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

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Abstract

This paper investigates how changes in credit availability influence house prices. We show that increases in household credit triggered by a relaxation of lending standards lead to higher transaction prices, higher shares and amounts of overbidding transactions and lower property sale times in the housing market. The impact on prices increases throughout the housing boom due to a higher take-up of credit by households. Also, it is stronger in locations with tighter housing supply and lower affordability, among liquidity-constrained but credit-unconstrained buyers, as well as for more expensive properties. The findings support the credit-driven household demand hypothesis and highlight that macroprudential policy contains systemic risk not only by reducing household leverage, but also by curbing house price growth over the cycle.

Keywords: House Prices, Household debt, Macroprudential policy, Credit.
JEL codes: G21, G28, G51.

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1 Introduction

Financial crises are almost always preceded by a sharp rise in debt-based financing (Mian and Sufi (2010)) and asset prices (Claessens and Kose (2013)). The Great Recession is simply one of the most recent and prominent examples. Between 2002 and 2006 mortgage origination increased across the whole income distribution, not just for low-income borrowers (Adelino et al. (2016)), facilitated by factors such as financial innovation, deregulation, and implicit public guarantees. The excess growth in credit led to a sharp rise in house prices, before their inevitable collapse. From a policy perspective, it is particularly important to distinguish supply-side credit expansions as these may call for a policy intervention before they turn into a "bad boom", where inefficient lending inflates asset prices above fundamentals (Perotti and Rola-Janicka (2022)). What role do credit expansions play for the boom and bust dynamics of house prices, and how can policies prevent the materialization of financial crises?

Both the theoretical and empirical literature on the consequences of expansions in credit supply on house prices tried to answer the question. In the theoretical domain, some studies tried to quantify the cumulative impact of credit expansions and contractions, i.e. the extent to which they drive housing booms and busts. For instance, Favilukis et al. (2017) and Justiniano et al. (2019) argue that changes in credit conditions explain most of the movements in house prices in the 2000s. Kaplan et al. (2020) instead argue that credit conditions explain none of the boom and bust in house prices. In this context, the assumptions posed for the functioning of the housing market play a key role, as pointed out by Greenwald and Guren (2021). If agents do not step in when credit conditions change, because of rental market frictions or credit constraints, shifts in credit supply lead to movements in house prices. In the empirical domain, most studies focused on the marginal impact of shifts in credit supply and all conclude that they do impact house prices, although the size of the effects can vary substantially across studies. Answering the question in empirical settings is difficult due to the endogeneity of the relation between credit and asset prices and the challenges of isolating shifts in credit supply. For instance, a wider access to credit boosts housing demand and leads to higher house prices, as found among others by Adelino et al. (2025), as housing transactions are largely debt-financed and housing supply is fixed in the short run. Conversely, higher levels of house prices allow households to take on higher credit amounts thanks to higher collateral values and via home equity based borrowing, as found by Cloyne et al. (2019) and Mian and Sufi (2011). Causal effects are most frequently derived by exploiting heterogeneous shifts in credit supply that are plausibly exogenous. These shifts usually stem from deregulation episodes that, in the US,

went through state-level regulation, often implemented in a staggered fashion across states. For example, Favara and Imbs (2015) use the US branching deregulation between 1994 and 2005 across states as instruments for credit, while Di Maggio and Kermani (2017) use a series of antipredatory lending laws adopted by some states to restrict the terms of mortgage loans to riskier borrowers and subsequent preemption rules barring their application to national banks. Alternatively, identification strategies rely on regulatory features inducing a different exposure to credit constraints across markets and groups of borrowers or financial institutions. For example, Adelino et al. (2025) and Loutskina and Strahan (2015) use changes in the threshold that determine which mortgages can be purchased or securitized by government-sponsored agencies as an instrument for the cost and availability of credit, to quantify the impact on prices across housing and mortgage market segments differently exposed to those changes. Mian and Sufi (2021) use the global surge in shadow banking in 2003 that enabled lenders relying on non-core deposit financing to increase credit supply more aggressively.

This paper empirically investigates the extent to which household credit influence house prices. Using a unique dataset that links household income and wealth data available from tax records, property-level data available from the property registry, and transaction-level data from the association of real estate agents, we investigate whether increases in borrowing capacity caused by a relaxation of lending standards lead to a higher take-up of household debt and to higher property prices in the housing market. Thanks to an identification strategy based on time-varying, heterogeneous, and exogenous shifts in credit availability triggered by frequent and tailor-made changes in macroprudential limits, we isolate demand and supply factors at highly granular level and estimate the direct and indirect impact of credit availability on household debt and house prices, respectively. The use of granular data allows isolating supply and demand factors more effectively than in aggregate data, as stressed by Mian and Sufi (2010), while the use of shifts in borrowing capacity given by regulatory changes unrelated to house price developments provides exogenous variation in credit supply to address the endogeneity of the relation between credit and house prices. To the best of our knowledge, this is the first paper to identify exogenous shifts in credit supply at such granular level and use this granularity to investigate determinants, effects, amplifying and mitigating factors, and the role of policy.

The empirical analysis focuses on the case study of the housing boom in the Netherlands in the past decade. The Netherlands is subject to high vulnerabilities stemming from the housing market, as highlighted by IMF (2017), ESRB (2019) and ESRB (2024)), including the second highest level of household debt worldwide and one of the strongest house price growth rates in the last decade. These vulnerabilities are exacerbated by generous lending standards which

allow households to borrow up to one hundred percent of the value of the property and up to six times the value of gross annual household income, as well as by strong fiscal incentives to take on high debt positions due to a generous mortgage interest deduction scheme. These lending standards are based on macroprudential limits introduced in primary legislation at the onset of a housing boom and subject to frequent and granular changes since their first inception. The activation of a uniquely tailor-made and frequently updated calibration system makes the case study of the Netherlands an ideal setting to test how credit shocks impact house prices. The prolonged period of excess house price growth during which this relation is tested further helps understanding the determinants of housing booms and the build-up of financial stability risk over the cycle.

The main finding of the paper is a strong and robust effect of credit availability on house prices through household debt. A relaxation of lending standards leads to material increases in household credit availability. This leads to higher household debt take-up, given the tight elasticity of household debt to borrowing capacity. Higher volumes of household debt then fuel housing demand, as house purchases are largely debt-financed, leading to an increase in house prices, as housing supply is fixed in the short term. In detail, the findings show that an increase in household debt favored by loosening lending standards leads to higher transaction prices, higher shares and amounts of overbidding transactions, and lower sale times for the properties in the market. The results also show how the relation between borrowing capacity, credit and house prices evolves over time and differs across markets, borrowers and properties. Over time, as housing market affordability deteriorates and credit constraints get tighter, increases in credit availability lead to a progressively higher take-up of household debt. Higher volumes of household debt imply larger effects on house prices, even if the marginal impact appears relatively stable over time. Across groups, the impact is stronger in cities with tighter housing supply and stronger affordability issues, among liquidity-constrained and credit-unconstrained borrowers, and in thinner property markets. Lastly, we document that changes in macroprudential policy yield desired yet asymmetric effects, where a policy tightening has a milder effects on household debt and house prices than a policy loosening.

Overall, the findings suggest two main policy implications. First, the findings support the "credit-driven household demand" hypothesis, i.e. the idea that changes in credit supply operate primarily through household demand, and are an important driver of cycle fluctuations and the build-up of financial stability risks. Tightening the macroprudential limits contains the build-up of risks not only by containing household leverage, but also by curbing the house price growth over the cycle. These financial stability benefits may come at the cost of market

accessibility, also considering the heterogeneity of the impact across groups documented in the analysis. Second, changes in borrowing capacity lead to larger changes in household debt in the late phase of the cycle. This suggests that it may be preferable to activate or tighten the limits early in the cycle to minimize any side effect and use them as automatic stabilizers, i.e. let them get automatically more binding once house price growth picks up later in the cycle. Valderrama (2022) indeed documents a higher use of the borrower-based measures in the early phase of the cycle, given the lower risks of pro-cyclical effects.

The remainder of the paper proceeds as follows. Section 2 discusses the institutional and economic background. Section 3 presents the data. Section 4 shows the results of the empirical analysis. Section 5 concludes.

2 Background

Institutional Background

The regulation on mortgage credit was first introduced in primary legislation in 2012. This regulation imposes limits to the amount of mortgage credit that can be granted to a borrower, in the form of limits to the Loan-to-Value (LTV) and Debt-Service-to-Income (DSTI) ratio. In detail, the LTV limit was first set at 106% and then tightened by 1% per year, until it would reach the level of 100% in 2018. The DSTI ratios were first set at 20-34% in 2012 and, based on a budgeting methodology used for their calibration, were since then re-calibrated every year to ensure debt-sustainability[1]. As part of the same package of reforms, the mortgage interest deduction (MID) was announced to be phased out over the course of the next twenty years, and its eligibility criteria were changed so that the rights to the MID would be conditional to an amortization of the loan within 30 years. This de facto introduced a maturity limit, in addition to the DSTI and LTV ratio. Given the maturity limit, each DSTI limit translates into an equivalent Loan-to-Income (LTI) limit that lenders use to determine the maximum borrowing capacity, given the level of income of the borrowers. The LTI limit complements the LTV limit that also contributes to determine the maximum borrowing capacity, given the collateral value of the property. In the remainder of the paper we will refer only to the resulting LTI limits[2].

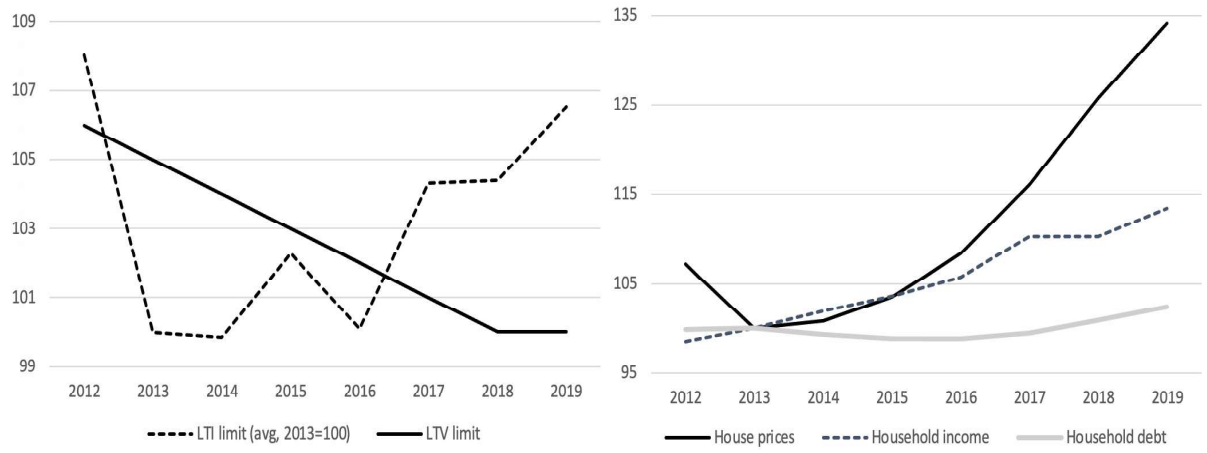
[1]The system used to calibrate the DSTI limits is well-described in IMF (2024). Complete details on the methodology can be found in the annual reports communicating the advice on the calibration of the limits. See `https://www.nibud.nl/onderzoeksrapporten/rapport-advies-financieringslastnormen-2023-2022/`

[2]The reason not to use directly the DSTI limits is threefold. First, the LTI ratio can be easily obtained from the outstanding value of the mortgage and the gross annual income, both of which are observed in the tax records. The conversion from the DSTI to the LTI limits is provided in the files containing the limits, so we use the latter to have a comparable measure. Second, the DSTI is a percentage of disposable income, which we do

Economic Background

Figure 1 shows the main developments with regard to the macroprudential policy and the housing market in the Netherlands during the 2012 - 2019 period. The macroprudential limits were activated towards the end of 2012, when house prices reached the bottom after the strong house price correction that followed the financial crises. As of early 2013, the housing market started to recover, and the LTV limit started to be tightened. Since then, house prices have grown at progressively higher growth rates following steady income and population growth, a structural scarcity of housing supply, and favorable financing conditions brought by the low interest environment. Put together, these factors turned the market turned into the still-ongoing housing boom. By the end of the period, house prices went up by about 75%, the LTV limit reached the 100% level after the phase-in period started in 2013, and LTI limits were progressively tightened, although only slightly. Despite this, the Netherlands received further recommendations by the European Systemic Risk Board and the International Monetary Fund to activate or tighten macroprudential measures and to address the structural factors that cause excessive risk developments in the housing market (ESRB (2019), IMF (2017)).

Figure 1: Macroprudential and housing market developments.



Note: The figure shows the development of the macroprudential LTI and LTV limit (left) and the development of household income, house prices and household debt (right).

not observe. Third, a maximum DSTI ratio does not necessarily mean that the borrower is using the maximum borrowing capacity, as one may decide to shorten the maturity. In fact, DSTI limits can be mapped into LTI limits conditional on a maturity limit, which in the Netherlands equals 30 years based on the eligibility rules for interest deduction.

3 Data

The empirical analysis of this paper uses three main data sources. The first data source consists of household income and wealth data from tax records available via Statistics Netherlands (CBS). Out of the population of tax-payers in the Netherlands covered by this data, we select the subsample of homeowners by linking this data with property-level data from the property registry, also available via Statistics Netherlands. Then, we further select housing transactions by linking the property-level data to the housing transactions data available from the Dutch associations of real estate agents (NVM)[3]. The final data consists of a repeated cross-section of housing transactions for the 2012-2019 period. This covers all housing transactions by natural persons. Transactions by Buy-to-Let investors (investment and pension funds) are not covered as these operate as legal entities. For each transaction, we observe the main outcomes of the deal (e.g. transaction price, time on the market etc.) as well as several characteristics of the property and the homeowner. For each homeowner, we observe the macroprudential limits (LTI and LTV limits) which we assign on the basis of household income, the mortgage interest rate and the year of purchase[4]. The LTI and LTV limits are available from public sources[5]. Table A1 in Appendix 1 shows mean values for the key variables used in the empirical analysis for each of the year covered in the sample period.

4 Empirical analysis

Identification strategy

Identifying the effect of household debt on house prices is not straightforward. Higher house prices allow higher household debt as they increase collateral values. In turn, higher household debt inflates house prices as housing demand is largely debt-financed, housing supply is fixed in short run, and because of credit market frictions.

[3]The link between the two sources is done by associating the personal identifier of each tax-payer to the personal identifier of each home-owner. The resulting drop of observations reflects house renters. The link between the second and third source is done by merging the identifiers of each property, from the property register and the housing transaction records. The resulting drop of observations reflects the houses that were not transacted. The resulting set of transactions were further validated by looking at whether the personal identifier associated to the owner of each property has changed during the transaction year

[4]The interest rate on the mortgage is derived from the interest rate expenses reported in the tax records, used to determine the mortgage interest deduction amount. Data gaps due to outliers are closed using the publicly available series of the interest rate on new mortgages from the Dutch National Bank.

[5]The latest values can be consulted in the law and in the report published by the external instruments that calibrates the limit on behalf of the government.

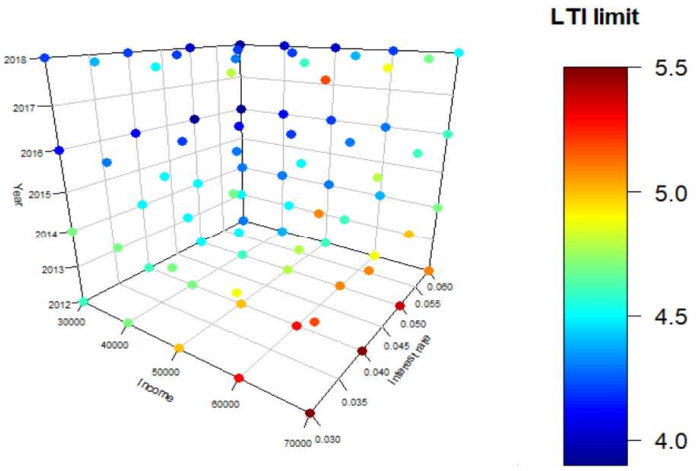
The identification strategy presented in this paper is based on two key elements. The first key element is the use of exogenous changes in household debt to address the endogeneity concern of the relation between household debt and house prices. This is done using shifts in borrowing capacity resulting from changes in macroprudential limits as an instrument for household debt. The second key element is the granularity and frequency of the shifts in credit availability, thanks to tailor-made macroprudential limits that are revised annually. This provides substantial cross-sectional and time variation in borrowing capacity which we use to explain the variation in household debt over time and across borrowers.

With regard to the first element, changes in the regulatory limits in the mortgage market have been widely used as exogenous shifts in credit supply and availability. Examples include Greenwald and Guren (2021), Adelino et al. (2025), Loutskina and Strahan (2015), DeFusco and Paciorek (2017), Defusco et al. (2019), Caloia (2024), Acharya et al. (2022), van Bekkum et al. (2024), Kelly et al. (2018). Changes in regulatory limits represent valid instruments as they affect house prices indirectly via borrowing capacity and household debt. One counterargument is that macroprudential changes may be the direct cause of house price or lending developments. For example, during a housing boom, authorities such as governments or central banks may refrain from tightening the macroprudential limits to preserve housing market accessibility or avoid risks of procyclicality. We argue that this is not a concern for this paper since the Dutch LTI limits are structural measures, as the methodology used to calibrate the limits aimed at ensuring debt sustainability from a budgeting perspective. As such, this accounts for factors affecting household debt-servicing capacity such as the income, interest rate, cost of living and taxation, but it is not linked to house price or credit developments.

With regard to the second element, Figure 2 shows the cross-sectional and time variation of the LTI limits. A value of four indicates that households can borrow up to four times the value of their gross annual income. Along the two horizontal axes, the limits display substantial cross-sectional variation as they range from 4.0 to 5.5 along the interest rate and income buckets. Lower LTI limits (dark blue dots) are assigned to low-income and high-interest rate buckets, since low-income households have lower saving rates due to some fixed expenses as part of their consumption, and high-interest expenses increase monthly payments (for given loan principals) and absorb a higher share of the debt-servicing capacity of households. Conversely, higher LTI limits (dark red dots) are assigned to high-income and low-interest rate buckets. The positive (negative) relationship between LTI limits and income (interest rate) is stable over time, as it results from the budgeting rules used to calibrate the limits. Along the vertical axis, the limits display substantial time variation too. Over time, the limits have been relaxed, on average,

as most dots display lighter colors in later years. Changes in the limits over time can be the result of both common factors leading to a change in debt-servicing capacity for all buckets (e.g. inflation or income taxation), as well as explicit policy choices to tighten or loosen the lending standards.

Figure 2: Heterogeneity and variation of the LTI limits.



Note: The figure shows how the LTI limits vary over the interest rate distribution (x axis), income distribution (y axis) and over time (z axis). The colour of the dots denotes the value of the limit for each income, interest rate and year combination. Due to the high number of possible limits in each year, only those corresponding to a few discrete values of income and interest rate are shown to simplify the chart.

The empirical strategy is similar to that of Caloia (2024), who quantifies the direct impact of macroprudential limits on household debt, during the same housing boom in the Netherlands. Similarly to this paper, macroprudential limits are used to determine households' borrowing capacity and estimate the impact on credit. Here, we take a step further and use shifts in borrowing capacity implied by the macroprudential limits as an instrument for credit, in order to investigate their indirect influence on house prices and a broad set of housing market outcomes.

Main results

As a first step, the analysis estimates the relationship between household borrowing capacity and debt, based on two specifications. The first uses as main independent variable the borrowing capacity implied by the LTI limits. This equals the product of household income and the LTI limit, and represents the main constraint of household borrowing choices as the limits are set from a debt-sustainability and consumer protection perspective. The second specification uses the minimum of the borrowing capacity implied by the LTI and LTV limit, respectively. Unlike the LTI limit, the LTV limit is usually not the binding constraint as its value always allowed to

borrow amounts at least equal to the collateral value of the property, which in virtually all cases is higher or equal to the market price of the property (DNB (2019)). In other words, it does not require borrowers to make any downpayment when buying a house. Results are reported in Table 1, showing separate estimates for the population of housing transactions and for the subsample of debt-financed transactions[6]. Both estimates represent first-stage regressions of a 2SLS estimation framework, run on the whole sample period of the analysis.

Table 1: Borrowing capacity and Household Debt

	Dep. variable: Household debt at origination			
	Debt-financed transactions		All transactions	
Borrowing capacity (LTI limit)	0.283***		0.194***	
	(0.005)		(0.002)	
Borrowing capacity (min LTI - LTV limit)		0.364***		0.248***
		(0.008)		(0.003)
Control variables	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓
Origination time FE	✓	✓	✓	✓
R squared	0.23	0.23	0.20	0.20
N. of observations	761,265	761,265	901,728	901,728

Note: The dependent variable is the amount of household debt at origination (in logarithm). The main independent variable is the borrowing capacity (in logarithm). The control variables include homeowner characteristics (age, education, income, a first-time buyer indicator), property characteristics (surface, construction year, insulation type, house type dummies, the number of rooms and bathrooms, a new building indicator, a monumental building indicator, the presence of amenities such as a garden, a garage, a lift), the mortgage interest rate and municipality and time fixed effects. All estimates are POLS. Standard errors are clustered at the municipality level (in parentheses). The symbols *, **, and *** denote conventional significance levels.

The results suggest a tight elasticity of household debt to borrowing capacity. A one percentage point increase in borrowing capacity is associated to an increase in household debt of about 0.3%. The coefficient of the borrowing capacity implied by both the LTI and LTV limit is slightly higher, as expected, as this definition considers the tightest among the two credit constraints. As also expected, in both specifications the elasticities obtained from the sample of the debt-financed transactions are larger than the ones from the sample of all transactions. This is because the latter includes liquidity-unconstrained agents who, regardless of their borrowing capacity, finance the purchase using own means and do not borrow any amount, so including

[6]Please note that for the sample of all transactions, the table reports second stage POLS estimates of an Heckman two-stage model (outcome equation). This uses a binary variable identifying first time buyers (FTB) as exclusion restriction. As FTB lack existing home equity to finance their house purchase, they are more likely to use external financing sources. As such, the variable FTB is included in the selection equation and excluded from the outcome equation.

them in the sample decreases the correlation between debt and borrowing capacity. The remainder of the paper will focus on the sample of debt-financed transactions to investigate the impact of changes in household debt on the intensive margin.

As a second step, we investigate whether higher household debt fueled by loosening lending standards lead to stronger house price growth in the housing market. More generally, we study the relation between household debt and a broad set of housing market outcomes, namely the house transaction price, whether the transaction price is above the asking price (overbidding transaction), the difference between the transaction and asking price (overbidding amount) and the length of time for which a property was listed for sale, expressed in number of days. The main hypothesis is that since the short-term housing supply is fixed, an increase in household credit would lead to higher house prices, as housing demand is largely debt-financed. Therefore, a relaxation of lending standards may lead to an inflationary effect in the housing market, given the tight elasticity of household debt to borrowing capacity as documented in Table 1. This is tested based on the second-stage coefficient associated to the fitted values of the first-stage regression. This second-stage specification consists of an hedonic pricing model where the transaction price of the property (and the other outcomes listed above) is regressed against a set of property and buyer characteristics, a set of fixed effects, and the predicted value of household debt from the first-stage. The coefficient of the instrumented variable informs us on whether higher household debt leads to stronger house price growth.

Results, reported in Table 2, suggest that a higher amounts of credit lent to households lead to an inflationary effect in the housing market. An increase in household debt is associated to higher transaction prices, higher overbidding transactions and amounts, and to lower sale times in the housing market. In detail, a one percentage increase in household debt increases transaction prices by 0.24%, the probability to overbid by 0.04%, overbidding amounts by 0.0028% and sales times reduce by 0.24%. All estimates, obtained via 2SLS, are statistically significant and the first stage F statistics above the rule-of-thumb thresholds by Stock and Yogo (2005) suggest that the borrowing capacity is a relevant instrument for household debt. Figure A1 in Appendix 2 provides a visualization of the role of credit for house price developments. This shows house price growth rates obtained from a house price index that accounts for household credit (obtained from Table 2 estimates), relative to the growth rates suggested by an equivalent index that does not account for credit and the official house price index for the Netherlands.

Overall, the results confirm that when households are allowed to borrow more, they tend to do so and that has an inflationary impact on the housing market. Conversely, tightening lending standards reduce household debt, as some borrowers get credit constrained, and indirectly curb

house price growth. This supports the "credit-driven household demand" hypothesis, i.e. that changes in credit supply operate primarily through household demand and are an important driver of business and property cycle fluctuations and for the build-up of financial stability risks.

Table 2: Household Debt and House Prices

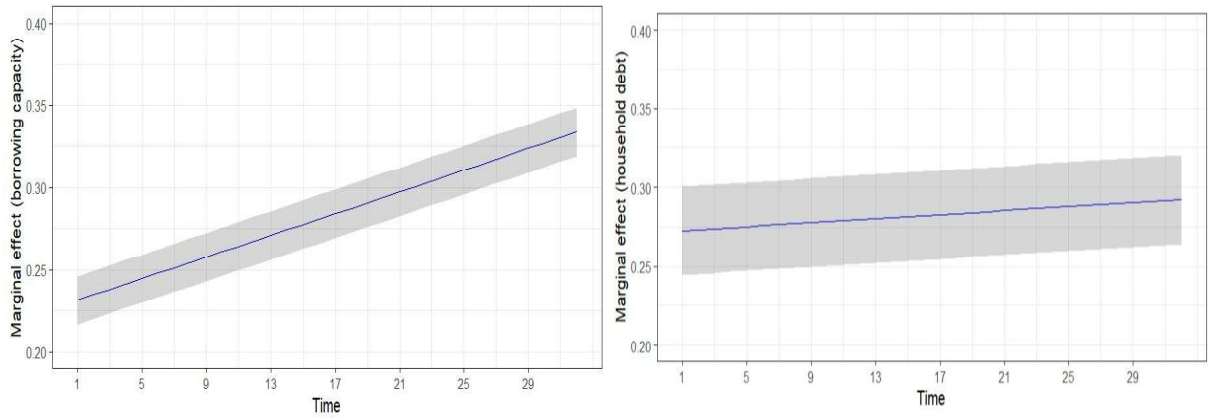
	Dependent variable:			
	House price (€)	Overbidding (yes/no)	Overbidding (%)	Sale time (N. days)
Household debt	0.241***	0.041***	0.284***	-0.240***
	(0.019)	(0.003)	(0.048)	(0.015)
Control variables	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓
Origination time FE	✓	✓	✓	✓
1st stage F stat	3,665.8	3,665.8	3,665.8	3,665.8
R-squared	0.51	0.23	0.31	0.18
N. observations	761,265	761,265	761,265	761,265

Note: The dependent variables of each specification are reported at the top of the table. All dependent variables are in logarithm, except the overbidding indicator and amount (in % of the asking price). The main independent variable is household debt (in logarithm). The control variables are those listed in the note to Table 1. All estimates are 2SLS. Standard errors are clustered at the municipality level (in parentheses). The symbols *, **, and *** denote conventional significance levels.

Figure 3 provides further evidence in this regards, by showing how the relation between borrowing capacity, credit and house prices evolves over the cycle. The figure plots the development over time of the marginal effect of borrowing capacity on the left panel and the marginal effect of household debt on house prices on the right. These are obtained by running new first- and second-stage specifications augmented with the interactions between a cycle indicator[7] and the instrumental and instrumented variables, respectively. The left panel shows that the same percentage change in credit availability leads to a progressively higher take-up of household debt throughout the housing boom, as the marginal effect shows a cumulative increase of about ten percentage points throughout the boom. The right panel shows the marginal impact of household debt on house prices display a positive slope, although it is relatively more stable over time. The point estimate increases by about four percentage points throughout the housing boom, but the increase does not appear statistically significant.

[7]This is a sequence variable $t = 1, ..., T$ capturing the state of the cycle, starting from the minimum value of the house price index.

Figure 3: Marginal effects through the cycle



Note: The figure shows the marginal effect of borrowing capacity on household debt (left panel) and the marginal effect of household debt on house prices (right panel).

The result of Figure 3 indicates that in the later phases of the cycle, the increase in house prices force households to use more of their borrowing space to finance more expensive properties. The increase in debt in turn feeds into house prices at a relatively stable pace over the cycle. Possibly, a role could also be played by adaptive expectations whereby households, observing higher house price growth, expect further house price increases and use credit to increase bids, sometimes above above asking prices, in order to secure the deal. The descriptive statistics in Table A1 in the appendix confirm that the share of overbidding transactions increased over the sample period, from a 2% share at the end of the previous housing market downturn (2012) to a 40% share in the latest phase of the housing boom (2019). The result also suggests that macroprudential policies have larger impacts in the latest phases of the cycle. One important implication is that this result supports the increasing consensus around policy makers about the preference towards an early activation of these instruments through the cycle and their use as structural rather than cyclical measures. This is because changes in macroprudential limits carry fewer side effects in terms of credit constraints and housing market accessibility in earlier phases of the cycle when house prices are lower, and they get automatically tighter later in the cycle when house price growth rates pick up. Instead, activating or tightening the limit later in the cycle may have procyclical effects which, in a context of housing market overvaluation and excess credit growth, could even induce rather than prevent a house price correction. Valderrama (2022) indeed documents a higher use of borrower-based measures in the early phase of the cycle. Lastly, the evidence of rising elasticities over the cycle suggests that a given increase in credit supply has increasingly higher effects on household debt demand,

which in turn induce stronger price effects in the market. This then has feedback effects on the borrowing capacity of unconstrained borrowers, as higher collateral values increase credit availability based on the LTV limit. This supports the hypothesis of a financial accelerator mechanism in the link between the real economy and credit markets advanced by macroeconomic models such as Bernanke et al. (1999) and Kiyotaki and Moore (1997).

Lastly, we present some heterogeneity analysis showing how the relationship between household debt and house prices varies across groups to investigate the role of mitigating and amplifying factors. We do so by exploring the heterogeneity at the level of the market, borrower and property. With regards to the market-level heterogeneity, Mian and Sufi (2011) show that an important source of cross-sectional variation in house price growth is due to land topology based measures of housing supply elasticity. They show that house price growth during the US housing boom was larger in cities with low housing supply elasticity, i.e. cities with limited expansion possibilities due to land constraints such as the presence of hills or water (lakes, oceans). The idea is that a shock in housing demand should induce larger price effects in cities with tighter housing supply and lower supply elasticity, as morphologic constraints prevent a significant increase in housing supply that could compensate, at least partially, the price impact of a housing demand shock. To test this hypothesis for the Netherlands, we use the share of developed lands at the municipality level as per 2012, just before the start of the housing boom studied in this paper. This is the ratio between the total developed land and the total developable land[8]. Another important source of cross-sectional variation in house price is related to the difference between metropolitan and rural areas. Here we look at prime versus non-prime locations, namely the difference between the price effect in the four largest cities in the Netherlands and in other smaller towns and villages, often located in more rural areas. The hypothesis is that price effects should be larger in the main cities. This is because prime locations are characterized by higher price levels, both in nominal and real terms (i.e. in terms of price-to-income and price-to-rent ratios), as documented in DNB (2017)[9]. Buyers in the big cities are therefore more dependent on external financing sources and conditions, and changes in credit availability for this group are more likely to be associated with a higher take-up of debt and, thus, to induce price-effects on the market. The top panel of Table 3 shows evidence in

[8]The same measure has been used in Ozturk et al. (2018) and DNB (2018). This is obtained from the Dutch land cover map, a 25x25m raster file containing data on 39 different land uses based on satellite images and aerial photos. The measure classifies as non-developable land the areas with salt water, sweet water, salt marsh, costal bare soil, open dune vegetation, closed dune vegetation, etc.

[9]Higher price levels are due to a variety of factors, including a larger penetration of buy-to-let investors, tourism, higher inflows of high-income migrants, etc.

favor of both hypotheses, as the impact of credit on house prices is larger in cities with tighter housing supply as well as in the four largest cities where housing affordability is lower.

With regards to the borrower-level heterogeneity, it is important to understand how the impact varies among first- and second-time buyers and among low- and high-income households. The differences in impact between these groups are informative about the role of credit and liquidity constraints. First-time buyers are more liquidity constrained than second-time buyers, as they lack existing home equity to finance their house purchase. Since tighter liquidity constraints translate into a stronger dependency from external financing sources, changes in credit availability should be associated with a higher take-up of debt among these borrowers, which in turn could induce larger price effects. Higher income households are typically less credit-constrained than lower-income households. As the LTI limit increases with income, higher-income households have a higher borrowing space, both in absolute and relative terms. A change in credit availability should induce larger price effects among higher-income households for two reasons. First, as borrowing space is larger, they can leverage more aggressively and use the additional credit to overbid. Second and perhaps more importantly, higher-income households pay higher effective income tax rates than low income households, so their incentive to take larger debt positions is higher, given the generous mortgage interest deduction scheme in place. The results of the mid panel of Table 3 confirm both hypotheses. The impact of household credit on house prices is larger among first-time and higher-income buyers.

With regards to the heterogeneity at the property level, the bottom panel shows the effect of higher credit volumes on the price of various types of property, to investigate the role of market segmentation. As price discovery is typically more volatile in thinner markets, changes in credit supply should induce stronger price effects on properties that are less homogeneous and thus less substitutable. For instance, apartments are the most common property type as they make up the highest share of objects for sale in the market, and are also more standardized than properties such as single family homes, as virtually-identical objects are built over different floors of the same building or in other similar buildings. Potential buyers who see their bid rejected would probably find a similar apartment for sale nearby, whereas buyers interested in a villa are more likely to see fewer units for sale. The bottom panel of Table 3 confirms that the price impact is lower than other property types. These include single family homes (terraced houses), detached houses (fully or semi detached) and other house types (lofts, boat houses, villas, etc.). For these property types, the impact of a unitary shift in credit supply is about twice as much the one for apartments. Within this group of properties, the point estimate is slightly higher for the more expensive properties (such as detached houses) and lower for the

least expensive properties (such as terraced houses).

To sum up, results of the heterogeneity analysis show that shocks in credit supply have a larger price effect in housing markets with tighter housing supply and lower affordability, among liquidity-constrained (FTB) and credit-unconstrained (high-income) borrowers, as well as in thinner property markets. This suggests a potential amplifying role of factors such as supply scarcity, affordability issues, liquidity constraints, and fiscal incentives.

Table 3: Heterogeneity Analysis

	Dependent variable: House price			
	Big cities	Elsewhere	Elastic supply	Tight supply
Household debt	0.317***	0.202***	0.189***	0.274***
	(0.016)	(0.006)	(0.007)	(0.023)
R-squared	0.53	0.53	0.51	0.51
N. observations	93,021	668,244	389,617	371,648
	Dependent variable: House price			
	FTB	STB	Low-income	High-income
Household debt	0.666***	0.151***	0.180***	0.299***
	(0.022)	(0.013)	(0.018)	(0.018)
R-squared	0.35	0.52	0.42	0.51
N. observations	175,2331	586,032	368,186	393,079
	Dependent variable: House price			
	Apartments	Terraced	Detached	Other houses
Household debt	0.139***	0.265***	0.282***	0.276***
	(0.040)	(0.018)	(0.008)	(0.019)
R-squared	0.47	0.50	0.51	0.44
N. observations	203.458	212,980	236,208	108,619
Control variables	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓
Origination time FE	✓	✓	✓	✓

Note: The dependent variable is the house transaction price (in logarithm). The main independent variable is household debt (in logarithm). The control variables are listed in the note to Table 2. Standard errors are clustered at the municipality level. The symbols *, **, and *** denote conventional significance levels.

Determinants, asymmetry and effects of shifts in credit supply

In this section, we further exploit the granularity of the calibration of the macroprudential measures to investigate in more depth the determinants and effects of changes in credit supply to understand the ultimate roots of the debt-driven housing demand.

We first decompose the borrowing capacity of households in the sum of the lag of borrowing capacity and its yearly change. As the system calibrates the LTI limits at the income and interest rate bucket level, it follows that a change in borrowing capacity over time may result from changes in household income and/or changes in the interest rate that move borrowers across buckets, as well as from changes in the LTI limit for the same bucket[10]. Appendix 3 provides the details of the decomposition. Then, we run new first-stage estimates where the instrument (borrowing capacity) is now decomposed in its lagged value and the change stemming from income, interest rate and limit changes. As such, these represent the changes in borrowing capacity due to income, monetary and macroprudential policy shocks. The first-stage coefficients associated to each of the factors responsible for the change in borrowing capacity allow us to understand how credit supply shocks feed into household debt and what are the ultimate roots of the credit-driven house price growth. It should be noted that these do not represent the overall effect of growth, monetary and macroprudential policies have on household debt, but represent their effect through households' credit availability.

Table 4 presents the results. In line with Table 1, the estimates for the population of housing transactions and the subsample of the debt-financed ones are reported. Since the use of the decomposed borrowing capacity leads to a slight drop in observations due to missing values of the household income in the year before the house purchase, the estimates of the main first stage regressions from the same sample are also reported. The table shows several interesting findings. First, the coefficient of the lagged borrowing capacity is close to the main coefficient of the non-decomposed model, especially in the sample of debt-financed transactions. This confirms the tight elasticity of household debt to the level of borrowing capacity found in Table 1. Second, the coefficient of the change in borrowing capacity due to interest rate changes is negative and significant, and suggest that a percentage point increase in the interest rate reduces household debt by 0.2 - 1.0 percentage points[11]. This suggests that monetary policy

[10] In the data, it is possible to compute the decomposition using the previous value of household income from the tax records and the average interest rate on new loans (per LTV bucket) offered by the three largest banks from publicly available data, in order to assign the LTI limit that would have been assigned to each borrower if they had decided to buy a house the year before.

[11] As stated in the note to Table 4, the changes in borrowing capacity are expressed as percentages of the lagged borrowing capacity. This is done to preserve the percentage point interpretation of the marginal effect

affects household credit take-up via the macroprudential limit, reinforcing the credit-channel of monetary policy (Bernanke and Gertler. (1995)), as higher interest rates reduce borrowing capacity based on the calibration system used in Dutch context. Third, the coefficient of the change due to income changes is also negative, even though its marginal effect (-0.3% - 0.0%) is not always significant. This does not mean that higher incomes lead to lower household debt in absolute terms but it suggests that, if anything, households use a slightly lower share of their higher financing space in relative terms as income increases, given that the calibration assigns higher LTI limits for higher incomes. Lastly, the results show that a change in the LTI limit at any given level of income and the interest rate leads to a change in household debt in the same direction, with a marginal effect of about 0.1-0.2 percentage points. This confirms that macroprudential policy is effective in containing the growth of household debt. This directly contains systemic risks, and contributes to slow-down house price growth over the cycle, as documented in Table 2.

Table 4: Determinants and effect of shifts in credit supply

	Dep. variable: Household debt at origination			
	Debt-financed transactions		All transactions	
Borrowing capacity (LTI limit)	0.290***		0.144***	
	(0.005)		(0.002)	
Lag of Borrowing capacity (LTI limit)		0.306***		0.190***
		(0.005)		(0.002)
Delta Borrowing capacity (income change)		-0.000		-0.003***
		(0.000)		(0.000)
Delta Borrowing capacity (int.rate change)		-0.002***		-0.010***
		(0.000)		(0.000)
Delta Borrowing capacity (policy change)		0.001***		0.002***
		(0.000)		(0.000)
Control variables	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓
Origination time FE	✓	✓	✓	✓
R-squared	0.25	0.24	0.25	0.24
N. observations	680,282	680,282	802,831	802,831

Note: The dependent variable is the amount of household debt at origination (in logarithm). In the first specifications, the main independent variable is the borrowing capacity (in logarithm). In the seconds specifications, the main independent variables are the lag of borrowing capacity (in logarithm) and the change in borrowing capacity due to income, interest rate and policy changes (in %). The control variables are listed in the note to Table 1. All estimates are POLS. Standard errors (in parentheses) are clustered at the municipality level. The symbols *, **, and *** denote conventional significance levels.

of the log-log specification of Table 1 while allowing for negative values of the independent variables. Given the switch to a log-linear specification, the marginal effect equals the coefficient divided by hundred.

Then, we investigate asymmetric effects of credit supply shocks, by looking at the household debt and house price response to positive and negative changes in credit availability. To do this, we estimate the main first- and second-stage specifications on the sample of debt-financed housing transactions for which the buyer was subject to a positive and negative change in borrowing capacity, respectively. Whether a borrower is subject to a positive or negative change in borrowing capacity is determined based on the total change in borrowing capacity, i.e. the sum of the changes attributable to the three components (income, interest rate and policy change) shown in Table 4. The first-stage results are reported in Table 5. The elasticity of household debt is positive, both for the positive and negative changes, suggesting that an increase (decrease) in borrowing capacity leads to an increase (decrease) in household debt. The elasticity is higher for positive changes in credit availability than negative changes. This suggests that a macroprudential policy loosening has a larger impact on household debt than a macroprudential tightening, given the same absolute change in the limit and conditional on all other factors. The stronger effect of positive changes in macroprudential limits has also been documented in previous research, for instance by Poghosyan (2019).

Table 5: Asymmetric effects of changes in credit supply (first stage)

	Dep. variable: Household debt at origination			
	Positive changes in LTI		Negative changes in LTI	
Borrowing capacity (LTI limit)	0.269***		0.303***	
	(0.003)		(0.004)	
Borrowing capacity (min LTI - LTV limit)		0.389***		0.324***
		(0.008)		(0.014)
Control variables	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓
Origination time FE	✓	✓	✓	✓
R squared	0.22	0.20	0.25	0.21
N. of observations	494,088	494,088	267,552	267,552

Note: The estimates are obtained on the sample of debt-financed transactions. The first (second) two columns shows the estimates based on the sample of borrowers with positive (negative) change in borrowing capacity. All specifications are equivalent to those used in Table 1. *, **, and *** denote conventional significance levels.

Table 6 shows the corresponding second-stage estimates. Positive changes in credit supply are associated to a higher impact on house prices, a higher probability to overbid (but a lower overbidding amount) and overall comparable property sale times, relative to the case of negative changes in credit supply. The combined result suggests that, when limits loosen, house price increase more as more borrowers tend to overbid, although the average overbidding amount reduces as the marginal over-bidders post bids that are slightly above asking prices.

Table 6: Asymmetric effects of changes in credit supply (second stage)

	Positive Changes in LTI Limits:			
	House price (€)	Overbidding (yes/no)	Overbidding (%)	Sale time (N. days)
Household debt	0.262***	0.044***	0.231***	-0.236***
	(0.019)	(0.005)	(0.069)	(0.020)
R-squared	0.51	0.23	0.31	0.18
N. observations	494,088	494,088	494,088	494,088
	Negative Changes in LTI Limits:			
	House price (€)	Overbidding (yes/no)	Overbidding (%)	Sale time (N. days)
Household debt	0.206***	0.037***	0.393***	-0.255***
	(0.018)	(0.004)	(0.059)	(0.016)
R-squared	0.51	0.20	0.28	0.17
N. observations	267,552	267,552	267,552	267,552

Note: The estimates are obtained on the sample of debt-financed transactions. The top (bottom) panrl shows the estimates based on the sample of borrowers with positive (negative) change in borrowing capacity. All specifications are equivalent to those used in Table 2. *, **, and *** denote conventional significance levels.

Overall, the results from Table 4, 5 and 6 suggest that changes in credit supply stemming from policy changes and unrelated to changes in fundamentals (such as income or interest rate changes) impact household borrowing choices in the desired direction. Both the household debt take-up response and the indirect effect on house prices are stronger in case of positive changes in credit supply. This suggests that higher credit availability induces more buyers to increase their leverage and post bids above asking prices. These findings highlight the effectiveness and asymmetry of the transmission of macroprudential policy on lending and borrowing choices. The evidence of milder household debt responses to macroprudential policy tightenings, combined with the earlier evidence of the milder effects of macroprudential policy in early phases of the cycle (Figure 3), suggests that it might be preferable to activate or tighten these instruments early in the cycle, when behavioral responses are more muted, house price growth and leverage are more contained, and the overall risk of pro-cyclical effects are lower. Tighter constraints early in the cycle would still bring benefits later in the cycle, as the limits work as automatic stabilizers, i.e. they become increasingly binding as house price growth and leverage start to pick up and housing affordability deteriorates.

Internal and external validity

As already mentioned, changes in regulatory limits in the mortgage market have been widely acknowledged as proxies for exogenous shifts in credit supply and therefore valid instruments. In this analysis, the relevance of the instrument is documented by the close relation between household debt and borrowing capacity shown in Table 1, and the exogeneity assumption is supported by the methodology used to calibrate the macroprudential limits, making them independent from house price developments. Still, there may be residual endogeneity concerns about the overall borrowing capacity, which is the product of the income and the regulatory limit. For instance, individuals may temporarily start a second job or shift to higher-paying occupations for the sake of increasing household income and qualify for a larger credit amount. Borrowing capacity in fact increases more than proportionally with income. A shown in Table 4, part of the change in borrowing capacity stems from income changes which, unlike the level of interest rates and the macroprudential limits, may partially reflect individual choices aimed at improving one's position in the housing market. The decomposition of borrowing capacity presented in Table 4 helps us to rule out this concern and further test the validity of the research design and the results of the previous section. We run new second-stage estimates that use as instruments the sum of the lagged borrowing capacity and the shift in borrowing capacity due to policy changes. This measure of borrowing capacity captures the truly exogenous and unexpected shifts in credit availability. These shifts are exogenous because they are completely outside the control of the borrower. They are also unexpected, as the limits are usually announced late in the year (in November) and take effect in January. In addition, the size of the change can vary substantially across income levels. Table 7 presents revised second-stage estimates, analogous to Table 2, after using this new instrument in the first-stage specification. The outcome of this exercise confirms all previous findings, as the coefficients are virtually equivalent to those in Table 2 and the differences do not appear statistically significant, and provides evidence in favor of the validity of the research design of this paper.

Table 7: Internal validity

	Dependent variable:			
	House price (€)	Overbidding (yes/no)	Overbidding (%)	Sale time (N. days)
Household debt	0.235***	0.039***	0.280***	-0.238***
	(0.017)	(0.003)	(0.046)	(0.015)
Control variables	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓
Origination time FE	✓	✓	✓	✓
1st stage F stat	1,457.44	1,457.44	1,457.44	1,457.44
R-squared	0.51	0.22	0.30	0.18
N. observations	680,282	680,282	680,282	680,282

Note: The dependent variables of each specification are reported at the top of the table. All dependent variables are in logarithm, except the overbidding indicator and amount (in % of the asking price). The main independent variable is household debt (in logarithm). The control variables are listed in the note to Table 2. All estimates are 2SLS. Standard errors (in parentheses) are clustered at the municipality level. The symbols *, **, and *** denote conventional significance levels.

We also test whether controlling for financial wealth and inter-generational transfers impact the estimates of the credit-driven household demand. Higher savings, especially if held in liquid assets such as bank accounts and safe financial assets, and the possibility to receive tax-free parental gifts[12] or inter-generational transfers can substantially increase the downpayment capacity of perspective buyers, who may reduce credit demand. Not controlling for wealth can therefore affect the estimates of the effect of credit supply on household debt and house prices, via the correlation between household debt and financial wealth. The results in Appendix 4 show that all the main conclusions hold when lagged financial wealth is included among the covariates or when receivers of parental gifts are excluded from the main estimating sample. The size of the effects slightly change, as the elasticity of household debt to borrowing capacity increases relatively to the baseline estimates of Table 1, whereas the size of the effects on three out of the four housing market outcomes reduce relative to the baseline estimates of Table 2. Overall both results, although obtained from smaller and selected samples[13], confirm the sizable and signficant effect of shifts in credit supply on the mortgage and housing market.

[12]Between 2013 and 2024, a law allowed tax-free gift exemption of up to EUR 100,000 for people aged 18 to 40 to help with housing. The gift could be used to buy a home, pay off a mortgage, renovate or maintain a home. It was often used by parents to help their children reduce or eliminate mortgage debt.

[13]The sample size reduces as parental gifts for house purposes are received by only 3% of buyers and we due not observe the lagged financial wealth for about 10% of buyers (no tax assessment was filed). Using lagged financial wealth prevents that the current value may be affected by the house prchase.

The empirical findings of this paper, while derived from the Dutch housing market and its unique institutional context, exhibit strong external validity in light of comparable results and mechanisms documented across advanced economies. The estimated elasticity of house prices with respect to household credit - approximately 0.24 percent per one percent increase in credit - is consistent with prior studies reporting similar magnitudes. In the US context, Favara and Imbs (2015) find that a one percent change in credit increases the growth rate of house prices by 0.2 percent between 1994 and 2005, whereas Di Maggio and Kermani (2017) document an elasticity of about 0.3 in the 2004-2006 period. In the Irish context, Kelly et al. (2018) find that a one per cent increase in credit available leads to an 0.15 per cent increase in the value of property purchased. Other studies such as Mian and Sufi (2009), Adelino et al. (2025), Loutskina and Strahan (2015) and Acharya et al. (2022) also document sizable effects of credit supply on house prices, although elasticities are not directly comparable due to the use of identification strategies yielding different effect types, such as local treatment effects around thresholds or the effect on exposed versus unexposed groups. Many of these studies also document the amplification role of constraints related for instance to credit and housing supply. Moreover, the theoretical channel underpinning the analysis, namely a credit-driven demand mechanism, is well established in macroeconomic models such as Bernanke et al. (1999) and Kiyotaki and Moore (1997).

5 Concluding remarks

This paper uses granular data and an identification strategy based on shifts in borrowing capacity stemming from frequent and highly heterogeneous changes in macroprudential policy to investigate the direct and indirect effect of credit supply shifts on household credit and house price growth. The granularity of the data, together with exogenous shifts in credit availability, allow us to disentangle demand and supply shocks down to the individual level, better quantify the impact on credit and asset prices, and investigate amplifying and mitigating factors. The findings highlight the key role of credit supply shocks in the mortgage and housing market. As house purchases are largely debt-financed, housing supply is relatively fix in the short run, and because of credit market frictions, shocks in credit supply feed into household demand and have significant impact on house prices and on a number of indicators used to measure housing market conditions. This suggests that, on aggregate, credit supply is an important driver of property cycle fluctuations and the build-up of financial stability risks. Since credit demand reacts to changes in credit supply, macroprudential policy can play a key role in curbing bank

lending, household debt and house price growth over the cycle. While the paper documents a strong role of credit for household borrowing and house price developments, this is likely still a lower-end estimate. In fact, we investigate the intensive margin responses to changes in credit supply, while a significant effect is expected also on the extensive margin. Tighter credit limits reduce housing market accessibility and may lead some highly-constrained borrowers not to qualify for credit, especially if tightened during a boom. We do not answer this question due to lack of data on mortgage applications and leave it open for future research.

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Appendix

Appendix 1: Descriptive statistics

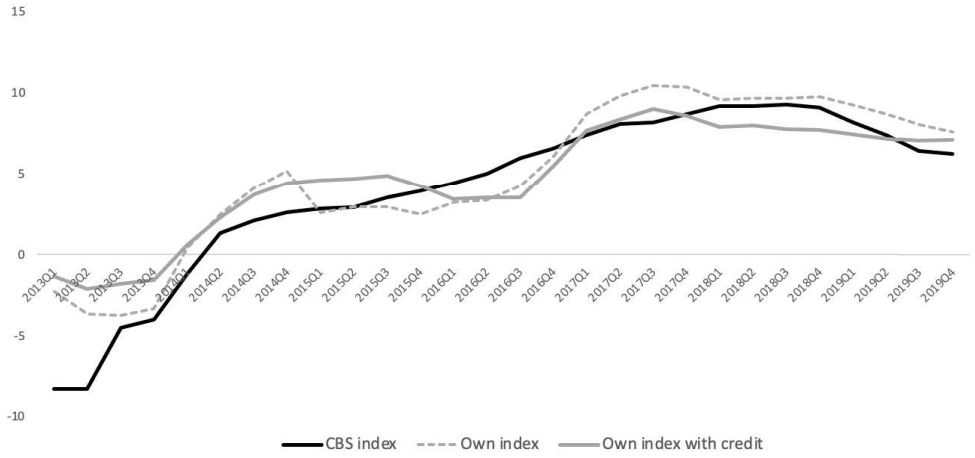
Table A1: Descriptive statistics

	2012	2013	2014	2015	2016	2017	2018	2019
Household debt at origination (000s)	204.9	189.9	196.2	209.8	220.7	237.5	273.7	282.9
Borrowing capacity(000s)	233.3	223.4	234.1	238.7	251.7	272.2	291.6	314.8
LTV Limits	106	105	104	103	102	101	100	100
LTI Limits	5.2	4.8	5.0	4.8	4.9	5.2	5.2	5.3
Interest rate (%)	3.96	3.61	3.27	2.85	2.57	2.49	2.33	2.23
Household income (000s)	95.3	98.8	103.6	100.1	103.3	108.8	111.7	117.9
Property value (000s)	247.1	239.4	232.1	226.7	232.7	245.4	259.2	285.3
Share of Overbidding (%)	2.5	3.1	4.8	8.3	13.9	24.0	35.0	40.2

Note: The table show the average of the main variables used in the empirical analysis, over the sample period.

Appendix 2: The role of credit for house price developments

Figure A1: House price indexes (with and without credit)



Note: The figure shows the year-on-year house price growth from a own house price index that accounts for credit (solid grey line), an equivalent house price index that does not account for credit (dashed grey line), and the official house price index from Statistics Netherlands (black line). The first index is obtained from the 2SLS estimate of the time fixed effects from Table 2. The second index is obtained from an OLS estimate of the time fixed effects of an equivalent hedonic model specification that excludes credit from the covariates. Given the fixed effects estimates $\widehat{\lambda_t}$, the index is obtained as $P_t = 100 \times exp(\widehat{\lambda_t} - \widehat{\lambda_0})$. The official house price index is available at `https://opendata.cbs.nl/statline/#/CBS/en/dataset/85773ENG/table?ts=1753969275215`.

Appendix 3: Decomposition of borrowing capacity

The borrowing capacity is the product of gross annual income and the LTI limit:

$$z_t = y_t \times \theta_t(y_t, r_t)$$

Where z_t denotes borrowing capacity and $\theta_t(y_t, r_t)$ is the LTI limit, which depends on income and the interest rate. This be re-written as the sum of its previous value and its change:

$$z_t = y_t \times \big[\theta_{t-1}(y_{t-1}, r_{t-1}) + \Delta\theta_t(y_t, r_t)\big]$$

Which can be further decomposed as follows:

$$z_t = y_t \times \big[\theta_{t-1}(y_{t-1}, r_{t-1}) + \Delta\theta_t(y_t, r_{t-1}) + \Delta\theta_t(y_{t-1}, r_t) + \Delta\theta_t(y_t, r_t)\big]$$

In words, the change in the limit can be decomposed in the change *due to* the change in income and interest rate (second and third term, respectively) and change *given* the level in income and interest rate (last term), i.e. the policy change. The use of borrowing capacity as instrument leads to the following first-stage specification:

$$x_{i,t} = c + \beta z_{i,t} + \delta' X_{i,t} + \epsilon_{i,t}$$

Where $x_{i,t}$ denotes the instrumented variable (household debt) and $X_{i,t}$ the set of covariates. It follows that the baseline and decomposed first-stage specifications can be written as:

$$x_{i,t} = c + \beta\big[y_t\, \theta_t(y_t, r_t)\big] + \delta' X_{i,t} + \epsilon_{i,t}$$

$$x_{i,t} = c + \beta' \left[y_t\, \theta_{t-1}(y_{t-1}, r_{t-1}) + y_t\, \Delta\theta_t(y_t, r_{t-1}) + y_t\, \Delta\theta_t(y_{t-1}, r_t) + y_t\, \Delta\theta_t(y_t, r_t)\right] + \delta' X_{i,t} + \epsilon_{i,t}$$

and the second-stage specification then can be written as:

$$p_{i,t} = a + \gamma\widehat{x_{i,t}} + \theta' X_{i,t} + u_{i,t}$$

Where $p_{i,t}$ is the transaction price of the house and $\widehat{x_{i,t}}$ is the fitted value from the first stage.

Appendix 4: Robustness checks

Table A2: The role of financial wealth and parental gifts (first stage)

	Dep. variable: Household debt at origination			
	Controlling for financial wealth		Excluding receivers of parental gifts	
Borrowing capacity (LTI limit)	0.321***		0.322***	
	(0.002)		(0.002)	
Borrowing capacity (min LTI - LTV limit)		0.384***		0.389***
		(0.001)		(0.010)
Financial Wealth (log)	-0.032***	0.001	-0.031***	0.001
	(0.002)	(0.004)	(0.001)	(0.004)
Control variables	✓	✓	✓	✓
Municipality FE	✓	✓	✓	✓
Origination time FE	✓	✓	✓	✓
R squared	0.24	0.24	0.24	0.20
N. of observations	690,366	690,366	663,467	663,467

Note: The estimates are obtained on the sample of debt-financed transactions. In the first two columns, the lagged value of financial wealth (in logarithm) such as savings and financial assets is controlled for. In the second two columns, financial wealth is controlled for and receivers of parental gifts and inter-generational transfers are excluded from the sample. Except for these, all estimates are analogous to those in Table 1.

Table A3: The role of financial wealth and parental gifts (second stage)

	Controlling for financial wealth:			
	House price (€)	Overbidding (yes/no)	Overbidding (%)	Sale time (N. days)
Household debt	0.158***	0.029***	0.332***	-0.156***
	(0.014)	(0.003)	(0.042)	(0.012)
R-squared	0.31	0.23	0.31	0.18
N. observations	690,366	690,366	690,366	690,366
	Excluding receivers of parental gifts:			
	House price (€)	Overbidding (yes/no)	Overbidding (%)	Sale time (N. days)
Household debt	0.162***	0.032***	0.372***	-0.159***
	(0.015)	(0.003)	(0.038)	(0.011)
R-squared	0.54	0.22	0.30	0.19
N. observations	663,467	663,467	663,467	663,467

Note: The estimates are obtained on the sample of debt-financed transactions. In the top panel, the lagged value of financial wealth (in logarithm) such as savings and financial assets is controlled for. In the bottom panel, financial wealth is controlled for and receivers of parental gifts and inter-generational transfers are excluded from the sample. Except for these differences, all estimates are analogous to those in Table 2.

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