An evaluation of the influence of loan-to-value ratios on own home investment. An Ordinary Least Squares and Instrumental Variable approach using microdata from the Netherlands.

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AN EVALUATION OF THE INFLUENCE OF LOAN-TO-VALUE RATIOS ON OWN HOME INVESTMENT.

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A thesis for the master public administration economics and governance

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ABSTRACT

Investments in home improvements or renovations alter the value of a home. The level of this investment into one's own home could be influenced by the Loan-To-Value ratio leading to a possible extra way limits on Loan-To-Value ratios influence housing prices. This thesis attempts to shed light on the relationship between the Loan-To-Value ratio of a home purchase and the level of home improvement or renovations an individual invests in later on. It does so by using a collection of regressors from the broader literature on home improvement and performing both an Ordinary Least Squares (OLS) and an Instrumental Variable regression (IV). Results from the OLS regression show that though there is reason to assume the Loan-To-Value ratio is impactful on home improvements from a theoretical standpoint, it ceases to be a significant predictor if the size of a home is taken in to account. This thesis also confirms previous research on the determinants of home improvement as it finds that the age of a home, the length of time an individual has lived there and a person's income are significant predictors. The results of the IV regression support this conclusion, but as instruments used are relatively weak the results from this IV regression could be biased and lack substantial statistical explanatory power.

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INTRODUCTION

When one invests in their own home by performing: a renovation, small house repairs or even a complete remodel, one spends money that afterwards is fixed to the house in question. These actions alter the value of a home that can be sold after its value has been changed. Because of this, this document refers to all actions of this nature as Own Home Investments (OHI). In other words: OHI does not discriminate between renovation, repairs or remodeling. Previous research into the determinants of OHI has never included the Loan-To-Value ratio (LTV), which is an individual ratio that is calculated by dividing the value of a home by the size of the mortgage acquired to finance this home. In this thesis the possible influence LTV has on OHI is explored empirically, while keeping in mind the possibility of endogeneity caused by an individual's opinion on the value of housing.

The housing market is relatively closely tied to the whole economy as Reinhart and Rogoff illustrate in their 2009 study that indicates there is a strong bond between housing busts and historical banking crisis (Reinhart & Rogoff, 2009). This connection between recessions and the housing market is also supported by the 1960-2007 cross-country study by Claessens et al. They implicate that economic output losses are three times the size of what they would be in a recession if there is a corresponding housing crisis (Claessens, Ayhan, & Terrones, 2008). Because the Netherlands has high levels of home ownership and high housing prices, the mortgage debt levels in the Netherlands are extremely high. The Netherlands has also been among countries that have seen the steepest rise in mortgage debt (Ronald & Dol, 2011). The ratio of mortgage debt to GDP in the Netherlands reached more than 100 % in 2009, indicating that the wider economy and the housing market are especially intertwined in the Netherlands (IMF, 2011).

An important aspect of the housing market are housing prices. Housing prices tend to be influenced by core economic and demographic principles such as income, GDP, population growth etc. in times of normalcy (Geng, 2018). Strong expectations about housing market behavior can move housing prices determinants away from these factors that would normally be dominant in shaping the price of housing (Shiller R. J., 2008) (McCue & Belsky, 2007) (Burnside, Eichenbaum, & Rebelo, 2011).

Because the housing market represents such a large part of the national economy through the value of assets and the size of the corresponding debts, the actions people take to change the value of their home can be impactful for the economy as a whole. Dipasquale points out that if the homeownership rate is large, a "major way in which the supply of housing adjusts to changing market conditions is through the investment and maintenance decisions of owners of housing units" (Dipasquale, 1999). As the Netherlands boasts a high homeownership rate one could say that Own Home Investments play a large role in the Netherlands as well.

In 2008 a global housing crisis brought much attention to the housing market internationally, but locally in the Netherlands the attention of lawmakers was caught as well. A surge in

housing price demand led to housing price inflation which in turn reduced foreclosures and increased credit ratings. In the United States this allowed individuals to borrow more which in turn drove up prices. (Taylor, 2007). When this housing bubble burst in 2008 housing prices faced a steep decline. The 2008 housing crisis prompted a shift from normal housing price drivers as it sparked unprecedented behavior on the housing market. Similar to many other countries, the Netherlands became concerned with LTV after its effects on the stability of the housing market became a central focus. The Dutch response has in part been a roof on the LTV. In many ways this limit seems like a logical response as indebtedness has been a driver of the housing market crash as illustrated by Oswald and Wenli's case (Oswald & Wenli, 2017). Geanakoplos supports this idea as he claims that restricting LTV in times of prosperity is one of the most important measures a government can take in ensuring a crash does not occur. (Geanakoplos, 2010).

The legal maximum on the LTV as suggested by the Dutch government started at 105% in 2013 and was to lowered by 1% each year until a roof of 100% was achieved in 2018 (Rijksoverheid, 2020). This however, has not been the only response to the housing crisis. The Dutch government also saved banks with financial packages, supplied benefits to middle and small companies, increased budgets for local governments, implemented broad social security measures and lowered taxes on the acquisition and sale of housing (Rijksoverheid, 2011) (Rijksoverheid, 2021). At this time the European bank continued lowering interest rates (ECB, 2021). In order to promote homeownership, the Netherlands employs mortgage interest relief methods through deductibility. This kind of interest relief has been shown to be most beneficial for wealthy households (IMF, 2009) (IMF, 2010) (OECD, 2011). The Dutch government implemented such a wide range of measures that it is hard to identify empirically what the impact of each individual measure has been on housing prices and the economy as a whole.

The 2008 housing crisis and the level of response needed to re-energize the Dutch economy truly indicate the perceived importance of the housing market. It also becomes clear that monetary policy used to control overall economic behavior can affect the housing market in a significant way. This creates a dilemma for any government that faces unfavorable housing prices as often monetary policy that could be used to change housing price behavior is also highly influential on other aspects of the economy. As the Netherlands is a part of the European monetary union, interest rates are set by the European bank, further complicating the use of interest based monetary policy to tackle disproportionate housing prices. In order to identify policy options that could be used to direct the housing market towards a social optimum, relationships need to be identified and documented. This is done in order to ensure housing prices don't rise to quickly in prosperous times, and crash too hard during economic hardship. The possible connection between LTVs and OHI constitutes such a relationship.

Available literature on Loan-To-Value ratios tend to focus on what rates are appropriate and the relationship between LTVs and boom bust behavior of the housing market. Literature that focusses on OHI tends to emphasize the role of these kinds of investments on housing prices. Research looking into the determinants of OHI often looks at income and social

capital as explanatory variables. No research has been found that analyses the impact LTV has on OHI. Given the idea that LTVs are instrumented by the government to combat increasingly high mortgages, and the direct relationship between OHI and housing prices, it seems prudent to look into the effect the LTV has on OHI from a policy and academic standpoint.

RELATED LITERATURE

Before any kind of statistical analysis can be carried out, it's important to have a notion of the possible mechanisms through which LTV affects OHI. A regression also needs to include the determinants of OHI as described in literature. For this reason an overview of empirical research on OHI has been included here. Firstly though it is important to gain understanding of the leverage cycle.

HOW IS THE LTV RELATED TO HOUSING PRICES?

The leverage cycle states that leverage and housing prices are positively correlated with each other forming a feedback loop that enlarges fluctuations in the housing market. Geanakoplos describes the relationship between leverage and housing prices in the following manner: "If they (buyers) can get their hands on more money through more highly leveraged borrowing (that is, getting a loan with less collateral), they will spend it on the assets and drive those prices up." (Geanakoplos, 2010). Leverage is effectively described as an important determinant for housing prices as it enables buyers to spend more on a house. Much of this behavior can be attributed to differences between individuals. For some, the utility of a house is simply higher than others. Because of this they are willing to get a higher loan in order to acquire this property. But the utility a buyer expects from a home also has to do with the expectations this buyer has about the behavior of the housing market. If one expects housing prices to rise for years to come, but no one else shares this sentiment, it seems logical that one is willing to pay more for a property than those who do not believe housing prices will rise.

Instead of leverage one could use the Loan-To-Value ratio (LTV). Leverage is closely related to the LTV in the following manner:

$$\text{LTV} = 1 - Leverage^{-1}$$

If, for example, one takes out a mortgage for 80% of the value of a property and pays the left over 20% with personal funds, the LTV equals 0.8 and the leverage equals 5. Though this ratio is synchronous and therefore LTV can always be expressed as leverage and vice versa, leverage is not at all related to mortgage height and housing price in a linear fashion.

Because of this and because governments, including the Dutch government, more often refer to LTV and not leverage, this thesis works with LTV instead of leverage.

The leverage cycle exacerbates fluctuations in the housing market, therefore a bust scenario is often preceded by a boom in housing prices. The Netherlands is currently facing such a boom in housing prices even though limits have been placed on the LTV by the government. The behavior seen in the Netherlands corresponds to that predicted by the leverage cycle (Hessel & Peeters, 2011)

Most studies on the subject focus on extreme fluctuations in the market and the corresponding extremes in leverage or LTV. In a study conducted by the IMF a correlation between average LTV ratios to housing prices is found using empirical data. The IMF finds that "both Loan-To-Value (LTV) ratios and the prevailing contract type play a role in amplifying house price dynamics." (IMF, 2011, p. 150). They use panel regression to find that a 10% increase in household credit leads to a 6 % increase in nominal house prices in OECD countries. The impact of the average LTV on housing price appreciation has been found significant in an empirical study of 50 US states conducted by Crowe et al. if they included state affects. The data shows a rise of 0.273 to 0.429 in housing price appreciation per increase of a percentage point in the LTV (Crowe, Dell'Ariccia, Igan, & Rabanal, 2011).

The ideas posed in by Geanakoplos in his literature regarding the leverage cycle are supported by Towbin and Weber (2015). They claim that between 1996 and 2006 about 30% of the increase in housing prices can be attributed to house price expectation shocks making it the most important driver (Towbin & Weber, 2015) . Case and Shiller find that a high level of respondents in their survey research claim to be motivated by investment purposes. This shows that when buying a house not only individual utility, but value development of the house is taken in to account. An individual's expectations regarding housing price developments should therefore be a mayor influence when buying a home and determining what Loan-To-Value ratio is appropriate (Case & Shiller, 2003).

Shiller (2007) claims that expectations regarding future housing prices played a big part in the creation of housing bubbles (Shiller R. J., 2007). And though a bubble is by definition not the same as a consistent long term price increase, it does constitute an increase in housing prices though temporarily. Lambertini et al find that shocks in housing price expectations explain a fair share of house price movements (Lambertini, Mendicino, & Punzi, 2013).

DETERMINANTS OF OHI IN LITERATURE

It is clear that LTV ratios have impact on housing prices. Less clear are the determinants of OHI. Helms claims in his 2002 study that "nearly all existing empirical studies" find that determinants of housing renovation are almost always unsignificant except for the age of the home (Helms, 2002). This lack of significant predictors in literature illustrates that much research is still to be done on the subject, but also that OHI might simply be hard to predict.

Potepan (1989) has used micro level data of the 1979 income dynamics panel study to look at the decisions of individuals choosing between home improvement or moving. It is Potepan's position that the height of interest rates and the height of one's income are important factors determining the attractiveness of home improvements for households that have a fixed-rate mortgage (Potepan, 1989). Montgomery, though at odds with the conclusions drawn by Potepan, finds income an influential determinant for household spending on home improvement as well. Montgomery also concludes that the age of the house and the length of time households occupy a house are relevant determinants for Own Home Investments. Montgomery gives an indication that though the speed of economic growth seems to be relevant for decisions regarding OHI, it is likely that these decisions are based on price expectations (Montgomery, 1992). Empirical evidence presented by Mendelsohn points to the idea that the age of a specific home is the only relevant predictor for home improvements (Mendelsohn, 1977). A similar conclusion has been reached by Chinloy who focusses on the cost of maintenance (Chinloy, 1980). Shear and Bogdon also come to the conclusion that age is a relevant factor, but in their research it is not the only significant predictor. Shear finds that structural soundness is a relevant factor as well (Shear, 1983). This seems logical, as a home would not need to be repaired if it is not broken. Bogdon finds that besides age square footing is a relevant determinant for renovation (Bogdon, 1992). This is a logical and intuitive conclusion as a large castle for example would require more maintenance at least from a cost perspective than a single story apartment.

Social capital is an important factor in determining renovations in central Eastern European countries. The study by Cirman et al supports the idea that physical characteristics of a home are important determinants for renovation, but it also illustrates that the social and therefore hard to quantify environment of an individual opting for a renovation is a determining factor (Cirman, Mandic, & Zoric, 2013). The idea that social capital is a relevant factor is supported by Helms who instead of social capital dubs it "neighborhood effects" (Helms, 2002).

The determinants found throughout the previously described quantitative research seem to be logical, intuitive and statistically relevant. These determinants for OHI are: the age of a home, the amount of time the current homeowner has resided in this particular home, social capital, the size of a home, structural soundness, short term interest rates and income.

WEAKNESSES OF RESEARCH SO FAR

The quantitative research found on own home improvement often stems from microdata and thus this type of research faces corresponding weaknesses. Research on LTV ratios and OHI is also often derived from microdata sets that are survey based (Cirman, Mandic, & Zoric, 2013) (Deniz, Heedon, Claessens, & Habermeier, 2011) (Chinloy, 1980) (Shear, 1983) (Gerlach-Kristen & Lyons, 2018) (Lambertini, Mendicino, & Punzi, 2013). In these surveys there are differences between individuals that can cause idiosyncratic behavior. Financial literacy for example can have an impact on the data causing bias to occur. This would be

exceptionally impactful for research that includes questionnaires about an respondent's financial situation which is the case for most. Another weakness of survey based micro datasets and corresponding research are the scope and the timing of these surveys. As Korteweg and Sorensen propose in their research on the estimation of Loan-To-Value ratios and foreclosure behavior, there is another shortcoming similar to financial literacy that could create bias in survey data (Korteweg & Sorensen, 2012). They point out that in research such as the work by Meltzer, homeowners might not be informed in a complete manner (Melzer, 2012). The differences that exist between microdata sets and the conclusions drawn from these sets illustrate how these sets are to a certain degree biased. Research by Cirman et al, for example, which focusses on OHI in Eastern Europe, is obviously biased because all data comes from these Eastern European surveys (Cirman, Mandic, & Zoric, 2013). Who is to say some amount of variation does not stem from cultural differences? Cross-country data could help reduce this weakness but as data would need to be on the individual level, the weaknesses of survey-based research remain. Chinloy reports on the difficulty of differentiating between spending on the house and the land upon which the house is built (Chinloy, 1980). Often questions in surveys do not differentiate between these two. In any situation where costs are shared between homeowners the results of surveys can also be inaccurate as shear proposes (Shear, 1983). If a survey is international, language issues could create bias when answering questions as connotations could differ.

In order to use these sources consistently the results of all relevant research should be placed next to each other as shall be attempted in the methodology chapter when choosing regression predictors. Theoretical research on LTVs and OHI can be based on discrete choice models. These models are a simplification of reality like all models and thus face their own shortcomings. Though often cited, the leverage cycle by Geanakoplos is an example of such a theoretical model that makes sizable assumptions (Geanakoplos, 2010). The first is that individuals behave rationally for example.

THEORY HYPOTHESIS

The previous paragraphs have emphasized the importance of the housing market for the general economy and how prices are a key element of the housing market. It has also become clear that when one invests into one's own home, the value of a property can increase. The leverage cycle illustrates how on a macro level, Loan-To-Value ratios can influence housing prices, but can Loan-To-Value ratios also influence Own Home Investment? If so, should it be included in the pantheon of predictors for OHI as described by Dipasquale (1999)? Literature and intuition insinuate there are many theoretical mechanisms through which LTV could influence OHI. Two of these mechanisms are discussed here: debt overhang, and more OHI through a higher level of capital. This chapter also contains ideas about possible endogeneity by individual appreciation for houses or housing price developments.

DEBT OVERHANG

Debt overhang is often defined as a state for an organization or entity where the debt one has accumulated is so large that this entity cannot take on additional debt even if this would be beneficial. When one relates this concept to the housing market the consequences seem clear from an intuitive standpoint. If one has a mortgage that is so large that a bank will not allow a second loan to finance OHI, this Own Home Investment cannot take place. There is more to this story however, as Melzer explains in his 2012 paper on debt overhang. Melzer claims that because individuals who are at risk of losing their collateral through loan default know what constitutes that collateral, they are less likely to invest in said collateral (Melzer, 2012). In other words: if a homeowner is unable to pay their mortgage and they are at risk of losing their home, they lose incentive to invest in said home. Meltzer illustrates that those who face default spend less on their house, and more on assets such as cars and appliances that are not seen as collateral for the mortgage. This idea has earlier applications in the corporate world with corporate debt overhang (Myers, 1977). This proves that "A long-standing and important idea in finance theory is that leverage can distort investment decisions" (Melzer, 2012). The higher a mortgage is compared to the value of a house the more likely it is that that homeowner cannot pay their mortgage in case of a crash. Because of this one could theorize that through this mechanism high LTVs lead to lower OHI.

MORE CAPITAL

If one has more income, it seems intuitive that one has more to spend if costs stay the same. The idea that this holds up for home improvements as well is supported by Bogdon's dissertation on the subject. She concludes that the relationship between own home improvement expenditure and income is inelastic, but also shows that these elasticities can vary widely and also differ greatly per type of renovation. Thus the income elasticity can range from 0.15 for roof replacements to 0.84 for new additions (Bogdon, 1992). This conclusion makes intuitive sense, as a roof needs to be repaired when broken, but a new addition to one's home is more of a luxury. Not all Own Home Investments are made strategically, sometimes something just needs to be repaired in order to keep a house functioning. Consequently, it can be said that the apparent intuitive correlation between income and home improvement is not as straight forward as one might think. When one thinks of an individual whose income is so constricting that there is almost no realistic way to pay for Own Home Investment, it seems clear that a lack of funds means Own Home Investments are impossible.

Thus income is a determining factor for OHI, but what about the LTV? If one where to imagine two homeowners in a hypothetical scenario that have similar income and whose houses are worth the same, it becomes possible to see how LTV could be relevant here. If one of these hypothetical individuals has a higher LTV than the other, their mortgage will be higher even though the home has the same value. Thus their monthly payments would be

higher as well, meaning they have less to spend each month and therefore less to spend on OHI. This effect is illustrated in the following model in which income, savings and expenses are the same for individuals a and b:

$$capital_a = income + savings - mortgage_a - expenses$$
$$capital_b = income + savings - mortgage_b - expenses$$
$$mortgage_a > mortgage_{\ b} \ \therefore \ capital_a < capital_b$$

When presented like this one could see that an increase in income or smaller mortgage payments amount to the same result in this case: more capital and therefore more available funds for OHI. We could therefore summarize that if one earns more, one has more cash available for Own Home Investments, and when one has a lower LTV because of a lower mortgage the effect is similar to earning more from a liquidity availability standpoint. The assumption would be that a lower higher LTV would mean a higher mortgage and therefore lower OHI because of a lack of funds.

INDIVIDUAL APPRECIATION OF HOUSING

Research points towards specific determinants for OHI as discussed in the previous chapter. Often these drivers are related to the house itself such as its age and physical state, but another important factor is an individual's opinion on the housing market in general.

People have different views on the housing market and they speculate on these views. One such view is an individual's opinion on housing prices. Do they correctly represent actual value or is the housing market overvalued? These views on housing prices affect an individual's behavior when choosing how high a mortgage to accept as has been explained by the leverage cycle. The same opinion however could be impactful on OHI as Dipasquale illustrates.

Dipasquale points out that if many people own a home, the decisions these people make regarding OHI are highly impactful on the supply of housing which would ultimately affect prices (Dipasquale, 1999). When an individual is capable of investing in one's own home it seems logical that they keep in mind the expected return on this investment. When regarding housing it becomes difficult to separate the utility people derive from the investment in one's own home that stems from a more enjoyable home, or the utility derived from a possible increased value of the house itself.

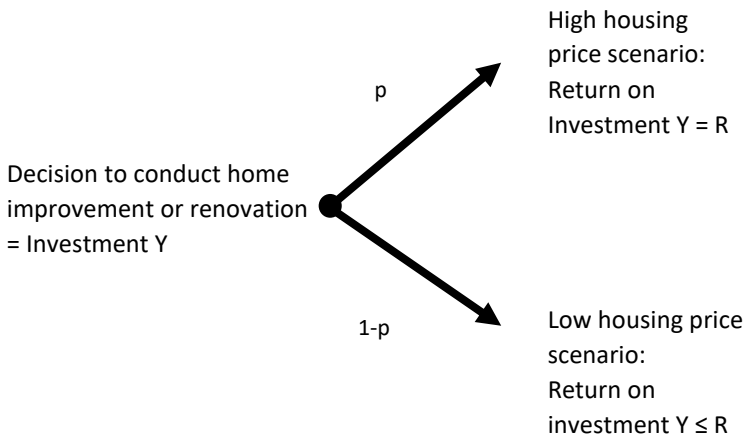

FIGURE 1: DIFFERENT SCENARIOS MEAN DIFFERENT PAYOFFS FOR OHI

A small discrete choice example illustrating the decisions an homeowner faces when choosing to invest in their own home is shown in figure 1

The above model shows that even though the exact quantities are unknown, it's possible to say that individuals who contemplate home remodeling have an incentive to think about housing price developments and weigh their opinion on this topic in their decision making process.

The previously discussed leverage cycle illustrates how individual personal ideas about market overvaluation or behavior can influence If one is more confident that housing prices will rise one might be open to bigger loans. This is the most basic way of explaining how expectations regarding housing price development influence Loan-To-Value ratios.

THE POSSIBILITY OF ENDOGENEITY BY INDIVIDUAL VIEWS ON THE HOUSING MARKET AND PERSONAL PROPERTY UTILITY

Though many possible mechanisms exist through which LTV could influence OHI the mechanisms that have been discussed here give sufficient reason to conduct empirical tests. When doing so there is the danger of possible omitted variable bias. The omitted variables in question are respondent's personal opinion on the housing market and an individual's personal property utility.

It has by now been established in the literature section of this thesis that it's not unreasonable to assume an individual's views on housing market behavior are impactful on OHI and LTV. This creates a problem when one tries to gain understanding of the relationship between LTV and OHI due to a bias that is known as omitted variable bias. Because housing price development expectations impact both LTV and OHI it becomes difficult to tell how much of the perceived influence of LTV on OHI stems from its own behavior, and how much is simply caused by housing price development expectations.

In his work about the leverage cycle Geanakoplos states that personal preference means that some individuals value some properties higher than their peers causing them to accept higher LTV ratios for said property (Geanakoplos, 2010). It seems logical then, that if one cares more for a specific property, one also invests more in said property. If an individual is willing to get a mortgage twice the size of a property's value for example, it seems plausible that this individual is also willing to spend more to keep the value of this property equal or even raise said value. This personal property utility could also be a cause of omitted variable bias.

RESEARCH QUESTION

Theory points to a connection between the Loan-To-Value ratio and Own Home Investment. Two mechanisms have been hypothesized, but it is likely many more exist. There are also variables that influence both LTV and OHI. An individual's opinion on the housing market or an individual utility of a specific home could both lead to an individual accepting a higher LTV. But these factors could also influence the amount of OHI. These hypothesized relationships are illustrated in figure 2.

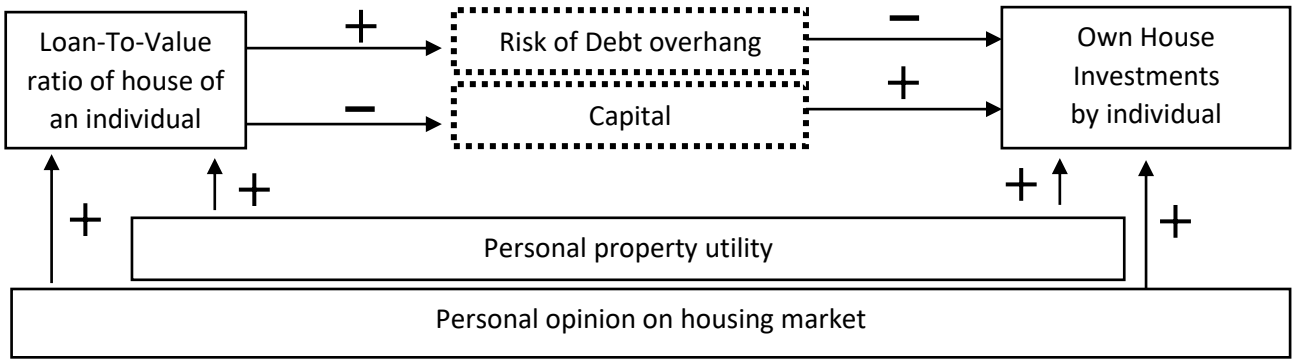

FIGURE 2: AN OVERVIEW OF RELATIONSHIPS, HYPOTHESIZED MECHANISMS AND ENDOGENEITY

As expectations about the housing market and external variables such as interest rates and housing market behavior could influence both the LTV and OHI, the question then becomes how much of the increase OHI can truly be attributed to an individual's Loan-To-Value ratio, and how much is simply caused by omitted variables that impact both the LTV and Own Home Investments. Given the effect of OHI on housing price, and housing prices role as an important fundamental of the housing market, the importance of gaining better understand of these effects for the overall economy seems clear. Policy should reflect the true effects that include the impact of omitted variables. If this is done governments can work towards policy that benefits society in an optimal fashion.

Based on the above described relationships the hypothesis proposed in this thesis is that higher Loan-To-Value ratios lead to lower Own Home Investments if opinions on the value of houses are not modelled as an omitted variable. When omitted variables are taken in to

account this relationship could lose significance. Thus this thesis aims to answer the following question:

Does a lower Loan-To-Value ratio lead to more Own Home Investment when talking into account possible endogeneity by Individual views on the housing market?

In order to answer this main question, it is important to first look at the effect of LTV on OHI without taking in to account the possibility of endogeneity. The first sub-question would thus be: '*Is LTV a significant predictor for OHI?'.* The direction of the relationship and the level of statistical significance should help in understanding the relationship between LTV and OHI. It will still be unclear how much of this relationship is caused by an individual's opinion on the housing market. Because if this the following sub-question needs to be answered: *'Is an individual's opinion on the value of houses a cause of endogeneity?'.*

DATA

The data used in this research stems from the Dutch household survey and the central Dutch statistical agency (DHS data acces, 2021) (CBS, 2021). Every year about 2000 respondents fill in the DHS survey that contains a wide range of questions regarding mortgages, housing market expectations and other factors. All quantitative research on own home improvement discussed in this thesis uses microdata to express statistical determinants for Own Home Investment. The reason microdata is often used in research on OHI is also the same reason micro data is used in this thesis: because of its disaggregated level of information. Data availability is an important factor in this. Discrete choice models that are sometimes used often give only theoretical implications, and macro data on Own Home Investment would not be suitable to aid in determining factors such as housing price development expectations which need to be measured on the individual level. The Dutch Household survey is thorough and has also been running since 1993. Because of this, this particular survey is well suited to conduct research on OHI and LTV ratios.

As claimed by Helms one of the shortcomings of microdata sets such as the one used here is that not all data filled out by respondents corresponds to the same point in time (Helms, 2002). In this specific case the date of home acquisition and survey response are rarely equal. In other words, one could say respondents fill out their opinion on housing price development at the time of the survey, but when they fill out the size of their mortgage this corresponds to the mortgage at the time of home acquisition which could be many years earlier than the survey. When looking at the causality between elements the shortcomings that are caused by this data property are obvious. It is impossible to do any kind of regression that has LTV as a dependent variable, because all possible independent variables occur later in time. This automatically leads to the biggest assumption made in this thesis: individual opinions about housing over and under valuation stay similar over time. This

thesis assumes in other words, that an individual who believes the market is overvalued at the time of the survey also thought this was the case when they acquired their property.

Because housing prices can differ quite extensively between individuals it is hard to distinguish between housing and mortgage prices that are real and very high or low, and housing prices that have simply been filled out by respondents. Often questions regarding large sums in euros are meant to be filled in as one thousandth of the actual number. Respondents are asked for example to fill out the size of their mortgage (*1000). This kind of questioning has obviously confused some respondents, but it is hard to determine if a respondent simply has a very cheap or expensive mortgage or has filled out the questionnaire wrong. Because of this difficulty the decision has been made in this thesis to not correct or delete individual cases put place a cap on LTV at 5. This means that this thesis considers every individual who has filled out the survey in such a way that the Loan-To-Value ratio is higher than five has not filled out the survey correctly. As the Loan-To-Value ratio is calculated using mortgage and housing price at the time of purchase this means that if a respondent has incorrectly filled out either one of these questions to an extend that leads the LTV to be higher than 5 this respondent is deemed to not be representative. The height of the level has been chosen at 5 because it seems very rare that a real-life situation includes a scenario where an individual acquires a mortgage that is five times the value of the acquired property.

The data set is missing individual level data regarding social capital. In order to correctly use social capital as a predictor a researcher would need to know something about the level of social integration of a respondent in their neighborhood. This could be done by asking respondents how well they know their neighbors for example. Because of a lack of data in this aspect social capital cannot be taken in to account when performing the regressions. There is also no real data available on the personal property utility. Because of this lack of information it is impossible to include it in the statistical research. The data set also lacks data on structural soundness which could be a relevant predictor for OHI.

Though the size of the data set is substantial with around 2000 respondents per year, the amount of respondents who filled out all questions required to answer questions posed in this thesis is significantly smaller. The questions on OHI have been added in 2012, therefore there is no data on the subject before this date seriously limiting the amount of data available. Because of this, more complicated analysis using follow-up questions becomes extremely complicated as these questions enjoy very few responses. This lack of data creates limitations on the possibilities for specific research methods.

EMPIRICAL APPROACH

The empirical approach used in this research knows three distinct steps. Firstly, a normal OLS regression is performed to gain understanding of the determinants of Own Home Investment and see how they align with the determinants described in the literature section. This regression could also be used later on in a comparison between the Instrumental Variable regression and this regular one. The variables used in this regression are largely the same as in the next step and stem from the related literature as has been discussed in the literature chapter. The second step of the empirical approach is the IV regression itself. Lastly, the quality of the IV regression is evaluated empirically.

THE DEPENDENT VARIABLES

The dependent variable in this case is OHI and like the other microdata used it stems from the DHS household survey (DHS data acces, 2021). In this thesis small home repairs are not seen as being substantially different then large home improvements such as an extra bathroom. Whilst research has shown that elasticities for these different kind of home improvement or repairs vary wildly (Bogdon, 1992), this research does not discriminate between different types of home improvement. The dependent variable is measured in euros and shows how much a household has spent on home improvements in the past year (CBS, 2021). As an evaluation of OHI has demonstrated it is a highly skewed variable the logarithm of OHI is used instead of OHI.

INDEPENDENT VARIABLES

As the focus of this thesis lies with the effect Loan-To-Value ratios have on Own Home Investment, the LTV is the most important independent variable. In order to gain insight in the hypothesized relationship between LTV and OHI a complete regression must be created that incorporates the elements that according to literature are most influential. These control variables have all been discussed in the previous literature chapter. They have been summarized here in a table that indicates what variable has been found a significant predictor by whom, and whether or not the data is available for integration in a regression.

Variable:	Included because of research by:	Data availability:
Interest rates (short term)	(Potepan, 1989)	(CBS, 2021)
period of construction of house	(Chinloy, 1980) (Cirman, Mandic, & Zoric, 2013) (Potepan, 1989) (Bogdon, 1992) (Shear, 1983)	(DHS data acces, 2021)
Length of time living in house	(Cirman, Mandic, & Zoric, 2013)	(DHS data acces, 2021)
income	(Bogdon, 1992) (Cirman, Mandic, & Zoric, 2013) (Montgomery, 1992)	(DHS data acces, 2021)
Social capital	(Helms, 2002)	unavailable
Size of house	(Bogdon, 1992)	(DHS data acces, 2021)
Structural soundness	(Shear, 1983)	unavailable
House price expectations	(Case & Shiller, 2003) (Shiller R. J., 2007) (Lambertini, Mendicino, & Punzi, 2013)	(DHS data acces, 2021)

TABLE 1: DETERMINANTS FOR OHI IN LITERATURE

Out of the control variables proposed by literature there are those who cannot be incorporated into this research because of data availability. The variables in question are structural soundness and social capital. Social capital is hard to measure and the questionnaire that is the main data source for this thesis contains no questions that could serve as a relevant proxy for social capital. Because of this social capital cannot be used in the regressions even though its relevance has been established. The second variable for which there is no data available is the structural soundness. It seems obvious that this is an important factor when looking at OHI, especially for the renovation side. The lack of available data on this topic means that the regressions will lose some significant explanatory power.

The above discussed variables are to be included in the regression based on the support for their influence in literature. There are other factors that literature does not support as they have not been found to be significant predictors in the past. These other factors must nevertheless be included in at least some of the regressions in order to check robustness but also gain some level of completeness. The variables should include an indication of macro-economic development in the form of GDP, an indication of housing market development and an indication of demographic development.

Economic development is obviously important for housing prices as buying a home is the biggest investment or expense many individuals will make in their lifetime. As discussed in the introduction, there is proof that the broader economy and the housing market are heavily intertwined. Thus GDP is a sensible element to add to the regression as a control variable for economic activity. OHI is also related to housing demand and supply as Shear proposed, since individuals weigh the options to move or renovate against each other (Shear, 1983). Because of this it is relevant to add a measure of the supply of housing. By

subtracting the amount of houses from the number of households in the Netherlands it is possible to create a variable that is an indication of this housing supply relative to the demand. This measure of the supply of housing does not show the complete picture, especially during a shortage. Often a housing shortage is disproportionally impactful on those who have yet to buy their first home (McKee, 2012). In order to take this extra element in to account as well a variable should be added that illustrates the demographics of the Dutch population. A percentage indicating the share of Dutch population between 20 and 40 years old could be seen as a proxy for the amount of people in the age group that is searching for their first home.

TABLE 2: MACROECONOMIC, HOUSING MARKET AND DEMOGRAPHIC CONTROL VARIABLES

Variable:	Included as a:	Data availability:
GDP	Control variable for economic development	(CBS, 2021)
Amount of households minus amount the number of houses	Control variable for housing market development	(CBS, 2021)
Percentage of population between 20 and 40 years old	Control variable for demographic development	(CBS, 2021)

AN OLS REGRESSION FOR THE LOGARITHM OF OHI

As discussed, a standard OLS regression can give an indication of the effect of LTV on OHI. The identification of incorporated variables stems from literature. It is clear that the age of the home should be included as it is the only variable that is consistently significant in literature. Because Cirman et al pointed to the amount of time an individual has been living in their home as a relevant factor this has been included as well (Cirman, Mandic, & Zoric, 2013). This also makes intuitive sense as it seems logical that an individual who just moved is more likely to invest in one's own home than someone else. Income has been included as a control variable as Bogdon and Montgomery point out it can be relevant for OHI (Bogdon, 1992) (Montgomery, 1992). In order to include an individual's opinion on housing price behavior the percentage that individual thinks the housing market is over or under valuated at the time of the questionnaire has been added as an independent variable. Lastly, two macroeconomic variables have been added: the Dutch GDP expressed in millions of euros and short term interest rates. Because data regarding OHI is only present for years later than 2011, the regression will focus on the period between 2011 and 2020. For reasons highlighted in the data chapter, datapoints with an LTV higher than 5 have not been taken into account.

The below formula describes the regression discussed:

$$Y_i = \propto_0 + \rho Z_i + \mu Q_i + \omega_a A_i + \omega_b B_i + \omega_c C_i + \cdots + e_i$$

Dependent variable:

- Y = logarithmic function of Own Home Investment in euros in the past year

Independent variable:

- Z = LTV : the Loan-To-Value ratio at the time of home acquisition

Control variables:

- Q = percentage the housing market is over or under valuated according to the respondent
- A = the period a house was built with 5-year intervals
- B = the year of acquisition of the house
- C = income in euros
- D = Dutch GDP in the year of the survey in millions of euros
- E = short term interest rates on a yearly basis
- F = percentage the housing market is over or under valuated according to the respondent

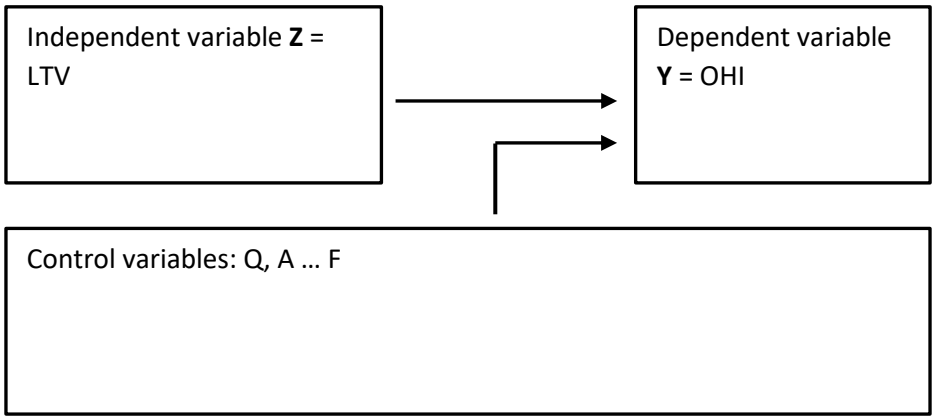

FIGURE 3: VISUALIZATION OF REGRESSION SETUP

AN INSTRUMENTAL VARIABLE REGRESSION

After a standard IV regression has been performed an Instrumental Variable approach is used that can shed some light on the possibility of omitted variable bias caused by an individual's opinion about housing market prices. The data from the survey rarely concerns the same individuals, therefore it cannot be described as panel data. Because of this the fixed effects methodology or time series models proposed (Rossi, 2014) are not feasible directions in order to deal with possible endogeneity problems. As the nature of the explanatory variable is continuous, and essential heterogeneity is a concern, the most logical

path forward is an Instrumental Variable approach (Sande & Ghosh, 2018). The first step in this process is determining possible instruments for the LTV.

CHOOSING INSTRUMENTS

In order to conduct an Instrumental Variable regression and gain better understanding of the possible endogeneity of housing price development expectations the correct instruments must be chosen. These instruments must enjoy some level of causality with the first stage, be independent of Own Home Improvements and satisfy the exclusion restriction.

The likelihood of satisfying the relevance assumption or first stage causality becomes larger when Instrumental Variables clearly describe the unit of analysis and are more related to the data set. An instrument that satisfies these conditions has been found in the survey. This instrument is the answer to the question: 'would you have gotten a higher mortgage if you would be allowed to do so?'. In order to satisfy the independence assumption or increase the likelihood that the exogeneity assumption is satisfied, an Instrumental Variable should be more distant from the unit of analysis whilst retaining a causal connection with the first stage. This would require instruments that lie further away from the data set such as regulatory or environmental variables (Sande & Ghosh, 2018). The instrument that has been found in this paper that approaches these conditions is the limit the Dutch government places on the maximum legal LTV.

LTV MAXIMUM

The LTV maximum is an indicator of the highest LTV that the government considers legal. Dutch regulators have created a maximum for the LTV in order to diminish behavior as described by the leverage cycle (Rijksoverheid, 2020). This method has become more common globally and limits on LTV ratios are widely used in a number of countries. This LTV roof can be used as an instrument to perform a more specific analysis of the relationship between the LTV and housing prices in the Dutch case.

Since the implementation of LTV limits by the Dutch government, average LTV ratios of newly built properties have slowed down noticeably. Loan level data from the Dutch national bank shows that average LTVs for those entering the housing market for the first time has steadily gone down since the implementation of the limits on LTV (Rijksoverheid, 2020). This would seem to indicate that the maximum LTV ratio could be used as a possible instrument for the LTV ratio itself. This idea is supported by evidence by Wong et al. (2011), who see a limited effect of maximum LTV ratios on mortgage delinquency in a cross-country study (Wong, Fong, & Choi, 2011). Similarly, Gerlach-Kristen and Lyons (2018) show using micro-data that defaults tend to be more common in countries with high LTV ratios,

indicating there is a connection between LTV ratios and the amount of individuals who cannot pay back their mortgage (Gerlach-Kristen & Lyons, 2018).

There are however also sources who place doubt on the use of limits on Loan-To-Value ratios as an instrument for the Loan-To-Value ratio itself. Deniz et al. find that limits on Loan-To-Value and debt-to-income ratios are associated with a decline in house price appreciation which is in line with other findings discussed so far. They however also find that the limits a government places on LTVs also alter expectations (Deniz, Heedon, Claessens, & Habermeier, 2011). The reason for performing an IV based regression is to understand the effect of LTV on OHI whilst taking into account the possible endogeneity of individual expectations of housing market prices. Because of this a connection between these expectations and a legal maximum on LTV would mean that LTV Is not a good instrument.

Grodecka uses Swedish microdata to illustrate that an LTV limit might even raise household prices whilst the debt-to-GDP ratio remains the same. This illustrates that an LTV limit could affect housing prices without altering LTV ratios (Grodecka, 2020). This idea is supported by research by Crowe et al. who find there is a positive correlation between the LTV maximum and housing prices (Crowe, Dell'Ariccia, Igan, & Rabanal, 2011).

More recent research using loan level data points to very specific percentages of 70% to 80% for uninsured homes and 90% for houses that are insured (de Haan & Mastrogiacomo, 2020). This specific cap is an obvious indication of the fact that an LTV limit can impact the LTV.

- **First stage causality:** The causal relationship between LTV and the maximum legal LTV must still be checked statistically. Data from the DNB shows that changes in the maximum legal LTV have had a significant effect on the average height of LTV (Rijksoverheid, 2020).
- **Independence assumption:** The maximum legal LTV influences housing prices only through the treatment variable which in this case is the LTV itself. There is no reason to assume a limit on LTV has a direct impact on OHI without the intermediary step of LTV in between.

WOULD YOU HAVE GOTTEN A BIGGER MORTGAGE?

This specific question in the survey asks respondents to state if they would have gotten a higher mortgage if this would have been accepted by the bank. This question is a good indicator if an individual were willing to get the highest loan they could get. As the LTV is calculated by looking at the size of a loan relative to the price of a house this indication could be a relevant instrument. There is no real literature on the subject as the question is specific tot his data set. Except for intuition pointing to the appropriateness of this measure as an instrument for Loan-To-Value ratios, there is no academic support for this as of yet. Statistical evaluation of this instrument shown in the results could help illuminate the appropriateness of this instrument ex ante. For now one could carefully say that as an

instrument, the answer to the question if people would have gotten a higher mortgage if they could does not break the independence assumption. Individuals buying a house with a loan can only affect the value of their property through the size of the loan they take out. Because of this, this instrument influences housing price only through the LTV satisfying the independence assumption. It's also clear there is some first stage causality as those who wish to borrow a high sum also acquire higher mortgages when possible, and mortgage size is an element of the LTV the first stage causality seems satisfied in theory.

- **First stage causality:** the causal relationship between the answer to the question: would you have gotten a bigger mortgage" and the LTV seems to be causal enough to use this instrument. It's safe to say that those who would not have gotten a bigger mortgage did not borrow the maximum they could and vice versa.
- **Independence assumption:** There is no reason to assume that the answer to the question: would you have gotten a bigger mortgage" has a direct influence on OHI.

OPERATIONALIZATION OF IV

Now that two possible instruments have been chosen, they can be added to the Instrumental Variable regression in the manner visualized in figure 4.

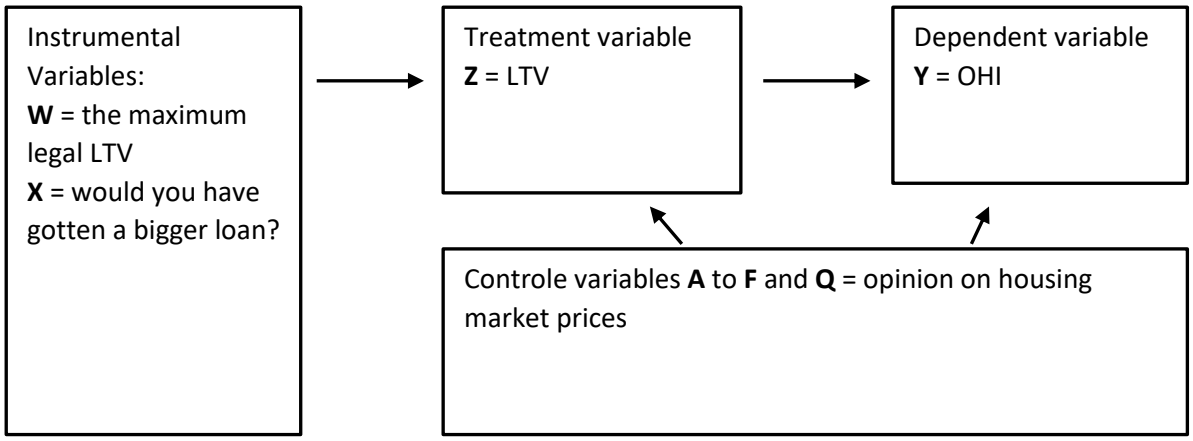

FIGURE 4: VISUALIZATION OF IV REGRESSION

The operationalization of the experiment shown in the diagram above knows three distinct elements. Firstly, there is the reduced form, secondly there is the first stage, and lastly the 2SLS second stage.

Reduced form:

$$Y_i = \propto_0 + \rho W_i + \mu X_i + \gamma_0 Q_i + \omega_{a0} A_i + \cdots + \omega_{F0} F_i + e_{0,i}$$

The reduced form in this case states that the value “Y” or Own Home Investment by household “i” at time of survey T can be estimated using the maximum legal LTV as Instrument “W”, “if people would have accepted a larger mortgage” as Instrument Q, and control variables ”A” to “F” .

First stage:

$$Z_i = \propto_1 + \Phi W_{i,T} + \Phi X_{i,T} + \gamma_1 A_{i,T} + \omega_1 B_{i,T+t} + \cdots + e_{1,i}$$

$$\hat{Z} = \propto_1 + \Phi W_{i,T} + \Phi X_{i,T} + \gamma_1 A_{i,T} + \omega_1 B_{i,T+t} + \cdots$$

The first stage regression estimates a value for LTV based on control variables A to F and Instruments W and X.

Two-Stage least squares (2SLS) second stage:

$$Y_i = \propto_2 + \lambda_{2SLS}\widehat{D}_i + \gamma_2 A_i + \omega_2 B_i + \cdots + e_{2,i}$$

The 2SLS second stage shows how value “Y” denoting the logarithm of the amount of money spent on OHI by respondent “i” can be estimated by using the estimated values for LTV for household “i” $\hat{Z}$ and control variables A to F.

EVALUATING THE INSTRUMENTAL VARIABLES EMPIRICALLY

In order gain a better understanding of the validity of instruments and the different models in general several test can be performed. The strength of the instruments needs to be evaluated numerically, and the level of endogeneity can be quantified. Though these values would not give a complete view of the situation they can strengthen or weaken the validity of the analysis.

When assessing the relevance of IVs it is important to look at the first stage data. By looking at the at the Cragg-Donald Wald F-statistic and comparing it to Stock-Yogo values from their 2005 paper the strength of instruments can be assessed (Stock & Yogo, 2005). The for this thesis relevant critical values described by Stock and Yogo are presented in table 3.

TABLE 3: CRITICAL VALUES FOR THE WEAK INSTRUMENT TEST

Accepted level of bias	Critical Values for the Weak Instrument Test (Stock & Yogo, 2005)						
0.05	15.75	16.88	17.70	17.70	18.30	18.30	18.76
0.10	9.48	9.92	10.22	10.22	10.43	10.43	10.58

Though the comparison of the F-statistic with the critical values described by Stock-Yogo is the method preferred in this thesis other options exist as well. If instruments are weak, the preferred estimator is Moreira's Conditional Likelihood Ratio (Bascle, 2008). If a single instrument is used it should be possible to conduct an Anderson Rubin test (Anderson & Rubin, 1949). If both instruments are used a conditional likelihood test should prove most informative. Both these tests as does the Cragg- Donald Wald test have a zero hypothesis that claims the coefficient of the endogenous regressor equals to the interceptor of the regression line. If this hypothesis is rejected the instruments are endogenous which is not preferred as it indicates that the instruments might not be strong enough to draw conclusions from (Andrews, 2005).

RESULTS

The results of the standard OLS regressions are shown in table 4. As the dependent variable is the logarithm of Own Home Investments, the coefficients can be interpreted as percentual change in Own Home Investment.

The different models illustrate different versions of the regression, some of which incorporate more control variables than others. Model 1 includes the basic results of a regression that does not take into account macroeconomic developments and only includes data from the DHS data set. Models 2 and 3 do feature macroeconomic factors, namely GDP and short-term interest rates. They are not statistically significant, with or without the addition of the percentage that indicates an individual's belief the market is over or under valuated. Thus the results shown here are in line with Potepan and Bogdon, but unlike research conducted by Potepan short term interest rates do not appear to be statistically significant (Potepan, 1989). Models 4 and 5 feature the living room size which serves as an indication of the size of a home. Bogdon finds this is a significant predictor and it is seen here that this is the case with this data set as well (Bogdon, 1992). The size of a home's living room seems to be a significant though weak predictor for OHI. The addition of the size of a living room means that the LTV will cease to be statistically significant. Models 6 and 7 include the number of households relative to the available homes in the Netherlands and the percentage of individuals between 20 and 40 years old. One could assume that they would be influential predictors for OHI based on the research by Shear who illustrates that individuals weigh OHI and moving to a new home against each other (Shear, 1983). The inclusion of these variables seems does not change much of the overall regression and their coefficients are not statistically significant.

TABLE 4: OLS REGRESSION RESULTS

	Regressions						
logarithm of Own Home Investment	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	b/se	b/se	b/se	b/se	b/se	b/se	b/se
LTV	-0.214*	-0.221*	-0.212*	-0.162	-0.114	-0.222*	-0.214*
	(0.09)	(0.09)	(0.09)	(0.10)	(0.10)	(0.09)	(0.09)
period house built (5-year intervals)	-0.039***	-0.039***	-0.038***	-0.039***	-0.037***	-0.039***	-0.038***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Year house acquired (year)	0.010***	0.012***	0.011***	0.012***	0.010***	0.012***	0.011***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Total net income of household (euro* 1000)	0.147***	0.141***	0.148***	0.112***	0.130***	0.141***	0.148***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Percentage housing market over or under valuated	0.013		0.015		0.013		0.016
	(0.01)		(0.01)		(0.01)		(0.01)
GDP (in millions of euros)		-0.000	0.000	-0.000	-0.000	0.000	0.000
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Short term interest rates		0.121	0.205	-0.032	0.014	0.593	0.532
		(0.17)	(0.18)	(0.20)	(0.21)	(0.76)	(0.78)
size living room (square meters)				0.002*	0.002*		
				(0.00)	(0.00)		
number of households minus available houses						0.000	-0.000
						(0.00)	(0.00)
percentage of population between 20 and 40 years old						-0.744	-0.484
						(1.23)	(1.27)
constant	-13.487**	-16.294***	-14.463**	-15.884**	-12.578*	-0.591	-4.260
	(4.65)	(4.58)	(4.69)	(4.91)	(5.11)	(26.45)	(27.27)
R-sqr	0.052	0.051	0.054	0.047	0.050	0.051	0.054
dfres	2235	2520	2233	2138	1890	2518	2231
BIC	7916.3	9053.1	7928.4	7574.0	6655.6	9068.1	7943.2

* p<0.05, ** p<0.01, *** p<0.001

In line with literature it has been found here that the age of a home is an significant predictor for Own Home Investment (Chinloy, 1980) (Cirman, Mandic, & Zoric, 2013) (Potepan, 1989) (Bogdon, 1992) (Shear, 1983). The correlation found here is negative, and it shows that households will spend around 0.04% more on own home improvements per 5-year age increase of a home. Similarly robust results are found for income and the age a house was acquired. A home which has been bought in a more recent year can lead to an 0.01 % increase in Own Home Investment. An increase in yearly income of a household of 1000 euros is associated with an increase Own Home Investment of 0.11 to 0.15 %. It appears that the LTV is a significant predictor for Own Home Investment as hypothesized. An increase in The LTV of 1 percentage point is associated with a decrease in Own Home Investment of 0.21 to 0.22 %. This seems to correspond to the hypothesis that those with a higher LTV have less to spend on OHI or that they have less incentive to do so as they are at higher risk of default. A respondent's opinion about the housing market, which is expressed as the percentage they think the housing market is overvalued or under valuated, does not prove to be a significant predictor for Own Home Investment. Thus the hypothesis that this was so does not hold up in this regression.

It is worth mentioning that the R-squared value of all models lies between 0.05 and 0.06, indicating that only a little over 5 % of the variance in Own Home Investment can be explained by the predictors taken into account in this model. Thus over 94% of variance must be explained by other factors. As discussed, there are two major predictors that could not be incorporated in this model but should be from a theoretical standpoint. The first is social capital, and the second is structural soundness. It is possible that at least some of the variance left unexplained here can be attributed to these two missing variables.

The OLS regression is informative regarding the relationship between LTV and OHI. This thesis also takes interest in the influence of LTV on OHI whilst taking in to account the fact that different variables might impact both LTV and OHI. The Instrumental Variable regression that has been performed shows that when this effect is taken in to account the LTV is not a significant predictor for OHI, though these results are most likely biased as the F-statistic illustrates. Only model 8 has a F-value that is higher than the prescribed value by Stock and Yogo for the 5% bias threshold (Stock & Yogo, 2005). The other models have F-values that are higher than the 10% bias threshold. This means that the chance that the models are biased by more than 10% is small. Though this may be the case, the instrumented variables explain very little variance in LTV. Because of this, conclusions from the Instrumental Variable regression should interpreted carefully and in a reserved manner.

Like for the normal OLS regression discussed earlier, the fist Instrumental Variable model is quite basic and does not take in to account macroeconomic developments. Its visible that in this model neither the LTV or the respondent's opinion on the over or undervaluation of the housing market are significant predictors for OHI. Models 9 and 10 do include GDP and short-term interest rates but they are not significant. Models 11 and 12 show that the size of a living room is a significant predictor for Own Home Investment. Models 13 and 14 show that demographics and the supply of houses relative to the amount of households are not significant predictors. The age of a house, how long someone has been living there, and

TABLE 5: IV REGRESSION RESULTS

second stage of Instrumental Variable regression (2 instruments)							
logarithm of Own Home Investment	Model 8 b/se	Model 9 b/se	Model 10 b/se	Model 11 b/se	Model 12 b/se	Model 13 b/se	Model 14 b/se
LTV	-1.828	-1.309	-1.448	-1.070	-1.095	-1.267	-1.272
	(1.11)	(1.20)	(1.08)	(1.14)	(1.06)	(1.23)	(1.09)
period house built (5-year intervals)	-0.058***	-0.052**	-0.053***	-0.050**	-0.049**	-0.051**	-0.051***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Year house acquired (year)	0.015***	0.015***	0.014***	0.015***	0.014**	0.015***	0.014***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Total net income of household (euro)	0.165***	0.154***	0.162***	0.120***	0.138***	0.153***	0.160***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Percentage housing market over or under valuated	0.012		0.013		0.012		0.015
	(0.01)		(0.01)		(0.01)		(0.01)
GDP (in millions of euros)		-0.000	-0.000	-0.000	-0.000	0.000	0.000
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Short term interest rates		0.071	0.146	-0.107	-0.054	0.467	0.358
		(0.18)	(0.19)	(0.23)	(0.23)	(0.80)	(0.82)
size living room (square meters)				0.002	0.002		
				(0.00)	(0.00)		
number of households minus available houses						0.000	-0.000
						(0.00)	(0.00)
percentage of population between 20 and 40 years old						-0.598	-0.253
						(1.27)	(1.32)
constant	-21.364**	-21.570**	-20.284**	-20.591**	-17.882*	-8776	-14.172
	(7.27)	(7.29)	(7.05)	(7.74)	(7.79)	(28.83)	(30.16)
N	2241	2527	2241	2146	1899	2527	2241
First stage statistics							
F (first stage)	17.75***	15.59***	13.58***	14.31***	12.78***	12.47***	11.03***

* p<0.05, ** p<0.01, *** p<0.001

income are consistently significant. In all models they show significance above the 0.001 threshold. The size of a home as represented by the living room size is also a significant predictor above the 0.05 threshold. Thus one could say that the age of a home, the length of time someone has lived there, an individual's income and the size of a house are all significant predictors for OHI. This thesis finds conclusions that align with earlier literature on the subject by (Chinloy, 1980) (Cirman, Mandic, & Zoric, 2013) (Potepan, 1989) (Bogdon, 1992) (Shear, 1983) (Montgomery, 1992). The significance of the LTV in the regular OLS regression does not hold up in IV and because if this one could say that the influence the LTV appears to have on OHI is most likely caused by the size of a home or other variables that are not present in the model.

DISCUSSION AND CONCLUSION

In this thesis the relationship between LTV and OHI has been assessed using different regression based techniques. It has been found that when controlling for macroeconomic and demographic factors, a higher LTV leads to lower OHI. This relationship loses significance however if a control variable for the size of a home is added: the size of the living room. Other predictors for OHI that have been found significant in existing literature have also been reestablished as significant predictors for OHI with a modern data set. Because of this conformation of existing conclusions with a new data set, this thesis has added to the overall larger literature on OHI determinants. The determinants that have been found significant in this thesis are the age of a home, how long an individual has lived there, and income. When LTV is instrumentalized in an Instrumental Variable regression, the relationship between LTV and OHI loses significance. This indicates that the relationship between LTV and OHI could be a symptom of omitted variable bias. Instruments however are not very strong, so any and all conclusions from the Instrumental Variable regression are not strong enough to base policy on. The origin of the omitted variable bias remains unclear, as the hypothesized source remains statistically unsignificant. It has been found that an individual's opinion on the overvaluation of the housing market is not a significant source of bias as it does not correlate with predicted LTV or OHI. Overall one could say that policy makers might refrain from regulating OHI through LTV's as it is doubtful a significant impact can be made.

The exact nature of the omitted variable bias could be a topic of future research. It could also be prudent to look into specific mechanisms such as debt overhang with a large data set in order to understand if specific mechanisms are influential predictors for OHI. As this thesis assumes that individual opinions of respondents regarding the overvaluation of the housing market stay constant over time, future research could be conducted to see if the conclusions presented here hold up without this assumption. In order to conduct such research, the opinions of respondents need to be known at the time they buy a home instead of at the time they fill out a survey. In order to continue the search for a more complete set of determinants for OHI future research should include structural soundness as well as social capital. A last possible direction of future research would be to separate specific parts of OHI based on elasticity before looking into determinants. The elasticity of specific home

improvements is an indication of its level of necessity or luxury. By separating them from each other a more inclusive set of regression formulas could be created.

APPENDIX A

This appendix contains the results of the Instrumental Variable regression described in the method chapter if the legal LTV limit has been taken out as an instrument. This table serves as a comparison table to understand how results differ if the weakest instrument is removed.

TABLE 6: IV REGRESSION RESULTS WITH ONE INSTRUMENT

second stage of Instrumental Variable regression (1 instrument)							
logarithm of Own Home Investment	Model 8 b/se	Model 9 b/se	Model 10 b/se	Model 11 b/se	Model 12 b/se	Model 13 b/se	Model 14 b/se
LTV	-1.507	-1.356	-1.517	-1.028	-1.042	-1.348	-1.516
	(1.08)	(1.18)	(1.09)	(1.15)	(1.07)	(1.18)	(1.10)
period house built (5year intervals)	-0.054***	-0.052**	-0.054***	-0.049**	-0.049**	-0.052**	-0.054***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Year house acquired (year)	0.014***	0.015***	0.014***	0.015***	0.013**	0.015***	0.014***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Total net income of household (euro)	0.161***	0.155***	0.163***	0.119***	0.137***	0.154***	0.163***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)
Percentage housing market over or under valuated	0.012		0.013		0.012		0.014
	(0.01)		(0.01)		(0.01)		(0.01)
GDP (in millions of euros)		-0.000	-0.000	-0.000	-0.000	0.000	0.000
		(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Short term interest rates		0.069	0.142	-0.104	-0.050	0.457	0.317
		(0.18)	(0.19)	(0.23)	(0.23)	(0.80)	(0.85)
size living room (square meters)				0.002	0.002		
				(0.00)	(0.00)		
number of households minus available houses						0.000	-0.000
						(0.00)	(0.00)
percentage of population between 20 and 40 years old						-0.587	-0.200
						(1.27)	(1.35)
constant	-19.797**	-21.796**	-20.610**	-20.374**	-17.597*	-9.410	-16.457
	(7.32)	(7.46)	(7.18)	(7.77)	(7.84)	(28.95)	(30.56)
N	2241	2527	2241	2146	1899	2527	2241

* p<0.05, ** p<0.01, *** p<0.001

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