DNB Working Paper
No. 741 / March 2022

The effect of introducing a Loan-to-Value limit on home ownership

Cindy Biesenbeek, Mauro Mastrogiacomo, Rob Alessie and Jakob de Haan

DeNederlandscheBank
EUROSYSTEEM

The effect of introducing a Loan-to-Value limit on home ownership

Cindy Biesenbeek, Mauro Mastrogiacomo, Rob Alessie and Jakob de Haan *****

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

Working Paper No. 741

De Nederlandsche Bank NV
P.O. Box 98
1000 AB AMSTERDAM
The Netherlands

March 2022

The effect of introducing a Loan-to-Value limit on home ownership

Evidence for The Netherlands using (semi)parametric survival models*

Cindy Biesenbeek[a,b,c], Mauro Mastrogiacomo[a,c,d], Rob Alessie[b,c], and Jakob de Haan[b,e]

[a]De Nederlandsche Bank
[b]University of Groningen
[c]Netspar
[d]VU University
[e]CESifo

March 2022

Abstract

We analyze the impact of the introduction of a Loan-to-Value (LTV) limit in The Netherlands on the probability for first time buyers to become homeowner using a duration model. Our research design is underpinned by a theoretical model that shows that a lower LTV limit results in suspending or renouncing home ownership, but only for liquidity constrained individuals. We use this finding to construct a treatment and control group with parents' financial wealth as a proxy for being liquidity constrained. We disentangle the effects of the LTV limit on the timing of the transition to first time home ownership from other market developments. We show that the effect of the LTV limit on this transition is approximately 6%.

Keywords: home ownership, down payment, liquidity constraints, inter-generational transfers, survival model

JEL classification: G51, R21

*We wish to thank our discussant Nicoleta Ciurila and seminar participants at CPB, seminar participants at DNB and conference participants at the Tenth Netherlands Economists Day 2021 (NED) for valuable feedback and comments. Any remaining errors are our own. We acknowledge the financial support of the Netspar grant "Program 5: The effect of macroprudential policies on pensions and retirement preparation". The views expressed here do not necessarily reflect the views of De Nederlandsche Bank or the Eurosystem. Corresponding author: Biesenbeek, Economics and Research Division, De Nederlandsche Bank (DNB), Postbus 98, 1000 AB Amsterdam, The Netherlands. Email: c.biesenbeek@dnb.nl.

1 Introduction

The financial crisis has shown that supervising individual financial institutions is not enough to maintain financial stability. Macroprudential policy is needed as well to limit system-wide financial risks. Examples of macroprudential instruments are regulatory capital requirements for systemic risks and Loan-to-Value (LTV) limits (Galati & Moessner, 2011).

However, macroprudential policies often imply a trade off between more financial resilience in the long run and short-term macroeconomic costs such as lower credit and output growth (Bank for International Settlements, 2019). This also holds for the introduction of a LTV limit, which may enhance bank stability but may also make it more difficult to buy a house, notably for entrants at the housing.

The Dutch example is a point in case. An LTV limit was introduced in The Netherlands in 2012. The average LTV ratio at origination of buyers below 35 years old - a proxy for housing market entrants - slightly decreased from 93% in 2012 to 90% in 2018 (own calculations based on DNB Loan Level Data) (Statistics Netherlands [CBS], 2021). In the same period, average house prices increased by 27% (CBS, 2021). Existing research shows that housing prices would have increased even stronger in the absence of macroprudential policy tools (De Nederlandsche Bank [DNB], 2015; Elbourne, Soederhuizen, & Teulings, 2020). A potential side effect of enhanced stability is a reduced demand for owner-occupied housing. Simulations show that the majority of first-time home buyers postpone the transition to homeownership to save for the required down payment (De Nederlandsche Bank DNB, 2015).

We analyze the impact of the introduction of a LTV limit in the Netherlands on the probability for first time buyers to become homeowner. This is an empirical extension of the simulations by DNB (2015). It is difficult to identify the LTV effect, as the probability and timing of the transition to home ownership are also affected by housing market conditions. For example, rising house prices impact the probability to become homeowner as shown by Boehm and Schlottmann (2011, 2014). Our theoretical model based on Brueckner (1986) confirms that both house price increases and a reduction of the LTV limit reduce the probability to become homeowner. However, the model also shows that the effect of the LTV limit is more binding for liquidity constrained individuals.[1] We use this finding to isolate the effect of the LTV limit

[1] Liquidity constraints induce consumers to save more early in life and deviate from their optimal consumption profile (Artle & Varaiya, 1978; Brueckner, 1986). Moreover, there is evidence that these constraints cause delayed home purchases and higher house prices (Barakova, Calem, & Wachter, 2014; Haurin, Hendershott, & Wachter, 1997; Ortalo-Magné & Rady, 2006).

from housing market conditions by constructing a treatment and control group. The treatment group consists of individuals whose parents have less than a given amount of financial wealth (50.000 in our baseline specification). The control group consists of individuals with wealthy parents who could therefore (potentially) make the required down payment. We exploit exogenous variation of LTV limits for liquidity constrained and unconstrained households to identify the effect of this macroprudential instrument on the timing of home purchases using a duration model.

We use a unique and highly granular data set that contains the exact dates of moves to a different address at the individual level. The dataset consists of more than 3.9 million individuals and their partners and parents. We also exploit mortgage data at the loan level, which allows us to estimate the required down payment for every individual in the data.

The average duration between an individual's 18^{th} birthday and first time home ownership has increased since the introduction of the LTV limit. However, our results suggest that this increase is mainly caused by housing market developments. The effect of a reduction of the LTV limit on the probability for first-time home buyers to become homeowner is limited, as the difference between the treatment and the control group is approximately 6%. Our results are robust. A comparison of parametric and semi-parametric models indicates a low risk of misspecification of our baseline model. We control for unobserved heterogeneity by including individual random effects. Furthermore, our results are robust for alternative definitions of the treatment and the control group.

The paper is structured as follows. Section 2 provides the theoretical framework that shows the effect of changes in the LTV limit and house prices on housing tenure (renting or home ownership). Section 3 describes the data set and section 4 outlines the methodology. Section 5 presents the results and Section 6 concludes.

2 Theory

Brueckner (1986) presents a two period model on optimal housing tenure choice (owning or renting). He shows that a down payment constraint induces a trade off: consumers need to reduce consumption in the first period to save enough for the required down payment to buy a house, but only enjoy the benefits of home ownership in the second period.

We extend his model to include the effect of changes in house prices and the LTV limit on tenure choice. This section presents the results; we refer to Appendix A for full details.

There are two types of consumers in Brueckner's model: lifelong renters (denoted R) and homeowners (H). The consumers' objective is to maximize the function $u(x_1) + \theta u(x_2)$, where x_1 and x_2 are non-housing consumption in periods 1 and 2, respectively, and $\theta < 1$ is the discount factor. Let y_1 and y_2 denote income in periods 1 and 2, and τ_1 and τ_2 income tax rates. Savings in period 1 are denoted by s and the interest rate by r. It is assumed that consumers cannot borrow against future income and pay a fixed rental or mortgage payment Q for housing. The renter's budget constraints in the two periods are $x_1^R = (1-\tau_1)y_1 - s^R - Q$, $x_2^R = (1-\tau_2)y_2 + (1+(1-\tau_2)r)s^R - Q$ and $s^R \geq 0$. Homeowners need to pay a down payment at the beginning of the second period and sell their house at the end of the second period. Let α denote the down payment percentage and P house prices. Moreover, homeowners benefit from a tax deductible mortgage payment in period 2. The budget constraints for the homeowners are $x_1^H = (1-\tau_1)y_1 - s^H - Q$, and $x_2^H = (1-\tau_2)y_2 + (1+(1-\tau_2)r)s^H - (1-\tau_2)Q$ where $s^H \geq \alpha P$ denotes the down payment constraint. Brueckner (1986) derives an owner-renter utility differential $\Omega = u(x_1^H) + \theta u(x_2^H) - u(x_1^R) - \theta u(x_2^R)$ to show the effect of parameters on tenure choice.

The effect of house prices on tenure choice is the derivative of the owner-renter utility differential with respect to house prices. After substitution of the budget constraints in the owner-renter utility differential, we use the envelope theorem to assess the effect of a change in the house price:

$$\begin{aligned}\frac{\delta\Omega}{\delta P} = &\underbrace{\alpha[-u'(x_1^H)]}_{\substack{\text{down payment}\\ -}} + \underbrace{\theta(1+(1-\tau_2)r)\alpha)[u'(x_2^H)]}_{\substack{\text{return}\\ +}} + \underbrace{\tau_2 r[u'(x_2^H)]}_{\substack{\text{deduction}\\ +}} \\ &\underbrace{-r([u'(x_1^H) - u'(x_1^R)]}_{\substack{\text{housing costs p1}\\ -}} \qquad \underbrace{-\theta r[u'(x_2^H) - u'(x_2^R)]}_{\substack{\text{housing costs p2}\\ +}} \end{aligned} \tag{1}$$

An increase in P leads to an increase in required savings and a reduction in first-period consumption. This reduction is partly offset by returns on those savings in the second period if the down payment constraint is binding[2]. Finally, housing costs of both homeowners and renters depend on house prices[3] but the effect of an increase in P on the utility function is not the same for renters and borrowers. Home owners face a higher utility loss in the first period, renters in

[2] If the down payment constraint is binding, the loss in utility from lower period 1 consumption is greater than the increase in utility from higher returns on those savings: $\alpha[-u'(x_1^H)] > \theta(1+(1-\tau_2)r)\alpha)[u'(x_2^H)]$

[3] From the non-profit condition, $Q = rP$

the second.[4] The total effect of price increases on tenure choice is ambiguous. It depends on multiple parameters, in particular on the time preference parameter θ. Higher house prices increase the required level of savings and hence reduce consumption in period 1, but also increase tax deduction and consumption in period 2. The latter effect is greater if tax rates τ_2 and/or interest rates r are high. Both increase the tax deduction of homeowners.

We extend the Brueckner (1986) model and allow for changes in prices, so that the effect on utility will depend on the timing of the price change. Let P_1 and P_2 denote house prices in both periods. The first-order derivative with respect to P_1 is:

$$\frac{\delta\Omega}{\delta P_1} = \underbrace{\alpha[-u'(x_1^H)]}_{\substack{\text{down payment} \\ -}} + \underbrace{\theta(1+(1-\tau_2)r)\alpha)[u'(x_2^H)]}_{\substack{\text{return} \\ +}} - \underbrace{[u'(x_2^H)]}_{\substack{\text{capital loss} \\ -}} + \underbrace{\tau_2 r[u'(x_2^H)]}_{\substack{\text{deduction} \\ +}} \quad \underbrace{-r[u'(x_1^H) + u'(x_1^R)]}_{\substack{\text{housing costs p1} \\ -}} \tag{2}$$

The first effect of an increase in P_1 (without any change in P_2) is the homeowner's utility loss due to reduced consumption in period 1. This effect is negative if the down payment constraint is binding (because the savings decision is more distorted) and zero otherwise. This utility loss is partly offset by higher consumption in period 2 from a higher return on savings (the second term). If the down payment constraint is binding, the sum of the first two terms is negative. The third term refers to the capital loss or gain after the homeowner sells the house at the end in period 2. If prices in period 2 do not change, an increase of prices in period 1 leads to a higher capital loss, so the effect of an increase in P_1 on the owner-renter utility differential is negative as well. The fourth term is the effect of the tax deduction, which is positive. Finally, the last term refers to the loss in utility from lower non-housing consumption for both renters and homeowners in period 1. This effect is negative. Recall from Brueckner (1986) that $x_1^H < x_1^R$ if the down payment constraint is binding, and since the utility functions are concave, homeowners face a greater utility loss compared to renters if house prices in period 1 increase.

Similarly to period 1, we discuss the effect of price changes in period 2 by taking the

[4] Fig. 1 in Brueckner (1986) shows that if the down payment constraint is binding, $x_1^H < x_1^R$ and $x_2^H > x_2^R$. From concavity of the utility function, $r([u'(x_1^H) - u'(x_1^R)] > 0$ and $\theta r([u'(x_2^H) - u'(x_2^R)] < 0$.

derivative with respect to P_2 using the envelope theorem:

$$\frac{\delta\Omega}{\delta P_2} = \underbrace{\theta[u'(x_2^H)]}_{\substack{\text{capital gain} \\ +}} + \underbrace{\theta r[u'(x_2^R)]}_{\substack{\text{housing costs p2} \\ +}} \tag{3}$$

An increase in prices in period 2 increases the attractiveness of home ownership compared to renting in two ways: it results in a capital gain, and homeowners do not face an increase in housing costs (unlike renters).

Next, we evaluate the effect of changes in leverage constraints on tenure choice. For simplicity, the required down payment is denoted as a fraction α of house prices as in Brueckner (1986). We will now show how the required down payment (and ultimately tenure choice) depends on the LTV limit.

In most countries, including The Netherlands, consumers need to pay transaction costs including taxes, bank commission and brokerage fees, to buy a house. We assume that these transaction costs are proportional and denote them as ρ. So the total costs C to purchase an house are $K = (1 + \rho)P$.

Until 2011, it was common for first-time home buyers in The Netherlands to obtain a mortgage M that exceeded purchasing costs $K : M > K$. An LTV limit of 106 percent was introduced in 2012, and gradually declined to 100 percent in 2018. We therefore have an exogenous variation in LTV limits that will help us identify its effect in the empirical analysis.

Denote the LTV limit as γ. The maximum value of the mortgage M is a percentage γ of the value of the house V: $M^* \leq \gamma V$. Assume for simplicity that the value of the house is equal to the purchasing price (there is no over- or underbidding), so $V = P$ [5]. Households need to make an out-of-pocket down payment D if the LTV constraint is binding, i.e. $K > M^*$ which implies that $(1 + \rho)P > \gamma P$. The required down payment is $D = (1 + \rho)P - \gamma P$. Now divide D by house prices and plug the required down payment into the budget constraints:

$$\alpha = (1 + \rho - \gamma) \tag{4}$$

We can substitute equation(4) to the savings constraint: $s^H \geq (1 + \rho - \gamma)P$.[6] Take the first-order derivative of the owner-renter utility differential with the new savings constraints to the

[5] In case of overbidding, $V > P$ and the required down payment increases

[6] If the down payment constraint is binding, it is sub-optimal for homeowners to save more than the required down payment, so that $s^H = (1 + \rho - \gamma)P$.

LTV limit γ using the envelope theorem:

$$\frac{\delta\Omega}{\delta\gamma} = \underbrace{P[u'(x_1^H)]}_{\substack{\text{down payment} \\ +}} \underbrace{-\theta P(1+(1-\tau_2)r)[u'(x_2^H)]}_{\substack{\text{return} \\ -}} \tag{5}$$

This derivative consists of two parts. The first one is the effect on consumption in period 1. If the down payment constraint is binding, an increase in the LTV limit increases non-housing consumption in period 1, because of lower required savings. This implies that the first effect is positive. The second part is the return on savings. A smaller down payment leads to smaller required savings and a smaller return on these savings. Once again, this is only the case if the down payment constraint is binding.

As some of the effects above are the combination of opposing effects, it is not always a priori clear which effects prevails. However, the model suggests that the effect of the LTV limit is more binding for liquidity constrained individuals. This finding is used to isolate the effect of the LTV limit from housing market conditions in our empirical analysis.

3 Data

Our unit of analysis is the individual housing spell from CBS. By this we mean the period elapsing between two subsequent moves to a different address. Every spell includes an anonymized person ID, an address ID and the start- and end date of the individual living at this address. Our dataset contains every inhabitant in The Netherlands since 1995 (23.0 million people). On average, each individual lives at 3.0 different addresses; so, there are 69.5 million spells in total (see Table 1).

Our sample is a subset of this large dataset. First, we are interested in first-time home buyers only, and therefore restrict the sample to individuals between 18-40 years (15.6 million individuals). We treat home ownership as an absorbing state: individuals are removed from the sample after their first transition to home ownership. We leave all individuals that are homeowners at the first observation out of the sample as well, because we cannot observe their transition to home ownership. Finally, we drop all individuals with one or more spells with unknown housing type, unknown parents' financial wealth and other unknown control variables. The control variables are available from 2006 on. This implies that individuals become at risk in 2006 or later, but we do use housing spells before 2006 to determine if individuals were homeowner before. There are 3.8 million individuals left (see Table 1).

Table 1: Sample size after selections (millions)

	Individuals	**Spells**
Total sample	23.0	69.5
Within age group 18-40 year	15.6	41.7
Dropped after transition	12.7	26.7
Without homeowners after first observation	9.3	23.3
Without unknown residence type	8.1	19.1
Parents' wealth available	5.4	10.3
Control variables available	3.8	7.2

We obtain additional information about individual characteristics by merging our database with several other data from Statistics Netherlands (CBS), including gender, age, migration background, parents' ID, highest level and field of education achieved, annual income, wealth, gifts and inheritances received, main social economic category and being part of a couple or not. We observe most of these characteristics annually so we can allow for time-varying control variables (exceptions are gender, day of birth and ethnicity).

The dataset contains a time-varying dummy variable for the LTV limit, which was introduced in 2012. The dummy therefore equals 0 for every individual until the end of 2011, and 1 thereafter. In the robustness analysis, we use the level of the LTV limit rather than a dummy. In our baseline model, we assume that the introduction of an LTV limit has a larger effect on the probability to become homeowner than the slight annual reduction of the LTV limit.

As the LTV limit was introduced to all potential buyers simultaneously, the selection of a control and a treatment group that would allow estimating the effect of the LTV limit is not obvious. As outlined above, for this purpose we need an indicator of liquidity constraints. Although data on personal wealth is available, it does not qualify to identify liquidity constraints, as it is evidently endogenous to the home purchase decision. Instead, we use parents' financial wealth. Financial support from parents can help to overcome liquidity constraints which distorts inter-temporal consumption (Cox, 1972; Engelhardt and Mayer, 1998; Guiso and Jappelli, 2002). Housing-related financial transfers from parents to children were exempted from taxes and hence missing in our data for an amount up to 100.000 euro in our dataset. Therefore, we use parents' financial wealth in stead of actual received transfers as a proxy being liquidity constrained.

Parents' financial wealth is calculated in two steps. First, we merge the (anonymized) parents' ID by a parent-child table. The mother's ID is available for 82.1% of our population and the father's ID for 77.8%. Second, we find the annual wealth levels of these mothers and fathers. Wealth is registered at the household level. In case the parents are not in the same household, parents' total wealth is calculated as the sum of the mother's and father's household wealth. Parents' wealth is available for 56.4% of the sample.[7] We assume individuals are unconstrained if their parents have at least 50,000 euro of financial wealth. Financial wealth is defined as the total value of financial assets, including bank balances, savings and securities.

As we are interested in transitions to the first owner-occupied house, we need to identify those being tenants, owner-occupant or living at their parents' house. We retrieve residential type from the registered property type of the address. This is available for almost all properties from 2006 on. If not, we use the first available property type of the address. In case an individual is registered on the same address as one or both parents, we set property type as *living at parents* rather than rental or owner occupied.[8]

We enrich the empirical analysis using a set of background variables. Age, gender and migration background are available for all individuals in the sample through the Municipal Records Database (Gemeentelijke Basisadministratie, GBA). The highest level of education attained and corresponding field of education are derived at a reference date from registers and from the Labour Force Survey and grouped to ISCED and ISCO classifications. Attained education is available for 85.5% of the sample.

Income is registered at the individual level and derived at a reference date from multiple sources, including the Dutch Tax Authority. The income variable in our database refers to gross income from labour, business and social benefits and it is normalized. The socioeconomic category refers to the most important source of income.

Besides CBS data, we use DNB loan level data. This database contains information on mortgages for individuals that purchased an house before or in 2016, including purchase price. Table 2 contains a summary of the key variables for the treatment and control group.

[7]People with a migration background are underrepresented in the data: parents' financial wealth is unavailable if they live abroad.

[8]There is one exception: if parent and child live on the same address but the child is the owner of the house, the residential type is defined as *owner occupied* rather than *living at parents*. This exception is uncommon, due in part to the fact that the owner of the house is only available in the data from 2012 on.

Table 2: Median values for variables in the treatment and control group in 2019

	Treatment	**Control**
Residential type		
Rental	32.9	32.3
With parents	67.1	67.7
Gender		
Male	51.8	53.5
Female	48.2	46.5
Level of education		
Low	37.0	20.1
Medium	52.0	58.4
Bachelor	8.5	15.0
Master	2.6	6.5
Migration background		
Dutch	72.9	90.3
Western	7.4	5.5
Non-western	19.8	4.2
Socioeconomic category		
Employee	75.0	73.8
Self-employed	20.1	18.0
Other	2.8	6.4
Median values		
Age	23.3	23.0
Income	13.5	14.8
Household income	17.7	18.9
Household wealth	12.7	141.1
Parents' household wealth	15.0	212.8
Received gifts	0.1	0.8
Received inheritances	0.1	0.4

Explanatory note: Categorical variables are reported in percentages. Age is denoted in years and other median values in 1000 euro. Individuals are in the treatment group (financial constrained) if their parents have at less than 50,000 euro of financial wealth and in the control group (unconstrained) if their parents have more financial wealth. The value of variables can change over time. In this table, the last available value for every individual is reported. We use the current values in our empirical model.

4 Methodology

The theoretical model in section 2 shows that a lower LTV limit reduces the probability to become homeowner in period 1 if the down payment constraint is binding. Our hypothesis is therefore that the reduction of the LTV limit reduces the hazard ratio of transitioning to first-time home ownership for constrained households only.

The effect of the introduction of the LTV limit, which was common to all households within a year, can be identified relative to other year-specific effects (like housing market conditions) by comparing a treatment group against a control group for whom the 6% down payment constraint is not binding (”the unconstrained”). The parameters of interest are the interactions of the treatment group dummy with the required down payment and with the dummy that indicates the years after the LTV limit had been introduced.

We use a duration model to estimate the probability for a first-time home buyer to purchase a house, conditional on covariates, among which a dummy for the presence of an LTV limit and a dummy for being liquidity constrained. Duration models are dynamic models with a hazard rate as key parameter. In economics, duration models are mostly known from their applications in unemployment studies. There are also some applications in housing economics, where the hazard rate is defined as the transition from one type of housing to another.[9]

The most common methods to estimate the effect of borrowing constraints on the probability of home ownership are binary choice models like logit and probit models (Acolin, Bricker, Calem, & Wachter, 2016; Bourassa, 1995; Linneman & Wachter, 1989; Quercia, McCarthy, & Wachter, 2003). However, duration models have several advantages. First, duration models control for right-censoring. Some individuals do not buy a house within the observation period, and those individuals are not random. Leaving them out would bias the estimated effect of the LTV limit on the probability of transition to home ownership. Furthermore, a duration model estimates the probability of home ownership over the full length of the spell before purchasing and thus employs more information than a simple model that estimates the probability at a specific point in time. Finally, duration models allow for time-varying covariates, and take life events, such as a new job with a higher wage or getting married, into account.

[9]For instance, Andrew, Hauren, and Munasib (2016), Boehm and Schlottmann (2008) estimate the hazard rate from renting to ownership, Bahchieva and Hosier (2001) examine the hazard rate of leaving a public house; Guiso and Jappelli (2002) estimate the effect of private transfers on the hazard rate of becoming a homeowner; Deutsch, Tiwari, and Moriizumi (2006) evaluate the spells starting at adulthood age to first time home ownership; while di Salvo and Ermisch (1997) use a competing risk proportional hazards model to estimate the hazard to either home ownership or social housing.

Figure 1: KM Survival function first-time home buyers

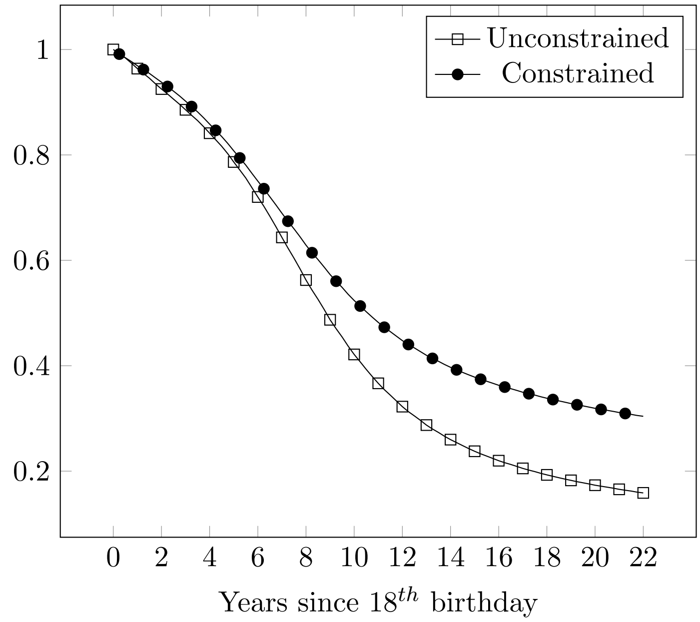

Figure 1 shows the Kaplan-Meier survival function. This is a non-parametric estimate of the probability that an individual has not yet made the transition to home ownership after a certain amount of time, without any controls. Time is denoted as years since the 18^{th} birthday and individuals leave the sample after the first purchase of an house, censoring at the 40^{th} birthday or leaving The Netherlands. The figure shows that the survivor function first increases at an increasing rate and later at a decreasing rate. The median time before purchasing a house is approximately 9 years for unconstrained individuals and 10.5 years for constrained individuals. This implies that after 9 (10.5) years, approximately half of the unconstrained (constrained) sample has made the transition to home ownership, while the other half of the sample still rents or lives at their parents' house. Approximately 30% of the constrained sample versus 16% of the unconstrained sample has not made the transition to home ownership at the age of 40.

We use a proportional hazard model, a class of duration models, to estimate hazard rates after controlling for censoring. This approach is similar to those used by Guiso and Jappelli (2002) and Deutsch et al. (2006). In contrast to these studies, our unit of observation is an individual rather than a household. We assume individuals would start considering home ownership from adulthood at age 18. The proportional hazard model can be written as a combination of a baseline hazard and an individual hazard:

$$h(t) = h_0(t)exp(\beta_x X'_{i,t}) \tag{6}$$

where $h_0(t)$ is the baseline hazard, t time of house purchase, x_i a vector of individual (time-varying) characteristics and β_x the effect of these characteristics on the hazard rate. Let the spell until home purchase be T while $f(t)$ is its probability distribution. The cumulative probability or the probability to become homeowner before t is the product of the probabilities up to t, or

$$F(t) = \int_0^t f(s)ds \tag{7}$$

The survivor function is the inverse of the cumulative probability function, or

$$S(t) = 1 - F(t) \tag{8}$$

The hazard rate $h(t)$ is the probability to become homeowner at t, given that one has not been homeowner before:

$$h(t) = \frac{f(t)}{S(t)} \tag{9}$$

This hazard rate can be estimated by several models, including parametric models or the semi-parametric Cox proportional hazard models. Parametric models assume a distribution of the baseline hazard, like Weibull, exponential or loglogistic. Cox proportional hazard models do not impose any restrictions on the baseline hazard and are less prone to misspecification. If the assumption about the baseline hazard rates are correct, parametric models are more efficient. Parametric models are feasible in the sense that the expected duration can be derived from the estimate of the survivor function.[10]

Since we do not have priors about the relationship between time elapsed since the 18^{th} birthday and the probability to buy a first house, we impose a Weibull distribution to the baseline hazard rate.[11] We control for misspecification of the baseline hazard rate with a Cox

[10]The expected value of the survival time (predicted mean duration) is:

$$\mu_{T_j} = E(T_j|\mathbf{x}_j) = \int_0^\infty tf(t|\mathbf{x}_j)dt = \int_0^\infty S(t|\mathbf{x}_j)dt$$

where probability function $f()$ and survivor function (S) depend on the choice of the parametric model (Cleves, Gould, Gutierrez, & Marchenko, 2010).

[11]The baseline hazard function for a Weibull distribution is $p\lambda^p t^{p-1}$, where p is the shape parameter. A Weibull distribution is flexible, since the hazard rate can be increasing ($p > 1$), constant ($p = 1$) or decreasing ($p < 1$)

proportional hazards model, which does not require assumptions about the baseline hazard rate.

We estimate the following hazard function:

$$h(t) = h_0(t) \cdot exp(\alpha C'_{i,t} \cdot \delta L'_t \cdot \gamma I'_{i,t} \cdot \beta_x X'_{i,t}) \tag{10}$$

where L is the LTV dummy, with value 0 before 2012 and 1 thereafter; C a dummy for being financially constrained, I is the interaction term of both dummies, and $X'_{i,t}$ is a vector of control variables. The interaction term I is the key variable of interest. We expect that the LTV limit reduces the hazard rate for constrained individuals, i.e. $exp(\gamma) < 1$.

We add control variables in Models 1-3 and add more variables (one by one to avoid collinearity) in subsequent models. An overview of the specifications of the estimated hazard function is listed in Table 3.

Table 3: Overview of hazard model specifications

Model	**Key parameter**	**Control variable**	**Additional variables**
Model 1	Constrained×LTV limit	-	-
Model 2	Constrained×LTV limit	Some	-
Model 3	Constrained×LTV limit	All available	-
Model 4	Constrained×LTV limit	All available	House price index
Model 5	Constrained×LTV limit	All available	Year dummies
Model 6	Constrained×LTV limit	All available	Predicted value house
Model 7	Constrained×LTV limit	All available	Required down payment

Explanatory note: Control variables in Model 2 are gender, migration background and a dummy for having a partner. In Models 4-7, we include the same variables and socioeconomic status, level of education, tenure status (renting or living at parents) and household income in addition. Each additional variable is in only one specification.

In a fourth model, we include an annual house price index as additional variable. Recall from equation 2 in the theory section that an increase in current house prices reduces the attractiveness of home ownership, since the required down payment is a fraction of current house prices. We therefore expect that the empirical hazard ratio on prices is below 1.

Beyond house prices, other year-specific effects might be important as well. This leads us to estimate a fifth model including year dummies. We expect the hazard ratio to be lower for 2012, the year of the introduction of the LTV limit. Afterwards, the LTV limit was reduced further, but only in small steps.

In a sixth model, we include the predicted value of the house in case an individual would become first time homeowner. This variable is constructed as follows. We take the conditional

over time.

mean of recently purchased houses by similar individuals in the DNB loan level data to proxy for their desired home and calculate the required down payment based on exogenous variation in the LTV limit. For those individuals, we regress the logarithm of observed purchase price on individual characteristics including municipality, age, income, year of birth, residential type situation before home ownership (rental or at parents), level of education, and use it to predict the purchase price for other households (see appendix B). The predicted house value is available for 93,8% of the sample. The mean predicted house value for first-time home buyers was approximately 159,000 euro in 2012 and 191,000 euro in 2018 (see Table 4).

In a seventh model, we include the predicted value of the required down payment. Recall from the theory section that the required down payment to buy an house is $(1 + \rho - \gamma)P$. We use the predicted value of the house and assume proportional transaction costs of 6% of the initial value of the house and calculate the predicted required down payment. The required down payment was 0 euro until 2012 and increased after the introduction of the LTV limit. We expect the hazard ratio of the required down payment to be smaller than 1.

Table 4: Mean predicted house values and required down payments

Year	Predicted house value	Required down payment
2006	193	0
2006	193	0
2007	191	0
2008	195	0
2009	185	0
2010	179	0
2011	172	0
2012	158	0
2013	146	1.5
2014	147	2.9
2015	151	4.5
2016	162	6.5
2017	178	8.9
2018	198	11.9
2019	225	13.5

Explanatory note: values in 1000 euro. The predicted house value is the conditional mean of recently purchased houses by similar individuals. It is based on a regression of observed purchase prices on individual characteristics.The required down payment is the amount of the purchasing costs that cannot be financed by a mortgage. It is based on the current LTV limit, on the predicted value of the house and on the assumption that transaction costs are 6% of the predicted value of the house.

5 Results

The main results for the duration models are shown in Table 5 in the form of hazard ratios.[12] A hazard ratio is the ratio of the hazard rates - or the probability to become homeowner - corresponding to two different values of an explanatory variable. A hazard ratio of 1 implies that the explanatory variable does not have an effect on the hazard rates.

The key parameter of interest is the effect of the LTV limit for the treatment group. The hazard ratio of the interaction term between being liquidity constrained and the LTV dummy is significant and is slightly below 1 in almost every model. As we hypothesized in Section 4, $exp(\gamma) < 1$. In presence of the LTV limit, the hazard rate of a liquidity constrained individual is approximately 0.935 times the hazard rate of an unconstrained individual. This is in line with the empirical literature (Acolin et al., 2016; Bourassa, 1995; Brueckner, 1986; Linneman & Wachter, 1989; Quercia et al., 2003). For example, Acolin et al. (2016) show that the probability to become homeowner dropped by 2.3% in the United States as a result of more stringent down payment constraints.

Model 4 shows that the hazard ratio is higher in times of higher house prices compared to periods of lower house prices. This is in contradiction from the expectations of the theoretical model. A potential explanation is that house prices are exogenous in the simple theoretical model, but are endogenous in reality. If there are more transactions, the probability to become homeowner increases, but high demand for houses drives up housing prices as well. It goes beyond the scope of this paper to study the development of house prices though. Next, we estimate a model with year-specific dummies for the treatment group. The hazard ratio for the constrained in 2012 is estimated at 1.245; we cannot tell if this is the effect of the LTV limit or other time varying variables. An higher desired value of the house reduces the probability to become homeowner. The coefficient of the predicted value of the house is 0.956, which is smaller than 1, as expected (see Model 6 in Table 5). An higher expected value of the house implies an higher required down payment in case an LTV limit prevents financing (part of) the transaction costs by a mortgage.

Finally, we exploit exogenous variation in the LTV limit by including the required down payment in the hazard model. The empirical results in Table 5 show that an increase in the down payment reduces the probability to become homeowner slightly, but only for the treatment

[12] Results of the full model are available on request.

group. The hazard ratio of the required down payment for the full sample is close to 1 while for the treatment group it is 0.992. This implies that an increase in the down payment, due to a more stringent LTV limit, an increase in house prices or a higher desired house value, has a small effect on the probability to become first time home owner. An increase in the required down payment by 1000 euro reduces this probability by approximately 1%.

Table 5: Parametric duration model with Weibull distribution, hazard ratios

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Constrained×LTV limit	0.936***	0.938***	0.935***	0.937***	0.715***	0.940***	0.984***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.005)
House price index				1.309***			
				(0.011)***			
Constrained×2012					1.245***		
					(0.007)		
Predicted house value						0.956***	
						(0.001)	
Req. savings							0.998***
							(0.000)
Req. savings×Constrained							0.992***
							(0.000)
Control variables included[a]	No	Some	Yes	Yes	Yes	Yes	Yes
Constrained × year dummies	No	No	No	Yes	No	No	No
Observations (millions)	3.8	3.8	3.8	3.8	3.8	3.8	3.8

Explanatory note: Dependent variable: analysis time in years, starting at 18^th birthday, ending at censoring or transition to home ownership. Robust standard errors in parentheses, clustered by the individual *** = 1%, ** = 5%, * = 10% significance level. Some control variables are gender, migration background and a dummy for having a partner; the full set of controls furthermore includes socioeconomic status, level of education, tenure status(renting or living at parents) and household income in addition. Model 5 includes year effects for liquidity constrained individuals for all years.

Our baseline result is that the introduction of the LTV limit has reduced the probability to become homeowner only to a small extent for the treatment group. Next, we change some of the main assumptions in our approach to examine whether the baseline result is robust.

First, we define the treatment group differently. We assumed in the baseline model that individuals are not financially constrained if their parents' wealth is at least 50.000 euro. Since this threshold is arbitrary, we test a threshold value of 100.000 euro of financial wealth as well. The key results do not change: the hazard ratio on the interaction term for the presence of an LTV limit and being liquidity constrained in the model with a larger threshold is 0.938, compared to 0.935 in the baseline model (see Model B in Table 6). We control the level of parents' financial wealth by the number of children, with little effect on the hazard ratio (Model C). When we use parents' housing wealth less mortgage in stead of financial wealth, the hazard ratio gets close to one, but we believe housing wealth is an inferior proxy compared to financial wealth due to its illiquid nature (Model D).

Another assumption that can be modified is related to the start of the spell. In the baseline model, we assume that individuals start considering home ownership at age 18, which is arbitrary. The key results do not change when we change this assumption to age 21 (Model E). Another alternative assumption is that spells start when individuals get their first job, as in the baseline model of Guiso and Jappelli (2002). The effect of the introduction of the LTV limit becomes slightly larger (0.909, see Model F). A caveat here is that part time student jobs are common in The Netherlands.

Finally, we test different estimation methodologies. We include individual random effects in Model G and assume that these effects are gamma distributed, as is common in the literature. The effect of the presence of an LTV limit on the treatment group hardly changes. This suggests that unobserved heterogeneity plays a limited role in our models. In Model H, we use a Cox proportional hazard model to estimate the baseline specification. Parametric hazard models assume a certain distribution of the baseline hazard function (see Section 4). Cox Proportional Hazard Models do not impose any restrictions on the baseline hazard function. We compare the outcomes of our fully parametric baseline model with those of a Cox proportional hazard model with the same specification (see Model H in Table 6). The hazard ratio on the presence of an LTV limit for the treatment group is 0.945, which is fairly close to the one in the fully parametric model. This indicates that the risk of misspecification of the Weibull baseline hazard function is low.

Table 6: Alternative duration models, hazard ratios

Model	**Changed assumption**	**HR interaction**	**N**
A	Baseline	0.935***	3.8
B	Unconstrained: Parents' wealth >100k	0.938***	3.8
C	Unconstrained: Parents' wealth/children >35k	0.930***	3.8
D	Unconstrained: Parents' housing wealth >100k	0.987***	3.8
E	Start spell: age 21	0.933***	2.9
F	Start spell: first job	0.909***	2.7
G	Baseline, with random effects	0.932***	3.8
H	Baseline, Cox model	0.945***	3.8

Explanatory note: HR interaction is the estimated hazard ratio of the interaction term between the presence of an LTV limit and being liquidity constrained. Dependent variable: time in years, starting at 18^{th} birthday (except Models E and F), until first time home ownership. Robust standard errors in parentheses, clustered by the individual. *** = 1%, ** = 5%, * = 10% significance level. Control variables are gender, migration background, a dummy for having a partner, socioeconomic status, level of education, tenure status(renting or living at parents) and household income.

6 Conclusion and discussion

The introduction of a sharper LTV limit is a macroprudential tool often used to improve financial stability. While the positive effects on financial stability have little opposition, detractors of this measure are often worried about the possible side effects for potential borrowers. They might need to save longer as a result of this policy change, before being able to purchase their first home.

In the present study, we find that the introduction of the LTV limit in the Netherlands in 2012 has reduced the probability to become first time homeowner at any point in time by approximately 6 percent. Our results are robust for using alternative ways to define liquidity constrained individuals, alternative assumptions of when individuals start considering homeownership, unobserved heterogeneity and potential misspecification of the baseline hazard function. Our findings are in line with the theoretical and empirical literature and do not imply that liquidity constrained individuals will never purchase a house, but will merely be facing a delay.

The average duration between an individual's 18^{th} birthday and first time home ownership has increased since the introduction of the LTV limit. However, we find little difference between the treatment and control group. This finding suggests that the increase in duration until home ownership is mainly caused by housing market developments, notably rapidly increasing house prices. The theoretical model and our extension thereof presented in Section 2 show that house prices are a lever of the effect of liquidity constraints on the required down payment, and hence the probability to purchase a first home. Previous research indicates that house price growth would have been even stronger in absence of macroprudential policy. The effect of the introduction of the LTV limit on house prices is a topic for further research.

A potential explanation for the limited effect of the LTV limit on the transition to home ownership could be that Debt-Service-to-Income limits bind first and that LTV limits simply impose a choice of what to buy and when, given the maximum amount of potential debt. Alternatively, the effect could be local, as the reduction from 106% to 100% in 7 years was small and slow; we cannot exclude that further reduction could entail larger side effects. The effect of other macroprudential policy tools on the transition to home ownership, is a topic for further research as well.

References

Acolin, A., Bricker, J., Calem, P., & Wachter, S. (2016). Borrowing constraints and homeownership. *American Economic Review*, *106*(5), 625–629.

Andrew, M., Hauren, D., & Munasib, A. (2016). Explaining the route to owner-occupation: A transatlantic comparison. *Journal of Housing Economics*, *15*, 189–216.

Artle, R., & Varaiya, P. (1978). Life cycle consumption and homeownership. *Journal of Economic Theory*, *18*(1), 38–58.

Bahchieva, R., & Hosier, A. (2001). Determinants of tenure duration in public housing: The case of New York City. *Journal of Housing Research*, *12*(2), 307–348.

Bank for International Settlements. (2019). *Examining macroprudential policy and its macroeconomic effects - some new evidence* (Working Paper No. 825). Bank for International Settlements.

Barakova, I., Calem, P. S., & Wachter, S. M. (2014). Borrowing constraints during the housing bubble. *Journal of Housing Economics*, *24*(1), 4–20.

Boehm, T. P., & Schlottmann, A. M. (2008). Wealth accumulation and homeownership: Evidence for low-income households. *Cityscape*, *10*(2), 225–256.

Boehm, T. P., & Schlottmann, A. M. (2011). Market conditions and housing choices: A comparison of homeownership across three decades. *Real Estate Economics*, *42*(3), 547–600.

Boehm, T. P., & Schlottmann, A. M. (2014). The dynamics of housing tenure choice: Lessons from Germany and the united states. *Journal of Housing Economics*, *25*, 1–19.

Bourassa, S. C. (1995). The impacts of borrowing constraints on home-ownership in australia. *Urban Studies*, *32*(7), 163–1173.

Brueckner, J. K. (1986). The downpayment constraint and housing tenure choice: A simplified exposition. *Regional Science and Urban Economics*, *16*(4), 519–525.

Cleves, M., Gould, W., Gutierrez, R., & Marchenko, Y. (2010). *An introduction to survival analysis using Stata*. College Station, Texas: Stata Press.

Cox, D. (1972). Regression models and life-tables. *Journal of the Royal Statistical Society. Series B (Methodological)*, *34*(2), 187–220.

De Nederlandsche Bank. (2015). *Effects of further reductions in the ltv limit* (DNB Occasional Study No. 1302). Dutch Central Bank, Research Department.

Deutsch, E., Tiwari, P., & Moriizumi, Y. (2006). The slowdown of the timing of housing purchases in Japan in the 1990s. *Journal of Housing Economics*, *15*(3), 230–256.

di Salvo, P., & Ermisch, J. (1997). Analysis of the dynamics of housing tenure choice in Britain. *Journal of Urban Economics*, *42*(1), 1–17.

Elbourne, A., Soederhuizen, B., & Teulings, R. (2020). *De effecten van macroprudentieel beleid op de woningmarkt*. Centraal Planbureau.

Engelhardt, G. V., & Mayer, C. J. (1998). Intergenerational transfers, borrowing constraints, and saving behavior: Evidence from the housing market. *Journal of Urban Economics*, *44*(1), 135–157.

Galati, G., & Moessner, R. (2011). *Macroprudential policy - a literature review* (Working Paper No. 337). Bank for International Settlements.

Guiso, L., & Jappelli, T. (2002). Private transfers, borrowing constraints and the timing of homeownership. *Journal of Money, Credit and Banking*, *34*(2), 315–339.

Haurin, D. R., Hendershott, P. H., & Wachter, S. M. (1997). Borrowing constraints and the tenure choice of young households. *Journal of Housing Research*, *8*(2), 137–154.

Linneman, P. D., & Wachter, S. M. (1989). The impact of borrowing constraints on homeownership. *Journal of the American Real Estate and Urban Economics Association*, *17*(4), 389–401.

Ortalo-Magné, F., & Rady, S. (2006). Housing market dynamics: On the contribution of income shocks and credit constraints. *The Review of Economic Studies*, *83*(2), 459–485.

Quercia, R. G., McCarthy, G. W., & Wachter, S. M. (2003). The impacts of affordable lending efforts on homeownership rates. *Journal of Housing Economics*, *12*(1), 29–59.

Statistics Netherlands. (2021). Bestaande koopwoningen; verkoopprijzen prijsindex 2015=100. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83906NED/table. (version: 22.10.2021)

Appendices

A Derivation of Formulas in the Theory Section

From Brueckner(1986):

$$x_1^R = (1 - \tau_1)y_1 - s^R - Q \tag{11}$$

$$x_2^R = (1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)s^R) - Q \tag{12}$$

$$x_1^H = (1 - \tau_1)y_1 - s^H - Q \tag{13}$$

$$x_2^H = (1 - \tau_2)y_2 + (1(1 - \tau_2)r)s^H) - (1 - \tau_2)Q \tag{14}$$

We plug in x_1^R, x_2^R , x_1^H and x_2^R in the owner-renter utility differential and get:

$$\begin{aligned} \Omega = {} & u((1 - \tau_1)y_1 - s^H - Q) \\ & + \theta u((1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)s^H - (1 - \tau_2)Q) \\ & - u((1 - \tau_1)y_1 - s^R - Q) \\ & - \theta u((1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)s^R) - Q) \end{aligned} \tag{15}$$

First-time home buyers in general have low current income and higher future income: $y_1 < y_2$. Moreover, we assume that they cannot borrow against future income to make the down payment (like Brueckner,1986). This implies that the down payment constraint is binding. First-time home buyers save just enough to be able to make a down payment, because additional savings reduces utility if the down payment constraint is binding. This implies that $s^H = \alpha P$. Note that from the non-profit condition, housing costs are $Q = rP$ for both renters and homeowners (Brueckner, 1986). Substitution of $s^H = \alpha P$ and $Q = rP$ in (12) yields:

$$\Omega = u((1 - \tau_1)y_1 - \alpha P - rP) \tag{16}$$

$$+ \theta u((1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)\alpha P - (1 - \tau_2)rP) \tag{17}$$

$$- u((1 - \tau_1)y_1 - s^R - rP) \tag{18}$$

$$- \theta u((1 - \tau_2)y_2 + (1 + (1 - \tau_)r)s^R) - rP) \tag{19}$$

Take the partial derivative with respect to house prices P:

$$\begin{aligned}\frac{\delta\Omega}{\delta P} &= (\alpha + r)[-u'(x_1^H)] \\ &+ \theta((1 + (1 - \tau_2)r)\alpha - (1 - \tau_2)r)[u'(x_2^H)] \\ &+ r[-u'(x_1^R)] \\ &+ \theta r[-u'(x_2^R)] \qquad (20)\end{aligned}$$

Rewriting (20) results in equation (1). The derivative is positive (implying that owning becomes more attractive compared to renting if house prices increase) if the following condition holds:

$$(\alpha + r)[-u'(x_1^H)] > \theta((1 + (1 - \tau_2)r)\alpha - (1 - \tau_2)r)[u'(x_2^H)] \qquad (21)$$

Brueckner (1986) assumes that house prices are constant, so the price of the down payment is equal to the price after the house is sold. The down payment is made at the beginning of period 1 and the house is sold at the end of period 2. Denote those prices as P_1 and P_2 respectively. Substitute $s_H = \alpha P_1$, $Q = rP_1$ in period 1 and $Q = rP_2$ in period 2. In the original model, αP cancels in out of the constraint for homeowners in period 2, because they get the down payment back after selling the house. In the model with varying house prices, the down payment does not cancel out, because house prices can change. Moreover, homeowners can make a loss or profit on the part of the house financed by a mortgage $(1 - \alpha)$ as well. The constraints become:

$$x_1^R = (1 - \tau_1)y_1 - s_R - rP_1 \qquad (22)$$

$$x_2^R = (1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)s^R - rP_2 \qquad (23)$$

$$x_1^H = (1 - \tau_1)y_1 - \alpha P_1 - rP_1 \qquad (24)$$

$$x_2^H = (1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)\alpha P_1 - (1 - \tau_2)rP_2 + P_2 - P_1 \qquad (25)$$

after substitution in the constraints, the owner-renter utility differential is now:

$$\begin{aligned}\Omega &= u((1 - \tau_1)y_1 - \alpha P_1 - rP_1) \\ &+ \theta u((1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)\alpha P_1 - (1 - \tau_2)rP_2 + P_2 - P_1) \\ &- u((1 - \tau_1)y_1 - s^R - rP_1) \\ &- \theta u((1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)s^R - rP_2) \qquad (26)\end{aligned}$$

Take first-order derivative with respect to to P_1 using the envelope theorem (note that P_1 is not in x_2^R):

$$\frac{\delta\Omega}{\delta P_1} = (\alpha + r)[-u'(x_1^H]$$
$$+\theta((1 + (1 - \tau_2)r)\alpha) - 1)[u'(x_2^H)$$
$$-r[-u'(x_1^R] \tag{27}$$

rewriting (27) results in (2).

Now take the derivative of (26) with respect to P_2 using the envelope theorem:

$$\frac{\delta\Omega}{\delta P_2} = \theta(1 - (1 - \tau_2)r))[u'(x_2^H)]$$
$$-\theta r[u'(x_2^R] \tag{28}$$

rewriting equation (28) results in equation (3).

From equation (4), $s^H \geq (1 + \rho - \gamma)P$. Assuming that this constraint is just binding, substitution of $s^H = (1 + \rho - \gamma)P$ in x_1^H and x_2^H yields:

$$x_1^H = (1 - \tau_1)y_1 - (1 + \rho - \gamma)P - Q \tag{29}$$
$$x_2^H = (1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)((1 + \rho - \gamma)P) - (1 - \tau_2)Q - (1 + \rho - \gamma)P + (1 - \gamma)P$$
$$= (1 - \tau_2)y_2 + (1 + (1 - \tau_2)r)((1 + \rho - \gamma)P) - (1 - \tau_2)Q - \rho P \tag{30}$$

The renter's constraints x_1^R and x_2^R do not change. The owner-renter utility differential becomes (after some simplification:

$$\Omega = u((-1 - \rho + \gamma)P)$$
$$+ \theta u((1 + (1 - \tau_2)r)(1 + \rho - \gamma)P + \tau_2 Q - \rho P)$$
$$- u(-s^R)$$
$$- \theta u(y_2 + (1 + (1 - \tau_2)r)s^R)) \tag{31}$$

Take the first-order derivative of the owner-renter utility differential with respect to γ using the envelope theorem:

$$\frac{\delta\Omega}{\delta\gamma} = u'(P) - \theta u'((1 + (1 - \tau_2)r)P \tag{32}$$

Rewriting equation (32) results in equation (5).

B Coefficients in Predicted House Value Model

The coefficients of the OLS-model on house purchase prices are listed in Table 7. The sample consists of all first-time home buyers in our sample who actually purchased an house in or before 2016 and are in the LLD. The dependent variable is the original purchase price of the house from the LLD denoted in 2016 prices, using a CBS national price index. The explanatory variables age, (household) income, residential status (living at parents or renting), partner, gender, year of birth, highest level of education achieved and region are from CBS registration files (see Section 3) and are stepwise added to the model. Region is the municipality of the individual's first owner-occupied house in the first model. In the second model, it is the municipality of the latest house before the transition to home ownership is made. The latter leads to a decrease in the predictive power of the model and hence we use the municipality of the first owner-occupied house in models 3-5. The R^2 improves from 0.186 (model 1) to 0.247 (model 3) after replacing income and $income^2$ by household income and household $income^2$. Finally, adding level of education and house tenure status increases the predictive power of the model further to 0.285. We use the coefficients of model (5) to predict house values for first-time home buyers.

Table 7: OLS-model of house purchase price at origination

	(1)	(2)	(3)	(4)	(5)
Age	0.004***	0.001***	0.001***	0.001***	0.000*
Female	0.075***	0.015***	0.014***	0.016***	−0.001
Income	0.100***				
Income^2	−0.001***				
Household income		0.178***	0.184***	0.179***	0.148***
Household income^2		−0.002***	−0.002***	−0.002***	−0.001***
Lives at parents				0.010***	0.027***
Without partner					−0.096***
Level of education					
Medium					0.032***
Bachelor					0.077***
Master					0.133***
Constant	11.855***	11.878***	11.898***	11.866***	11.945***
Year of birth	Included	Included	Included	Included	Included
Region	Current	Previous	Current	Current	Current
R^2	0.186	0.260	0.246	0.260	0.285
N (1000 obs)	286	286	286	283	223

Dependent variable: Log value of the house at origination of observed transitions, denoted in 2016 prices. Source: DNB loan level data (dependent variable) and CBS Microdata (other variables)

* = 1%, ** = 5%, *** = 10% significance level

C Used data sources

GBAPERSOONTAB: Demographic information on individuals registered in the Netherlands Key Register of Persons (Basisregistratie Personen) from October 1^{st} 1994.

GBAADRESOBJECTBUS: Addresses in The Netherlands of everyone registred in the Key Register of Persons since 1995, including beginning- and end date.

EIGENDOM(WOZ)TAB: Information about addresses, including ownership status.

KINDOUDERTAB: Parents' ID of every individual in the Key Register of Persons since 1995.

GBASAMENWONERSBUS: Information about living together in a couple for every individual in the Key Register of Persons, including beginning- and end date of living together. Beyond marriage, having a child together, moving together from one address to another or being fiscal partners count as being a couple.

VRKTAB: Received inheritances, applicable to inheritance tax.

SCHTAB: Inter vivos gifts, applicable to gift tax.

(S)POLISBUS: Information about jobs and wages of employees in The Netherlands.

HOOGSTEOPLTAB: Highest level and field of education achieved.

INPATAB and INTEGRAAL PERSOONLIJK INKOMEN (previous version): Annual income information for Dutch inhabitants.

VEHTAB: Annual wealth level of Dutch households.

DeNederlandscheBank

EUROSYSTEEM

De Nederlandsche Bank N.V.
Postbus 98, 1000 AB Amsterdam
020 524 91 11
dnb.nl