative research

The duration of the interviews ranged from 26 to 46 minutes, but it should be taken into account that some interviewees had limited time for the interview. All interviews were recorded and afterwards transcribed by the interviewer. The transcripts are accessible by sending an email to the author of this thesis. The transcripts were analysed using different codes and the code tree can be found in appendix VI. The codes are organised in different categories; the five categories and the frequency of the categories are mentioned and can be seen in Table 5. During the interviews the most mentioned code is reasons for changes in the housing market; sentiment and mortgage rate are themes that are often mentioned as reasons for changes. In Chapter 6 these different themes are discussed and related to the literature in Chapter 2.

Table 5: Frequency table code categories.

	Interview 1	Interview 2	Interview 3	Interview 4	Interview 5	TOTALS:
Consequence	5	0	0	0	1	**6**
Evaluation	2	9	4	3	2	**20**
Experience	3	2	5	6	6	**22**
Prediction	0	3	1	3	2	**9**
Reasons	5	5	9	5	9	**33**
TOTALS:	**15**	**19**	**19**	**17**	**20**	**90**

Note: The different categories are specified as follows: Consequence (consequences of a housing bubble), Evaluation (evaluation of a housing bubble), Experience (experiences of the Amsterdam housing market), Prediction (prediction of housing bubble), and Reasons (reasons for changes in the Amsterdam housing market). This table is a result of the analysis of the conducted interviews and is used as input for chapter 6.

6. Qualitative analysis

The structure of this chapter is similar to the structure of the interview guide; first the definitions given by the interviewees will be compared to the definitions that are described in Chapter 2. In the second part of the chapter the experiences of the interviewees with the Amsterdam housing market are presented. The chapter ends with a review of the results from the quantitative analysis acquired from the real estate professionals. All quotes have been translated from Dutch to English by the author of the thesis. The interviewees are referred to as interviewee 1, interviewee, interviewee 3, interviewee 4, and interviewee 5.

6.1 Definition housing bubble

As stated in Chapter 2, the definition of a housing bubble that is broadly accepted in the literature is articulated by Stiglitz (1990), "*a bubble refers to house price levels that depart markedly from fundamental values."* Compared with Stiglitz (1990), interviewees 2, 3, 4, and 5 gave similar definitions of a housing bubble. Interviewee 5, for example, gave the following definition: "*I think there is a housing bubble when the house prices increase faster than inflation, income and other similar variables."* After asking the interviewee if he could elaborate on this definition, he mentioned that according to him the main drivers that have an impact on the housing market, and therefore a housing bubble, are interest rates, and supply and demand. According to interviewee 1, a bubble can be defined as sentiment. He explained that housing prices are determined by several variables, for example interest rates and imputed rent, but the most important variable is sentiment. Other interviewees did not directly mention sentiment when asked to define a housing bubble. However, both interviewee 4 and 5 mentioned sentiment as an important reason for changes in the Amsterdam housing market. Interviewee 4 for example said, "*What I noticed when we came out of the financial crisis is that the economy only grew with 2% or something like that. But the sentiment with the people was the crisis is in the past, which boosted demand enormously."* What is striking about the reactions of the interviewees when asked to define a housing bubble, is that they all found it difficult to answer the question, but nevertheless offered similar definitions.

6.2 Experience interviewees

During the interviews the interviewees were asked to share their experiences of the Amsterdam housing market between 2005 – 2015. The interviewees' descriptions of the period around the GFC (2007/2008), shared resemblances. Interviewee 1 and 5 recollect that the period just before GFC was very similar to the current state of the Amsterdam housing market. Interviewee 5 said "*the period was comparable with the current situation, only now it is even more extreme. Business was doing really well and people made a lot of money. In 2007 I started at DTZ Zadelhoff, it was an euphoric atmosphere and investments did really well. A lot of money was made and a lot was spent, so in* *general it was a kind of similar situation."* De Long et al. (1990) identify this euphoric atmosphere as a momentum driven bubble, which is characterized as a market where houses are bought and sold based on previous price dynamics. Interviewee 3 recognized that the house prices were high and he argued that the main reason for these high house prices was mortgage terms: "*(...) we all thought the interest rates were low, but with today's knowledge it was very high. I believe on average it was a mortgage rate of about 5%, but with the price levels of 2015. So if you put that into monthly charges, it is only possible to buy a house with very good mortgage terms."* The described situation shows similarities with an intrinsic bubble as described in Chapter 2. Froot and Obstfeld (1989) argue that exogenous fundamental factors are the main drivers of intrinsic bubbles, in the described situation the mortgage terms are the main driver of the house price dynamics. The mortgage terms are a recurring subject during the interviews and it is the most mentioned reason (13 times) for changes in the housing market. The house prices declined when the GFC struck and all interviewees had similar experiences during this time. They experienced decreasing house prices and fewer housing transactions. However, interviewee 3 made a contradictory statement about the societal consequences that emerged from the GFC. Firstly, he argued that the problem for society was a fictional problem, as long as you were employed and were able to continue to pay your monthly bills. Following this he said that he had some friends who were not able to sell their houses when they had to move out due to family expansion or marital problems. In general, the main societal problem was inflexibility among home-owners and this was also experienced by interviewee 5. After years of declining house prices in 2013 the market showed signs of recovery. According to interviewee 1, a crisis or housing bubble and the end of a crisis can be recognized in the transactions of the expensive apartments. As he states, "*The all-time low was in 2013, you can always recognize it if the more expensive apartments won't sell anymore. The cheaper apartments will always be sold. If the expensive apartments won't sell anymore everything falls apart. In 2013 the expensive apartments were sold again, when the expensive apartments are sold then it's the end of a crisis."* After the increase of house prices the turning point was in 2015, at which the same price level as before the GFC was reached according to interviewees 2, 3, and 5. Interviewee 2 claimed that in real estate the increase in house prices is always bigger than the decrease before: *"The upside of value development is always bigger than the negative value development in real estate. (...) There is also a certain inflation that keeps on going, that force means that the value will always increase in the long run."* According to interviewee 2 this is what happened between 2009 and 2015. Between 2008 and 2013 there was a decrease in value of approximately 20%, but between 2013 and 2015 the value grew in double digits. As a result, the real estate market was restored to the price levels of 2008 within 2 years. After sharing their experiences the interviewees were asked if they ever had the feeling that the Amsterdam housing market was experiencing a housing bubble. During the peak of house prices in 2008 none of the interviewees thought there was a housing bubble at the time. Interviewee 3 recollected: *"At the time all the prices were sky high. At a certain moment a litre of gas was 2 euros. Many other things were super expensive as well. There was* *a feeling that this might be the new economic standard. But all of a sudden prices fell really fast and we landed back on our feet."* This feeling about a new economic standard is in line with the reasoning of Case et al. (1996) about irrational bubbles. They argue that a housing bubble starts when homebuyers believe that houses are a safe investment, while they previously thought these houses were too expensive. This feeling about the peak in 2008 is shared by the other interviewees and it is the same feeling as some are experiencing in the current market. There are some important differences however, the financial climate is much healthier at the moment than it was in 2008. This is especially the case because mortgage terms are stricter and the loan-to-value has been brought back to 100%. Nevertheless, interviewee 2 noticed that people are more cautious in the market. However, he argued that there is less reason to be cautious than in 2008: *"I think there should be less reason for fear. The financing structure is different, for example it is mandatory to amortise your loan. Also the rules around financing a house have become more strict. This is a problem for the current first time buyers on the housing market, they experience difficulties when buying a house. So from that perspective we are better prepared for another blow."*

6.3 Review of quantitative results

As mentioned in paragraph 5.1 the interviewees were asked to compare their own experiences with the results presented in Chapter 4. In particular, the interviewees recognized the price-income ratio graph and the multivariate regression graph as representative of how they experienced the housing market. For some interviewees it was difficult to understand the graphs that were computed using the regression analysis. This is in line with the criticism of Bourassa et al. (2016) on the regression method, the authors argue that the method is too complex to understand.

The interviewer helped how to read the graphs through an explanation of how the gradient of the graph represented events that changed the housing market over time. Interviewee 1 made clear how the steep increase between 1995 and 2001 can be explained, that can be seen in all the graphs: *"In that time, when you bought a house only people with the highest incomes could get a full mortgage, the second income only counted for 30% because the banks argued that people have children and as a result one of the parents may be going to work less. The government thought that this was discriminatory, so they changed this regulation. This caused a huge increase in house prices."* This indicates that the price-income ratio as introduced by Case and Shiller (2003) is not only dependent on the income, but also on regulations that impact how much of the income can be spend on a house. This underlines the statement made earlier by interviewee 3, namely that mortgage terms are the main reason for high house prices. Interviewee 3 illustrates the impact of the mortgage terms when explaining the decrease in housing prices in 2008: *"From this point on, mortgage lending becomes a problem, the banks had problems. So they revised the mortgage terms, for a mortgage you could get about your yearly income times 3,5 with a risk premium. (...) In the end with the same income as before you could get about*

75% of the mortgage that you could get before." After the decrease a short period of recovery can be seen in the price-income ratio graph while the price-rent ratio graph and the regression graphs show an immediate increase. According to the interviewees the situation of the market just after the GFC is best shown in the price-income graph. After the short recovery that can be seen in the price-income ratio, another decrease in the ratio follows. For interviewee 5 this is a very recognizable phenomenon known as *"the double dip."* The price-income ratio is the only graph that shows this double dip and interviewee 5 therefore indicates that for him the price-income ratio graph is the most suitable graph for explaining changes in the Amsterdam housing market. When the price-income ratio shows the double dip, the price-rent ratio actually increases and indicates a second housing bubble. This can be explained in the data, because both variables decrease, but the housing prices decrease more than the average rent. The interviewees identify this period of bubble detection as a misinterpretation of the market. In contrast to the opinion of the interviewees that the price-income graph best represents changes in the Amsterdam housing market, Ambrose et al (2013) state in their research that the price-rent ratio is the most effective method to detect multiple bubbles for a long period of time. Their research concerns the Amsterdam housing market between 1650 and 2005, so a reason for the conflicting results misinterpretation of the housing market could be the short time period taken into consideration in the present study. Interviewee 2 suggested that the increase in price-rent ratio from 2009 until 2010 can be explained by price effect. This price effect occurs when only a certain type of house is sold on the market, which causes a misrepresentation of the market. However, if this effect occurs for the price-rent ratio, it should also occur for the price-income ratio. Since the price-income ratio does not show the same pattern, the reason for the increase in price-rent ratio lays elsewhere. Interviewee 3 argued that again this can be explained by mortgage terms. As explained earlier the mortgage terms changed after the GFC, making it more profitable to rent instead of buying a house. This theory is supported by another observation made by interviewee 3 when he states that the government had started to support first time buyers in the housing market: "*At a certain moment measures were taken, that's why it the price-rent ratio declines again. The government handed out loans to support first time buyers in the housing market. At that point you had a mortgage of three times your income, but there was still a gap of 100000 euros. It was possible to fill this gap with a loan handed out by the municipality against profitable terms and it would not negatively affect your mortgage. However this regulation was only for first time buyers. Besides, your parents were able to help financing up to 100 000 euros, this is still the case. So what happened was that the asset side was being repaired."* After these measures the price-rent ratio dropped to the same level as the price-income ratio in 2013. According to the interviewees and according to the graphs, 2013 marks the lowest point of the housing market in the past decade. Since 2013 the ratio graphs and the regression graph show an increase until the end of the graph. The multivariate regression graph shows a steep increase between 2013 and 2014 but starts to decrease after 2014. The price-income ratio and the multivariate ratio show a similar pattern until a decrease in 2014. Due to this decrease most interviewees indicate the price-income ratio as the most representative graph of the Amsterdam housing market. An overview of the pros and cons as stated by the real estate professionals and the literature of the different methods is displayed in table 6. The preferred method by the real estate professionals is unanimously the price-income ratio. The main argument in favour of the price-income ratio is that it shows the best representation of the Amsterdam housing market between 2005 and 2015.

Table 6: Pros and cons of various housing bubble detection methods.

Method	Pros	Cons
Price-income ratio	-Easy to compute -Easy to understand -Accurate representation of housing market -Requires few variables	
Price-rent ratio	-Easy to compute -Easy to understand -Requires few variables	-Inaccurate representation of housing market
Multivariate regression analysis	-Accurate representation of housing market	-Hard to understand -Hard to compute -Requires many variables
Parsimonious regression analysis	-Requires few variables	-Inaccurate representation of housing market

The interviews show that among real estate professionals there is consensus about the definition of a housing bubble. This definition is in line with the definition used in the academic literature. However, the interviewees do not agree on how a housing bubble can be identified in the housing market. Some of the interviewees called the collapse of the housing market in 2008 a housing bubble but others did not. Another interesting finding from the interviews was that mortgage terms can be seen as the main driver of housing bubble formation.

7. Conclusion and discussion

This chapter discusses the results presented in Chapters 4 and 6. In the second part of the chapter the limitations of the study are discussed.

7.1 Conclusion

This research aims to review existing housing bubble detection methods and to examine if they could detect a housing bubble in Amsterdam between 2005 and 2015. The different methods are reviewed by showing the results of the quantitative analysis to different real estate professionals. From the methods tested in this thesis the price-income ratio proves to be most suitable in detecting a housing bubble in Amsterdam. This method shows the most accurate representation of the Amsterdam housing market and is easy to understand and compute. The other methods lack some of these qualities and are therefore less suitable for detecting a housing bubble in Amsterdam. Due to rent regulations the price-rent ratio is less capable of showing an accurate representation of the Amsterdam housing market. The regression analyses are hard to compute and the real estate professionals find it difficult to understand the regression methods. Another aim of this research is to test if existing methods can identify a housing bubble in Amsterdam, and to compare the results with the opinion of real estate professionals about the occurrence of housing bubbles in the time frame 2005-2015. The results concerning housing bubble detection methods are rather in contrast with the experience of the real estate professionals. The existing methods show several bubble periods in 2008 and in 2010. However, the real estate professionals state that it is highly debatable that there was a bubble in 2008 and there was no housing bubble in 2010 according to them. This indicates that the price-rent ratio is incapable of detecting a housing bubble in Amsterdam. The price-income ratio however, did successfully show a bubble period in 2008 according to some real estate professionals, although other real estate professionals stated that there was no bubble. This indicates that some of the findings of this research are inconclusive.

7.2 Discussion

The reliability of the data used in this research is impacted by the lack of primary data. Therefore multiple data sources were often computed for one variable. This implies that a part of the data is not an accurate representation of the actual Amsterdam housing market and the variables that impact this housing market during the examined period. This could affect the validity of the results that are presented in this research. The data is primarily affected in computing the long-term average while the data used for the tested bubble period is mainly unmodified data.

The interviews also had some limitations, specifically the fourth and fifth interviews were limited by time constraints. Another limitation is that the interviews were held in Dutch and as such, the translation of the answers may have been prone to interpretation bias of some of the answers by the interviewer. When conducting the interviews some ethical decisions had to be made. For an unbiased interview the interviewee and the interviewer should have no personal connection. Furthermore, the goal was to have five interviews in order to collect enough data. It took a significant amount of time to establish an arrangement with the fifth real estate professional. When the plan of an interview with a stranger started to fall through the interviewer decided to contact someone in his own network for an interview. This interview was set up much quicker but violated the rule of no personal connection. This decision was made due to the pressured time frame in which the interviews needed to be conducted and in order to fulfil the requirement of five separate interviews.

Although the findings should be interpreted with caution, this study shows the strengths and weaknesses of several housing bubble detection methods.
Further qualitative research on the price-income ratio can resolve the inconclusiveness of this study. Another interesting topic for further research is the effect of mortgage terms on housing markets. During the interviews it became clear that mortgage terms have a significant impact on the Amsterdam housing market. For further research it could be interesting to consider how much mortgage terms influence regional or national house prices and the influence of mortgage terms on bubble formation.

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Appendix

Appendix I: preparing NVM data

```
clear all

use "C:\Users\Gijs\Documents\Master\Master thesis\DATA\2019_Keizer.dta"

*clear all non-Amsterdam data
drop in 174900/276857

*clear from unnecessary variables
drop obj_ID
drop obj_PC6Code
drop obj_pc6_ID
drop obj_prov_ID
drop obj_afd_ID
drop obj_nvmreg~D
drop obj_gem_ID
drop obj_plaats~D
drop obj_hid_CA~E
drop obj_hid_BW~R
drop obj_hid_PE~L
drop obj_hid_WO~P
drop obj_hid_IN~D
drop obj_hid_TYPE
drop obj_hid_HU~E
drop obj_hid_SO~S
drop obj_hid_KE~G
drop obj_hid_SO~P
drop obj_hid_SO~G
drop obj_hid_VE~D
drop obj_hid_NV~S
drop obj_hid_OP~K
drop obj_hid_LIFT
```

```
drop obj_hid_KW~T
drop obj_hid_NV~P
drop obj_hid_NK~S
drop obj_hid_VT~P
drop obj_hid_ZO~R
drop obj_hid_VL~R
drop obj_hid_PR~R
drop obj_hid_WO~A
drop obj_hid_NB~N
drop obj_hid_ND~P
drop obj_hid_ND~S
drop obj_hid_NK~N
drop obj_hid_N~UK
drop obj_hid_NWC
drop obj_hid_NB~K
drop obj_hid_PA~R
drop obj_hid_IN~G
drop obj_hid_TU~G
drop obj_hid_TU~W
drop obj_hid_ONBI
drop obj_hid_ONBU
drop obj_hid_VERW
drop obj_hid_ISOL
drop obj_hid_LI~R
drop obj_hid_LI~I
drop obj_hid_LI~W
drop obj_hid_ER~N
drop obj_hid_PE~T
drop obj_hid_ST~S
drop Sleutel
drop BAG_PC6NR
drop X
drop Y
drop obj_hid_OO~R
```

```
drop obj_hid_DA~R
drop obj_hid_LA~R
drop obj_hid_PO~E
drop obj_hid_HU~R
drop obj_hid_PR~L
drop obj~FMELDING
drop pc6
drop hn
drop bag_pc6nr
drop OBJECTID
drop Identifica
drop OpenbareRu
drop Huisletter
drop Huisnummer
drop Huisnumm_1
drop Postcode
drop obj_hid_HUISNUMM~G


*get rid of invalid transactionprices and m2
drop if obj_hid_TRANSACTIEPRIJS < 0
drop if obj_hid_M2 < 1

*check for outliers
summarize obj_hid_TRANSACTIEPRIJS
summarize obj_hid_M2

*outliers detected, sort for outliers
sort obj_hid_TRANSACTIEPRIJS

*get rid of unlikely transactionprices
drop if obj_hid_TRANSACTIEPRIJS < 65000
drop if obj_hid_TRANSACTIEPRIJS >20000000
```

```
*drop duplicates
duplicates drop obj_hid_TRANSACTIEPRIJS obj_hid_DATUM_AANMELDING
obj_hid_M2 year, force


*sort for year and month
sort year month

*calculate transaction price per sqaure meter
gen transpricepm2=(obj_hid_TRANSACTIEPRIJS)/(obj_hid_M2)

*check for outliers
summarize transpricepm2

*outliers detected, sort for outliers
sort transpricepm2

*according to source highest square meter price is 12500, to be sure
drop if transpricepm2 > 13000

*calculate average price per year
egen avgtranspricepy=mean(obj_hid_TRANSACTIEPRIJS), by(year)
egen avgtranspricepmpy=mean (transpricepm2), by(year)

*calculate average price per quarter
egen avgtranspricepq=mean(obj_hid_TRANSACTIEPRIJS), by((year)(quarter))
egen avgtranspricepmpq=mean(transpricepm2),by((year)(quarter))

*label new variables
label var avgtranspricepy "average transaction price per year"
label var avgtranspricepq "average transaction price per quarter"
label var avgtranspricepmpy "average transaction price per m2 per year"
label var avgtranspricepmpq "average transaction price per m2 per quarter"
```

*sort for year and month
sort year month

*obtain descriptive statistics of variables transactionprice,
*average transactionprice and average transactionprice per square meter
summarize obj_hid_TRANSACTIEPRIJS avgtranspricepy avgtranspricepmpy

Appendix II: preparing ratio data

```
clear all

*Import excel data
import excel "C:\Users\Gijs\Documents\Master\Master thesis\DATA\Gecombineerde data
MT-GijsKeizer.xlsx", sheet("Blad1") firstrow clear

*drop unnecessary variables
drop Rentincrease
drop Averageimp~t
drop Population
drop unemployme~n
drop Realintere~e
drop Constructi~x
drop Interestra~d
drop Consumerse~x

*drop missing values
drop if Year==.

*create price income ratio and long term average for price earnings ratio
*per square meter
*generate price income ratio m2 for all years
gen p_i_ratiom2=(Averagetransactionpriceperm2)/(Averageincome)
*generate long term average price income ratio
egen lta_pim2=mean(p_i_ratiom2)

*create index for comparison
*make p/i ratio to index
gen pi_indexm2=((p_i_ratiom2)/(lta_pim2))*100

*create price earnings ratio and long term average for price earnings ratio
*for average transaction price
```

```
*generate price earnings ratio average transaction price
gen p_i_ratioavg=(Averagetransactionprice)/(Averageincome)
*generate long term average
egen lta_piavg=mean(p_i_ratioavg)
*make p/i ratio to index
gen pi_indexavg=((p_i_ratioavg)/(lta_piavg))*100

*create price rent ratio and long term average for price rent ratio
*per square meter
*generate price rent ratio m2 for all years
gen p_r_ratiom2=(Averagetransactionpriceperm2)/(Averagerent)
*generate long term average
egen lta_pr=mean(p_r_ratiom2)
*make p/r ratio to index
gen pr_indexm2=((p_r_ratiom2)/(lta_pr))*100

*create price rent ratio and long term average for price rent ratio
*for average transaction price
gen p_r_ratioavg=(Averagetransactionprice)/(Averagerent)
*generate long term average
egen lta_pravg=mean(p_r_ratioavg)
*make p/r ratio average to index
gen pr_indexavg=((p_r_ratioavg)/(lta_pravg))*100

*summarize descriptive statistics
summarize Averageincome Averagerent p_i_ratiom2 p_i_ratioavg p_r_ratiom2 p_r_ratioavg,
separator(0)

*drop variables that are only used for long term average
drop if Year==1995
drop if Year==1996
drop if Year==1997
drop if Year==1998
drop if Year==1999
```

```
drop if Year==2000
drop if Year==2001
drop if Year==2002
drop if Year==2003
drop if Year==2004


*create graph
twoway (line pi_indexm2 pr_indexavg pr_indexm2 pi_indexavg Year, sortAppendix 3:
```

Appendix III: Preparing regression data

```
clear all

import excel "C:\Users\Gijs\Documents\Master\Master thesis\DATA\Data
MTregression3.xlsx", sheet("Blad1") firstrow clear

*generate log for average transactioprice for multivariate and parsimonious regression
gen lnprice=ln(Averagetransactionprice)
*generate log for income
gen lnincome=ln(Averageincome)
*generate log for construction cost index
gen lnconstruction=ln(Constructioncostindex)

summarize lnprice lnincome unemploymentin Realmortgagerate Interestratespread
lnconstruction, separator(0)

*execute multivariate regression
reg lnprice Averageincome Population unemploymentin Realmortgagerate
Constructioncostindex Interestratespread Consumersentiment

*execute multivariate regression with significant variables
reg lnprice lnincome unemployment Realmortgagerate lnconstruction Interestratespread

*predict new ln values
predict lnprice_multi

*execute parsimonious regression
reg lnprice lnincome

*predict new ln values
predict lnprice_parsi

*generate long term average for multivariate and parsimonious regression
```

```
egen lta_lnprice=mean(lnprice)

*drop unnecessary years
drop if year==1995
drop if year ==1996
drop if year==1997
drop if year==1998
drop if year==1999
drop if year==2000
drop if year==2001
drop if year==2002
drop if year==2003
drop if year==2004

*generate index for regression models
gen index_multi=(lnprice_multi/lta_lnprice)*100
gen index_parsi=(lnprice_parsi/lta_lnprice)*100

*create indexgraph
twoway (line index_multi index_parsi year, sort)
```

Appendix IV: Interview Guide (English)

Interview guide master thesis Gijs Keizer (English)

This interview will be used for my research conducted at the university of Groningen. I would like to research different methods of house bubble detection and test these methods with data on Amsterdam. I would like to make you aware that the answers you give can be anonymized if you prefer. When the research is finished I will delete the collected data. Do you agree with these terms of the interview?

How would you define a housing bubble?

- ➔ Which variables do you think influences housing prices?
- ➔ Do these variables also influence housing bubbles?

What is your experience in the Amsterdam housing market in the period 2005 – 2008 (just before GFC)?

What is your experience in the Amsterdam housing market in the period 2009 – 2015?

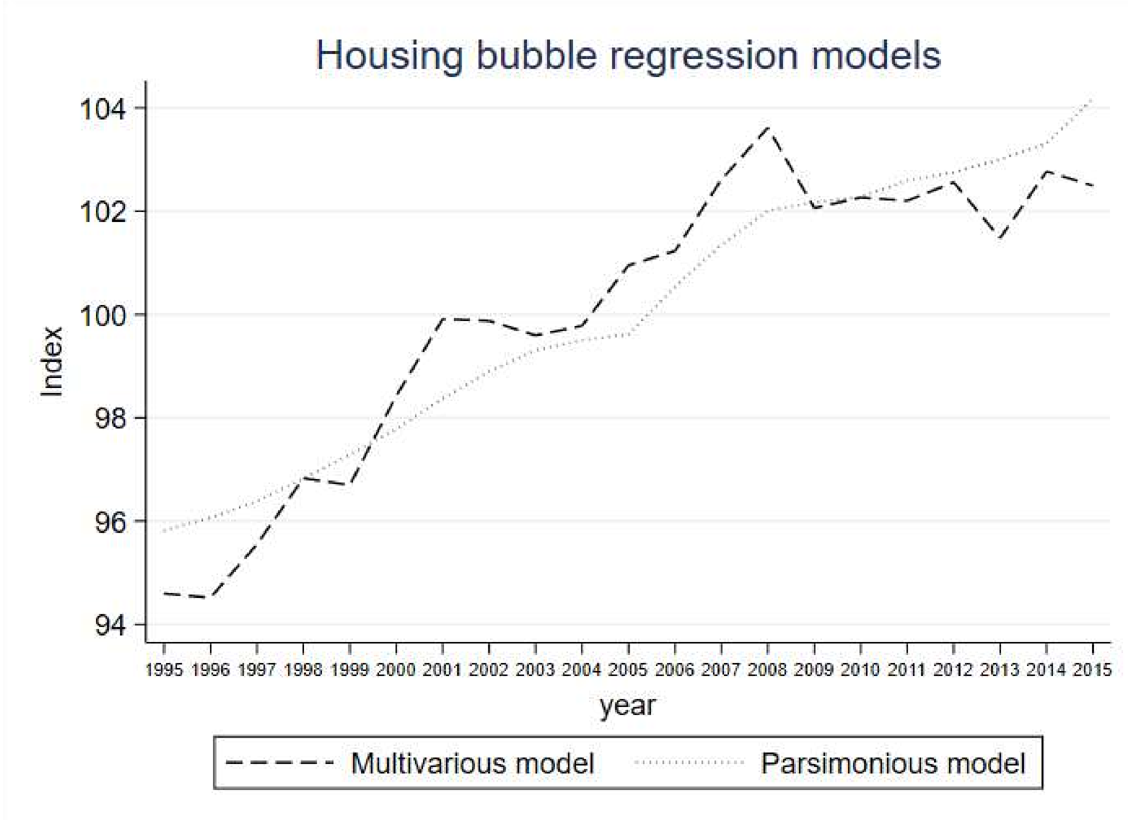
Have you ever felt that there was a housing bubble in Amsterdam during your professional career?

show the interviewee the graphs of the housing bubble detection methods

Do you think different about the experience of a housing bubble now I showed you these graphs?

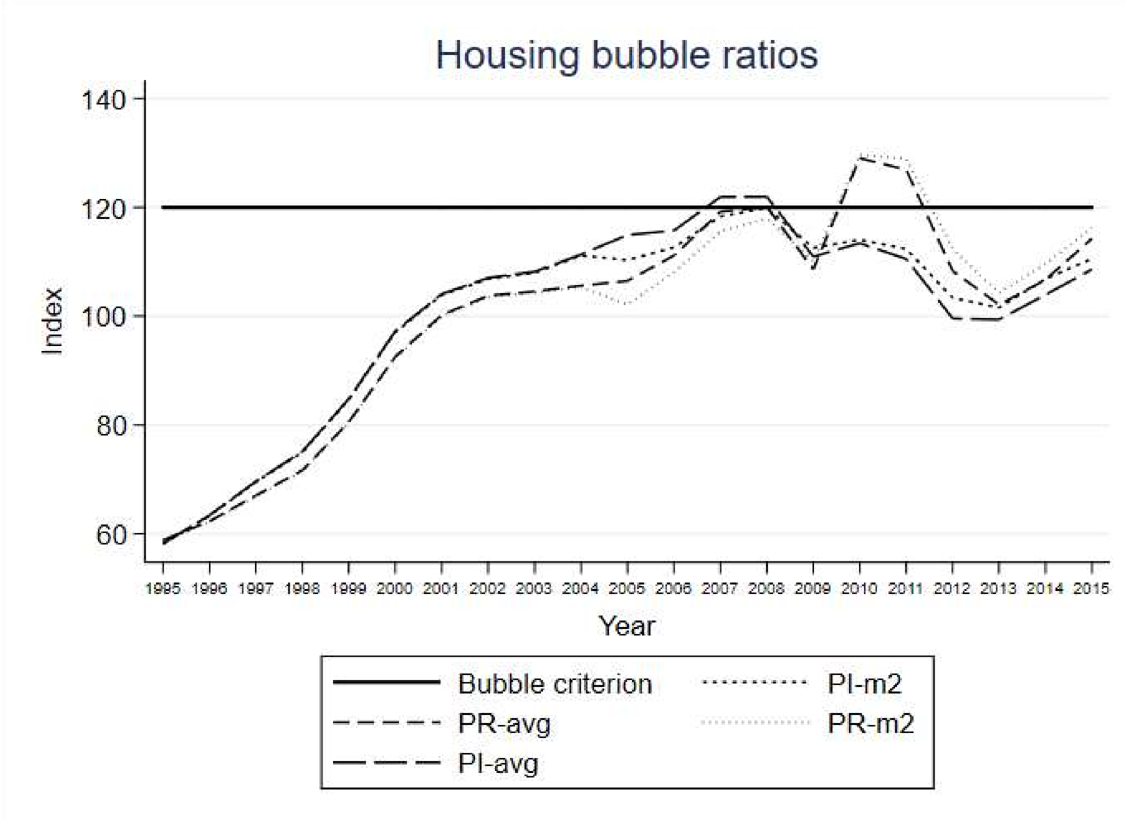
Which of the applied methods best shows the development of the Amsterdam housing market?

Do you have any remarks or want to elaborate on one of the previous questions?



The multivariate regression is created using various variables (income, rate spread, construction costs, unemployment and mortgage rate) to predict house prices. This prediction is set against the actual average of house prices, if the line exceeds 20 index points from a 100 there is a housing bubble.

The parsimonious regression is created using the variable income to predict house prices. This prediction is set against the actual average of house prices, if the line exceeds 20 index points from a 100 there is a housing bubble.



The price-income ratio is the average income in Amsterdam set against the average house price in Amsterdam per square metre (PI-m2) or the average house price per transaction (PI-avg). This is set against the average ratio from 1995 till 2015, if the line exceeds 20 index points from a 100 there is a housing bubble.

The price-rent ratio is the average rent price in Amsterdam set against the average house price in Amsterdam per square metre (PR-m2) or the average transaction price (PR-avg). This is set against the average ratio from 1995 till 2015, if the line exceeds 20 index points from a 100 there is a housing bubble.

* Due to the way the data was created, there is no distinction between the ratios from 1995 to 2004.

Appendix V: Interview Guide (Dutch)

Interview guide master thesis Gijs Keizer (Dutch)

Dit interview wordt gebruikt voor mijn onderzoek dat ik doe aan de Rijksuniversiteit Groningen. Ik wil onderzoek doen naar verschillende methodes die gebruikt worden om huizenbubbels te detecteren. Deze methodes test ik op data van Amsterdam. Ik wil u er op attenderen dat de antwoorden volledig kunnen worden geanonimiseerd mocht u dit willen. Als het onderzoek voltooid is dan verwijder ik de verkregen data. Bent u het eens met de voorwaarden van dit interview?

Hoe zou u een huizen bubbel definiëren?

- ➔ Welke variabelen beïnvloeden huizenprijzen en daarmee een huizen bubbel?
- ➔ Hoe heeft variabel X dan bijvoorbeeld invloed op de huizenmarkt?
- ➔ Bent u bekent met verschillende methodes voor het voorspellen van een vastgoed bubbel?

Denkt u dat een huizenbubbel beter te voorspellen vanuit methodes of vanuit de theorie? (en waarom)

Wat is uw ervaring van de Amsterdamse huizenmarkt in de periode 2005 – 2008 (net voor de financiële crisis)?

Wat is uw ervaring van de Amsterdamse huizenmarkt in de periode 2009 – 2015?

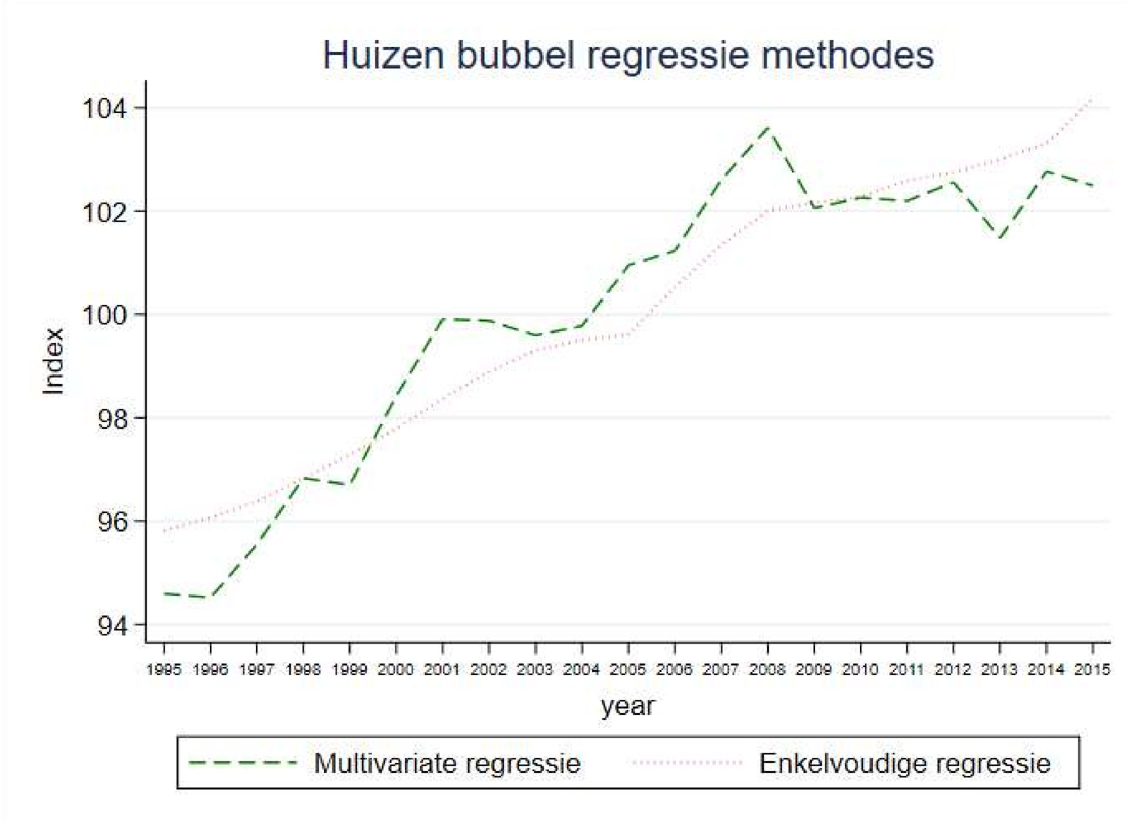
Heeft u ooit een huizen bubbel ervaren tijdens uw professionele carrière?

toon de geïnterviewde de grafieken van de huizen bubbel detectie methodes

Denk u nu anders over uw ervaring over de huizen bubbel na het zien van deze grafieken?

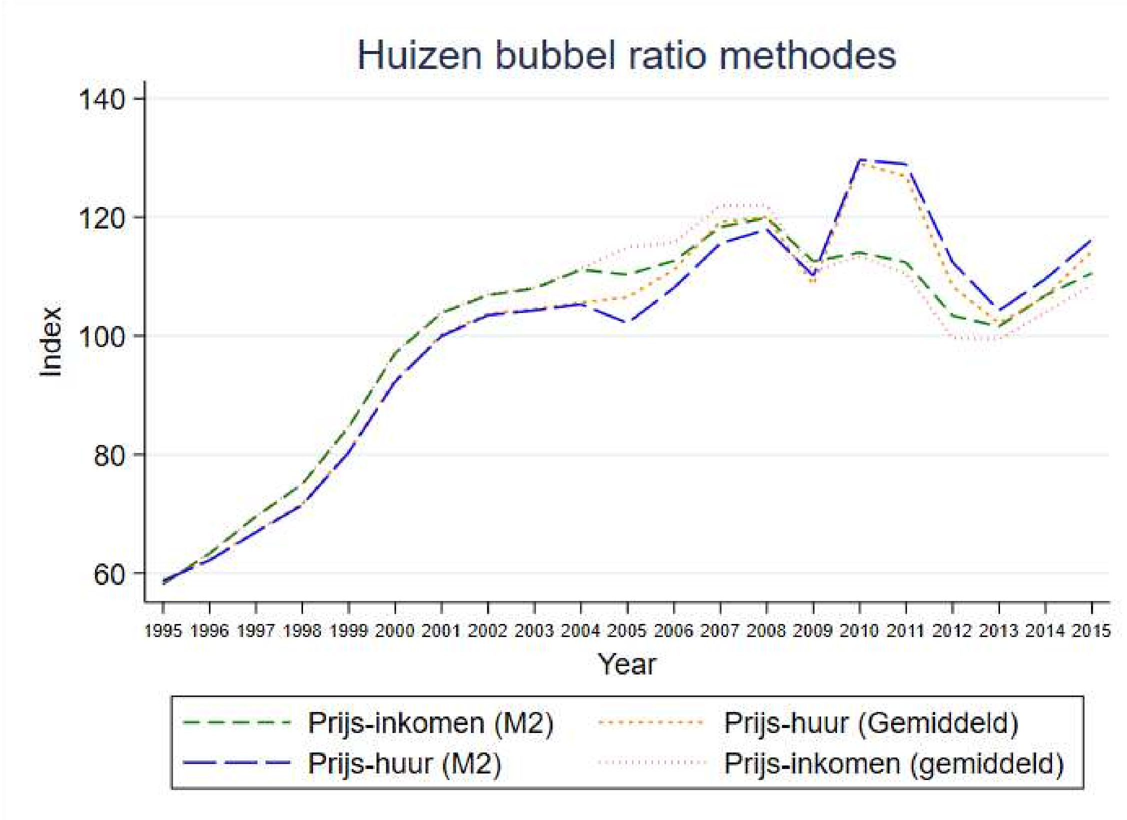
Welke van de toegepaste methodes laat het beste het verloop van de Amsterdamse huizenmarkt zien?

Heeft u nog op- of aanmerkingen aan de hand van de voorgaande vragen?



De multivariate regressie is tot stand gekomen door verschillende variabelen (inkomen, rentespreiding, constructiekosten, werkloosheid en hypotheekrente) de huizenprijs te laten voorspellen. Deze voorspelling is afgezet tegen het daadwerkelijke gemiddelde, als de lijn meer dan 20 indexpunten afwijkt van 100 is er sprake van een huizenbubbel.

De enkelvoudige regressie is tot stand gekomen door de variabele inkomen de huizenprijs te laten voorspellen. Deze voorspelling is afgezet tegen het daadwerkelijke gemiddelde, als de lijn meer dan 20 indexpunten afwijkt van 100 is er sprake van een huizenbubbel.



De prijs-inkomen ratio is het gemiddeld inkomen in Amsterdam afgezet tegen de gemiddelde huizenprijzen in Amsterdam per vierkante meter (M2) of de gemiddelde huizenprijs per transactie (Gemiddeld). Dit is afgezet tegen de gemiddelde ratio van 1995 tot en met 2015, als de lijn meer dan 20 indexpunten afwijkt van 100 is er sprake van een huizenbubbel.

De prijs-huur ratio is de gemiddeld huurprijs in Amsterdam afgezet tegen de gemiddelde huizenprijzen in Amsterdam per vierkante meter (M2) of de gemiddelde huizenprijs per transactie (Gemiddeld). Dit is afgezet tegen de gemiddelde ratio van 1995 tot en met 2015, als de lijn meer dan 20 indexpunten afwijkt van 100 is er sprake van een huizenbubbel.

*Door de manier waarop de data tot stand is gekomen, is er geen onderscheid tussen de ratio's van 1995 tot en met 2004.

Appendix VI: Code tree

Codes:

DEF: DEFINITION HOUSING BUBBLE

- DEF: Housing bubble

RE: REASONS FOR HOUSING BUBBLE

- RE: Sentiment
    - RE: Sentiment: positive
    - RE: Sentiment: negative
- RE: Interest rate
    - RE: Interest rate: low
    - RE: Interest rate: high
- RE: Mortgage
    - RE: Mortgage rate low
    - RE: Mortgage rate high
    - RE: Mortgage terms
- RE: Supply
    - RE: Supply: high
    - RE: Supply: low
- RE: Investors
    - RE: Investors
- RE: Trends

CON: CONSEQUENCES OF HOUSING BUBBLE

- CON: Emotional
    - CON: Emotional positive
    - CON: Emotional negative
- CON: Financial
    - CON: Financial positive
    - CON: Financial negative
-

EV: EVALUATION OF HOUSING BUBBLE

- EV: Financial
    - EV: Financial positive (healthy financial environment)
    - EV: Financial negative (unhealthy financial environment)
- EV: Negative (no housing bubble)
- EV: Positive (housing bubble)
- EV: Ambivalence
- EV: Neutral
- EV: Origin

EX: EXPERIENCES ABOUT HOUSING BUBBLE

- EX: Recognizable
- EX: Not recognizable
- EX: Positive (bubble)
- EX: Negative (no bubble)
- EX: Prediction
    - EX: prediction: positive

- EX: prediction: negative

PR: PREDICTOR OF HOUSING BUBBLES:

- PR: Methodology
- PR: Theory

Appendix VII:

Definition	Description	Source
Housing bubble	A bubble refers to house price levels that depart markedly from fundamental values.	Stiglitz, J., (1990). Symposium on Bubbles. *Journal of Economic Perspectives*, 4(2), 13-18.
Price-income ratio	A ratio where the average increase of annual income is set against the annual increase of house prices.	Case, K. E., & Shiller, R. J. (2003). Is there a bubble in the housing market? *Brookings papers on economic activity*, 2003 (2), 299-362.
Price-rent ratio	A ratio where the average increase of annual rent is set against the annual increase of house prices.	Bourassa, S., Hoesli, M., & Oikarinen, E. (2016). Measuring house price bubbles. *Real Estate Economics*, 1, 1-30.
Price-imputed rent ratio	A ratio where the average increase of imputed rent is set against the annual increase of house prices.	Bourassa, S., Hoesli, M., & Oikarinen, E. (2016). Measuring house price bubbles. *Real Estate Economics*, 1, 1-30.
Fundamentals	Variables such as rent and income, in the remainder of the thesis it is referred to as fundamentals	Stiglitz, J., (1990). Symposium on Bubbles. *Journal of Economic Perspectives*, 4(2), 13-18.
Sequential triangulation mixed methods	Sequential triangulation is utilized when the results of one approach are necessary for planning the next method.	R. B. Johnson, (2016). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research*, 1, 112-133.
Momentum bubble	A momentum bubble is driven only by price and is against rationality of the marketplace. Agents buy when the price increases and sell when the price decreases, and momentum occurs when prices rise and when they are expected to continue to rise.	De Long, J. B., Shleifer, A., Summers, L. H., & Waldmann, R. J. (1990). Noise trader risk in financial markets. *Journal of Political Economy*, 98(4), 703-738.
Explosive bubble	An explosive bubble occurs when prices deviate from fundamentals due to factors extraneous to asset value. These are non-fundamental factors that cannot be explained by economic trends.	Black, A., Fraser, P., & Hoesli, M. (2006). House prices, fundamentals and bubbles. *Journal of Business Finance & Accounting*, 33(9-10), 1535-1555.

Intrinsic bubble	Exogenous fundamental factors are the main drivers of the price dynamics of intrinsic bubbles. These factors are fundamental, because they are based on trends in the economy, like rent.	Froot, K. A., & Obstfeld, M. (1989). *Intrinsic bubbles: The case of stock prices* (No. w3091). National Bureau of Economic Research.

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