Residential mortgage lending and energy-efficient homes
A study on the loan-to-value ratio in relationship to residential energy labels of Dutch households

Abstract

We are on the verge of an energy transition in the Netherlands. However, this transition seems rather problematic. Many homeowners miss funds to invest in the energy efficiency of their homes because of the sharply rising housing prices market. Therefore the question arises, to what extent the mortgage lending of Dutch households is associated with the energy efficiency of their home on the verge of the energy transition? The research problem of this study is the relationship between the loan-to-value ratio of new loans and residential energy labels. This study makes use of CLRM and the data is provided by the Dutch Land Registry Office. The main findings show that residential energy labels are negatively related to the loan-to-value ratio of new loans in the Netherlands between 2019 and 2020. In addition to this, the findings reveal that households with the most efficient dwelling have the lowest loan-to-value ratio. Followed up by households with the second most efficient dwelling, etcetera. An explanation for the higher loan-to-value ratios on less energy-efficient housing could be the maximum 106 percent loan-to-value ratio (instead of 100 percent) for sustainability upgrades. However, these higher loan-to-value ratios combined with an inefficient label might result in high mortgage- and energy expenditures. This comes with a higher risk of mortgage arrears and ultimately no improvements in the energy efficiency of the dwelling. Therefore, the findings of this study underline the earlier observed problem for households with an inefficient energy label in terms of mortgage risk and the progress of the Dutch energy transition.

Keywords: Energy labels, Loan-to-value ratio, Residential mortgage lending, Energy efficiency

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1. Introduction

1.1 Motivation

We are on the verge of an energy transition in the Netherlands. The climate is changing rapidly worldwide and to achieve the goal of the Paris Climate Agreement by 2050 action needs to be undertaken. Energy savings can reduce CO2 emissions from households' heating consumption by 50 to 80 percent in 2050 compared to 2010 (PBL, 2021). However, to achieve this, more than seven million houses (and one million buildings) must be transformed into sustainable housing by the property owners (RIVM, 2021). This transition seems rather problematic because many homeowners miss funds to invest. This is particularly problematic in the current overheated housing market in the Netherlands. In brief, there is an ongoing housing market shortage, with the supply of homes for sale being at a historical low (ING, 2021; De Groot et al., 2021). The current situation drives buyers to bid against each other (Trouw, 2021). Statistics Netherlands and the Dutch Land Registry Office (2021a) even observed the highest price increase of owner-occupied homes in almost 20 years. This is not without risk. Bidding against each other can lead to rather high loan-to-value ratios[1] (LTV) and to extra down payments that may reduce the financing of the upcoming energy transition (NU.nl, 2021).

The upcoming energy transition and associated investments depend on the current energy efficiency of the house. The energy label of properties provides the household information on the energy efficiency of the house. The most energy-efficient homes have a rating of A, the least energy-efficient get a G (Government of the Netherlands, 2021ab). To create further awareness among potential buyers about the energy efficiency, properties must have an energy label at the time of selling since 2015. According to Statistics Netherlands (2016), the most energy-efficient households (label A) have lower energy costs than less energy-efficient households (label C). However, to improve the energy efficiency of a dwelling, financing is needed. Not all owner-occupiers have enough funds to pay for these improvements. Therefore households are allowed to exceed the maximum 100 percent LTV ratio by six percent (up to 106 percent LTV) if the household is using the fund to upgrade the sustainability of their homes (ECORYS, 2021). However, a higher LTV ratio also implies a higher risk of payment arrears for households. Therefore, investments in the energy label cannot only be

[1] Loan-to-value (LTV) is an often-used ratio in mortgage lending to determine the amount necessary to put in a down payment and whether a lender will extend credit to a borrower (Hayes, 2020).

seen as a tool to improve sustainability and reduce energy expenditures. It can also be seen as an important factor in the management of a household's mortgage risk management (Janssen, 2019). Therefore the question arises, to what extent the mortgage lending (expressed as the LTV ratio) is associated with the energy efficiency of a home (expressed as residential energy labels) of Dutch households on the verge of the energy transition?

1.2 Literature Review

Earlier studies on households and LTV ratios address the following three aspects. First of all, earlier literature addresses the household mortgage product choice. The decision to purchase a home is one of the most important financial decision made in the course of a households' lifetime (Bacon & Moffatt, 2012). Setting the LTV ratio requires households to trade-off costs and benefits at different points in time. These decisions with consequences in multiple periods are referred to as intertemporal choices (Chabris, et al., 2010). For instance, Kaza et al. (2014) find in their study that households in the U.S. market for energy-efficient homes are likely to weigh the long-term savings derived from energy efficiency against the short-term higher costs. Additionally, their results show a significant and inverse relationship between energy efficiency and mortgage default risk. In their study on the Dutch residential market, Billio et al. (2021) find the same results. The theoretical explanation is that mortgages issued on energy-efficient houses have lower risks for households relative to less efficient houses. That is, energy efficiency frees up a part of the household's income, which improves the ability to repay debt (Burt et al., 2010; Billio et al., 2021).

Secondly, the literature addresses LTV ratios in conjunction with lender behavior. Lenders need to act according to macroprudential LTV policy that controls the rate of growth in property loans and generated credit risk (Sasikrono et al., 2019; Morgan et al., 2018; Armstrong et al., 2019; de Arauja et al., 2020). The higher equity stake and lower leverage required by these policies are designed to increase borrower resilience and lower lender losses during downturns (de Araujo et al., 2020). When providing a loan, lenders take risks of non-performing loans (Sasiktono et al., 2019). Gerlach-Kristen and Lyons (2017) show that non-performing loans tend to be more common in countries with high LTV ratios. Haillisey et al. (2014) find the same effects in Ireland. Thus higher LTVs do not only imply a higher credit risk for the household, but also the lender (Dungey et al., 2015). Despite the high LTV ratio in

the Netherlands, the non-performance rate for Dutch residential mortgage loans has been low compared to other countries (De Haan & Mastrogiacomo, 2020). However, the relatively high LTV ratios for Dutch residential mortgages make the residual debt risk and the potential loss given default large. This in turn affects expected losses and thus also capital requirements of lenders (Japelli et al., 2008; Stanga et al., 2017). According to Pivo (2013) lenders could improve their risk management practices by taking stock of whether a property has certain sustainability features when loans are originated. For instance by imposing different (lower) mortgage pricing with energy-efficient residential buildings (Billio et al., 2021).

Third, a small but growing literature addresses mortgage lending and energy efficiency. In this study, sustainability is considered as green building and location factors. Pivo (2014) finds that sustainability features play an important role in a household's availability to repay their debt. According to Lorenz and Lützkendorf (2008), it is generally agreed that sustainable buildings are more cost and energy-efficient, functionally effective, profitable, and marketable than conventional buildings. While at the same time sustainability offers loss prevention benefits, risk reduction potential as well as reduced negative impacts on the natural environment. On the contrary, sustainable buildings do have higher upfront costs because of better construction practices and the use of efficient but costly appliances leading to a higher LTV ratio (Kaza et al., 2014). However, this can lead to issues since it is not uncommon that households and lenders are unwilling to bear this kind of risk (Shi et al., 2016).

To summarize, theory on household mortgage product choice, lender behavior, and sustainability help to understand to what extent residential mortgage lending is associated with energy efficiency, but not all of it. Analyzing the LTV ratio in terms of energy labels can help to obtain a better understanding of the relationship between residential mortgage lending and energy efficiency. A better understanding of this relationship can play an important role in promoting energy efficiency, improving the environment, and addressing some of the problems associated with financing energy-efficient residences (Kaza et al., 2014).

1.3 Research Problem Statement

The research problem of this study is the relationship between the LTV ratio of new loans and residential energy labels in the context of the sharply rising housing prices market on the verge

of the energy transition. The role and importance of LTV's have increased significantly since the financial and economic crisis (Bazilinska & Panchenko, 2020). As well as the interest in energy-efficient houses is also a topic of recent interest (Sandford et al., 2015). Current research mainly focuses on LTV policies and the risk of mortgage payment arrears. However, less is known about the relationship between residential energy labels and the LTV ratio. Billio et al. (2021) did investigate the relationship between building energy efficiency and the probability of mortgage default in the Dutch housing market. However, their research is a first step in understanding whether energy efficiency plays a role in the European mortgage market (Billio et al., 2021). Therefore, a knowledge gap can be observed regarding LTV ratios and residential energy labels. The following research question will be answered.

To what extent can a relationship be observed between the loan-to-value ratio of new loans from households and residential energy labels in the Netherlands?

This research question will be answered by addressing three sub-questions. The first sub-question will be on explaining the theory on the mortgage market and LTV ratios. Therefore sub-question one is stated as: *What tells theory about patterns on the mortgage market and the loan-to-value ratio?* This sub-question will be answered by using earlier studies and theories underpinning the rest of the research. In this theory part, a theoretical prediction on loan-to-value ratios will be derived focusing on the mortgage product choice, lending behavior, and sustainability.

The second sub-question will help to understand the type and strength of relationship between residential energy labels and the loan-to-value ratio between 2019 and 2020 in the Netherlands. The second sub-question is stated as: *To what extent can a relationship be observed between the loan-to-value ratio of new loans from households and residential energy labels between 2019 and 2020 in the Netherlands?* The results of the first sub-question will also be used to answer this question. Furthermore, this question will be explored by a quantitative analysis using data from the Dutch Land Registry Office and Stata software. The complete dataset from the Dutch Land Registry Office contains 151,089 new residential mortgage registrations at the Dutch Land Registry. The dataset contains microdata on newly concluded residential mortgages of natural persons in the Netherlands from January 1st, 2019

till the 31st of December 2020. Since the dataset contains samples over two years, the focus of this study will be on a cross-sectional analysis.

The third sub-question will be on exploring the heterogeneity between Dutch first-time buyers and seasoned buyers. Therefore the question is stated as: *To what extent can a difference be observed concerning residential energy labels and the loan-to-value ratio between Dutch first-time buyers and seasoned buyers in 2019 and 2020?* With the results of the second sub-question, the third sub-question will be explored. If the outcomes of the second sub-question show significant differences, these results need to be explained. In this part of the research, the relationships are explored on the household's basis. To explore if any difference can be observed a Chow test will be performed on the dataset of the Dutch Land Registry Office. The Chow test is a parameter stability test, for this test the data will be split into two subsamples (first-time homebuyer and seasoned buyer).

This study is organized into five chapters, the remainder of this study is organized as follows. Chapter two firstly observes existing theory to get a better understanding of the loan-to-value ratio. Chapter three addresses the Dutch (sustainable) housing market context, the data, and methodology. Chapter four highlights the findings of the regression and discusses the findings. Lastly, chapter five concludes and offers an outlook for further research.

2. Theory

Mortgage LTV ratios, or loan-to-values, are accepted by banks and households at the time of mortgage origination, subject to government regulations. This chapter explains how to understand these LTV ratios. Firstly theory on household- and lender behavior will be elaborated, followed up by theory on sustainability. After discussing theory, the hypotheses for this study will be formulated.

2.1 The Mortgage Product Choice

The decision to purchase a home is one of the most important financial decision made in the course of a households' lifetime. A closely related decision is on how the purchase will be financed; the mortgage product choice (Bacon & Moffatt, 2012). To decide on how the purchase needs to be financed households trade-off costs and benefits at different points in time. These decisions with consequences over multiple time periods are referred to as intertemporal choices (Chabris, et al., 2010). Intertemporal choices such as mortgage choice involve many considerations that are at the frontier of finance theory and need to be assessed as an aspect of household risk management (Campbell and Cocco, 2003). After all, households trade-off a rational desire to save against a preference for immediate consumption (Chen and Schwartz, 2012).

One of the decisions a household has to make regarding the mortgage product choice is the mortgage type choice. In general, households can make different financial trade-offs between the type of mortgage loans. A variety of types of mortgages are available (Bacon & Moffait, 2012). However, the household often chooses between an amortized loan or a non-amortized loan. Amortized loans are scheduled, periodic payments that are applied to the loan's principal amount and the interest accrued. Non-amortized loans on the other hand are a type of loan for which payments on the principal are made by lump sum. Therefore the value of the principal does not decrease over the life of the loan. An example of a non-amortizing loan is an interest-only loan. Interest-only mortgages delay repayment and are riskier in terms of repayment (Toussaint, 2012). On the other hand, interest-only mortgages allow households to better match future higher income (Cocco, 2013). Furthermore, a distinction can be made in (non)-amortized loans between a fixed interest rate or a variable interest rate. Households may choose a fixed-rate mortgage if they prefer to be contracted to pay a fixed monthly

amount over a specific period. Alternatively, households may choose a variable rate if they prefer their monthly interest payments to be determined by the prevailing market rate of interest (which can rise or fall at any time) (Bacon & Moffait, 2012). Fixed-rate loans are considered as the less risky choice because it results in a sequence of monthly payments that are known with certainty in advance. Variable-rate loans are considered as riskier because it results in uncertainty over future monthly payments (Bacon & Moffait, 2012). The mortgage type choice thus clearly depends on the risk attitude of the household which fluctuates over time according to the short-term rate level and housing market conditions (Cox et al., 2014; Kim and Ziobrowski, 2016). However, it needs to be taken into account that households generally only have a limited understanding of basic economic principles (Van Rooij et al. 2011; Lusardi and Mitchell, 2007; Lee and Hogarth 1999).

Along with the mortgage type choice, the household has to make financial trade-offs regarding the LTV ratio (housing equity position) (Follain, 1990). For the majority of the households, the purchase of a house necessitates the taking out of a mortgage that covers some or all of the purchase price of the property (Bacon & Moffait, 2012). Therefore, at least part of the house purchase needs to be financed with mortgage debt. Hence, the LTV ratio represents the financial risk attitude of the household. A household's willingness to take financial risks is influenced by how financially constrained they are. A high LTV ratio is for example more likely financially constraining (Bian, 2017). The reason for this is that a high LTV ratio implies that funding is unavailable or scarce. Hence, households with high LTV ratios are more likely to prefer certainty in their mortgage repayments when they have a low and unstable income for example (Dungey et al., 2015).

Besides the households' financial trade-offs, households also base their mortgage product choice on their individual circumstance, strongly supporting the relevance of household characteristics on the LTV ratio (Coulibaly and Li, 2009; Fortowksy et al., 2011). Household characteristics included in earlier studies on LTV-ratios are job tenure, self-employed, race of borrower, homeownership counseling, educational attainment by the head, marital status, and households' income (Delgadillo and Gallagher, 2006.; Bian, 2017). Furthermore, Lindbergh et al. (2008) state that today's older generation has established good income and education levels, therefore it is reasonable to expect this group to be less concerned about

the financial situation than younger age groups. Hence, a young population might demand higher LTV ratios than an older population with a history of savings and accumulated equity (Ambrose and Capone, 2000; Anderson and VanderHoff, 1999)**.** Moreover, older people strongly embrace older values, which hold that saving is 'good' and having debt is 'bad' resulting in lower LTV ratios and increasing risk aversion for an older generation (Follain, 1990, Donkers & van Soest, 1999; Toussaint, 2012). Furthermore, being married increases the probability of being a homeowner (Thomas & Mulder, 2016). Dungey et al. (2015) find that married homeowners and multiple dependents are willing to take more risk resulting in a higher LTV ratio. Additionally, LTV ratios among first-time homebuyers are high because they are usually less financially experienced and they borrow as much as possible in the early years to smooth their intertemporal housing consumption path (Dungey et al., 2018; Follain, 1990). Seasoned homeowners might be more aware of the mortgage market as well as the risks and features of certain mortgage products, subsequently altering their literacy and risk aversion levels, resulting in a lower LTV (Cox et al., 2014).

2.2 Lender behavior

Both households and lenders contribute to variations in the mortgage product and the LTV ratio (Borgersen, 2017). Lenders need to act according to macroprudential LTV policy that controls the rate of growth in property loans and generated credit risk (Sasikrono et al., 2019; Morgan et al., 2018; Armstrong et al., 2019; de Arauja et al., 2020). The higher equity stake and lower leverage required by these policies are designed to increase borrower resilience and lower lender losses during downturns (de Arauja et al., 2020). In the traditional loan origination business, the default risk of applicants for consumer and mortgage loans is usually assessed through the use of credit scores. The input for these scores includes behavioral, financial, and demographic information supplemented by loan-specific characteristics such as the LTV ratios for mortgage loans (Billio et al., 2021).

Lenders take on risk on non-performing loans when providing a mortgage (Borgersen, 2018). A higher LTV ratio makes more households able to fulfill the corresponding down-payment constraint and become mortgagors. However, higher LTV ratios also have a higher credit risk associated with the lender (Dungey et al., 2015). This risk implies the failure or inability of the debtor to pay the principal and/or interest in the installment of the property within a

predetermined period (Sasiktono et al., 2019). Major risk factors for loan default are cash flow and property value, commonly measured as the LTV ratio. Default risk increases if declining cash flow prevents loan repayment or if falling value produces negative net equity (Pivo, 2013).

In terms of energy efficiency, lenders appear to benefit from growth in the energy efficiency in the housing stock (Sanderford et al., 2015). Mortgages on energy-efficient homes have significantly lower risks than those on less efficient homes, yet mortgage-underwriting practices do not reflect this fact (Kaza et al., 2014). Mortgages on energy-efficient homes are associated with lower mortgage risk; the more energy-efficient, the lower the risks (Kaza et al., 2014). Lower default risk for mortgages on energy-efficient residential buildings could imply different mortgage pricing by the lender (Billio et al., 2021). Moreover, Bilio et al. (2021) state that energy efficiency information complements rather than substitutes household credit information. Lenders who use information from both sources (household credit information and energy efficiency) can make superior lending decisions compared to lenders who do not exhaust all available information.

2.3 Sustainability

A growing number of studies show that buildings with sustainability features generate more cash flow and value (Pivo, 2013). Moreover, support comes from studies around the world documenting that homebuyers recognize the contributory value of 'green', 'sustainable', and 'energy efficiency' (Bilio et al., 2021). Going 'green' can be both socially responsible as well as economically beneficial. Sustainable housing should cover the 'green' concept, recourse usage, economic demand as well as meeting the humans' need for comfortable living (Cole, 2005). Nonetheless, despite the increasing sustainability awareness, only a smart but growing literature addresses mortgage lending and sustainability.

Pivo (2014) finds that sustainability features such as green building and building location play an important role in a household's availability to repay their debt. According to Lorenz and Lützkendorf (2008), it is generally agreed that sustainable buildings are more cost and energy-efficient, functionally effective, profitable, and marketable than conventional buildings. While at the same time sustainability offers loss prevention benefits, risk reduction potential as well

as reduced negative impacts on the natural environment. Energy-efficient homes are designed and constructed with superior environmental performance that translates into lower operating costs relative to non-energy-efficient competitive homes; in other words, potential cash flows to the occupant. These cash flows created by innovative building strategies, technologies, or locations are important as they affect default behavior (Sanderford et al., 2015). In the context of sustainability, the default behavior is positively affected since higher sustainability ratings are less susceptible to default risk (Billio et al., 2021).

Additionally, households may trade-off risk in terms of sustainability and the LTV ratio. High LTV ratios issued on energy-efficient houses have lower risks for households relative to less efficient houses. That is, energy efficiency frees up a part of the household's income, which provides access to funding and improves the ability to repay debt (Burt et al., 2010; Billio et al., 2021). Household energy expenditures have represented about one-quarter of average household expenditures in the last few years (Kaza et al., 2015). Therefore, it is reasonable to expect that households benefit from energy expenditure savings, which could offset some mortgage risks (Frey, 2003; McLaren, 1992). However, according to Majcen et al. (2013), a dwelling with a green label does not necessarily mean low energy usage and thus does not necessarily result in primary energy savings. They do find the better the label, the lower the average gas consumption. However, as opposed to what they observed on gas consumption, electricity consumption does not depend much on the label. Contradictory to Majcen et al. (2013), Kaza et al. (2014) do observe that households with red-labeled homes have a higher probability to be in arrears on their mortgages, especially if they spend a relatively large part of their income on energy. Supplementary, the energy label could have financial utility for households as the energy savings (resulting from a more efficient building) may result in higher property values (Brounen and Kok, 2011). To demonstrate one’s point, Brounen and Kok (2011) observed a price premium on A, B, C labeled homes and price discounts for homes rated E, F, and G in the Netherlands.

In essence, both sustainability features and sustainable location/transportation reduce the probability of mortgage default (Pivo, 2013). Emphasizing sustainable location, LTV ratios vary across countries and periods (Borgersen, 2017). Rauterkus et al. (2010) showed that buyers of locational efficient homes have a lower probability of mortgage default. In fact, the extra risk

produced by a higher LTV would be offset by the lower risk produced by locating in a more sustainable location, leaving the total risk unchanged (Pivo 2013). Based on these ideas, Holtzclaw et al. (2002) proposed that location efficiency be considered part of the mortgage product process.

However, because research on mortgage lending and sustainability is quite new, three issues can be observed. Firstly, sustainable housing does have higher upfront costs because of better construction practices and the use of efficient but costly appliances resulting in a higher LTV ratio (Kaza et al., 2014). These higher costs and higher LTV ratio might lead to difficulties. Since it is not uncommon that households and lenders are unwilling to bear this kind of risk (Shi et al., 2016). Secondly, property-specific information about sustainability is not necessarily conveyed, resulting in asymmetric information distribution that disadvantages potential buyers (Ifegbesan et al. 2016; Zhou et al. 2015). One of the reasons for this asymmetric information distribution is the inherent uncertainty and ambiguity of sustainability features which makes it difficult for buyers to identify and quantify the benefit of purchasing housing that includes sustainability features (Nelms et al. 2005). Thirdly, it appears that economic performance considerations, and not environmental and social performance, still largely drive mortgage decision-making (Hoek and Johnson, 2009).

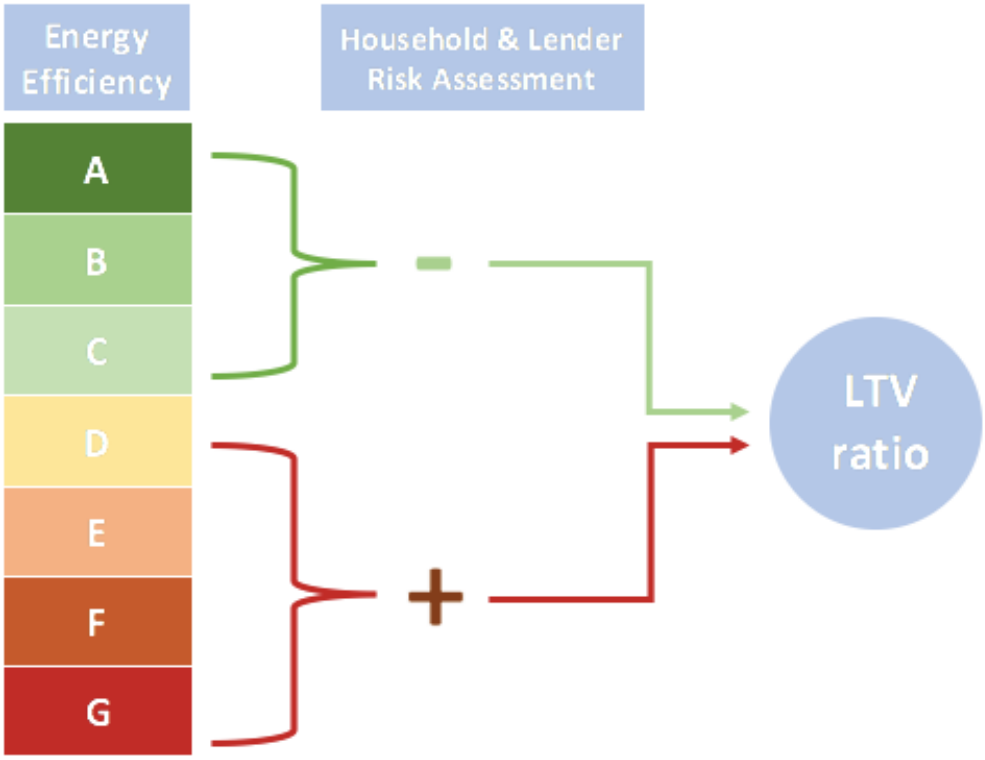
2.4 Hypothesis

Theory on household mortgage product choice, lender behavior, and sustainability help to understand to what extent residential mortgage lending is associated with energy efficiency. By examining the relationship between the LTV ratio and energy efficiency, this study contributes to the observed knowledge gap concerning residential mortgage lending and energy efficiency. The central hypothesis of this study has been modeled in the conceptual model (figure 1). Setting an LTV ratio is based on financial risk assessments made by households (intertemporal choices) and lenders at a certain time. Mortgage issued on energy-efficient houses has lower risks for households relative to less efficient houses (Kaza et al., 2014). That is, energy efficiency frees up a part of the household's income, which provides access to funding and improves the ability to repay debt (Burt et al., 2010; Billio et al., 2021). According to Frey (2003) and McLaren (1992), it is reasonable to expect that households might

benefit from energy expenditure savings, which could offset some mortgage risks. Based on these findings the following central hypothesis is stated.

''The LTV ratio of Dutch borrowers is lower among households with an efficient energy label (A, B, C) relative to households with an inefficient energy label (D, E, F, G).''

Figure 1 – Conceptual Model



According to Coulibaly and Li (2009) and Fortowksy et al. (2011), household characteristics also influence the LTV ratio. Therefore the following sub-hypotheses are formulated. First, it is expected that the LTV ratio among older borrowers is lower relative to younger buyers since the risk aversion increases when age increases (Follain, 1990; Donkers & van Soest, 1999). Secondly, Dungey et al. (2015) find that married homeowners and multiple dependents are willing to take more risks. Hence, it is expected that the LTV ratio is higher when the amount of dependents exceeds one. Lastly, based on the assumption of Borgerson (2017) it is expected that the LTV ratio differs regionally.

3. Context, Data, and Method

The dataset provided by the Dutch Land Registry Office contains Dutch mortgage cases between the 1st of January 2019 and the 30th of December 2020. Therefore this section will start with an explanation of the context including the Dutch mortgage market, LTVs, and the energy label system between 2019 and 2020. Secondly, the measures will be operationalized, and the data explored. Lastly, the regression methodology will be elaborated.

3.1 (Sustainable) Housing Context

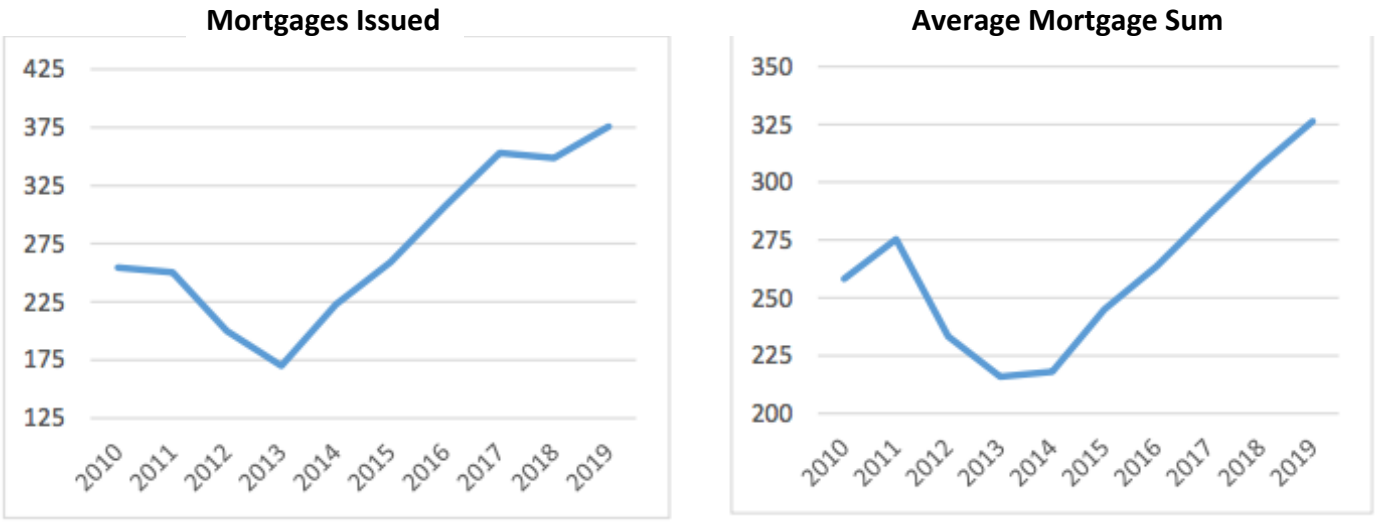
The mortgage market in the Netherlands is well-developed and innovative, with a wide range of non-traditional mortgage products to offer (van Ooijen et al., 2016). The most common mortgage type is the annuity mortgage. In the Netherlands, there is no requirement to make a down payment upon the purchase of a home. Furthermore, the provision of mortgages in the Netherlands is to a large extent still a local (or regional) activity. Compared to other mortgage markets in Europe, the Dutch residential mortgage market knows a high degree of competition between mortgage lenders (Dutch Securitisation Association, 2020). Dutch mortgage lenders can be categorized into three categories: banks, insurance companies, and pension funds that operate through 'regiepartijen'[2]. In the third quarter of 2019 the share of banks in new mortgage production was 65.9 percent, that of pension funds 14.3 percent, and other parties 8.9 percent (Dutch Government, 2020b).

Two trends can be observed regarding the Dutch mortgage market in 2019 and 2020. First, the value of Dutch houses has been rising since 2014 and this is still the case in 2019 and 2020 (Dutch Government, 2019). DNB and NVM (2019) expected in 2019 a decrease in house value growth and stabilization of the residential housing market. However, due to economic growth, housing market tightness, and low interest rates the house value steadily increased in both 2019 and 2020. The second trend can be observed on mortgages loans. In 2019, 376,000 mortgages were provided. This is an increase of 7.8 percent compared to 2018 (Dutch Government, 2020b). However, this increase can mainly be attributed to an increase in the number of refinancers and second mortgages since the number of sold houses decreased by 1.4 percent. Nonetheless, in both 2019 and 2020, the value of owner-occupied homes have

[2] 'Regiepartijen' are a relatively new group of providers that have gained a significant market share since the credit crisis. These parties retrieve capital from (institutional) investors and provide for mortgage lending to households (The Financial Glossary, 2021)

risen faster than borrowing capacity. Figure 2 shows the number of mortgage issued and the average mortgage amount.

Figure 2 - Number of mortgages issued (in thousands, left-hand graph) and the average mortgage sum (in thousands of euros, right-hand graph) in the Netherlands between 2010 and 2019 (Dutch Government, 2020b)



To control for high risk on the mortgage market, the Dutch government has taken measures regarding the LTV ratio. The maximal LTV ratio is since 2013 in the Netherlands anchored and reduced yearly by one percent till 100 percent was reached in 2018 (Dutch Government, 2020a). This measure reduces the incentive for debt financing and thereby contributes to a more stable development of housing values (DNB, 2019). Other measures to reduce the incentives for debt financing such as the implementation of the tax repayment requirement and the accelerated reduction of the maximum deduction rate of the interest and costs of owner-occupied housing show that risks have declined. The mortgage debt monitor shows that, because of these government measures, Dutch homeowners are better off now than at the start of the great financial crisis (Dutch Government, 2020b). Despite the current overheated housing prices market in the Netherlands. According to the report of the Dutch Government (2019), in 2019 (relative to 2018) a small decrease of new loans with a high LTV ratio (LTV > 90 percent) for both first-time buyers and seasoned homeowners can be observed. In 2019 60 percent of first-time buyers closed a mortgage with a LTV ratio of more than 90 percent, for seasoned buyers this was 45 percent (Dutch Government, 2020b). In 2020

the average LTV ratio for new mortgages has fallen and the proportion of the total mortgage debt of mortgages that are fully repaid has increased (Dutch Government, 2020a).

Lastly, the energy efficiency of the Dutch housing market is indicated by the energy label of a residential house. In the Netherlands houses and apartments must have an energy label when they are being built, sold, or rented (Netherlands Enterprise Agency, 2021). Owner-occupied homes usually get a label when transactions happen. The labels range from A (green label), B, C, D, E, F, and G (red label). Energy labels are registered by RVO and are valid for ten years. As of January 1th, 2019, nearly 3.7 million homes in the Netherlands have a registered energy label, representing 46 percent of the total housing stock. Until Q1 2020 these labels were mainly present in the rental sector, only 20 percent was owner-occupied sector (Figure 3). However, by maintaining and simplifying the energy label in 2015, the number of labeled homes in the owner-occupied sector has increased. In December 2020 even a sharp increase of 200,000 registered energy labels can be observed because of the rising costs of energy label registering as of January 1th, 2021 (Dutch Land Registry Office, 2021c). Figure 4 shows the distribution of residential energy labels in 2019 and 2020. The share of bad energy labels turns out to be higher among older homes (Dutch Government, 2019). Moreover, the average energy label in 2019 for the owner-occupied sector was C, whereas for 2020 label A was best represented (Dutch Government, 2019).

Figure 3 – Number of energy label registrations per quarter in the Netherlands (Dutch Land Registry Office, 2021c)

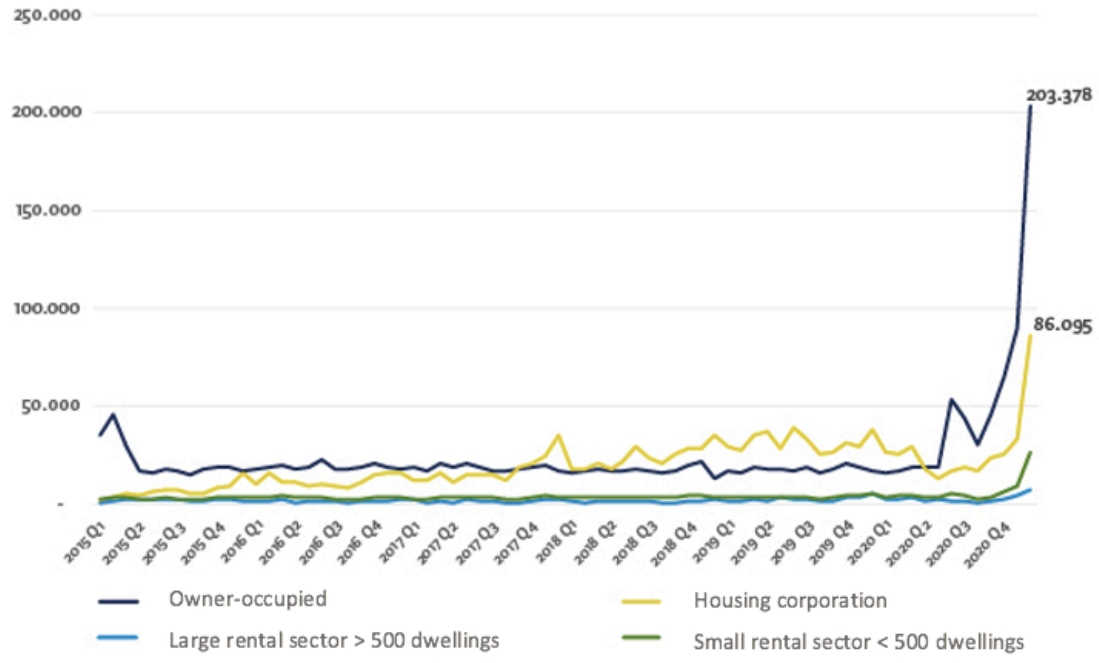
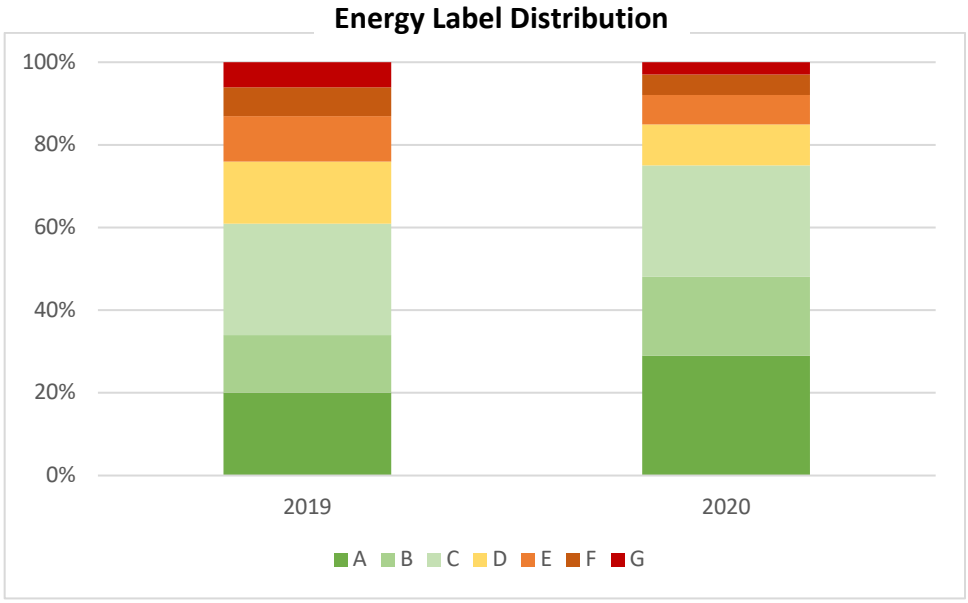


Figure 4 - Distribution of definitive residential energy labels in the Netherlands in 2019 and 2020 (Dutch Government, 2019; Dutch Land Registry Office, 2021c)



3.2 Data

The data comes from the Dutch Land Registry Office and includes new Dutch mortgage deeds between 2019 and 2020. A mortgage deed contains a deed with information on the data that is processed in the 'Basisregistratie Kadaster'. The Dutch Land Registry Office provides an overview of the mortgage market based on this essential data: the 'Kadaster mortgage scan'. The 'Kadaster mortgage scan' is a statistical information product on mortgage market trends. The scan is particularly aimed at the market segment of owner-occupied homes. The dataset contains information on mortgage loans, appraised home values, energy labels, household characteristics, lender behavior, housing characteristics, and locational characteristics of newly concluded mortgages. The data include the population of new mortgagors in the Netherlands between the 1st of January 2019 and the 31st of December 2020. The observations in the dataset are collected between 2019Q1 – 2020Q4 and after cleaning the dataset a total of 151,089 observations are left.

3.3 Operationalization

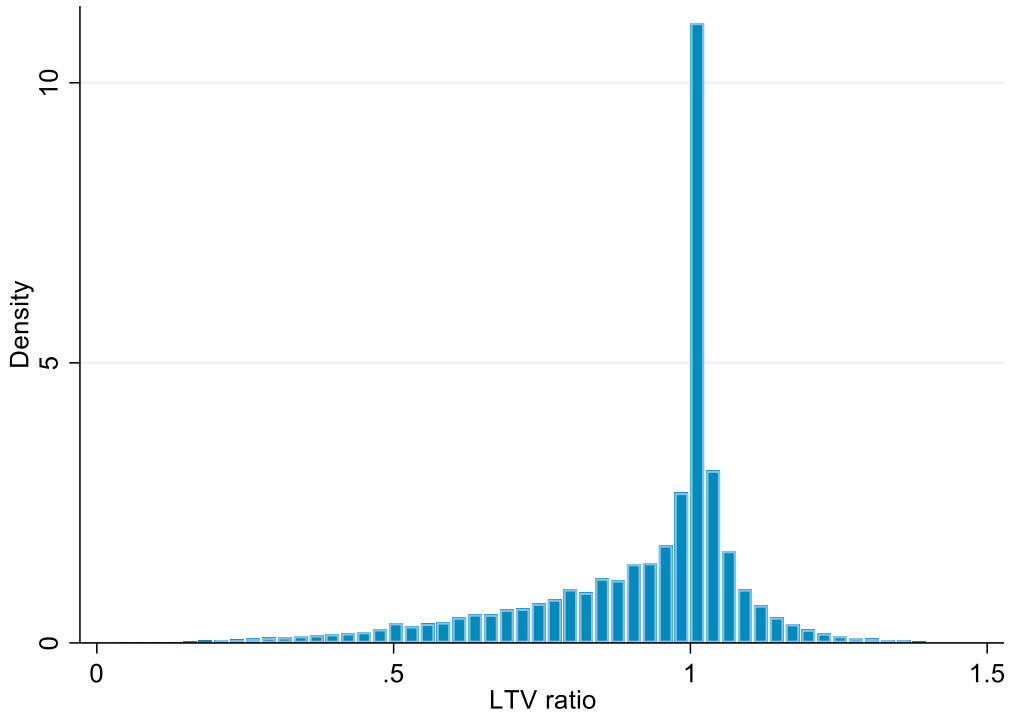
LTV ratio

The dependent variable in this study is the LTV ratio. Defined as the mortgage loan over the purchase price or appraised value of the property. Thus the equation for the LTV ratio is.

$$LTV_t = \frac{L_t}{P_t} * 100$$

Where LTV stands for the loan-to-value ratio, L the loan amount, and P the property value at time *t*. The distribution of the LTV ratio in the dataset is illustrated in figure 5. LTV = 1 stands for a LTV ratio of 100 percent. Furthermore, 71.6 percent of the households obtain a LTV ratio of 100 percent or lower. Initially, households are not allowed to exceed a LTV ratio of 100 percent. The dataset does contain cases exceeding a LTV ratio of 100 percent, reason being that households are allowed to exceed this ratio when they are financing a residual debt in making their home more energy-efficient (AFM, 2021). See appendix D for the correlation matrix.

Figure 5 – Graph of the LTV ratio distribution in the data set



Energy Label

The independent variable in this study is the energy label. As of January 2021, about 40 percent of all private owner-occupied homes have a fixed energy label (Dutch Land Registry Office, 2021b). During a transaction it is mandatory to establish an energy label. Mortgage closings go together with these transactions. Therefore, the percentage of mortgages including an energy label in the dataset is slightly higher. Missing energy labels are due to enclosures of mortgages, missing matching key points, exempted transactions, and/or violations (Dutch Land Registry Office, 2021b). The energy labels in the dataset are defined as

A, B, C, D, E, F, G and the distribution of the energy labels can be derived from table 1**.** An energy label is based on housing characteristics such as the energy performance of a house (isolation, solar panels, heating etcetera.). In this study, the focus energy label serves as the main explanatory variable and is therefore detached from other housing characteristic variables. For the descriptive statistics of all the variables see appendix B.

Table 1 – Overview of energy label distributions

Label	Observation	Mean LTV ratio	Std. Dev.	Min	Max
All labels	157,146	0.918096	0.184266	0.036	1.39923
A	27,733	0.895357	0.18632	0.046632	1.39286
B	21,915	0.904518	0.189083	0.042553	1.39745
C	46,230	0.921829	0.177252	0.036	1.39394
D	23,273	0.922103	0.183964	0.062762	1.39535
E	16,729	0.927799	0.178493	0.105932	1.39484
F	11,945	0.932504	0.18763	0.074074	1.39319
G	9,321	0.953278	0.196815	0.1	1.39923

Control variables

The control variables in this study consist of four sub-groups: housing characteristics, household characteristics, lender behavior, and locational characteristics. Housing characteristics include information on year of construction, dwelling surface, housing type, property value, and an indication of whether the house is newly constructed. For the dwelling surface and property value to be normally distributed the logarithm of both variables is used. For the display of the scatterplots of these variables, see Appendix C. The housing type is categorized into five types: apartment, terraced, corner, semi-detached, and detached housing. Variables on the household in the dataset are the age of the oldest titleholder, the number of titleholders, and an indication of the type of buyer. The age of the oldest titleholder is divided into six dummy variables, indicating the cohort category of the titleholder (based on earlier approaches of Statistics Netherlands). The indication of the type of buyer depends on earlier records of homeownership of the Dutch Land Registry Office. If there are no earlier records, the person is identified as a first-time buyer. See table 2 for the distribution of the LTV ratio among the five types of buyer categories. The sub-group lender behavior contains a variable with 27 mortgage lenders that are remained anonymous in this study. These mortgage lenders are categorized into another variable containing four types of lenders: small

banks, large banks, insurance companies, and other kinds of lenders. Lastly the model controls for locational characteristics containing the variables degree of urbanity and region.

Table 2 - Overview of type of buyer distributions

Type of buyer	Observation	Mean LTV ratio	Std. Dev.	Min	Max
One first-time buyer	29,744	0.892642	0.1737353	0.0843384	1.39875
Two first-time buyers	49,648	0.9735144	0.1243258	0.0677966	1.39923
One first-time buyer and one seasoned buyer	15,093	0.9407679	0.1690246	0.0425532	1.395349
One seasoned buyer	25,399	0.8404437	0.2213995	0.0466321	1.394842
Two seasoned buyers	31,385	0.9156501	0.2011326	0.036	1.398298

Earlier studies on LTV-ratios have shown that not all variables influence the LTV ratio. Therefore the following variables are excluded in this study. First of all, gender is not a factor that has been seen to affect mortgage rate choice (Dungey et al., 2015). Secondly, in most European countries, and the Netherlands as well, a substantial part of the population continues to rent, and owner-occupiers are typically the households with higher incomes (Mulder, 2004). Therefore income is also excluded from this study.

3.4 Regression model

To analyze if there is a relationship between energy labels and LTV ratios of newly concluded mortgages between 2019 and 2020 in the Netherlands an Ordinary Least Squares regression (classical linear regression model) has been used. The regression model is concerned with describing and evaluating the relationship between a given variable and one or more other variables (Brooks & Tsolacos, 2012). Five assumptions are underlying the classical linear regression model concerning disturbance terms and their interpretation. First, the errors have zero mean. Second, the variance of the errors is constant and finite overall values of x_t. Third, the errors are statistically independent of one another. Fourth, there is no relationship between the error and the corresponding x variable. Lastly, the error term is normally distributed (Brooks & Tsolacos, 2012). See for assumption testing appendix D.

The main linear regression model is defined in the model (1) below.

$$LTV_{it} = \alpha + \beta_1 energy\ label_{it} + \beta_2\ housing\ characteristics_{it} + \beta_3\ household\ characteristics_{it} + \beta_4\ lender\ behavior_{it} + \beta_5\ locational\ characteristics_{it} + \varepsilon_{it} \quad (1)$$

Where LTV represents the dependent variable LTV of household i at transaction time t. $\beta_1 energy\ label_{it}$ represents the explanatory variable energy label. Whereas $\beta_2\ housing\ characteristics_{it}$ represents the control variables dwelling surface, year of construction category, property value, newly built, and dwelling type. $\beta_3\ household\ behavior_{it}$ represents the control variables type of buyer, age cohorts, and amount of dependents. $\beta_4\ lender\ behavior_{it}$ represents the type of lender. $\beta_5\ locational\ characteristics_{it}$ represents the control variables region and degree of urbanity. Furthermore, ε_i is an error term and α the constant. For the display of all variables in the subgroups of the model see appendix A**.**

To determine whether significant differences between first-time buyers and seasoned buyers can be observed, a chow-test will be performed based on these two subsamples. The hypothesis for this test is: no difference can be obtained between the subsamples first-time homebuyers and seasoned homebuyer. This hypothesis will be tested based on the following model (2).

$$F = \frac{R\ RSS - U\ RSS}{U\ RSS} \times \frac{(n-2k)}{(2k-k)} \quad (2)$$

4. Results

In this section the results of the linear regression model are presented and discussed. First the relationship between the loan-to-value ratio and energy label will be presented. The model has been performed step-wise. Therefore the results will also be discussed step by step. First, the relationship between the LTV ratio and other housing characteristics is tested. Then the housing characteristics energy label was added. Thirdly, household characteristics are added to the model, followed up by lender behavior and lastly locational characteristics. The model outcomes can be found in table 3. Secondly, the heterogeneity across first-time buyers and seasoned buyers will be elaborated. Lastly a discussion will follow.

4.1 Loan-to-value ratio and residential energy labels

Model 1: housing characteristics

The first step of the model is aimed at controlling for housing characteristics. The results of the model (1) deliver the first impression of housing characteristics on the LTV ratio. All the characteristics are statistically significant on a 99 percent significance level, except for the variable newly built. The coefficient of Ln property value accounts for -0.0709, so if the property value increase by one, the LTV ratio decreases exponentially by 0.0709. For the other variables a positive coefficient can be observed. If the housing type is for example a corner dwelling, the LTV ratio increases by 4.6 percent. These findings indicate that based on housing characteristics (except whether the property is newly built), the LTV ratio differs. However, for this model it must be noted that the R-squared is 0.037, indicating that 3.7 percent of the variation in the LTV ratio is explained by the variation of housing characteristics in the model (1).

Model 2: housing characteristics and the energy label

The second step of the model is aimed at controlling for the extra housing characteristic (and the independent variable of this study) the energy label. The energy label is observed as an independent housing characteristic and therefore added in the second model (2). The results show that all the labels are significant at the 99 percent significance level. Moreover, with label G being the reference category, the results show for every other label a negative relationship on the LTV ratio. The LTV ratio of a B-labeled home is for example 3.25 percent lower compared to a G-labeled home. The results also show that the LTV ratio is lower if the

label is green (A, B, C) compared to a red label (D, E, F). These findings suggest that based on energy labels, the LTV ratio differs. However, for this model it must be noted that the R-squared is 0.038, indicating that 3.8 percent of the variation in the LTV ratio is explained by the variation of housing characteristics and energy labels in the model (2).

Model 3 and 4: housing characteristics, the energy label, and household characteristics

The third step of the model is aimed at controlling for household characteristics. Model 3 controls for the household characteristics including the age of the oldest mortgagor as a continuous variable. The results of this model show that all variables are significant at the 99 percent significance level, except for the variables 'one first-time buyer and one seasoned buyer' & 'one seasoned buyer'. These variables are significant at the 95 percent significance level. The results of the model show that if the household consists out of multiple dependents the LTV ratio is higher (8.93 percent). Furthermore, the older the head of the household the lower the LTV ratio (if age increases by one, the LTV ratio decreases by 0.344 percent). These findings indicate that based on household characteristics the LTV ratio differs. The R-squared of model 3 is 0.152, indicating that 15.2 percent of the variation in the LTV ratio is explained by the variation of housing characteristics, energy labels, and household characteristics in the model (3).

In model 4 the continuous variable age has been replaced for age cohort dummy variables. The input of these cohort variables shows some changes in the model outcomes. The variables 'two seasoned buyers' and 'two first-time buyers' are no longer significant. Moreover, the variable 'one first-time buyer and one seasoned buyer' is significant at the 90 percent significance level. For all cohort variables, the outcomes are significant at the 99 percent significance level with a positive coefficient compared to the reference category (age cohort > 66), resulting in a higher LTV ratio for these cohort groups. The LTV ratio of a household that belongs to the cohort group age 36 - 45 is for example 25.8 percent higher than the reference category. For both model 3 and model 4 the energy label variables remain significant at the 99 percent significance level with a negative coefficient, suggesting a lower LTV ratio compared to the least efficient label G. These findings indicate that based on household characteristics (except for 'two seasoned buyers' and 'two first-time buyers'), the LTV ratio differs. Controlling for age cohorts in the model results in a R-squared of 0.191, indicating that

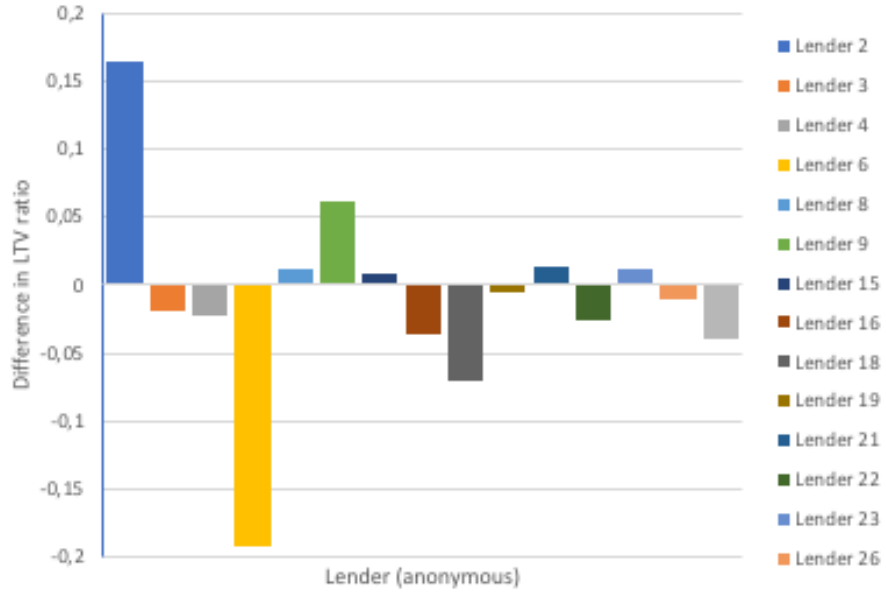
19.1 percent of the variation in the LTV ratio is explained by the variation of housing characteristics, energy labels, and household characteristics in the model (4).

Model 5 and 6: housing characteristics, the energy label, household characteristics, and lender behavior

Models 5 and 6 are aimed at controlling for lender behavior. Model 5 controls for the type of lender. The results of this model show that all variables are significant at the 99 percent significance level. Both small and large banks have a negative coefficient concerning the LTV ratio, indicating that the LTV ratio is lower if the loan is provided by a bank compared to the reference category (insurance companies). For other types of lenders (such as pension funds) a positive coefficient can be observed. Implying that other types of lenders provide higher LTV ratios compared to the reference category. These findings indicate that based on the type of lender, the LTV ratio differs. However, it must be noted that the R-squared only shows a small increase to 0.194. Indicating that 19.4 percent of the variation in the LTV ratio is explained by the variation of housing characteristics, energy labels, household characteristics, and lender behavior in the model (5).

Model 6 is more detailed and has the lenders (anonymous) integrated. The highest coefficient can be observed by lender 2 (0.163) at a significance level of 95 percent. Indicating that if the loan is provided by lender 2, the LTV ratio increases by 16.3 percent compared to the reference category (lender 1). The lowest coefficient can be observed by lender 6 (-0.199) at a significance level of 99 percent. Indicating that if the loan is provided by lender 6 the LTV ratio is 19.9 percent lower than the reference category. Figure 6 shows an overview of the difference in LTV ratio per significant lender (at the 95 and 99 percent significance levels). For both model 5 and model 6 the energy label variables remain significant at the 99 percent significance level with a negative coefficient, still indicating a lower LTV ratio compared to the least efficient label G. Moreover, these findings suggest that for a substantial part of the lenders the LTV ratio differs. The R-squared of the model increases to 0.204. Indicating that 20.4 percent of the variation in the LTV ratio is explained by the variation of housing characteristics, energy labels, household characteristics, and (detailed) lender behavior in the model (6).

Figure 6 – Difference in LTV ratio per (anonymous) lender



Model 7: housing characteristics, the energy label, household characteristics, lender behavior, and locational characteristics

The main model of this study is model 7. In this model locational characteristics are integrated and controlled for. For all locational variables (except East) the results are significant at the 99 percent significance level. If the house is for example located at a very rural location, the LTV ratio of the household is 2.29 percent lower compared to the reference category (very urban). These findings indicate that based on locational characteristics (except for region East), the LTV ratio differs. After integrating locational characteristics the model suggests that if the building is newly built, constructed between 1985-2004, the household consists of two first-time buyers, the loan is provided by lender 5, 7, 10, 11, 12, 13, 14, 17, 20, 25, or located in region East the LTV ratio does not differ.

However, the energy label variables do remain significant at the 99 percent significance level. Indicating that between 2019 and 2020 the LTV ratio of Dutch household differed based on residential energy labels. The coefficients suggest a negative relationship between the LTV ratio and energy labels. The most energy-efficient dwelling has the lowest coefficient (-0.0377) compared to the least efficient dwelling (the reference category label G). This suggests that the LTV ratio of a household with an A-labeled home is 3.77 percent lower compared to that of a household with a G-labeled home. The second-lowest LTV ratio can be observed by the

second most energy-efficient home B (3.62 percent) followed by the third C (3.24 percent), etcetera. These results indicate that the LTV ratio is lower among households with an efficient energy label (A, B, C) relative to households with an inefficient energy label (D, E, F, G). Moreover, a test has been performed on whether the coefficients of the individual energy labels differ from each other. The results show that, except between energy label A and B, the coefficients significantly differs between all the labels. Indicating that the LTV ratio as well differs between the individual energy labels and not only compared to the reference category label G. These results support the observed relationship of the main model, that the LTV ratio differs based on the energy label (except between A- and B-labelled households). See appendix D for the testing results. To my knowledge, these findings are not been identified by literature since there is only a small amount of literature that addresses LTV ratios and energy efficiency.

The consequences of higher LTV ratios and less efficient homes are discussed in earlier literature by Kaza et al (2014), Billio et al (2021), and Burt et al. (2010). The scatterplots in Appendix C show the LTV ratio in terms of the property value of households with an A-labeled home and a G-labeled home. These scatterplots can be interpreted as that there are more households with the least efficient label (G) and a high LTV ratio in contrast to households with the most efficient label (A) and a high LTV ratio. This may suggest a higher risk of mortgage arrears and less funds to invest in the energy efficiency of their property for G-labeled households. Since the households obtain high expenditure costs because of the funding of the property and energy supplies.

Summarizing, the findings of model 7 reveal that based on housing characteristics, energy labels, household characteristics, lender behavior, and locational characteristics the LTV ratio differ. The R-squared of the main model is 0.206, indicating that 20.6 percent of the variation in the LTV ratio is explained by the variation of housing characteristics, energy labels, household characteristics, lender behavior, and locational characteristics in the model (7).

Table 3 – Estimates of OLS regression model

VARIABLES	(1) LTV_ratio	(2) LTV_ratio	(3) LTV_ratio	(4) LTV_ratio	(5) LTV_ratio	(6) LTV_ratio	(7) LTV_ratio
Housing Characteristics							
Ln Dwelling Surface	0.0232***	0.0228***	0.0212***	0.0168***	0.0165***	0.0160***	0.0187***
	(0.00163)	(0.00163)	(0.00155)	(0.00152)	(0.00152)	(0.00151)	(0.00156)
Ln Property Value	-0.0709***	-0.0681***	-0.0923***	-0.112***	-0.109***	-0.109***	-0.112***
	(0.00136)	(0.00138)	(0.00136)	(0.00135)	(0.00136)	(0.00137)	(0.00156)
Type of Housing							
Apartment	-	-	-	-	-	-	-
Corner Dwelling	0.0460***	0.0450***	0.0126***	0.00644***	0.00536***	0.00552***	0.0115***
	(0.00166)	(0.00167)	(0.00159)	(0.00156)	(0.00156)	(0.00155)	(0.00165)
Semi-detached Dwelling	0.0472***	0.0458***	0.0140***	0.00921***	0.00788***	0.00821***	0.0176***
	(0.00186)	(0.00187)	(0.00179)	(0.00175)	(0.00175)	(0.00174)	(0.00194)
Terraced Dwelling	0.0444***	0.0448***	0.0125***	0.00568***	0.00481***	0.00492***	0.00967***
	(0.00137)	(0.00137)	(0.00132)	(0.00129)	(0.00129)	(0.00129)	(0.00137)
Detached Dwelling	0.0297***	0.0269***	0.00631***	0.00339*	0.00173	0.00243	0.0140***
	(0.00208)	(0.00210)	(0.00201)	(0.00196)	(0.00196)	(0.00195)	(0.00224)
Newly Built	-0.00142	-0.00154	-0.000383	0.000213	0.000586	0.00102	0.000849
	(0.00347)	(0.00347)	(0.00326)	(0.00318)	(0.00317)	(0.00315)	(0.00315)
Construction Category							
Constructed before 1945	0.0351***	0.0198***	0.0188***	0.0120***	0.0120***	0.0112***	0.00710***
	(0.00176)	(0.00275)	(0.00258)	(0.00253)	(0.00252)	(0.00250)	(0.00253)
Constructed between 1945 - 1964	0.0252***	0.0142***	0.0115***	0.00680***	0.00663***	0.00602**	0.00513**
	(0.00190)	(0.00277)	(0.00260)	(0.00254)	(0.00254)	(0.00252)	(0.00252)
Constructed between 1965 - 1984	0.0171***	0.0131***	0.00957***	0.00565**	0.00531**	0.00489**	0.00402*
	(0.00168)	(0.00245)	(0.00230)	(0.00225)	(0.00224)	(0.00223)	(0.00223)
Constructed between 1985 - 2004	0.00584***	0.00630***	0.00601***	0.00411**	0.00387**	0.00379**	0.00251
	(0.00171)	(0.00213)	(0.00200)	(0.00195)	(0.00195)	(0.00193)	(0.00194)
Constructed after 2004	-	-	-	-	-	-	-
Energy Label							
Label A		-0.0298***	-0.0349***	-0.0366***	-0.0369***	-0.0378***	-0.0377***
		(0.00304)	(0.00286)	(0.00279)	(0.00279)	(0.00277)	(0.00278)
Label B		-0.0325***	-0.0363***	-0.0358***	-0.0364***	-0.0367***	-0.0362***
		(0.00280)	(0.00263)	(0.00256)	(0.00256)	(0.00254)	(0.00255)
Label C		-0.0271***	-0.0333***	-0.0333***	-0.0338***	-0.0337***	-0.0334***
		(0.00246)	(0.00231)	(0.00226)	(0.00225)	(0.00224)	(0.00224)
Label D		-0.0189***	-0.0247***	-0.0257***	-0.0259***	-0.0259***	-0.0258***
		(0.00240)	(0.00225)	(0.00220)	(0.00220)	(0.00218)	(0.00219)
Label E		-0.0158***	-0.0188***	-0.0196***	-0.0198***	-0.0198***	-0.0200***
		(0.00248)	(0.00233)	(0.00228)	(0.00227)	(0.00226)	(0.00226)
Label F		-0.0136***	-0.0161***	-0.0162***	-0.0164***	-0.0161***	-0.0163***
		(0.00253)	(0.00238)	(0.00232)	(0.00232)	(0.00231)	(0.00230)
Label G		-	-	-	-	-	-
Household Characteristic							
Type of buyer indication							
One first-time buyer			-	-	-	-	-
Two first-time buyers			0.0158***	0.00728	0.00715	0.00666	0.00650
			(0.00588)	(0.00574)	(0.00573)	(0.00570)	(0.00569)
One first-time buyer and one seasoned buyer			0.0130**	-0.0112*	-0.0127**	-0.0117**	-0.0115**
			(0.00601)	(0.00587)	(0.00586)	(0.00582)	(0.00582)
One seasoned buyer			0.00309**	-0.0220***	-0.0235***	-0.0226***	-0.0221***
			(0.00157)	(0.00154)	(0.00154)	(0.00154)	(0.00154)
Two seasoned buyers			0.0188***	-0.00469	-0.00722	-0.00624	-0.00582
			(0.00596)	(0.00583)	(0.00581)	(0.00578)	(0.00578)
Multiple Dependents			0.0893***	0.0995***	0.0992***	0.0979***	0.0981***
			(0.00580)	(0.00566)	(0.00565)	(0.00562)	(0.00561)

Age	-0.00344***				
	(4.52e-05)				
Age cohort					
Age 18 -25		0.218***	0.217***	0.218***	0.218***
		(0.00300)	(0.00299)	(0.00298)	(0.00298)
Age 26 -35		0.239***	0.239***	0.239***	0.238***
		(0.00273)	(0.00272)	(0.00271)	(0.00271)
Age 36 - 45		0.258***	0.259***	0.257***	0.255***
		(0.00273)	(0.00272)	(0.00271)	(0.00272)
Age 46 - 55		0.221***	0.221***	0.219***	0.218***
		(0.00282)	(0.00281)	(0.00280)	(0.00280)
Age 56 - 65		0.102***	0.102***	0.102***	0.101***
		(0.00315)	(0.00314)	(0.00312)	(0.00312)
Age > 66		-	-	-	-
Lender Behavior					
Lender Type					
Insurance company			-		
Large bank			-0.0118***		
			(0.00106)		
Small bank			-0.0155***		
			(0.00123)		
Other			0.0153***		
			(0.00127)		
Lender Anonymous					
Lender 1				-	-
Lender 2				0.163**	0.164**
				(0.0722)	(0.0721)
Lender 3				-0.0193***	-0.0192***
				(0.00246)	(0.00246)
Lender 4				-0.0231***	-0.0228***
				(0.00168)	(0.00168)
Lender 5				-0.00427*	-0.00328
				(0.00236)	(0.00236)
Lender 6				-0.199***	-0.192***
				(0.0722)	(0.0721)
Lender 7				0.0404	0.0433
				(0.114)	(0.114)
Lender 8				0.0112***	0.0118***
				(0.00185)	(0.00185)
Lender 9				0.0620***	0.0617***
				(0.00494)	(0.00494)
Lender 10				0.174	0.173
				(0.114)	(0.114)
Lender 11				-0.0145	-0.0153
				(0.0255)	(0.0255)
Lender 12				0.000771	0.00131
				(0.00369)	(0.00369)
Lender 13				-0.000396	-0.00238
				(0.0295)	(0.0294)
Lender 14				0.0573	0.0466
				(0.161)	(0.161)
Lender 15				0.00769***	0.00805***
				(0.00199)	(0.00199)
Lender 16				-0.0352***	-0.0356***
				(0.00177)	(0.00177)
Lender 17				-0.0129	-0.0131
				(0.0104)	(0.0104)
Lender 18				-0.0707***	-0.0702***
				(0.00259)	(0.00259)
Lender 19				-0.00453**	-0.00475**
				(0.00224)	(0.00223)
Lender 20				0.000711	0.00123
				(0.00206)	(0.00206)

Lender 21						0.0128***	0.0134***
						(0.00181)	(0.00181)
Lender 22						-0.0255***	-0.0251***
						(0.00210)	(0.00210)
Lender 23						0.0108***	0.0111***
						(0.00167)	(0.00167)
Lender 24						0.0584	0.0603
						(0.161)	(0.161)
Lender 25						0.00577	0.00513
						(0.0659)	(0.0658)
Lender 26						-0.0113***	-0.0110***
						(0.00382)	(0.00381)
Lender 27						-0.0408***	-0.0396***
						(0.00193)	(0.00193)
Locational Characteristics							
Degree of urbanity							
Very Urban							-
Urban							-0.00588***
							(0.00136)
Medium Urban							-0.00779***
							(0.00161)
Rural							-0.0168***
							(0.00170)
Very Rural							-0.0229***
							(0.00188)
Region							
West							-
North							0.00875***
							(0.00168)
East							0.000215
							(0.00123)
South							-0.00680***
							(0.00118)
Constant	1.646***	1.643***	2.045***	1.978***	1.948***	1.956***	1.987***
	(0.0158)	(0.0158)	(0.0158)	(0.0160)	(0.0161)	(0.0164)	(0.0183)
Observations	151,089	151,089	151,089	151,089	151,089	151,089	151,089
R-squared	0.037	0.038	0.152	0.191	0.194	0.204	0.206

Note: Dependent variable is LTV ratio and independent variable is energy label in dummy categories. The reference category include Type of housing apartment, Construction category after 2004, Energy label G, Type of buyer indication one first-time buyer, Age cohort > 66, Lender type insurance company, Lender anonymous lender 1, Degree of urbanity very urban, and Region West. Standard errors in parentheses with *** p<0.01, ** p<0.05, * p<0.1, indicating significant at 1%, 5% and 10% respectively.

4.2 Heterogeneity across first-time buyers and seasoned buyers

In this part of the research the relationships between the LTV ratio and energy labels are explored on the household's basis. To test whether the true coefficients are equal across the type of buyer a Chow test is performed on two subsamples (first-time homebuyer and seasoned buyer).

Table 4 – Chow test outcomes based on the OLS regression model Chow test

Chow test	Pooled	First-time buyers	Seasoned buyers
Residuals	4,939.8927	1787.07365	3061.27199
Observations	151,089	79,540	71,549
F-Value	(33, 151055) = 1101.16	(33, 79506) = 435.46	(33, 71515) = 549.86
Critical F Value (2.5% significance level)	1.57	1.57	1.57
Chow F statistics	86.4	86.4	86.4

Table 4 shows the outcome of the Chow-test. Main model 7 cannot be used for the Chow-test since the type of buyer is already accounted for in the model. Therefore table 5 shows the regression results for the Chow-test without the variable type of buyer. Moreover, in the model lender behavior is accounted for as type of lender, since the detailed lender variable contains missing cases for first-time buyers. Inserting the residuals for the pooled- and subsamples results in the following F-statistic.

$$F = \frac{4939{,}8927 - (1787{,}07365 + 3061{,}27199)}{(1787{,}07365 + 3061{,}27199)} \times \frac{(151089 - 2 * 33)}{(2 * 33 - 33)} = 86.4$$

The critical F-value on a 2.5% significance level (obtained from the F-Value statistics table) is 1.57. The critical F-value is lower than the test results (86.4). Thus, there is no parameter stability throughout the sample groups of first-time buyers and seasoned buyers. Therefore the earlier stated null hypotheses 'no difference can be obtained between the subsamples first-time homebuyers and seasoned homebuyers' can be rejected. The parameter instability corresponds to the study of Follain (1990). An explanation for this can be that first-time homebuyers borrow as much as possible in the first years, resulting in a different LTV ratio than seasoned buyers.

Table 5 – OLS regression Chow test

VARIABLES	Pooled Model	First-time buyers	Seasoned buyers
Housing Characteristics			
Ln Dwelling Surface	0.0177***	0.00829***	0.0312***
	(0.00157)	(0.00189)	(0.00255)
Ln Property Value	-0.114***	-0.109***	-0.118***
	(0.00154)	(0.00188)	(0.00249)
Type of Housing			
Apartment	-	-	-
Corner Dwelling	0.0105***	0.0150***	0.00932***
	(0.00166)	(0.00191)	(0.00285)
Semi-Detached Dwelling	0.0159***	0.0210***	0.0153***
	(0.00195)	(0.00241)	(0.00315)
Terraced Dwelling	0.00902***	0.0137***	0.00672***
	(0.00138)	(0.00156)	(0.00244)
Detached Dwelling	0.0117***	0.0127***	0.0120***
	(0.00225)	(0.00319)	(0.00345)
Newly Built	0.000965	0.00807**	-0.0122**
	(0.00317)	(0.00343)	(0.00587)
Construction Category			
Constructed before 1945	0.00801***	0.00984***	0.00347
	(0.00255)	(0.00307)	(0.00413)
Constructed between 1945 – 1964	0.00611**	0.00863***	0.00179
	(0.00254)	(0.00305)	(0.00415)
Construted between 1965 - 1984	0.00476**	0.00724***	0.000881
	(0.00225)	(0.00275)	(0.00358)
Constructed between 1985 - 2004	0.00241	0.00313	0.00183
	(0.00195)	(0.00245)	(0.00303)
Constructed after 2004	-	-	-
Energy Label			
Label A	-0.0363***	-0.0267***	-0.0481***
	(0.00280)	(0.00337)	(0.00452)
Label B	-0.0358***	-0.0284***	-0.0455***
	(0.00257)	(0.00304)	(0.00422)
Label C	-0.0335***	-0.0286***	-0.0398***
	(0.00226)	(0.00266)	(0.00373)
Label D	-0.0257***	-0.0199***	-0.0334***
	(0.00220)	(0.00258)	(0.00367)
Label E	-0.0201***	-0.0180***	-0.0217***
	(0.00228)	(0.00265)	(0.00381)
Label F	-0.0167***	-0.0159***	-0.0167***
	(0.00232)	(0.00275)	(0.00380)
Label G	-	-	-
Household Characteristics			
Multiple Dependents	0.111***	0.107***	0.112***
	(0.000989)	(0.00117)	(0.00165)
Age Cohort			
Age 18 – 25	0.231***	0.164***	0.229***
	(0.00288)	(0.00670)	(0.00671)
Age 26 – 35	0.248***	0.185***	0.242***
	(0.00265)	(0.00664)	(0.00340)
Age 36 – 45	0.260***	0.196***	0.265***
	(0.00272)	(0.00674)	(0.00336)
Age 46 – 55	0.220***	0.165***	0.226***
	(0.00281)	(0.00699)	(0.00344)
Age 56 – 65	0.102***	0.0880***	0.102***
	(0.00314)	(0.00796)	(0.00380)

Age > 66	-	-	-
Lender Characteristics			
Lender Type			
Insurance Company	-	-	-
Large Bank	-0.0111***	-0.00907***	-0.0161***
	(0.00106)	(0.00123)	(0.00180)
Small Bank	-0.0156***	-0.0149***	-0.0162***
	(0.00123)	(0.00145)	(0.00203)
Other	0.0145***	-0.00725***	0.0337***
	(0.00127)	(0.00156)	(0.00200)
Locational Characteristics			
Degree of Urbanity			
Very Urban	-	-	-
Urban	-0.00753***	-0.00544***	-0.00689***
	(0.00137)	(0.00153)	(0.00241)
Medium Urban	-0.00969***	-0.00824***	-0.00794***
	(0.00162)	(0.00188)	(0.00274)
Rural	-0.0193***	-0.0169***	-0.0181***
	(0.00171)	(0.00203)	(0.00285)
Very Rural	-0.0251***	-0.0200***	-0.0265***
	(0.00189)	(0.00227)	(0.00310)
Region			
West	-	-	-
Noord	0.00839***	0.00887***	0.00804***
	(0.00169)	(0.00207)	(0.00269)
Oost	-0.000523	-0.000272	-0.00115
	(0.00123)	(0.00147)	(0.00200)
Zuid	-0.00685***	-0.00753***	-0.00719***
	(0.00119)	(0.00141)	(0.00195)
Constant	1.995***	2.036***	1.977***
	(0.0180)	(0.0230)	(0.0283)
Observations	151,089	79,540	71,549
R-squared	0.194	0.153	0.202

Note: The table represents the separate model results, based on grouping of the dataset. Dependent variable LTV ratio and independent variable is energy label in dummy categories. The reference category include Type of housing apartment, Construction category after 2004, Energy label G, Age cohort > 66, Lender type insurance company, Degree of urbanity very urban, and Region West. Standard errors in parentheses with *** p<0.01, ** p<0.05, * p<0.1, indicating significant at 1%, 5% and 10% respectively.

4.3 Discussion

The upcoming energy transition and associated investments depend on the LTV ratio and the energy efficiency of the house. However, a problem could be observed regarding mortgage lending and energy efficiency in the current Dutch housing market context. The current housing market situation results in households bidding against each other which can lead to rather high LTV ratios and to extra down payments that may reduce the financing of the upcoming energy transition. Therefore the main interest of this study was on to what extent the mortgage lending (expressed as the LTV ratio) is associated with the energy efficiency of

a home (expressed as residential energy labels) of Dutch households on the verge of the energy transition. The results show three main findings that match the earlier stated expectations. First, residential energy labels are negatively related to the LTV ratio of new loans in the Netherlands. Secondly, the findings show the better the energy label of the house, the lower the LTV ratio of the household, and vice versa. Thirdly, there are more households with the least efficient label (G) and a high LTV ratio in contrast to households with the most efficient label (A) and a high LTV ratio.

To my knowledge, these findings have not been identified by literature. However, what does this mean in terms of the earlier stated problem? The findings indicate that Dutch households with least efficient homes obtain relatively higher debts (expressed as the LTV ratio) compared to households with more efficient homes. Specifically, the LTV ratio of Dutch borrowers is lower among households with an efficient energy label (A, B, C) relative to households with an inefficient energy label (D, E, F, G). A higher LTV ratio implies higher mortgage risk and unavailable or scarce funding for the household. Households with high LTV ratios and efficient labels face less risk because energy efficiency frees up a part of the household's income, which provides access to funding and improves the ability to repay debt (Burt et al., 2010; Billio et al., 2021). However, for households obtaining an inefficient label this might be problematic. Due to the inefficient home, households spend a larger amount of their income on energy expenditures. Therefore they do not have access to extra funding to repay debt or improve the energy efficiency of their homes. Based on these findings we can learn that the energy transition might indeed be problematic for households with an inefficient label since they are at a higher risk. These risks imply higher mortgage- and energy expenditures. Which results in fewer funds to repay debt and to invest in the energy efficiency of the house. However, it should be borne in mind that the higher LTV ratios on less efficient houses can be the result of the 106 percent LTV ratio for sustainability improvements. In addition, the explanatory power of the main model must also be taken into account, since it is at its highest at 20.6 percent.

5. Conclusion

The focus of this study was to what extent a relationship can be observed between the LTV ratio of new loans from households and residential energy labels in the Netherlands on the verge of the energy transition. Earlier studies and theories on the LTV ratio have been used to understand patterns in the mortgage market and the LTV ratio concerning energy efficiency. Subsequently, data from the Dutch Land Registry Office was analyzed to understand the type and strength of the relationships. The dataset contained 151,089 microdata observations on newly concluded residential mortgages of natural persons in the Netherlands from January 1st, 2019 till the 31st of December 2020. This data has been analyzed by performing an Classical Linear Regression Model, to answer the research question:

To what extent can a relationship be observed between the loan-to-value ratio of new loans from households and residential energy labels in the Netherlands?

The main findings show that residential energy labels are negatively related to the LTV ratio of new loans in the Netherlands. Moreover, the findings show the better the energy label of the house, the lower the LTV ratio of the household and vice versa. Therefore, the main hypothesis cannot be rejected, that the LTV ratio of Dutch borrowers is lower among households with an efficient energy label (A, B, C) relative to households with an inefficient energy label (D, E, F, G). Thirdly, the findings indicate that the LTV ratio differs based on housing characteristics, household characteristics, lender behavior, and locational characteristics. Lastly, the findings suggest that there is no parameter stability throughout the sample groups of first-time buyers and seasoned buyers. These observations are supported by earlier studies from Coulibaly and Li (2009), Fortowksy et al. (2011), Follain, (1990), and Donkers & van Soest, (1999).

Based on these findings we have obtained a better understanding of the association between mortgage lending and energy efficiency on the verge of the energy transition in the Netherlands. However, what can we learn from it? To my knowledge, the observed relationship between the LTV ratio and residential energy label has not been identified by the literature. However, an explanation for the higher LTV ratios on less energy-efficient housing could be the maximum 106 percent LTV ratio for sustainability upgrades. The consequences

of LTV ratio differences based on energy efficiency are discussed in earlier literature. The findings complement the earlier studies of Burt et al. (2010) and Billio et al. (2021) that the high LTV ratios issued on energy-efficient houses have lower risks for households relative to less efficient houses. Energy efficiency frees up a part of the household's income, which provides access to funding and improves the ability to repay debt. This corresponds to the studies of Frey (2003) and McLaren (1992) stating that the energy expenditure savings offset some mortgage risks. However, households with a high LTV ratio combined with an inefficient label might be at a higher risk. That is, because of the high LTV ratio and the inefficient energy label, households obtain high mortgage- and energy expenditures. This comes with a higher risk to be in mortgage arrears and leaving no fund to invest in the improvements of the energy efficiency of their dwelling. Therefore, the findings of this study underline the earlier observed problem for households with an inefficient energy label in terms of mortgage risk and the progress of the Dutch energy transition.

Analyzing the LTV ratio in terms of energy labels contributed to a better understanding of the relationship between residential mortgage lending and energy efficiency. However, since the role and importance of LTV's have increased as well as the interest in energy efficiency, further research is recommended. As the main model of the thesis only reaches an explanatory power of 20.6 percent it is recommended to add extra regulatory variables. One of these extra regulatory variables is the loan-to-income ratio. The loan-to-income ratio is an often-used measure by lenders to determine the mortgage amount. A second extra regulatory variable is the energy efficiency index of the house. Including these variables will provide a more detailed insight into residential mortgage lending and energy efficiency. Lastly, in this study the focus is on Dutch newly concluded loans between 2019 and 2020. Earlier studies address that the LTV ratio differs across countries and periods. Therefore, future research could look at the relationship between the LTV ratio and energy labels in other countries and across different time periods.

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7. Appendices

Appendix A - Variable Definitions

Table A1 – Variable definitions

Category	Label	Type	Description
Dependent variable	Loan-to-value ratio	Continue	The LTV ratio is derived by dividing the loan amount (GELDLENING_BEDRAG) by the property value (TNS_BEDRAG) and represents the down payment percentage of the mortgagor
Independent variable	Energy label	Continue	Type of energy label A, B, C, D, E, F, G
	Energy label dummies		
	Label A, B or C	dummy	indication whether the dwelling is labeled A, B or C, whereas 1 = yes and 0 = no
	Label A	dummy	indication whether the dwelling is labeled A, whereas 1 = yes and 0 = no
	Label B	dummy	indication whether the dwelling is labeled B, whereas 1 = yes and 0 = no
	Label C	dummy	indication whether the dwelling is labeled C, whereas 1 = yes and 0 = no
	Label D	dummy	indication whether the dwelling is labeled D, whereas 1 = yes and 0 = no
	Label E	dummy	indication whether the dwelling is labeled E, whereas 1 = yes and 0 = no
	label F	dummy	indication whether the dwelling is labeled F, whereas 1 = yes and 0 = no
	Label G	dummy	indication whether the dwelling is labeled G, whereas 1 = yes and 0 = no
Housing characteristics	Dwelling Surface	Continue	The amount of square meters of the dwelling
	Property Value	Continue	The value of the property in euro's
	Year of construction	Continue	The year of construction of the dwelling
	Construction dummy		
	Constructed before 1945	Dummy	Indication if the dwelling is constructed before 1945, whereas 1 = yes and 0 = no
	Constructed between 1945 - 1964	Dummy	Indication if the dwelling is constructed between 1945 - 1964, whereas 1 = yes and 0 = no
	Constructed between 1965 - 1984	Dummy	Indication if the dwelling is constructed between 1965 - 1984, whereas 1 = yes and 0 = no
	Constructed between 1985 - 2004	Dummy	Indication if the dwelling is constructed between 1985 - 2004, whereas 1 = yes and 0 = no
	Constructed after 2004	Dummy	Indication if the dwelling is constructed after 1945, whereas 1 = yes and 0 = no
	Newly Build	Dummy	Indication whether the dwelling is newly build, whereas 1 = newly constructed and 0 = not newly constructed
	Apartment	Dummy	Indication whether the dwelling is an apartment, whereas 1 = yes and 0 = no
	Terraced dwelling	Dummy	Indication whether the dwelling is a terraced dwelling, whereas 1 = yes and 0 = no
	Corner dwelling	Dummy	Indication whether the dwelling is a corner dwelling, whereas 1 = yes and 0 = no
	Semi-detached dwelling	Dummy	Indication whether the dwelling is a semi-detached dwelling, whereas 1 = yes and 0 = no
	Detached dwelling	Dummy	Indication whether the dwelling is a detached dwelling, whereas 1 = yes and 0 = no
Household characteristics	First-time buyer indication	Dummy	Indication whether the mortgagor is a first time buyer, whereas 1 = first-time buyer and 0 = seasoned buyer
	Type of buyer dummy		
	One first-time buyer	Dummy	Indication whether the mortgagor is one first time buyer, whereas 1 = yes and 0 = no
	Two first-time buyers	Dummy	Indication whether the mortgagors are two first time buyer, whereas 1 = yes and 0 = no
	One first-time buyer one seasoned buyer	Dummy	Indication whether the mortgagors are one first time buyer and one seasoned buyer, whereas 1 = yes and 0 = no
	One seasoned buyer	Dummy	Indication whether the mortgagor is one seasoned buyer, whereas 1 = yes and 0 = no
	Two seasoned buyers	Dummy	Indication whether the mortgagors are two seasoned buyers, whereas 1 = yes and 0 = no
	Age	Continue	Represents the age of the oldest mortgagor
	Age dummy		
	Age 18 - 25	Dummy	Indication whether the age of the oldest mortgagor is between 18 - 25, whereas 1= yes and 0 = no
	Age 26 - 35	Dummy	Indication whether the age of the oldest mortgagor is between 26 - 35, whereas 1= yes and 0 = no
	Age 36 - 45	Dummy	Indication whether the age of the oldest mortgagor is between 36 - 45, whereas 1= yes and 0 = no
	Age 46 - 55	Dummy	Indication whether the age of the oldest mortgagor is between 46 - 55, whereas 1= yes and 0 = no

	Age 56 - 65	Dummy	Indication whether the age of the oldest mortgagor is between 56 - 65, whereas 1= yes and 0 = no
	Age > 66	Dummy	Indication whether the age of the oldest mortgagor higher than 65, whereas 1= yes and 0 = no
	Multiple dependents	Dummy	Indication whether there are multiple mortgage dependents whereas 1 = multiple dependents and 0 = one dependent
Lender Behavior	Insurance company	Dummy	Indication whether the lender is an insurance company, whereas 1 = yes and 0 = no
	Small bank	Dummy	Indication whether the lender is a small bank, whereas 1 = yes and 0 = no
	Large bank	Dummy	Indication whether the lender is a large bank, whereas 1 = yes and 0 = no
	Other kind of lender	Dummy	Indication whether the lender is another kind of lender (for example pension funds), whereas 1 = yes and 0 = no
	Lender 1	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 2	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 3	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 4	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 5	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 6	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 7	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 8	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 9	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 10	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 11	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 12	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 13	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 14	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 15	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 16	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 17	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 18	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 19	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 20	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 21	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 22	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 23	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 24	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 25	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 26	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
	Lender 27	Dummy	Indication type of lender (anonymous), whereas 1 = yes and 0 = no
Locational characteristics	Very urban	Dummy	Degree of urbanity of the neighborhood, where 1 = very urban and 0 = not
	Urban	Dummy	Degree of urbanity of the neighborhood, where 1 = urban and 0 = not
	Medium urban	Dummy	Degree of urbanity of the neighborhood, where 1 = medium urban and 0 = not
	Rural	Dummy	Degree of urbanity of the neighborhood, where 1 = rural and 0 = not
	Very rural	Dummy	Degree of urbanity of the neighborhood, where 1 = very rural and 0 = not
	North	Dummy	Indication if the dwelling is located in the North of the Netherlands (Groningen, Friesland, Drenthe), whereas 1 = yes and 0 = no
	South	Dummy	Indication if the dwelling is located in the South of the Netherlands (Noord-Brabant, Limburg), whereas 1 = yes and 0 = no
	West	Dummy	Indication if the dwelling is located in the West of the Netherlands (Noord-Holland, Zuidholland, Zeeland, Utrecht), whereas 1 = yes and 0 = no
	East	Dummy	Indication if the dwelling is located in the East of the Netherlands (Overijssel, Gelderland, Flevoland), whereas 1 = yes and 0 = no

Appendix B – Descriptive analysis

Table A2 – Descriptive Analysis

Variable	Mean	Std. Dev.	Min	Max
LTV ratio	.92	.181	.036	1.399
Energy Label	3.328	1.712	1	7
Label A	.177	.381	0	1
Label B	.14	.347	0	1
Label C	.296	.456	0	1
Label D	.148	.355	0	1
Label E	.106	.308	0	1
Label F	.076	.264	0	1
Label G	.059	.235	0	1
Dwelling Surface	123.718	52.526	20	500
Property Value	301870.27	146344.53	75000	4500000
Apartment	.211	.408	0	1
Corner Dwelling	.158	.365	0	1
Semi-detached Dwelling	.114	.317	0	1
Terraced Dwelling	.414	.493	0	1
Detached Dwelling	.103	.304	0	1
Newly Build	.018	.134	0	1
Year of Construction	1969.035	32	1364	2020
Constructed before 1945	.203	.402	0	1
Constructed between 1945 – 1964	.15	.357	0	1
Constructed between 1965 – 1984	.31	.463	0	1
Constructed between 1985 – 2004	.229	.42	0	1
Constructed after 2004	.107	.31	0	1
One first-time buyer	.197	.398	0	1
Two first-time buyers	.327	.469	0	1
One first-time buyer and one seasoned buyer	.1	.3	0	1
One seasoned buyer	.168	.374	0	1
Two seasoned buyers	.208	.406	0	1
Age	37.081	11.427	18	88
Age 18 – 25	.112	.315	0	1
Age 26 – 35	.438	.496	0	1
Age 36 – 45	.234	.424	0	1
Age 46 – 55	.137	.344	0	1
Age 56 – 65	.052	.223	0	1
Age > 65	.027	.15	0	1
Insurance Company	.306	.461	0	1
Small Bank	.187	.39	0	1
Large Bank	.336	.472	0	1
Other	.171	.376	0	1
Lender 1	.196	.397	0	1
Lender 2	0	.006	0	1
Lender 3	.034	.181	0	1
Lender 4	.093	.29	0	1
Lender 5	.038	.191	0	1
Lender 6	0	.006	0	1
Lender 7	0	.004	0	1
Lender 8	.068	.252	0	1
Lender 9	.007	.086	0	1
Lender 10	0	.004	0	1
Lender 11	0	.016	0	1
Lender 12	.014	.116	0	1
Lender 13	0	.014	0	1
Lender 14	0	.003	0	1
Lender 15	.057	.233	0	1

Lender 16	.078	.269	0	1
Lender 17	.002	.04	0	1
Lender 18	.03	.17	0	1
Lender 19	.043	.203	0	1
Lender 20	.052	.221	0	1
Lender 21	.074	.261	0	1
Lender 22	.049	.215	0	1
Lender 23	.092	.288	0	1
Lender 24	0	.003	0	1
Lender 25	0	.006	0	1
Lender 26	.013	.112	0	1
Lender 27	.062	.241	0	1
Very Urban	.211	.408	0	1
Urban	.314	.464	0	1
Medium Urban	.184	.387	0	1
Rural	.162	.368	0	1
Very Rural	.129	.335	0	1
West	.46	.498	0	1
East	.208	.406	0	1
North	.103	.303	0	1
South	.23	.421	0	1

Appendix C – Scatterplots

Transformation Dwelling Surface

Figure A1 – Scatter LTV Ratio x Dwelling Surface

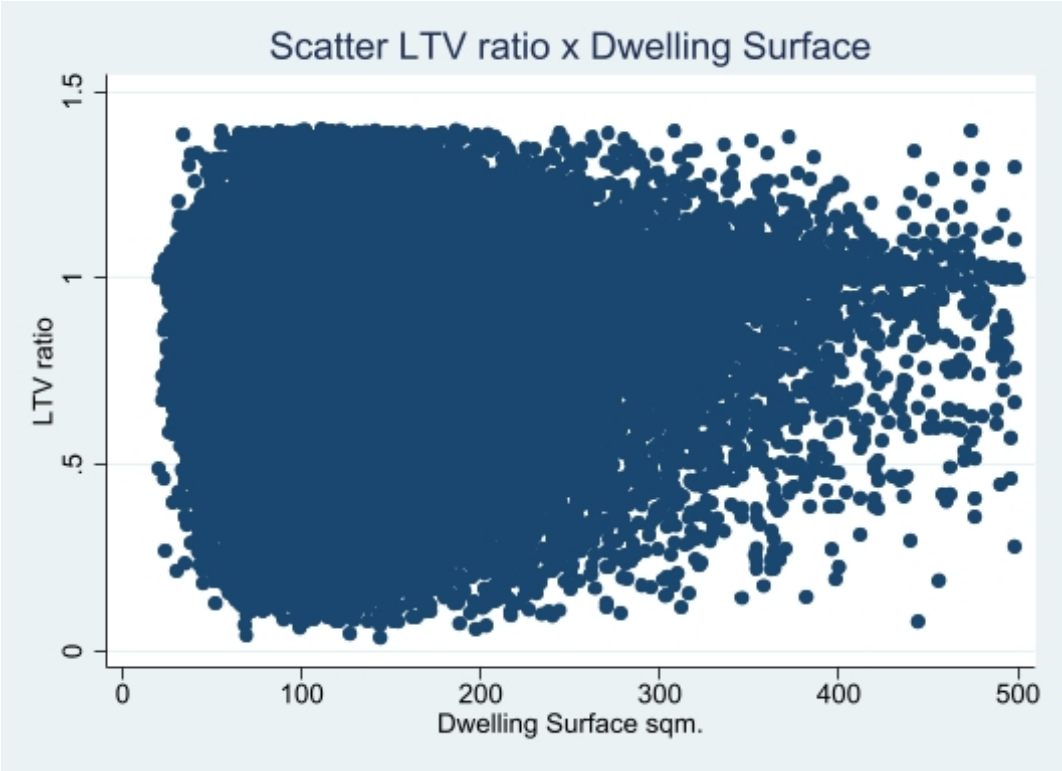
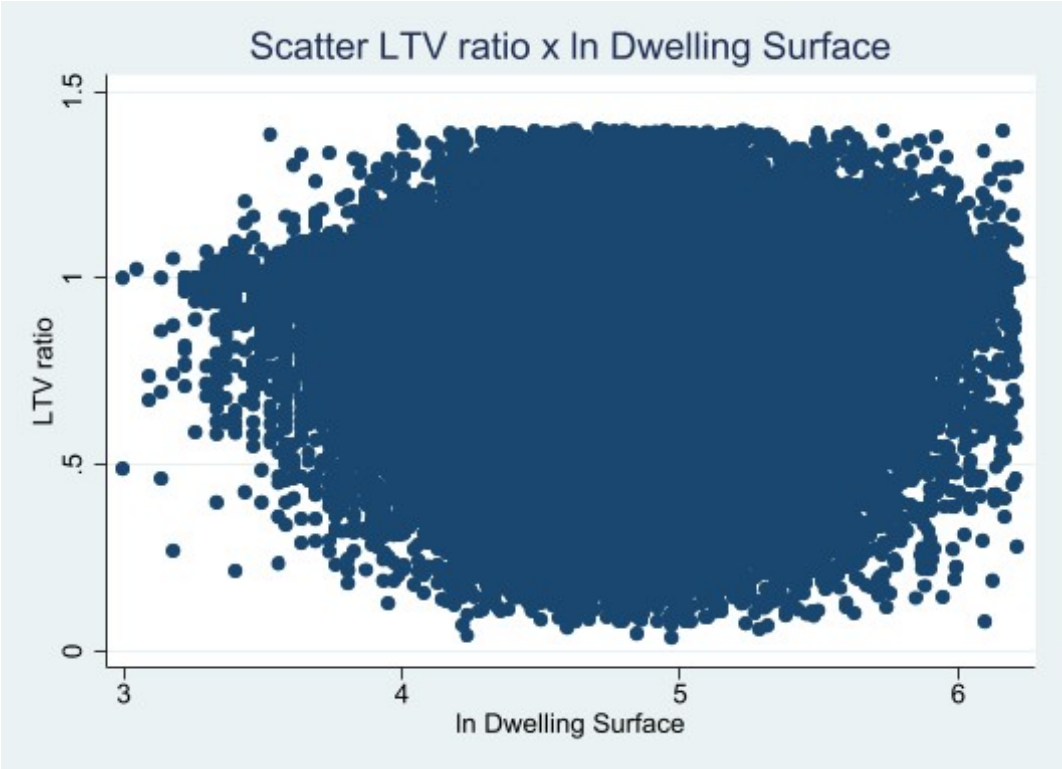


Figure A2 – Scatter LTV Ratio x ln Dwelling Surface



Transformation Property Value

Figure A3 – Scatter LTV Ratio x Property Value

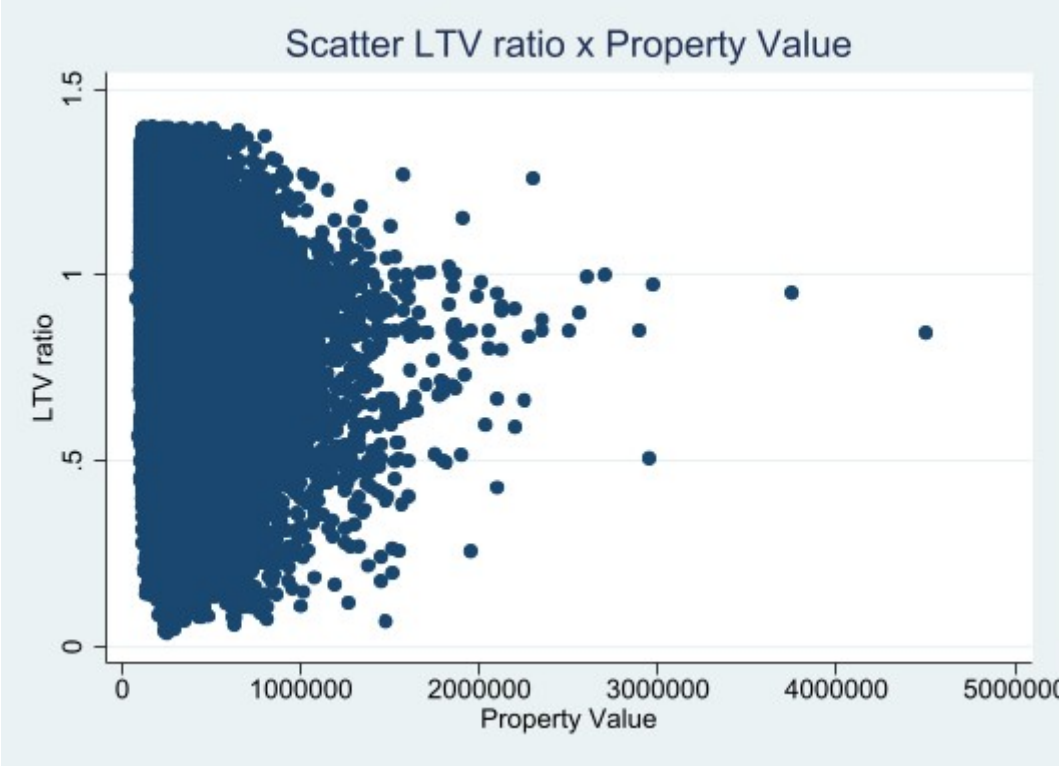
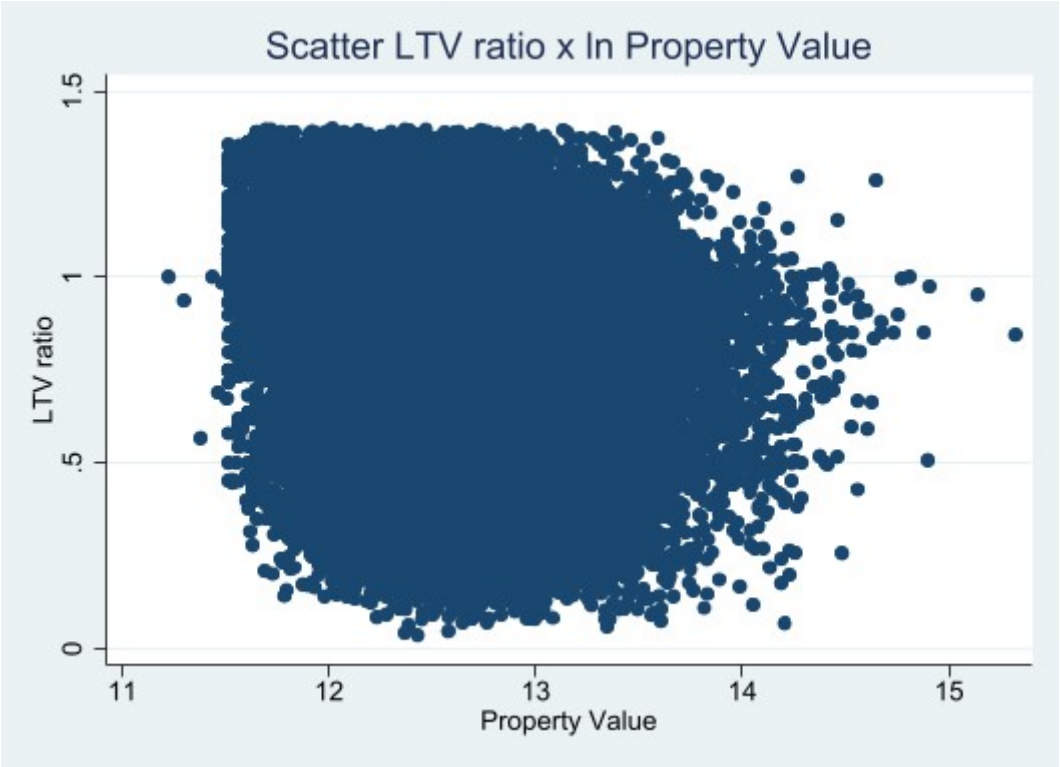


Figure A4 – Scatter LTV Ratio x Ln Property Value



Difference in LTV ratio between least efficient and most efficient energy label

Figure A5 – Scatter LTV Ratio x Property Value Label A versus Label G

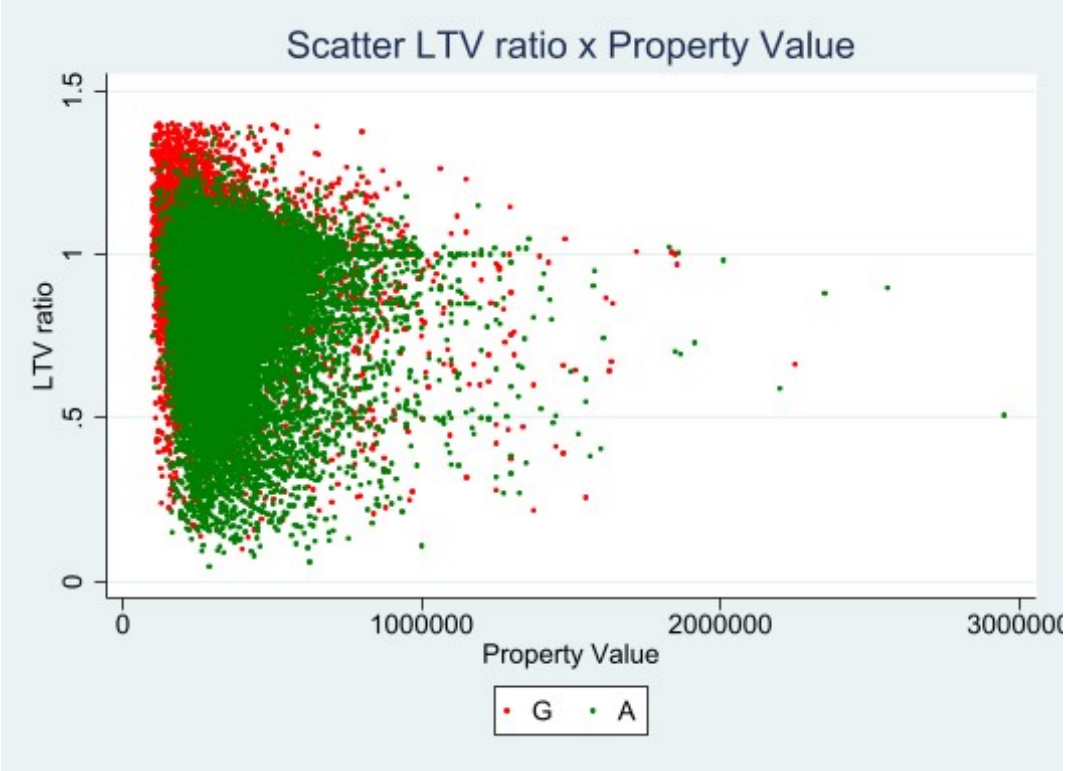
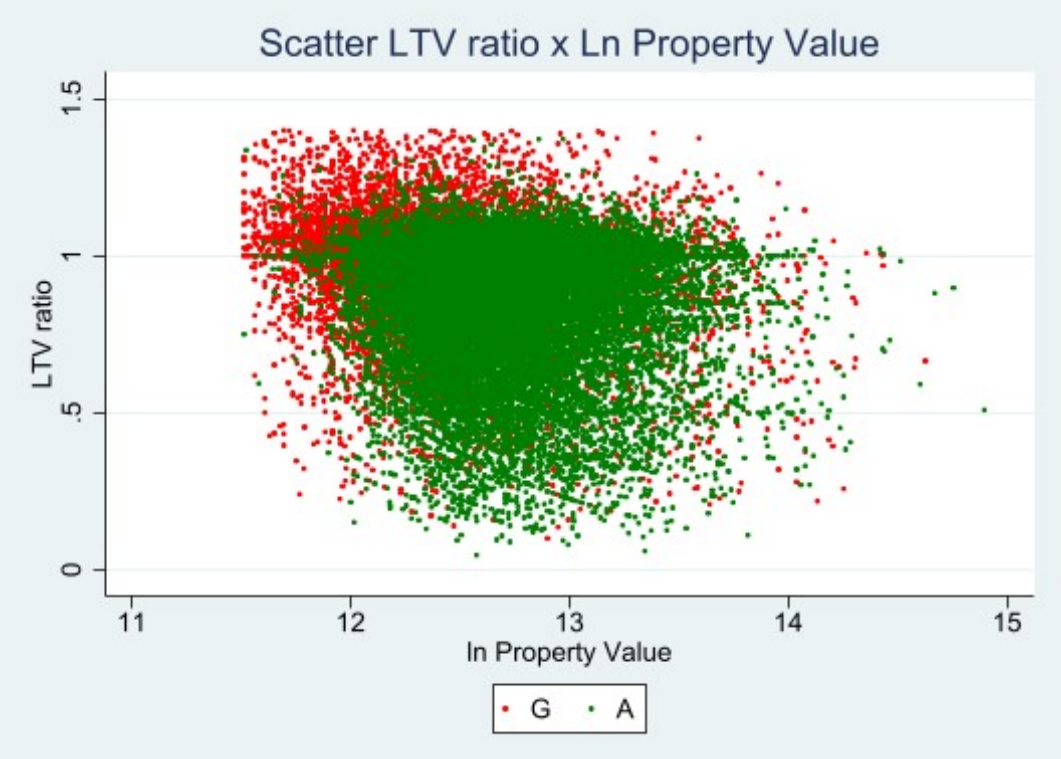
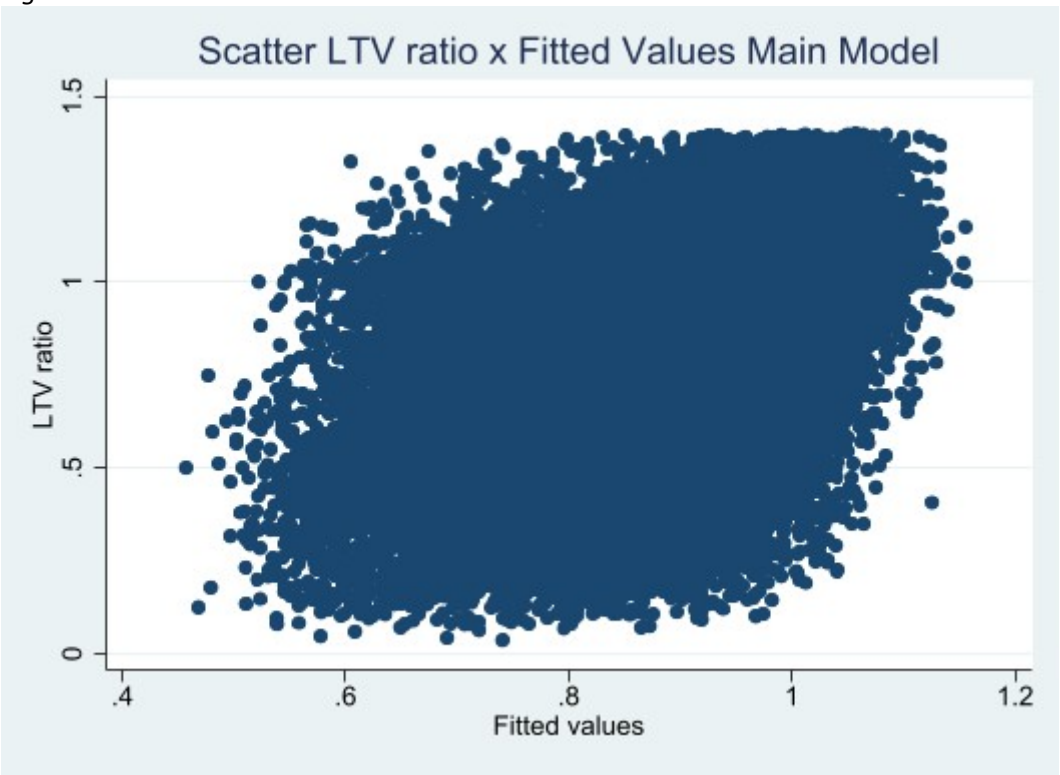


Figure A6 – Scatter LTV Ratio x Ln Property Value Label A versus Label G



Assumption Testing

Figure A7 – Scatter LTV ratio x Fitted Values Main Model



Appendix D – Assumption testing

Testing the value of the energy label coefficients

After running the main model (7), a test has been performed on the coefficients of the individual energy labels to test if any significant differences can be observed between the other labels. See table A3 for the results. The test has not been performed on energy label G, since the label is part of the reference category of the main model. The results show that between label A and B no significant outcomes can be observed, indicating no differences between the coefficients of the labels.

Table A3 – Individual energy label coefficient test significance outcomes

	Label A	Label B	Label C	Label D	Label E	Label F
Label A	x					
Label B	not significant	x				
Label C	5%	10%	x			
Label D	1%	1%	1%	x		
Label E	1%	1%	1%	1%	x	
Label F	1%	1%	1%	1%	10%	x

Correlation

One of the assumptions that are made of the CLRM's disturbance terms is that the covariance between the error terms over time is zero. In other words, it is assumed that the error terms are uncorrelated with one another (Brooks and Tsolacos, 2010). Table A4 shows the most important correlations. The variable 'construction year' and 'energy label' were highly negatively correlated. Therefore the variable 'construction year' is transformed into five year categories.

Multicollinearity

A problem occurs when the explanatory variables are very highly correlated with each other, this is known as multicollinearity. To test the severity of multicollinearity, a variance inflation factor test has been performed (table A5). The outcomes show a high VIF of the variables 'type of buyers' and 'multiple dependents'. However, according to Brooks and Tsocalos (2010) this can be ignored if the model is otherwise adequate. According to Potters (2021), a VIF between one and five indicates moderate correlation. The VIF of the main model (7) is 3.87, and therefore the model is seen as adequate.

Table A4 – Correlation matrix specific variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) LTV Ratio	1.0000																
(2) Energy Label	0.0830	1.000															
(3) Construction Year	-0.0426	-0.7053	1.000														
(4) Property Value	-0.1323	-0.1219	-0.0096	1.000													
(5) Newly Built	-0.0299	-0.0510	0.0446	0.0466	1.000												
(6) Constructed before 1945	0.0157	0.5378	-0.7808	0.1460	-0.0062	1.000											
(7) Constructed between 1945 - 1964	0.0334	0.3027	-0.1514	-0.1250	-0.0106	-0.2124	1.000										
(8) Constructed between 1965 - 1984	0.0388	-0.0291	0.1110	-0.1974	-0.0394	-0.3387	-0.2823	1.000									
(9) Constructed between 1985 - 2004	-0.0422	-0.4011	0.4276	0.0782	-0.0323	-0.2749	-0.2292	-0.3654	1.000								
(10) Constructed after 2004	-0.0596	-0.4605	0.4434	0.1436	0.1229	0.1750	-0.1459	-0.2324	-0.1889	1.000							
(11) Age 18 - 25	0.0358	0.0569	-0.0144	0.2088	-0.0022	-0.0401	0.0627	0.0622	-0.0588	-0.0334	1.000						
(12) Age 26- 25	0.1114	0.0083	-0.0224	-0.0900	0.0164	0.0273	0.0056	0.0000	-0.0264	-0.0062	-0.3131	1.000					
(13) Age 36-45	0.0646	-0.0308	0.0165	0.1673	-0.0068	0.0097	-0,0264	-0.0264	0.0265	0.0215	-0.1963	-0.4879	1.000				
(14) Age 46 - 55	-0.0592	0.0029	-0.0071	-0.0071	-0.0128	0.0129	-0.0147	-0.0148	0.0159	0.0008	-0.1413	-0.3513	-0.2202	1.000			
(15) Age 56 - 65	-0,1738	-0.0133	0.0124	0.0124	-0.0044	-0.0122	0.0113	-0.0097	0.0288	0.0044	-0.0835	-0.2076	-0.1302	-0.0937	1.000		
(16) Age > 66	-0.2153	-0.0432	0.0515	0.0515	0.0052	-0.0415	-0.0235	-0.0072	0.0527	0.0203	-0.0590	-0.1467	-0.0920	-0.0662	-0.0391	1.000	
(17) First-time buyer	0.1508	0.0421	-0.0494	-0.1874	0.0267	0.0157	0.0480	0.0410	-0.0806	-0.0277	0.2992	0.3272	-0.2233	0.2788	-0.1909	-0.1396	1.000

Table A5 – Variance inflation factors

VIF test	model 1	model 2	model 3	model 4	model 5	model 6	model 7
Ln Dwelling Surface	1.84	1.84	1.9	1.9	1.9	1.9	2.04
Ln Property Value	1.44	1.49	1.63	1.68	1.72	1.78	2.30
Apartment	x	x	x	x	x	x	x
Corner Dwelling	1.76	1.78	1.84	1.85	1.85	1.85	2.12
Semi-detached Dwelling	1.67	1.69	1.76	1.76	1.76	1.77	2.2
Terraced Dwelling	2.18	2.2	2.31	2.32	2.32	2.33	2.67
Detached Dwelling	1.91	1.96	2.03	2.03	2.04	2.05	2.7
Newly Built	1.04	1.04	1.04	1.04	1.04	1.04	1.04
Constructed before 1945	1.76	1.69	1.7	1.7	1.7	1.7	1.76
Constructed between 1945 - 1964	1.67	2.94	2.94	2.95	2.95	2.95	3.09
Constructed between 1965 - 1984	2.18	3.46	3.47	3.48	3.48	3.48	3.61
Constructed between 1985 - 2004	1.91	3.48	3.48	3.49	3.49	3.49	3.57
Constructed after 2004	x	x	x	x	x	x	x
Label A		2.34	2.34	2.34	2.34	2.34	2.34
Label B		4.11	4.11	4.11	4.11	4.11	4.12
Label C		3.46	3.46	3.46	3.46	3.46	3.47
Label D		3.08	3.08	3.08	3.08	3.08	3.10
Label E		2.64	2.65	2.65	2.65	2.65	2.67
Label F		2.46	2.46	2.46	2.46	2.46	2.48
Label G		x	x	x	x	x	x
One first-time buyer			x	x	x	x	x
Two first-time buyers			41.49	41.49	41.50	41.50	41.50
One first-time buyer and one seasoned buyer			17.67	17.69	17.69	17.70	17.70
One seasoned buyer			1.88	1.90	1.91	1.92	1.92
Two seasoned buyers			31.88	31.89	31.91	31.93	31.94
Multiple Dependents			42.40	42.43	42.43	42.44	42.44
Age		1.45	x	x	x	x	x
Age 18 -25				2.95	2.95	2.96	2.97
Age 26 -35				2.93	2.93	2.94	2.96
Age 36 - 45				2.43	2.43	2.44	2.44
Age 46 - 55				1.62	1.62	1.62	1.63
Age 56 - 65				1.29	1.29	1.30	1.30
Age > 66				x	x	x	x
Insurance company					x	x	x
Large bank					1.45	x	x
Small bank					1.33	x	x
Other					1.30	x	x
Lender 1						x	x
Lender 2						1.00	1.00
Lender 3						1.14	1.14
Lender 4						1.37	1.38
Lender 5						1.18	1.18
Lender 6						1.00	1.00
Lender 7						1.00	1.00
Lender 8						1.27	1.27
Lender 9						1.04	1.04
Lender 10						1.00	1.00
Lender 11						1.00	1.00
Lender 12						1.06	1.07
Lender 13						1.00	1.00
Lender 14						1.00	1.00

Lender 15						1.24	1.24
Lender 16						1.31	1.31
Lender 17						1.02	1.02
Lender 18						1.13	1.13
Lender 19						1.19	1.19
Lender 20						1.21	1.21
Lender 21						1.30	1.30
Lender 22						1.19	1.19
Lender 23						1.35	1.35
Lender 24						1.00	1.00
Lender 25						1.00	1.00
Lender 26						1.06	1.06
Lender 27						1.25	1.26
Very Urban							x
Urban							2.31
Medium Urban							2.26
Rural							2.29
Very Rural							2.30
West							x
North							1.52
East							1.44
South							1.44
VIF Mean	**1.68**	**2.45**	**7.78**	**6.78**	**6.26**	**4.07**	**3.87**

Heteroscedasticity

Another assumption is that the variance of the errors is constant. If the errors do not have constant variance, they are said to be heteroscedastic (Brooks and Tsolacos, 2010). The White's test and Breusch-Pagan test suggest that the errors are heteroscedastic for all the models at the 99 percent significance level. To control for heteroscedasticity all the models have been performed using heteroscedasticity-consistent standard error estimates. The robust regression models are shown in table A6. The standard errors of the models in table A5 are differently than the standard errors in table 3. However, while comparing with the results of the classic linear regression model no significant differences can be observed on the beta's.

Table A6 – Regression model robust

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	LTV_ratio	LTV_ratio	LTV_ratio	LTV_ratio	LTV_ratio	LTV_ratio	LTV_ratio
Dwelling Surface	0.0232***	0.0228***	0.0212***	0.0168***	0.0165***	0.0160***	0.0187***
	(0.00171)	(0.00171)	(0.00164)	(0.00160)	(0.00160)	(0.00159)	(0.00164)
Property Value	-0.0709***	-0.0681***	-0.0923***	-0.112***	-0.109***	-0.109***	-0.112***
	(0.00142)	(0.00145)	(0.00148)	(0.00148)	(0.00149)	(0.00152)	(0.00170)
Newly Built	-0.00142	-0.00154	-0.000383	0.000213	0.000586	0.00102	0.000849
	(0.00379)	(0.00379)	(0.00357)	(0.00350)	(0.00350)	(0.00348)	(0.00347)
Corner Dwelling	0.0460***	0.0450***	0.0126***	0.00644***	0.00536***	0.00552***	0.0115***
	(0.00171)	(0.00171)	(0.00165)	(0.00161)	(0.00161)	(0.00160)	(0.00172)

Semi-Detached Dwelling	0.0472***	0.0458***	0.0140***	0.00921***	0.00788***	0.00821***	0.0176***
	(0.00195)	(0.00196)	(0.00188)	(0.00184)	(0.00183)	(0.00182)	(0.00204)
Terraced Dwelling	0.0444***	0.0448***	0.0125***	0.00568***	0.00481***	0.00492***	0.00967***
	(0.00142)	(0.00143)	(0.00138)	(0.00135)	(0.00135)	(0.00135)	(0.00145)
Detached Dwelling	0.0297***	0.0269***	0.00631***	0.00339	0.00173	0.00243	0.0140***
	(0.00235)	(0.00238)	(0.00228)	(0.00222)	(0.00221)	(0.00220)	(0.00250)
Constructed before 2004	0.0351***	0.0198***	0.0188***	0.0120***	0.0120***	0.0112***	0.00710***
	(0.00182)	(0.00283)	(0.00267)	(0.00260)	(0.00259)	(0.00258)	(0.00261)
Constructed between 1945 - 1964	0.0252***	0.0142***	0.0115***	0.00680***	0.00663**	0.00602**	0.00513**
	(0.00193)	(0.00283)	(0.00266)	(0.00259)	(0.00258)	(0.00257)	(0.00257)
Constructed between 1965 - 1984	0.0171***	0.0131***	0.00957***	0.00565**	0.00531**	0.00489**	0.00402*
	(0.00171)	(0.00252)	(0.00237)	(0.00230)	(0.00229)	(0.00228)	(0.00228)
Constructed between 1985 - 2004	0.00584***	0.00630***	0.00601***	0.00411**	0.00387*	0.00379*	0.00251
	(0.00177)	(0.00221)	(0.00207)	(0.00201)	(0.00200)	(0.00199)	(0.00199)
Label A		-0.0298***	-0.0349***	-0.0366***	-0.0369***	-0.0378***	-0.0377***
		(0.00317)	(0.00301)	(0.00294)	(0.00293)	(0.00292)	(0.00292)
Label B		-0.0325***	-0.0363***	-0.0358***	-0.0364***	-0.0367***	-0.0362***
		(0.00290)	(0.00275)	(0.00269)	(0.00269)	(0.00268)	(0.00268)
Label C		-0.0271***	-0.0333***	-0.0333***	-0.0338***	-0.0337***	-0.0334***
		(0.00255)	(0.00243)	(0.00239)	(0.00238)	(0.00237)	(0.00238)
Label D		-0.0189***	-0.0247***	-0.0257***	-0.0259***	-0.0259***	-0.0258***
		(0.00250)	(0.00238)	(0.00234)	(0.00234)	(0.00233)	(0.00234)
Label E		-0.0158***	-0.0188***	-0.0196***	-0.0198***	-0.0198***	-0.0200***
		(0.00254)	(0.00243)	(0.00239)	(0.00238)	(0.00237)	(0.00238)
Label F		-0.0136***	-0.0161***	-0.0162***	-0.0164***	-0.0161***	-0.0163***
		(0.00263)	(0.00251)	(0.00247)	(0.00246)	(0.00245)	(0.00245)
Two first-time buyers			0.0158**	0.00728	0.00715	0.00666	0.00650
			(0.00636)	(0.00641)	(0.00643)	(0.00635)	(0.00634)
One first tme-buyer and one seasoned buyer			0.0130**	-0.0112*	-0.0127*	-0.0117*	-0.0115*
			(0.00648)	(0.00652)	(0.00654)	(0.00646)	(0.00646)
One seasoned buyer			0.00309*	-0.0220***	-0.0235***	-0.0226***	-0.0221***
			(0.00179)	(0.00174)	(0.00174)	(0.00173)	(0.00173)
Two seasoned buyers			0.0188***	-0.00469	-0.00722	-0.00624	-0.00582
			(0.00647)	(0.00651)	(0.00653)	(0.00645)	(0.00644)
Age			-0.00344***				
			(5.99e-05)				
Age 18 – 25				0.218***	0.217***	0.218***	0.218***
				(0.00452)	(0.00448)	(0.00445)	(0.00445)
Age 26 - 35				0.239***	0.239***	0.239***	0.238***
				(0.00440)	(0.00436)	(0.00433)	(0.00433)
Age 36 - 45				0.258***	0.259***	0.257***	0.255***
				(0.00441)	(0.00436)	(0.00433)	(0.00433)
Age 46 - 55				0.221***	0.221***	0.219***	0.218***
				(0.00454)	(0.00450)	(0.00446)	(0.00446)
Age 56 - 65				0.102***	0.102***	0.102***	0.101***
				(0.00515)	(0.00510)	(0.00506)	(0.00506)
Multiple Dependents			0.0893***	0.0995***	0.0992***	0.0979***	0.0981***
			(0.00631)	(0.00636)	(0.00637)	(0.00629)	(0.00629)
Large Bank					-0.0118***		
					(0.00105)		
Small Bank					-0.0155***		
					(0.00119)		
Other					0.0153***		

	(0.00123)		
Lender 2		0.163***	0.164***
		(0.0396)	(0.0408)
Lender 3		-0.0193***	-0.0192***
		(0.00228)	(0.00228)
Lender 4		-0.0231***	-0.0228***
		(0.00172)	(0.00172)
Lender 5		-0.00427**	-0.00328
		(0.00201)	(0.00201)
Lender 6		-0.199**	-0.192*
		(0.0992)	(0.0997)
Lender 7		0.0404	0.0433
		(0.0676)	(0.0704)
Lender 8		0.0112***	0.0118***
		(0.00161)	(0.00161)
Lender 9		0.0620***	0.0617***
		(0.00585)	(0.00584)
Lender 10		0.174**	0.173**
		(0.0764)	(0.0762)
Lender 11		-0.0145	-0.0153
		(0.0314)	(0.0311)
Lender 12		0.000771	0.00131
		(0.00377)	(0.00376)
Lender 13		-0.000396	-0.00238
		(0.0186)	(0.0186)
Lender 14		0.0573***	0.0466***
		(0.00332)	(0.00353)
Lender 15		0.00769***	0.00805***
		(0.00223)	(0.00223)
Lender 16		-0.0352***	-0.0356***
		(0.00202)	(0.00202)
Lender 17		-0.0129	-0.0131
		(0.0142)	(0.0142)
Lender 18		-0.0707***	-0.0702***
		(0.00271)	(0.00271)
Lender 19		-0.00453**	-0.00475**
		(0.00230)	(0.00230)
Lender 20		0.000711	0.00123
		(0.00179)	(0.00179)
Lender 21		0.0128***	0.0134***
		(0.00161)	(0.00161)
Lender 22		-0.0255***	-0.0251***
		(0.00230)	(0.00230)
Lender 23		0.0108***	0.0111***
		(0.00156)	(0.00156)
Lender 24		0.0584***	0.0603***
		(0.00405)	(0.00406)
Lender 25		0.00577	0.00513
		(0.0628)	(0.0605)
Lender 26		-0.0113***	-0.0110***
		(0.00354)	(0.00354)
Lender 27		-0.0408***	-0.0396***
		(0.00210)	(0.00209)
Urban			-0.00588***
			(0.00138)
Medium Urban			-0.00779***
			(0.00162)

Rural							-0.0168***
							(0.00173)
Very Rural							-0.0229***
							(0.00194)
North							0.00875***
							(0.00167)
East							0.000215
							(0.00120)
South							-0.00680***
							(0.00118)
Constant	1.646***	1.643***	2.045***	1.978***	1.948***	1.956***	1.987***
	(0.0167)	(0.0167)	(0.0174)	(0.0181)	(0.0182)	(0.0186)	(0.0204)
Observations	151,089	151,089	151,089	151,089	151,089	151,089	151,089
R-squared	0.037	0.038	0.152	0.191	0.194	0.204	0.206

Note: Dependent variable is LTV ratio and independent variable is energy label in dummy categories. The reference category include Type of housing apartment, Construction category after 2004, Energy label G, Type of buyer indication one first-time buyer, Age cohort > 66, Lender type insurance company, Lender anonymous lender 1, Degree of urbanity very urban, and Region West. Standard errors in parentheses with *** p<0.01, ** p<0.05, * p<0.1, indicating significant at 1%, 5% and 10% respectively.

Normality of residuals

Lastly, the disturbances need to be normally distributed. To test for normality a normal probability plot (figure A8) and Kernel Density Plot (figure A9) have been performed. Both plots show only small deviations between the observed dependent and predicted values. Therefore it is assumed that the residuals follow a normal distribution.

Figure A8 – Standardized Normal Probability Plot

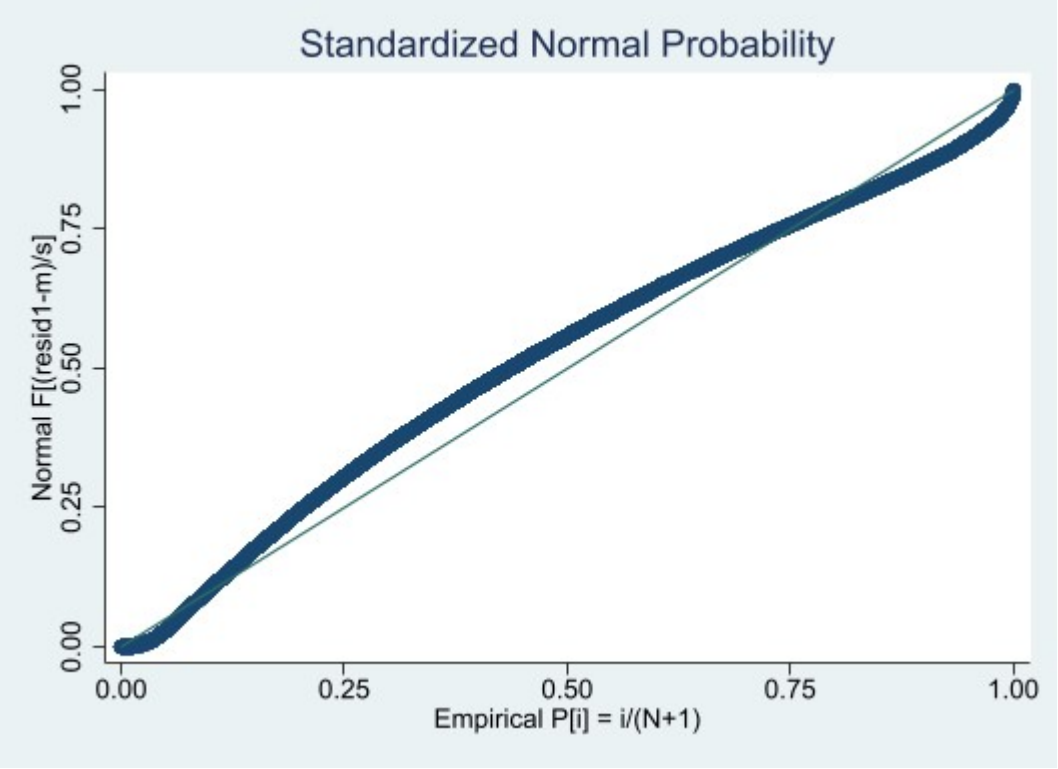
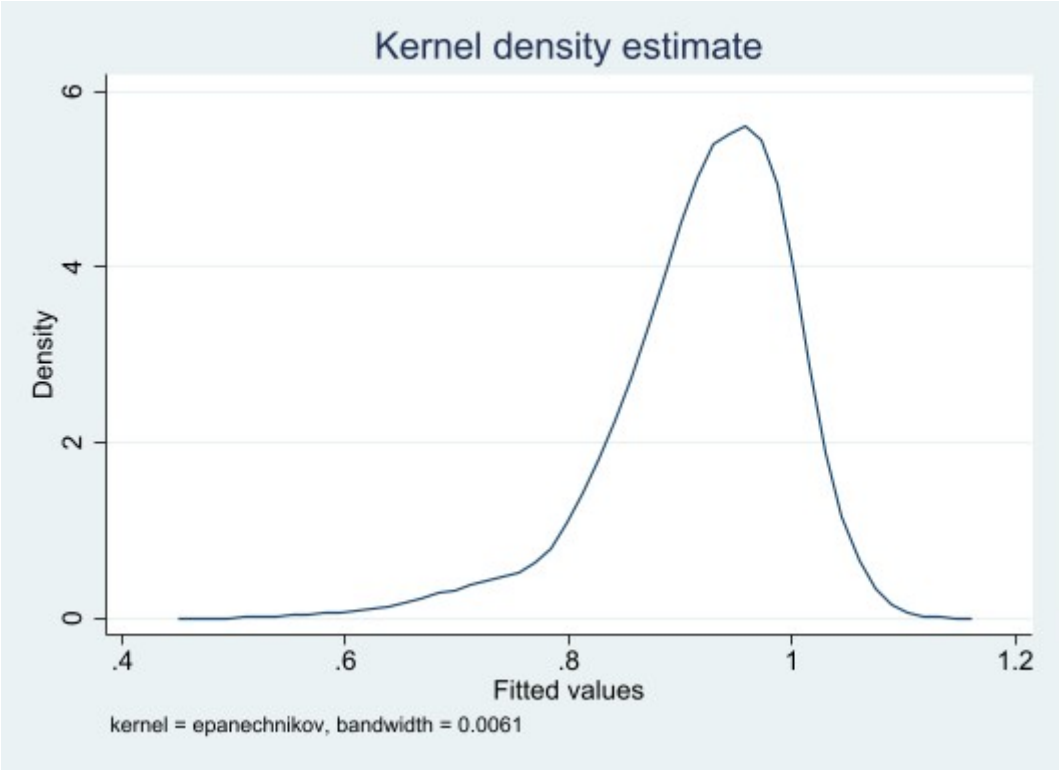


Figure A9 – Kernel Density Estimate



Appendix E – Stata Syntax

```
*1.Generating New Variables and cleaning the dataset
Dependent variable
gen LTV_ratio = GELDLENING_BEDRAG / TNS_BEDRAG
drop if LTV_ratio > 1.4
drop if LTV_ratio < 0.0001
drop if LTV_ratio == '.'

*Independent variable
encode Energielabel, generate (ENERGIELABEL2)
drop if ENERGIELABEL2 == '.'
gen labelA = 0
replace labelA = 1 if ENERGIELABEL2 == 1
gen labelB = 0
replace labelB = 1 if ENERGIELABEL2 == 2
gen labelC = 0
replace labelA = 1 if ENERGIELABEL2 == 3
gen labelD = 0
replace labelD = 1 if ENERGIELABEL2 == 4
gen labelE = 0
replace labelE = 1 if ENERGIELABEL2 == 5
gen labelF = 0
replace labelF = 1 if ENERGIELABEL2 == 6
gen labelG = 0
replace labelG = 1 if ENERGIELABEL2 == 7

*Control variables
gen stedelijkheid_n = Real (stedelijkheid)
encode IND_STARTER, generate (IND_STARTER2)
drop if IND_STARTER2 == 3
drop if IND_STARTER2 == 4
generate STARTER = 0
replace STARTER = 1 if IND_STARTER2 > 1
encode KAD_OBJECT_TOTAAL_OPP, generate (OBJECTOPPERVLAK)
encode WONINGTYPE, generate (WONING)
drop if WONING == '.'
drop if JAARMAAND < 201900
destring BAG_BOUWJAAR, generate (BAG_BOUWJAAR2) force
drop if BAG_BOUWJAAR2 == '.'
recode BAG_BOUWJAAR2 (min/1994=1) (1945/1964=2) (1965/1984=3) (1985/2004=4)
(2005/max=5), gen cat_Bouwjaar
tabulate cat_Bouwjaar, generate (constructionyear)
recode TNS_LEEFTIJD (min/25=1)(26/35=2)(36/45=3)(46/55=4)(56/65=5)(66/max), gen
AGEgroup
tabulate AGEgroup, generate (cat_AGE)
tabulate starterstransactie, generate (cat_starter)
drop if IND_TYPE_VERKRIJGER = particuliere investeerder
```

```
keep if IND_OVERBRUGGING == 'N'
drop if bag_tot_opp_vbo > 500
drop if TNS_BEDRAG <= 100000
destring MOEDER, generate (MOEDER2)
destring PROVINCE, generate(PROVINCE2)
generate Oost == 0
replace Oost = 1 if PROVINCE2 ==(4,9,2)
generate West == 0
replace West = 1 if PROVINCE2 ==(8,12,11,10)
generate Noord == 0
replace Noord = 1 if PROVINCE2 ==(1,3,5)
generate Zuid == 0
replace Zuid = 1 if PROVINCE2 ==(6,7)
generate bank_klein == 0
replace bank_klein = 1 if MOEDER2 == (anonymous)
generate bank_groot == 0
replace bank_groot = 1 if MOEDER2 == (anonymous)
generate verzekeraar_groot == 0
replace verzekeraar_groot = 1 if MOEDER2 == (anonymous)
generate overig = 0
replace overig = 1 if MOEDER2 == (anonymous)
generate ln_KOOPSOM = ln(KOOPSOM)
generate log_WOONOPPERVLAK = ln(BAG_TOT_OPP_VBO)

*2. Descriptive Analysis
summarize LTV_ratio ENERGIELABEL2 labelA labelB labelC labelD labelE labelF labelG
BAG_TOT_OPP_VBO KOOPSOM i.WONING IND_NIEUWBOUW BAG_BOUWJAAR2
i.cat_BOUWJAAR i.starterstransactie TNS_LEEFTIJD i.AGEgroup verzekeraar_groot
bank_klein bank_groot overig i.MOEDER2 i.stedelijkheid _n West Oost Noord Zuid
summarize LTV_ratio if starterstransactie == 1
summarize LTV_ratio if starterstransactie == 2
summarize LTV_ratio if starterstransactie == 3
summarize LTV_ratio if starterstransactie == 4
summarize LTV_ratio if starterstransactie == 5
histogram LTV_ratio
scatter LTV_ratio ENERGIELABEL2
scatter LTV_ratio ln_KOOPSOM
scatter LTV_ratio log_WOONOPPERVLAK
scatter LTV_ratio BAG_BOUWJAAR2
scatter LTV_ratio ln_GELDLENING_BEDRAG
graph twoway (scatter LTV_ratio log_KOOPSOM if labelG==1) (scatter LTV_ratio
log_KOOPSOM if (labelA==1), legend(label(1 G) label(2 A))
graph twoway (scatter LTV_ratio KOOPSOM if labelG==1) (scatter LTV_ratio KOOPSOM if
(labelA==1), legend(label(1 G) label(2 A))

*3. Regression
```

```
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
i.cat_BOUWJAAR
predict resid1
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
i.cat_BOUWJAAR labelA labelB labelC labelD labelE labelF
predict resid2
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
i.cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie TNS_LEEFTIJD
multiple_dependents
predict resid3
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1
cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents
predict resid4
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1
cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.verstrekker
predict resid5
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1
cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.MOEDER2
predict resid6
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1
cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.MOEDER2
i.stedelijkheid_n Noord Oost Zuid
predict resid7

*4. Testing the value of the energy label coefficients
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1
cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.MOEDER2
i.stedelijkheid_n Noord Oost Zuid
test labelA = labelB
test labelA = labelC
test labelA = labelD
test labelA = labelE
test labelA = labelF
test labelB = labelC
test labelB = labelD
test labelB = labelE
test labelB = labelF
test labelC = labelD
test labelC = labelE
test labelC = labelF
test labelD = labelE
test labelD = labelF
```

```
test labelE = labelF

*5. Robust regression
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4,
r
outreg2 using C:\Users\VeenIlsevander\Documents\Database\Basis\robust2.doc, word
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF, r
outreg2
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie TNS_LEEFTIJD
multiple_dependents, r
outreg2
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1 cat_AGE2 cat_AGE3
cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents, r
outreg2
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1 cat_AGE2 cat_AGE3
cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.verstrekker,r
outreg2
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1 cat_AGE2 cat_AGE3
cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.MOEDER2, r
outreg2
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1 cat_AGE2 cat_AGE3
cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.MOEDER2 i.stedelijkheid_n Noord
Oost Zuid, r
outreg2

*6. Chow Test
reg LTV_ratio lOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF cat_AGE1 cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5
cat_AGE6 multiple_dependents i.verstrekker i.stedelijkheid_n Noord Oost Zuid
reg LTV_ratio lOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF cat_AGE1 cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5
```

```
cat_AGE6 multiple_dependents i.verstrekker i.stedelijkheid_n Noord Oost Zuid, if STARTER
== 1
reg LTV_ratio lOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF cat_AGE1 cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5
cat_AGE6 multiple_dependents i.verstrekker i.stedelijkheid_n Noord Oost Zuid, if STARTER
== 0

*. Checking conditions
correlation
corr LTV_ratio ENERGIELABEL2 labelA labelB labelC labelD labelE labelF labelG
log_WOONOPPERVLAK ln_KOOPSOM IND_NIEUWBOUW appartement hoekwoning
vrijstaand tweeondereenkap tussenwoning BAG_BOUWJAAR2 cat_constructionyear1
cat_constructionyear2 cat_constructionyear3 cat_constructionyear4 cat_constructionyear5
STARTER TNS_LEEFTIJD cat_AGE1 cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6
cat_AGE7 verzekeraar_groot bank_klein bank_groot overig very_urban urban
medium_urban rural very_rural West Oost Noord Zuid

*Multicollinearity
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
i.cat_BOUWJAAR
estat vif
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
i.cat_BOUWJAAR labelA labelB labelC labelD labelE labelF
estat vif
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
i.cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie TNS_LEEFTIJD
multiple_dependents
estat vif
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1
cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents
estat vif
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1
cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.verstrekker
estat vif
reg LTV_ratio  LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1
cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.MOEDER2
estat vif
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_BOUWJAAR labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1
cat_AGE2 cat_AGE3 cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.MOEDER2
i.stedelijkheid_n Noord Oost Zuid
estat vif
```

```
*Heteroskedasticity
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
estat hettest
estat imtest, white
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF
estat hettest
estat imtest, white
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie TNS_LEEFTIJD
multiple_dependents
estat hettest
estat imtest, white
reg LTV_ratio OG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1 cat_AGE2 cat_AGE3
cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents
estat hettest
estat imtest, white
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1 cat_AGE2 cat_AGE3
cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.verstrekker
estat hettest
estat imtest, white
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1 cat_AGE2 cat_AGE3
cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.MOEDER2
estat hettest
estat imtest, white
reg LTV_ratio LOG_WOONOPPERVLAK log_KOOPSOM IND_NIEUWBOUW i.WONING
cat_constructionyear1 cat_constructionyear2 cat_constructionyear3 cat_constructionyear4
labelA labelB labelC labelD labelE labelF i.starterstransactie cat_AGE1 cat_AGE2 cat_AGE3
cat_AGE4 cat_AGE5 cat_AGE6 multiple_dependents i.MOEDER2 i.stedelijkheid_n Noord
Oost Zuid
estat hettest
estat imtest, white

*checking standard errors
scatter LTV_ratio resid1
scatter LTV_ratio resid2
scatter LTV_ratio resid3
scatter LTV_ratio resid4
```

```
scatter LTV_ratio resid5
scatter LTV_ratio resid6
scatter LTV_ratio resid7

*Normality of Residuals
kdensity resid1
pnorm resid1
kdensity resid2
pnorm resid2
kdensity resid3
pnorm resid3
kdensity resid4
pnorm resid4
kdensity resid5
pnorm resid5
kdensity resid6
pnorm resid6
kdensity resid7
pnorm resid7

clear
```