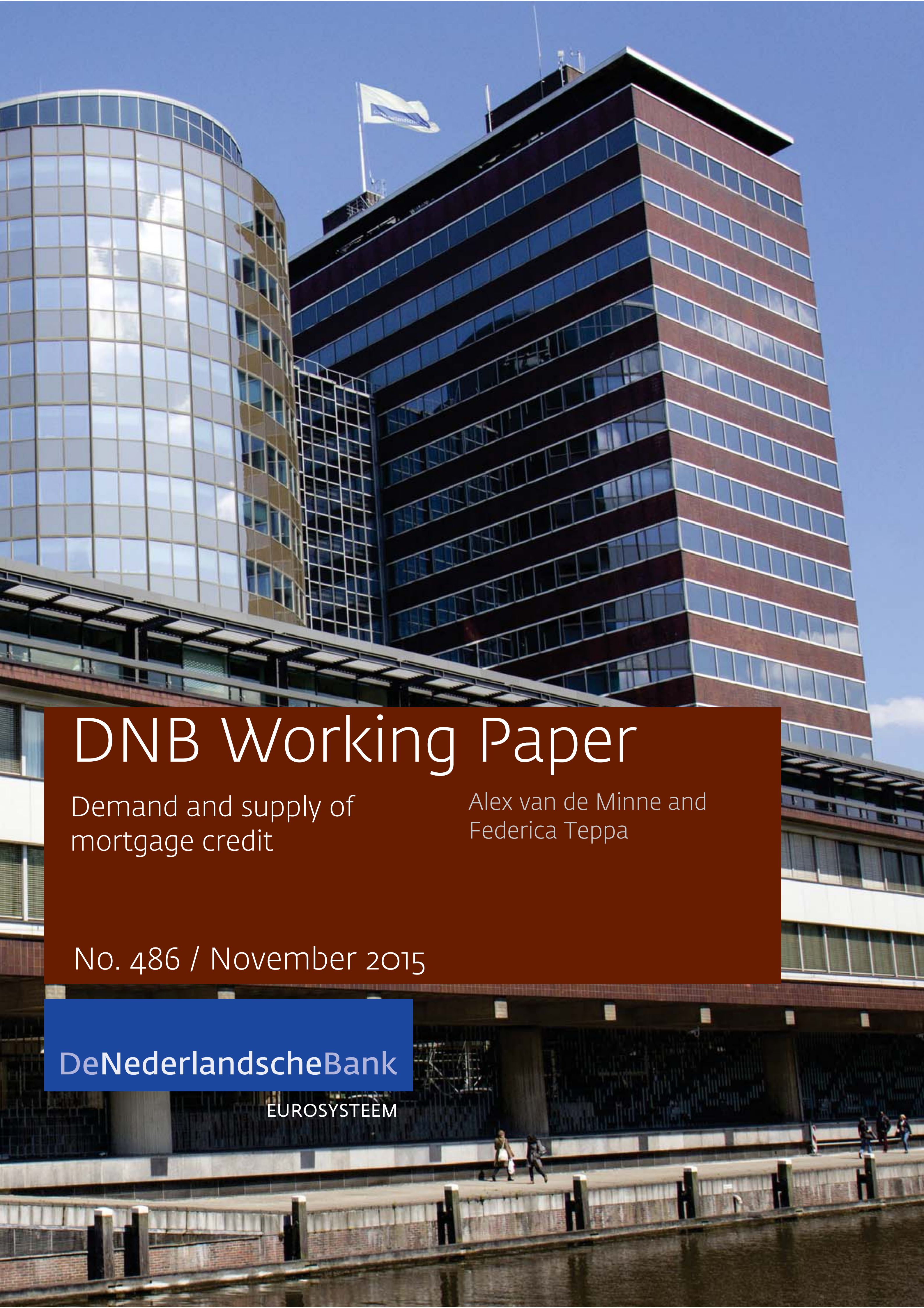

DNB Working Paper

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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Demand and supply of mortgage credit*

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Abstract

This paper estimates demand and supply of mortgage credit by using a hierarchical trend model. The empirical analysis is based on loan-level data covering the years 2005-2014 in the Netherlands. We find that high-income households take out higher loan amounts and have higher collateral values. Interest rates are negatively related to both loan amounts and collateral values. The common trend in the loan equation, a proxy for the changes in demand and supply of mortgage credit over time, suggests a large decline in mortgage demand and supply after 2007. The common trend in the collateral value equation is highly correlated with the common trend in the loan equation, suggesting a high pass-through rate of changes in credit conditions from loan to value. We also find that young household cohorts can afford to buy better quality houses in 2014 than in 2005, even if they could borrow less. On the contrary, older household cohorts take out higher loans in 2014 than in 2005, but their collateral values do not change. We argue that younger households took up less mortgage debt as they became more credit constraint over time. Older households on the other hand suffered from negative home equity, forcing them to take up higher mortgage loans.

Keywords: house prices; mortgage credit; credit conditions.
JEL-classifications: G21, E51, C32.

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1 Introduction

In the last two decades the Netherlands has experienced a rapid increase in housing wealth and household debt, accompanied by a strong growth of mortgage markets and a corresponding rising share of housing loans in bank assets. Between 1995 and 2015 household mortgage debt became roughly four times larger in nominal terms, going from about 200 to 700 billion euros. In the same period, house prices in the Netherlands experienced pronounced swings similar to those observed in other countries, first rallying sharply and then peaking around the time of the onset of the global financial crisis. The combination of high levels of mortgage debt and declining house prices represents a threat to financial stability (Oikarinen, 2009), and it is typically associated to higher probabilities of households defaulting on their mortgage (Vandell and Thibodeau, 1985). Moreover there is evidence that high levels of mortgage debt let to the Great Recession (Mian and Sufi, 2014).

In this paper we focus on how mortgage lending has evolved over time, taking into account both demand and supply factors. More specifically, we are interested whether or not certain households took up either more or less mortgage debt over time, *ceteris paribus*. This is especially interesting in the Netherlands as De Nederlandsche Bank (Dutch Central Bank or DNB) and the Dutch government forced banks to change their lending policies (see Francke et al., 2014, for a more detailed description of all the policy changes in recent years in the Netherlands). From a mortgage demand perspective it is interesting as our analysed period witnessed both years of persistent house price increases (2005 – 2008) and declines (2009 – 2014).

We use a hierarchical trend model to identify different trends in the data. The trends are defined as a common trend, a cluster for the age of the household, and a cluster for 2-digit ZIP codes. This way we can identify whether lending behaviour changed over time between different age cohorts, *ceteris paribus*. The empirical analysis is based on a new (micro) loan-level data set constructed from reports that lenders must report to De Nederlandsche Bank as of 2014. Therefore the data contains detailed information on all mortgages in the Netherlands. A detailed description of the data can be found in Mastrogiacomo and Van der Molen (2015). More specifically, our loan-level data set covers 2005 through 2014 and includes a number of key variables of interest, such as mortgage loan application characteristics (specifically reported loan amount, interest rates (maturity) and value and location of the collateral at origination), and demographic variables such as the income of first and second earner, type of mortgage, age of the first and second earner, whether or not households purchased a default insurance, type of vocation of the main earner and whether the collateral is a single- or multifamily home.

This paper is related to studies examining the household's mortgage-size decision and the relationship between household mortgage debt burdens and micro-level characteristics that proxy for household risk preferences and life cycle effects. Within this literature, the papers closest to ours are Brueckner (1994) and Ling and McGill (1998). The former paper models the decision to take out a mortgage jointly with the collateral value and the savings level. He finds that the relationship between the mortgage interest rate and the rate of return on investment has a direct effect on the amount of mortgage. Similarly, Ling and McGill (1998) estimate mortgage debt level equations and house value equations simultaneously, controlling for the contemporaneous nature of these two choices. Their main finding is that larger debt levels are positively associated with greater house values and with the level of household income.

Our work is also related to another strand of literature that examines the relation between housing price dynamics and homeowner borrowing patterns. The role of mortgage markets – and more in general financial factors – are documented in a number of studies based on cross-counry data (Muellbauer and Murphy, 1997; Herring and Wachter, 1999; Lamont and Stein, 1999; Iacoviello and Minetti, 2003; Davis and Zhu, 2004; Hofmann, 2003; Tsatsaronis and Zhu, 2004; Warnock and Warnock, 2008). This line of research suggests that house price changes depend importantly on the flexibility of domestic mortgage markets, as well as the tax treatment of homeowners (and in particular the extent to which mortgage payments are tax deductible).

This paper makes a novel contribution to this literature along several dimensions. Most importantly, we allow key variables – the age of the borrower and location – to be time-varying. This is especially interesting as our sample period includes the recent financial crisis and a period which is characterized by more stringent controls on banks. We complement existing research by exploiting the rich database available at the DNB. In particular, the data is unique in that it helps us isolating the determinants of (changes in) mortgage levels in more details than in previous research. Finally, our results show that model diagnostics improve slightly when allowing for time-varying parameters.

Our findings can be summarized as follows. High-income households take out higher loan amounts and are associated with higher collateral values. Interest rates are negatively related to both loan amounts and collateral values. The common trend in the loan equation, a proxy for the changes in demand and supply of mortgage credit over time, suggests a large decline in mortgage demand and supply after 2007. The common trend in the collateral value equation is highly correlated with the common trend in the loan equation, suggesting a high pass-through rate of changes in credit conditions from loan to value. We also find that young household cohorts can afford to buy better quality houses in 2014 than in 2005, even if they could borrow less. On the contrary, older household cohorts took up higher loans in 2014 than in 2005, but their collateral values do not change. We argue that households in the first group are credit constraint. However, house prices declined more than their capacity to take up mortgage debt. Households in the latter group were not able to profit from house price declines as they lost home equity in the process.

The rest of the paper is organized as follows. Section 2 describes the empirical methodology. Section 3 reports the data and main descriptive summary statistics. Section 4 presents the core results of our analysis, and Section 5 concludes the paper.

2 Empirical Analysis

In this study we are interested in estimating multiple (unobserved) trend components. Firstly, a common trend in mortgage lending will describe demand and supply of mortgage debt for both households and banks. This common trend represents the general changes in credit and market conditions over time. Secondly, age (cohort) trend are an important part of the analysis. Changes in legislation and market conditions will affect households differently, mainly depending on their (non-)housing wealth and other financial assets. We use the age of the head of household heads as the proxy for household wealth (which is not directly available to us), which is not uncommon in literature (Fernandez-Corugedo and Muellbauer, 2006). Also note that we *do* control for household income, which is also highly correlated with household wealth. Regional house price levels, price expectations, volatility and overall market performance will affect mortgage lending as well. It is therefore important to correct the model for regional unobserved effects, by estimating regional trends.

The hierarchical trend model (HTM) addresses the issues described above. In a HTM a common price trend, cluster-level trends, and specific characteristics play a role. Every cluster, a combination of regions and age of households, has its own development and is therefore treated as a random effect. As each household determines the common trend, the cluster trends are estimated as deviation from the common trend. The trends (common and clusters) are estimated using a structural time series approach. The model is provided by:

$$
\begin{array}{llr}
 & l_t = \mathbf{i}\mu_t + d_{\theta,t}\theta_t + d_{\lambda,t}\lambda_t + x_t'\beta + \varepsilon_t & \varepsilon_t \sim N(0,\sigma_\varepsilon^2), \quad (1)\\
\textbf{Common:} & \mu_{t+1} = \mu_t + \kappa_t + \varphi_t, & \eta_t \sim N(0,\sigma_\varphi^2),\\
 & \kappa_{t+1} = \kappa_t + \zeta_t, & \zeta_t \sim N(0,\sigma_\zeta^2),\\
\textbf{Region:} & \theta_{t+1} = \theta_t + \omega_t, & \omega_t \sim N(0,\sigma_\omega^2 I),\\
\textbf{Age cohort:} & \lambda_{t+1} = \lambda_t + \varsigma_t, & \varsigma_t \sim N(0,\sigma_\varsigma^2 I),
\end{array}
$$

where l_t is a vector of the loan amounts at origination (in logs), $\mathbf{i}$ is a l_t vector of ones,

μ_t is the common trend, θ_t is a vector of regional trends, and λ_t is a vector of age trends. The matrices d are selection matrices, containing 0 and 1 to select the appropriate district and age group. We impose the restriction $\mu_1 = \lambda_{1,1} = 0$ for identification reasons. Vector x_t' are the characteristics of the loan with corresponding coefficients β.

The common trend is specified as a local linear trend, and the district and age cluster trends are estimated as random walk deviations from the common trend. In order to see μ_t as the common trend we have that:

$$\sum_{k=1}^{K} \theta_{kt} = 0, \qquad \text{and that} \qquad \sum_{j=1}^{J} \lambda_{jt} = 0,$$

where k refers to the different regions (2-digit-zip codes in our application) and j refers to the different age categories. Please note that the subscripts k and j were suppressed previously in Eq. (1) for reading easiness.

Once the model is reformulated in state-space form, the model can be estimated with the Kalman filter and smoother. If the initial state is known, standard Kalman filter recursions can be applied to the model, providing estimates of the state vector and likelihood. This likelihood is optimized with respect to the unknown variance parameters. In the HTM, the nonstationarity of the transition equation and the presence of explanatory variables lead to a diffuse initial state. For that reason the diffuse Kalman filter of De Jong (1991) is applied, a method previously used by Schwann (1998) and Francke and De Vos (2000).

In Francke and De Vos (2000), it is shown how a HTM with explanatory variables can be computed efficiently. Firstly, we calculate the means per cluster $\hat{y}_1, \ldots, \hat{y}_T$, and the deviations form these means $\hat{y}_1, \ldots, \hat{y}_T$. The length of vector $\hat{y}_t$ is the number of different clusters for which we have observations at time t, while $\hat{y}_t$ has the same dimension as y_t. Likewise, we calculate means and deviations from means for the explanatory variables. The coefficients of the explanatory variables are time and cluster invariant, and can be computed by using OLS on the stacked deviation from mean vectors and matrices $\hat{y} = [\hat{y}_1', \ldots, \hat{y}_T']'$ and $\hat{X} = [\hat{X}_1', \ldots, \hat{X}_T']'$. Subsequently, the Kalman filter is ran with the mean data and with the OLS estimates as initial mean and variance of the explanatory variables in the state. The likelihood is obtained as the product of the OLS likelihood and the Kalman filter likelihood.

In addition we redo the regressions using the value of the property (V) and the Loan-to-Value (LTV) as the explained variables instead of the loan amount (L), using the *same* exogenous variables. We can do this, since the housing demand decision is given outside the model (Bokhari, 2012). It is well known that in a system of *seemingly unrelated equations* with identical regressors, estimating the models equation-by-equation yields efficient parameter estimates (Greene, 2008). By including the value and loan-to-value as separate regressions, it allows us to better understand the mortgage decision and the effects on house prices.

3 Data and Descriptive Statistics

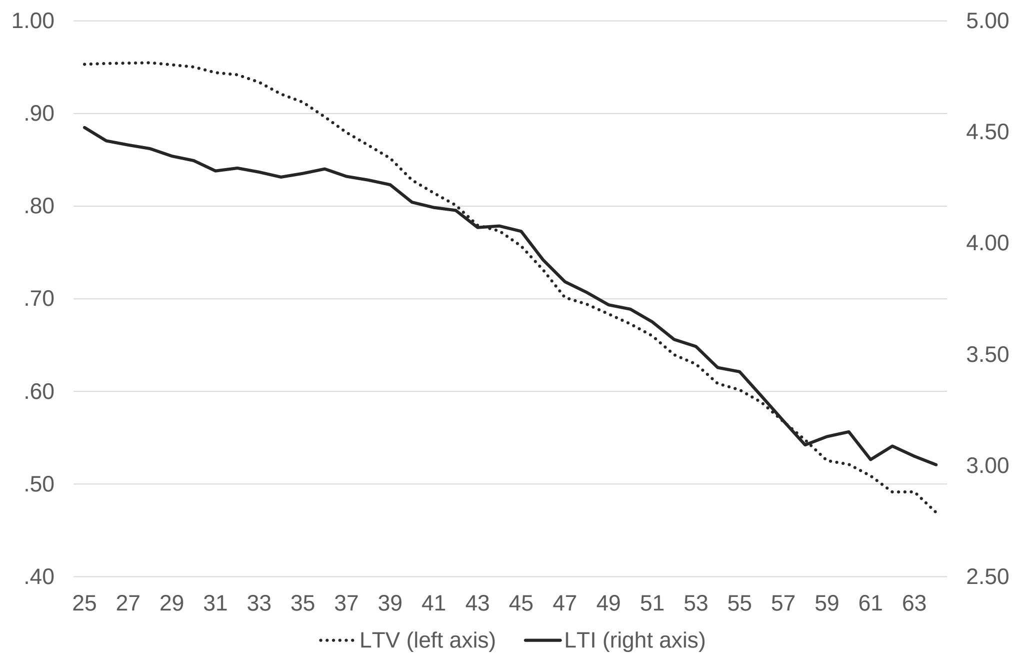
For this study we utilize the Loan-Level-Data (LLD) available at De Nederlandsche Bank (DNB). This micro data contains detailed information on every mortgage in the Netherlands. Lenders are obliged to report these details to DNB starting in 2014. As such, the *entire* population of mortgages on the balance sheet of lenders and SPVs in the Netherlands is observed in the LLD, which results in more than 6 million observations. Before 2014, banks had no standardized (internal) reporting standard. A full description of the data is provided in Mastrogiacomo and Van der Molen (2015).

All data, except for the interest rate, is observed as of origination (which is our focus). Only interest rates are observed as of *now* (2014 in our case). However, we do observe the length at which the interest rates are fixed. We use this maturity to filter out the observations with reported interest rates on dates other than origination. The average number of years Dutch households fixed their mortgage is approximately 10 years, so this should not bias our data to a large extent. Other filters are applied as well. For example, we are only interested in loan purchases and not in refinanced mortgages. In total we will use 10 years of data, as the data before 2005 is less reliable (in particular, the number of observations drops considerably). Besides the reported loan amount, interest rates (maturity) and value and location of the collateral at origination we also observe the income of first and second earner (if present), type of mortgage, age of the first and second earner, whether or not households purchased a default insurance (NHG, see below), type of vocation of the main earner and whether the collateral is a single or multifamily home.

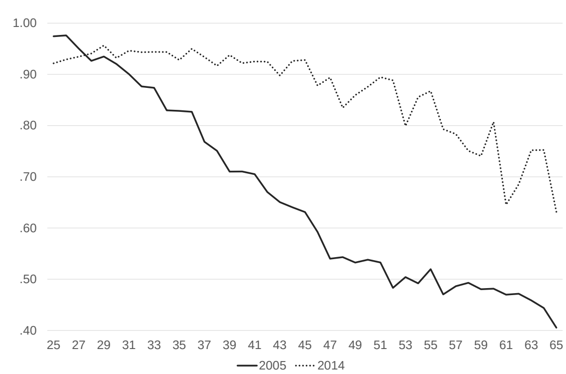
Next, we reshape the data so that we observe mortgage data per property (as opposed to information per loan) and filter out all cases for which the main variables needed for our research purposes are missing. As a result of reshaping and filtering the data we end up with $264,461$ observations, with at least 300 observations per month.

An average LTV ratio equal to 85% is high compared to international figures (Andrews et al., 2011). However, there is a large difference between younger and older households, see Figure 1. Households of age 37 or younger have an average LTV (LTI) of 90% (4.25) or higher, whereas households of age 53 or older have an average LTV of 60% (3.50) or lower at origination. Younger households do not have any notable savings and are therefore almost completely reliant on mortgage debt (Francke et al., 2014). In addition, putting money aside when young (as stated by the life-cycle theory) has not been encouraged, due to presence of fiscal arbitrage in the Netherlands (Schilder, 2012). Households are allowed to deduct interest payments from their income. The lower left panel of Figure 1 shows that

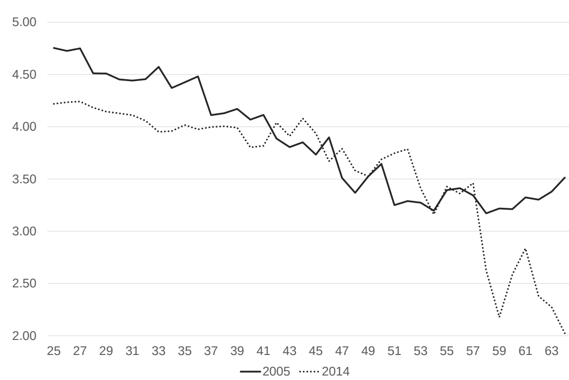
Figure 1: Average LTV and LTI per age as of origination.



(a) Average LTV (left axis) and LTI (right axis) per age as of origination.



(b) Average LTV in 2005 and 2014.



(c) Average LTI in 2005 and 2014.

Table 1: Descriptive statistics of continuous variables.

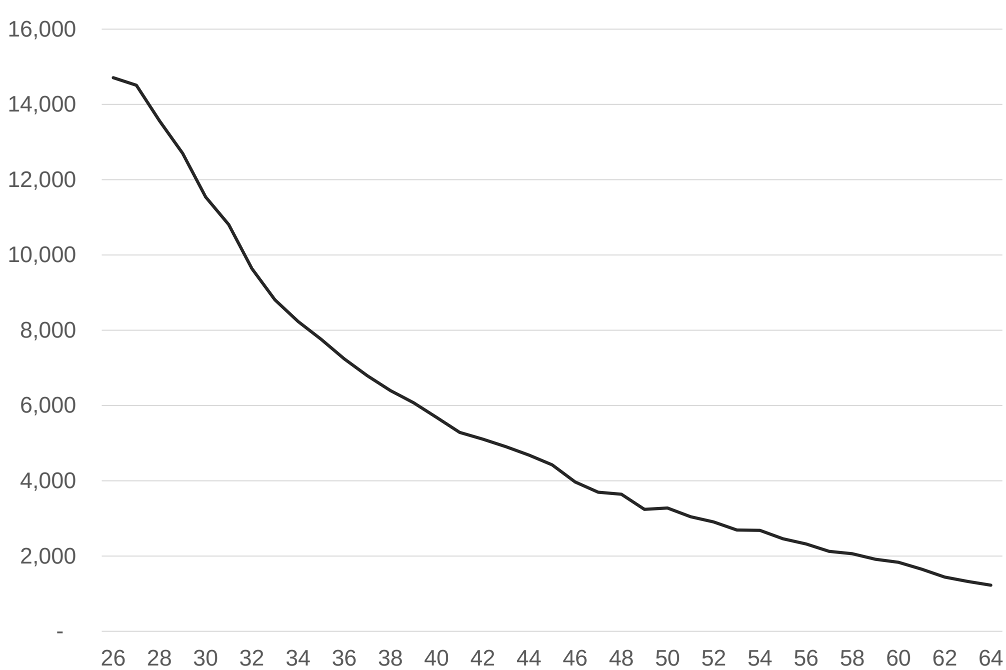
	Mean	**Median**	**Std. Deviation**	**Minimum**	**Maximum**
Loan	€200,935	€180,000	€109,462	€10,000	€2,744,900
Value	€250,677	€215,430	€144,646	€28,995	€2,941,177
LTV	0.85	0.94	0.25	0.10	1.35
Household income	€50,166	€44,095	€28,182	€2,450	€1,180,854
Interest rate	4.65	4.65	0.56	1.70	7.75
Months to maturity	137	120	64	9	900
Annuity	11%	0%	32%	0%	100%
Linear	1%	0%	10%	0%	100%
Non-amortizing	45%	0%	50%	0%	100%
+ Savings	37%	0%	48%	0%	100%
+ Life insurance	4%	0%	20%	0%	100%
+ Investment	2%	0%	14%	0%	100%

Table 2: Descriptive statistics, *continued*.

Variable	**No**	**Yes**	**Total**
NHG	107,882	156,579	264,461
Permanent job	36,115	228,346	264,461
Second earner	187,871	76,590	264,461
Multifamily home	192,507	71,954	264,461

Permanent job is when the main earner has a permanent position as opposed to a temporary contract or being unemployed.

Figure 2: Number of originations per age group.



there is a big difference between LTVs at origination between 2005 and 2014 as well. For example, on average, a 50 year old household would have had a 50% LTV at origination in 2005, whereas a 50 year old household in 2014 has an average LTV of nearly 90%. These differences are much less pronounced for younger households. We hypothesize that these differences arise mainly because older households became equity constrained as house prices dropped significantly in the wake of the financial crisis, and thus needed higher leverage. For comparison, we also included the median equity (with and without home equity) and the percentage of households 'under water' (i.e. with LTVs > 1) of *all* households (not just at origination) per age cohort over the years in Appendix A.1. Due to high initial LTVs and declining house prices the number of households with negative home equity tripled between 2006 and 2014. Approximately 70% of households aged 45 and younger has negative home equity, compared to 'only' 25% (4%) of households aged between 45 – 65 (65 and older). It is also evident from Tables A1 – A2 that home equity is the most important asset of households aged 45 and older. In contrast, home ownership results in less equity for households aged 45 and younger after 2010 (due to the high number of households being under water).

The median LTV is even higher, as younger households originate more mortgages in our data than older households, see Figure 2. We observe more than $10,000$ households of age 32 and younger. We observe much fewer households of age 50 and older.

Since 1995 the National Guarantee Fund (government backed) has sold insurances and reimbursed losses, after a control process, to lenders by an organization called 'National Mortgage Guarantee' (NHG). It is an insurance that only covers losses that are the result of unfortunate events like unemployment, divorce and disease. If borrowers wish to insure the mortgage by NHG, they pay a one-time fee upfront (1% of the loan as of 2014). In return borrowers can stipulate a lower mortgage interest rate. The NHG insurance is not aimed specifically at high-risk households (Francke and Schilder, 2014). In the period preceding the global financial crisis banks used less stringent criteria for mortgages than the NHG. Since the financial crisis the underwriting criteria of banks have changed and are currently in line with the criteria set by the NHG. There are three main criteria to qualify for the insurance program: a maximum loan-to-value (LTV), a maximum loan-to-income (LTI) and a maximum mortgage debt amount. These criteria have changed over time. The total number of insured mortgages in 2012 is just over 1 million. These mortgages represent an insured mortgage debt of over €154 billion.

Non-amortizing mortgages are the most popular type of mortgage in the Netherlands. Almost 80% of the total mortgage debt at origination is through a type of non-amortizing mortgage loan. Non-amortizing loans result in larger fiscal benefits from interest deductions and have become very popular over time. The return on capital of financial accounts tied to the mortgage of the primary residential dwelling is untaxed. Households thus started to buy different mortgage products given the fiscal incentive from the interest deductibility (Schilder, 2012). However, after 2013 the government cancelled the interest rate deductibility on any type of non-amortizing loan altogether. This only applies to new originations.

Finally, in most cases the main earner has a permanent contract, there is only one (main) earner on the mortgage contract and the collateral is a single-family home (Table 2).

4 Results

As discussed in Section 2 we regressed the same variables on the loan amount, the value of the collateral (henceforward value) and the LTV at time of origination equation-by-equation. However since all variables are in log form, we can simply find the LTV estimates be deducting the value estimates of the loan estimates. Table 3 presents the parameter estimates. The common and some age trends can be found in Figures 3 – 6. To conserve space we do not show the 89 region trends per equation. In addition, not all age trends have been presented to conserve space as well. However, all trends are available upon request. The trend components are on a quarterly basis.

We have made a few transformations. First of all, we have grouped the time to maturity of the interest rates into three groups: 0 to 9 years, 10 to 15 years and 16 years or longer. Secondly, we have grouped everyone of age 25 and younger into one category and everyone of age 65 or older into one category. The NHG variable has been interacted with yearly dummies, as the criteria to obtain the insurance change on a yearly basis. The reference category is not having any NHG. These results can be found in Appendix A.2.

In addition, we estimated a model were all clusters are replaced by dummy variables. This 'fixed effects model' is used in the mortgage market by (among others) Bokhari (2012) and is quite common in the literature for estimating hedonic house prices (Malpezzi, 2002). The results of this more 'classical' model (also shown in Table 3) can be compared with ours for robustness and model fit.

The estimated coefficient for the household income is 0.759 in the loan equation in the HTM. If the household consists of more than one earner the total loan amount is slightly less. Households with a tenured position have a slightly lower loan than households with a temporary contract. Households with temporary contracts only take up a small portion of the sample (see Table 2) and it is known that it is difficult for non-tenured households to get a mortgage (Schilder, 2012).

We obtain a negative coefficient for linear mortgages, implying that a linear mortgage is more expensive at first than an annuity mortgage. Having a non-amortizing mortgage affects the loan amount not-significantly and has a negative impact on the LTV. In these cases, the lender has more risk as the principle is not paid for and thus the probability of

Table 3: Main results

	Hierarchical Trend Model			**Fixed Effects Model**		
	Loan	**Value**	**LTV**	**Loan**	**Value**	**LTV**
Household Income	0.759	0.564	0.195	0.761	0.566	0.195
	(462.48)***	(423.41)***		(462.55)***	(422.67)***	
Second Earner	-0.053	-0.063	0.009	-0.061	-0.065	0.004
	(36.77)***	(53.17)***		(41.98)***	(55.01)***	
Permanent Job	-0.035	-0.068	0.032	-0.034	-0.069	0.034
	(17.91)***	(42.00)***		(17.21)***	(42.17)***	
Linear	-0.137	-0.027	-0.110	-0.134	-0.018	-0.116
	(22.98)***	(5.54)***		(22.33)***	(3.65)***	
Non-Amortizing	-0.001	0.102	-0.104	0.024	0.147	-0.123
	(-0.29)	(33.29)***		(9.60)***	(73.11)***	
+ Savings	0.033	0.047	-0.014	0.059	0.090	-0.031
	(8.72)***	(15.42)***		(25.33)***	(47.74)***	
+ Life insurance	0.076	0.027	0.049	0.087	0.047	0.040
	(15.83)***	(7.03)***		(22.15)***	(14.71)***	
+ Investment	0.202	0.092	0.110	0.220	0.126	0.095
	(36.46)***	(20.52)***		(45.44)***	(31.83)***	
Interest Rate	-0.013	-0.364	0.351	0.084	-0.200	0.284
	(1.87)*	(66.11)***		(16.01)***	(46.72)***	
FRM (10 to 15 years)	0.030	0.063	-0.033	0.029	0.049	-0.019
	(14.14)***	(37.05)***		(14.69)***	(29.89)***	
FRM (15 years or more)	-0.031	0.049	-0.080	-0.039	0.028	-0.066
	(16.63)***	(31.73)***		(21.72)***	(18.94)***	
Multifamily home	-0.076	-0.170	0.094	-0.071	-0.167	0.095
	(45.27)***	(124.82)***		(42.09)***	(120.87)***	
Default insurance	Figure A.1			-0.035	-0.198	0.163
				(22.05)***	(151.14)***	
Diagnostics						
Common level (σ^2_φ)	0.022	0.019				
Common drift (σ^2_ζ)	0.008	0.003				
Age cluster (σ^2_ς)	0.020	0.013				
Region cluster (σ^2_ω)	0.005	0.008				
Measurement error (σ^2_ϵ)	0.297	0.241		0.302	0.246	
Observations	264,461			264,461		
2-digit-zip-code	RE			FE		
Age of borrower	RE			FE		

The reference categories are: Only a main earner, not a permanent contract, annuity type mortgage, Fixed Interest Rates with less than 10 year maturity and a single family home. FE = Fixed Effects and RE = Random Effects.

default increases (Vandell and Thibodeau, 1985; Elul et al., 2010). However, when the non-amortizing loan is conjoined with a savings account (i.e. the borrower is obliged to save in a long-term deposit account) the negative effect on the LTV diminishes and the loan amount increases slightly. The largest positive effect is found for the non-amortizing loans conjoined with an investment portfolio (which is managed by the lender).

Higher interest rates only slightly affect (negatively) the loan amount. From a mortgage **demand** perspective, lower interest rates increase the demand for mortgage debt, whereas from a **supply** perspective lower interest rates imply less profit, *ceteris paribus*. Indeed when instrumenting the interest rate for interbank swap rates (typical supply side shifters), the parameter estimate increases to -0.6. The time to maturity of the interest rate is relativity small in all cases. These estimates suggest that, other things being equal, households and lenders are only moderately sensitive to interest rates on multi-year fixed purchase mortgages.

The parameter estimate of the dummy for a house occupied by more than one person ('multifamily home' from now on) is -0.076. This means that the demand and supply of mortgage debt is 7.6% lower in case of a multifamily home purchase, compared to a purchase of a house occupied by just one person. The price of multifamily homes is also lower in magnitude (by 17%) than the one for single households.

Interestingly, the parameters of the Hierarchical Trend Model show that the estimated quarterly volatility level of the regional clusters is almost twice as high in the value equation compared to the loan equation. In contrast, the estimated volatility level for the age clusters is almost twice as high in the loan equation compared to the value equation. In both equations the standard deviation is higher for the age cluster. This suggests that - on top of the interest rates, interest rate maturity and mortgage types - the (unobserved) changes in the mortgage market affects house prices as well (see Gerlach and Peng, 2005; Francke et al., 2014, for more evidence on how mortgage markets can affect house prices). Even though we used data on mortgages, the value equation actually has a better model fit.

The estimates of the Hierarchical Trend Model are comparable to the more classical 'fixed effects model'. All coefficients - except for interest rates in the loan equation - have the same sign and order of magnitude. We nevertheless observe a slight improvement of the overall measurement error in the HTM.

Even though we do not present all 2-digit ZIP code trends, Figure 7 provides the average parameter coefficient for both the loan and the value equation from highest to lowest in five (equally sized) categories. The Northern Randstad area[1], the most densely populated and dynamic region of the country, has the highest values of mortgages and house prices. In

[1]The Randstad is a conurbation in the Netherlands. It consists of the four largest Dutch cities (Amsterdam, Rotterdam, The Hague and Utrecht) and the surrounding areas. With a population of $7,100,000$ it is one of the largest conurbations in Europe, comparable in size to Milan or the San Francisco Bay Area, and covers an area of approximately $8,287$ km^2.

contrast, the lowest values of mortgages and house prices are found in the most peripheral areas of the country, characterized by pronounced demographic declines(Francke and Van de Minne, 2014).

Figure 3: Common trends, normalized to zero in 2005.Q1.

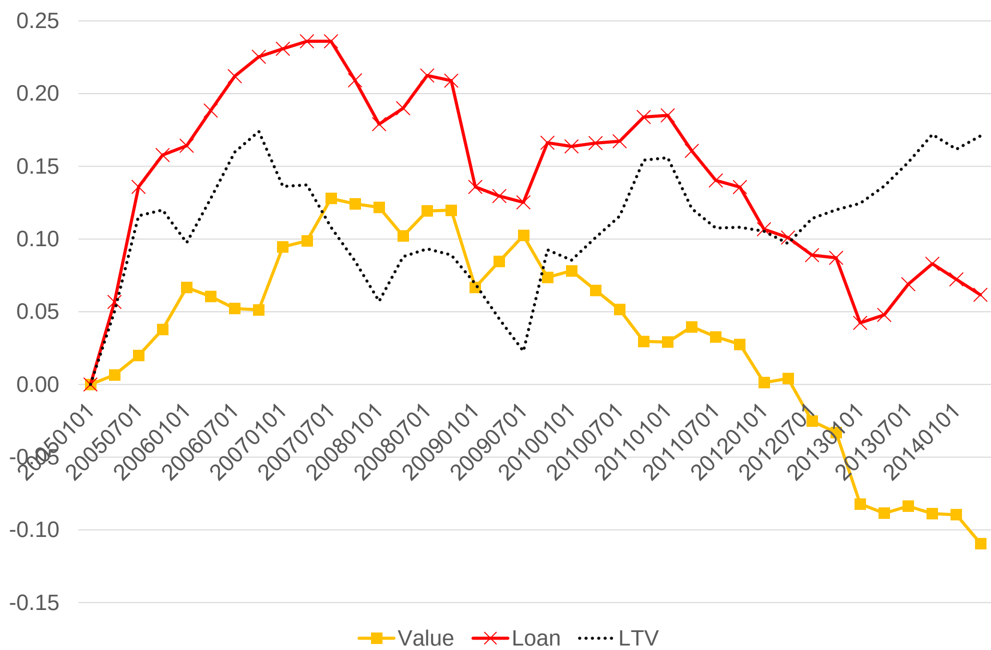


Figure 3 shows the common trend of all three models. The common trend in the loan equation can be interpreted as the changes in demand and supply of mortgage credit over time, *ceteris paribus*. Figure 3 shows a large decline in mortgage demand and supply after 2007. The supply of mortgage credit is mainly driven by the credit conditions (Francke et al., 2014). As we already control for mortgage types the common trend does not reflect the different fiscal treatment of non-amortizing loans after 2013. Interestingly, the common trend in the value equation is highly correlated with the common trend in the loan equation. More specifically, the correlation between the loan and value trend components is 0.81 in levels and 0.41 in returns. This suggests a high pass-through rate of changes in credit conditions from loan to value. This is further confirmed by the the common component in the LTV equation, which is relatively flat, especially between 2007 and 2013. Although the exact causality is difficult to establish in this model, changes in mortgage markets have been argued to affect mortgage lending and subsequently house prices (see Francke et al., 2014, as they discuss the causality between mortgage and house prices in the Netherlands in detail).

Figures 4 – 6 show the trend components by age of the head of household for the the first

Figure 4: Age trends (as deviations from common) in Loan Equation.

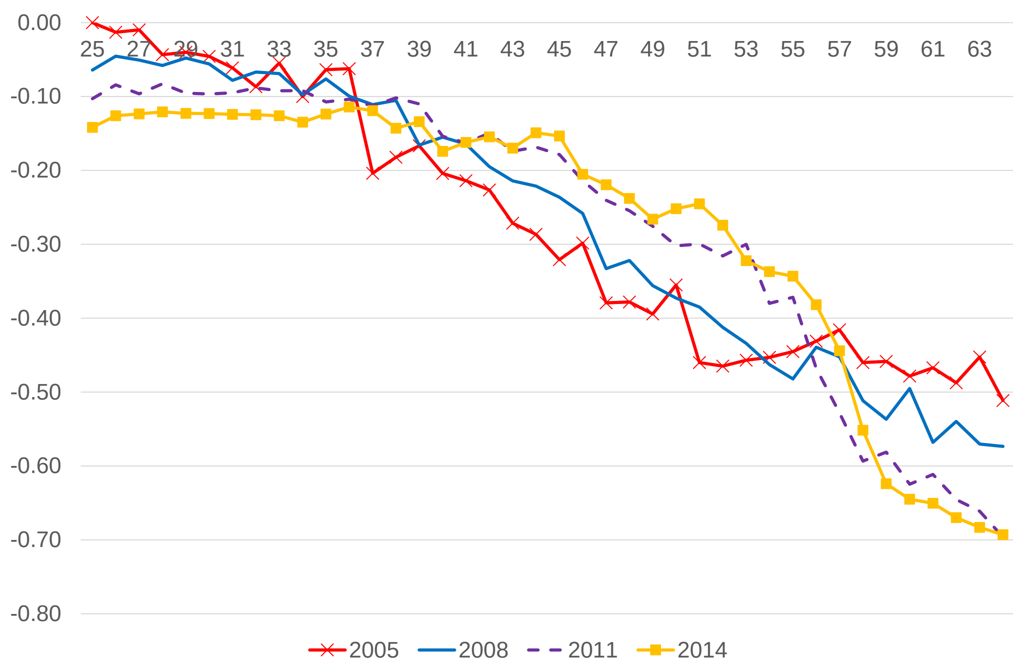


Figure 5: Age trends (as deviations from common) in Value Equation.

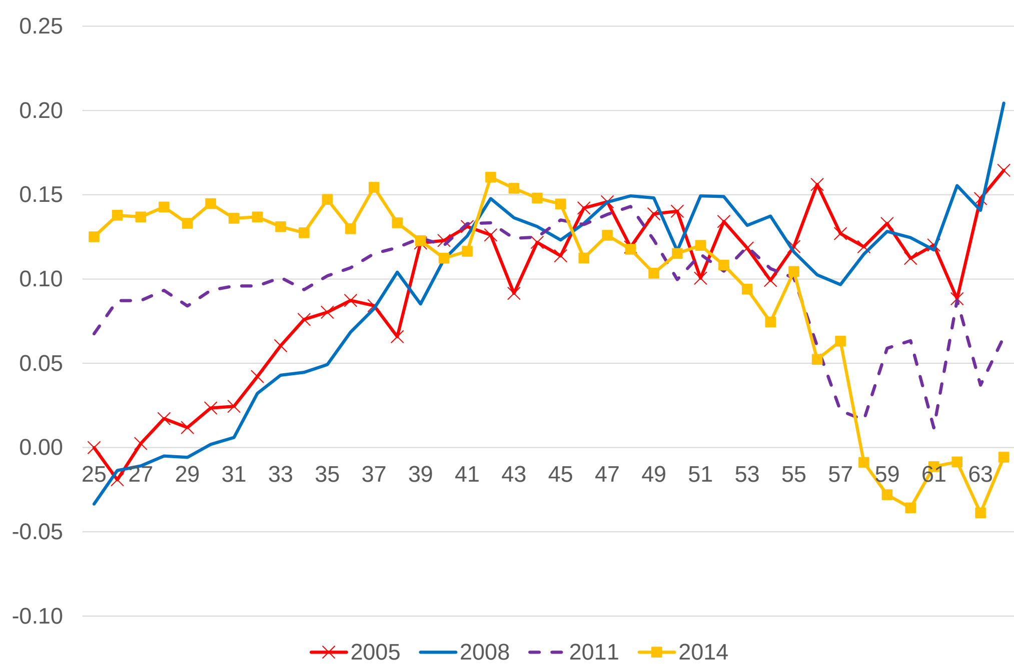
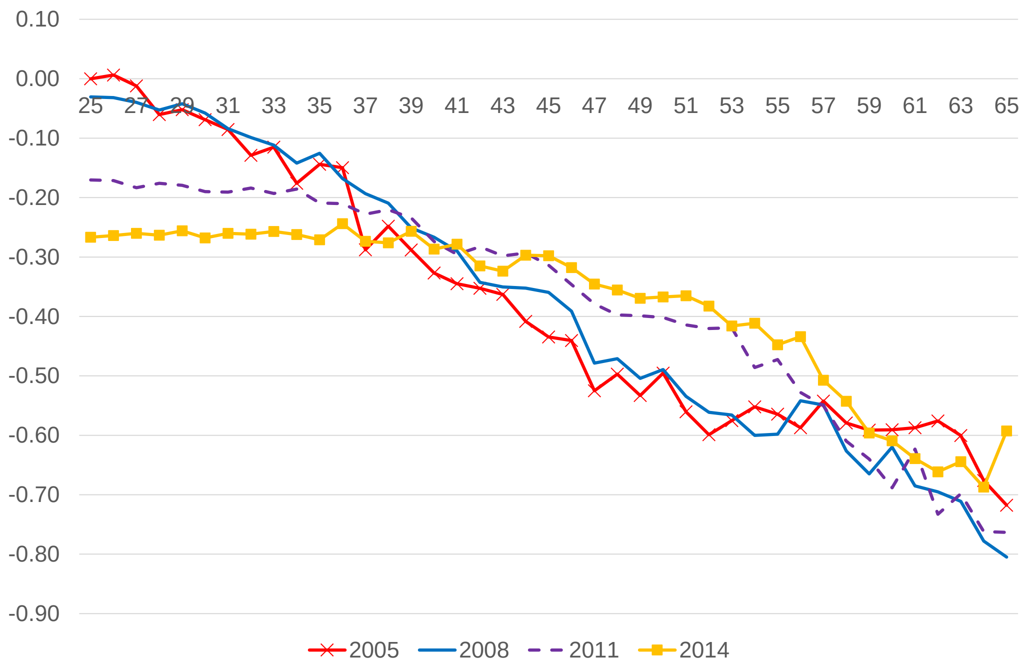


Figure 6: Age trends (as deviations from common) in LTV Equation.



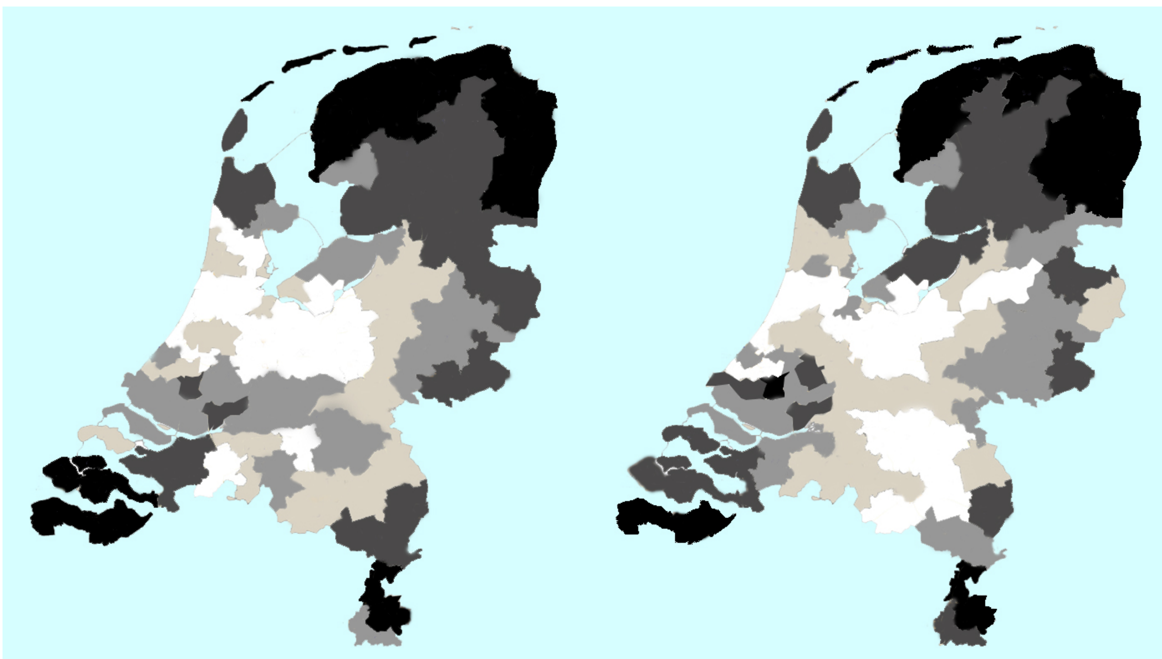
quarters of 2005, 2008, 2011 and 2014. All trends represent the deviation from the common trend observed previously in Figure 3.

Households whose head is aged 35 or younger got approximately 13% higher mortgages in 2005 than they did in 2014. In contrast, they bought higher quality houses in 2014 as compared to 2005. These homebuyers are credit constrained as the bank lending policies became more stringent (Francke et al., 2014). These individuals almost completely rely on the **supply** of mortgage credit as they typically have insufficient cash-at-hand or liquid assets or other forms of savings to finance their home purchase (Fernandez-Corugedo and Muellbauer, 2006). However, the decline in house prices between 2005 and 2014 was so sharp that these young homebuyers can afford higher quality homes in 2014 than their counterparts were able to do in 2005. In other words, younger households are not affected by negative home equity.

Households whose head is aged between 35 and 55 had a completely different (opposite) experience. These 'medium aged' households got more mortgage credit in 2014 than they did in 2005. However, these households did *not* buy higher quality houses. As house prices declined, these households suffered home equity losses (see Tables A2 – A3), especially as the initial LTVs were very high (Andrews et al., 2011). In order to purchase the same quality home as their counterparts previously owned, the **demand** for debt has to increase.

Finally, the 'older' households (whose head is aged 60 and higher) bought less quality

Figure 7: Average parameter coefficient of 2 digit zip code trends, ranked from highest estimate (white) to lowest estimate (black) in five categories.



(a) Loan Equation.

(b) Value Equation.

homes in 2014 and took on less debt than the same households did in previous years. One possible explanation is that owning a home was no longer a valuable investment for these relatively rich households due to the change in the fiscal treatment of interest rate deductibility, or to the decline of house prices.

5 Concluding Remarks

This paper explores the development of mortgage lending over time and estimates multiple trend components of demand and supply of mortgage credit by using a hierarchical trend model. In this model key variables like the age of the borrower and location are allowed to be time-varying. The empirical analysis is based on a unique loan-level data set covering the years 2005-2014 in the Netherlands. This period is particularly interesting in view of the recent global financial crisis, changes in bank lending policies, and in view of the house price dynamics in the Dutch housing market. The data is unique in that it helps isolating the determinants of (changes in) mortgage levels in greater detail than in previous research.

Our findings can be summarized as follows. High-income households take out higher loan amounts and have higher collateral values. Interest rates are negatively related to both loan amounts and collateral values. The common trend in the loan equation, a proxy for the changes in demand and supply of mortgage credit over time, suggests a large decline in mortgage demand and supply after 2007. The common trend in the collateral value equation is highly correlated with the common trend in the loan equation, suggesting a high pass-through rate of changes in credit conditions from loan to value. We also find that young household cohorts can afford to buy better quality houses in 2014 than in 2005, even if they could borrow less. On the contrary, older household cohorts could get higher loan values in 2014 than in 2005, but their collateral values do not change.

The policy reform put in place in the Netherlands as of 2013 aimed primarily at the deleveraging in the household sector. Our estimates show that this objective can be achieved, because interest-only mortgages are associated with an increase of the loan value if compared to annuity mortgages. However, our estimates also show that interest-only mortgages are associated with an increase of the collateral value, therefore with an increase of house prices. It follows that a potential consequence of the abolishment of this kind of mortgage contracts is a decline in house prices. In a scenario of declining house prices, or more in general of deflation, this policy might amplify this trend. In addition, this paper shows that the younger household cohorts are the ones who benefited from the policy reform the most, while the older household cohorts were the ones who benefited the least. In a dynamic life cycle framework, one should take into account that younger households now will be older households tomorrow. The empirical evidence from this paper suggests that the policy measures implemented as of

2013 are effectively reducing the debt burden of Dutch households, but can have side-effects. Therefore it would be wise to keep implementing them slowly while monitoring their effects on the economy.

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A Appendix

A.1 Statistics of Home-owners in the Netherlands, per age-cohort

Table A1: Equity Dutch households, *excluding* home equity, $\times$€$1,000$

	Aged $\leq$ 25	**Aged 25 − 45**	**Aged 45 − 65**	**Aged $\geq$ 65**
2006	3	12	23	23
2007	3	13	24	25
2008	3	12	25	26
2009	3	12	24	26
2010	3	11	24	27
2011	2	8	20	25
2012	2	8	19	25
2013	1	7	17	24

Age is based on the age of the main earner. Source: Statistics Netherlands.

Table A2: Equity Dutch households, *including* home equity, $\times$€$1,000$

	Aged $\leq$ 25	**Aged 25 − 45**	**Aged 45 − 65**	**Aged $\geq$ 65**
2006	1	19	112	49
2007	1	21	123	61
2008	1	22	130	84
2009	1	16	119	101
2010	1	8	101	104
2011	1	6	92	103
2012	1	5	92	102
2013	1	4	83	107
2014	1	1	59	99

Age is based on the age of the main earner. Source: Statistics Netherlands.

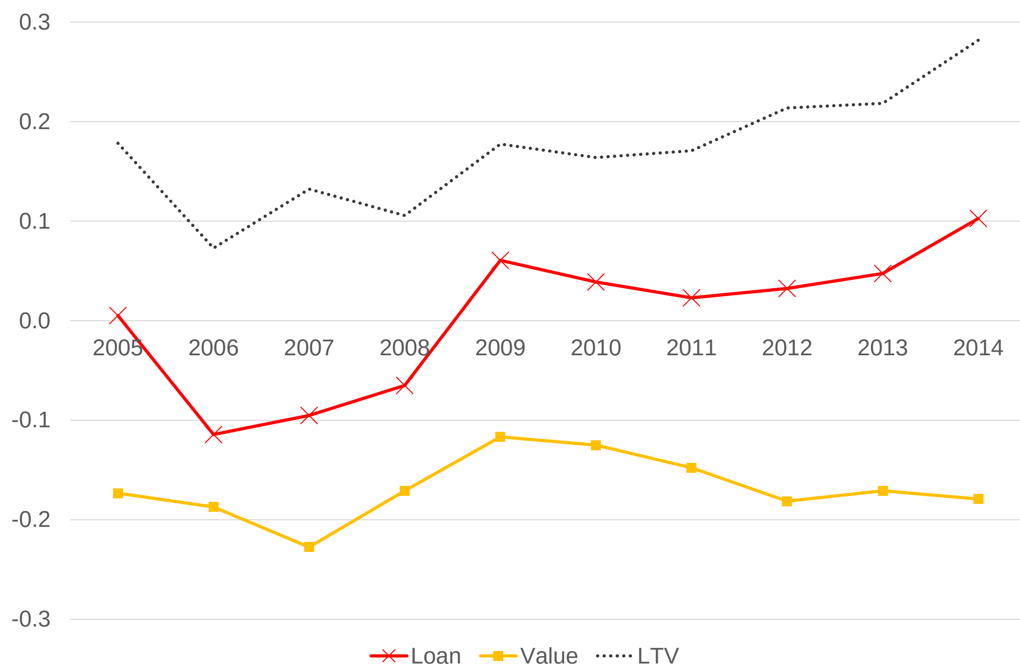
Table A3: Percentage of households with a LTV > 1.

	Aged ≤ 25	**Aged 25 − 45**	**Aged 45 − 65**	**Aged ≥ 65**	**Total**
2006	56.8%	25.3%	7.3%	1.1%	14.1%
2007	47.4%	23.5%	6.2%	0.9%	12.6%
2008	45.9%	23.7%	6.6%	0.7%	12.7%
2009	59.0%	31.6%	7.7%	1.1%	16.0%
2010	76.9%	45.2%	11.2%	1.4%	22.5%
2011	70.3%	51.0%	13.8%	1.7%	25.0%
2012	70.6%	54.0%	14.9%	1.8%	25.9%
2013	75.0%	68.7%	22.7%	3.3%	33.9%
2014	72.0%	69.7%	24.7%	3.9%	34.4%

All data is based only on households in the owner-occupier market. Source: Statistics Netherlands.

A.2 Estimates of the NHG coefficients

Figure A.1: NHG results.



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