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How do house prices respond to mortgage supply? *

Guglielmo Barone[a] Francesco David[b] Guido de Blasio[c] and Sauro Mocetti[d]

Abstract. We examine the impact of household mortgages on house prices. Using biannual data on Italian cities in the 2003-2015 period, we build an exogenous and fully data-driven indicator of mortgage supply stance and use it as instrument for actual extended mortgages. Our results indicate that mortgages have a positive and significant causal effect on house prices, with an estimated elasticity of around 0.1. The estimated effect is larger during the expansionary phase of the housing cycle. We also find evidence of significant spatial heterogeneity: mortgages push real estate values more in cities where the housing supply curve is less elastic or households are more dependent on external finance.

Keywords: mortgage supply, house prices, local housing market.
JEL classification: G21, R21, R51.

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1. Introduction

In the last two decades, real estate and mortgage markets in advanced economies have been characterized by large co-movements: while before the Great Recession the housing boom has been accompanied by easy access for households to the mortgage market, these trends have reversed in the following years.

Understanding whether and to what extent credit supply affects house prices is of the utmost importance since real estate plays a key role along several dimensions. Under the urban economics perspective, the cost of housing largely shapes households' mobility and firms' location choices. However, house prices play a crucial role also at the macroeconomic level. For example, property values affect households' consumption through wealth effects. Moreover, real estate is typically used as collateral, thus having feedback effects on credit supply and amplifying the business cycle. Therefore, and unsurprisingly, house prices have gained increasing attention among monetary authorities and financial regulators.

From an empirical point of view, establishing a causal link between lending policies and the real estate market is very challenging as reverse causality and omitted variable biases are both rampant issues. On the one hand, there could be reverse causation: surging house prices may lead households to demand larger mortgages, as they cannot finance the increased cost of housing. Moreover, the credit supply likely depends on the price of assets, which may be used as collateral (i.e., lenders may be willing to lend more when collateral values increase). On the other hand, the omitted variable bias is also likely to be at work: both house prices and credit volumes are of course (simultaneously) exposed to other economic conditions, such as an income or a population shock.

These identification issues have hampered credible empirical studies, which are relatively few. Mian and Sufi (2009) show that in the years preceding the financial crisis, within a given county in the US, house prices increase disproportionately more for ZIP codes with a disproportionately large share of subprime borrowers. Glaeser et al. (2013) show that interest rates and approval rates are correlated with house prices in the US but they cannot explain most of their variation, even though their estimated impact varies considerably according to the temporal window they consider. According to Favara and Imbs (2015), none of the previous empirical papers convincingly identified a causal nexus. They exploit the post-1994 US branching deregulation to compare the mortgage origination of

previously regulated and hence affected lenders to that of independent mortgage lenders, included in the control group. They find that the increase in mortgage supply attributable to branching deregulation raised annual house price growth, with an estimated elasticity slightly larger than 0.1. Di Maggio and Kermani (2017) exploit the fact that in the US, starting from 1999, some states adopted anti-predatory-lending (APL) laws limiting mortgages to riskier borrowers and that, in 2004, national banks were exempted from state-level APL laws. They find that the increase in lending due to this regulatory change is associated with a rise in house price growth.[1]

In this paper, we provide causal evidence on the effect of mortgage supply on house price using a different empirical strategy. We look at Italian cities in the 2003-2015 period and adopt an instrumental variable approach, inspired by Greenstone et al. (2020), and used by Barone et al. (2018) and Berton et al. (2018). The intuition underlying our identification strategy is as follows: first, by examining the dynamics of mortgages extended by different banks to the same city (therefore facing the same local demand) we obtain a proxy of the tightness of lending policies for each bank; second, each city is exposed to overall tighter lending policies if banks with tighter credit orientation have a greater market share. More formally, our strategy exploits bank-city-time data on mortgage dynamics to isolate the portion that can be attributed to supply factors. Then, we map bank-time supply stances into the city-time dimension by means of the beginning-of-the-period bank-city shares. Finally, the predicted city-time mortgage growth rate is used as instrument for the actual one. We find that changes in house prices are causally affected by changes in household mortgages, with a positive and mild elasticity (around 0.1). Interestingly, the impact on house prices is higher during housing market boom periods, thus suggesting that easier lending conditions can underpin ''irrational exuberance'' and housing price growth. Exploring cross-sectional heterogeneity, we show that the impact of mortgage supply on house prices is higher in more densely populated cities: this result might reflect the fact that cities with a lower extent of developable land, and therefore with a more rigid housing supply, are more sensitive to variation in the housing demand. Finally, we show that the impact of mortgage supply is higher in cities that are more dependent upon external finance, i.e. cities with a lower per capital financial wealth with respect to housing cost, because of the more binding role of liquidity constraints.

[1] Basten and Koch (2015) examine the causal effect in the opposite direction, i.e. from house prices to mortgage demand by exploiting immigration as exogenous shock to house prices. However, one may argue that demographic shock may also affect credit demand.

We contribute to the literature on two main aspects. Firstly, with respect to previous contributions that exploit quasi-experimental settings due to changes in the regulation of banking activity, our approach has the advantage of being easily replicable across different periods and different countries since it is not chained to specific policy changes. Beyond being more generalizable, this exogenous source of variation is appealing also because it allows studying the impact of mortgages for both normal times and exceptional circumstances. Indeed, we show that the impact of mortgages on house prices might vary considerably over the business cycle. Secondly, we study a country other than the US that shares the main features of the housing market in other EU countries such as lower household indebtedness and lower housing supply elasticity (Caldera and Johansson, 2013). It is worth noting that these structural features might lead to asymmetric impacts of the same credit shock on house prices across areas. As a matter of fact, our results suggest that local characteristics, such as the elasticity of housing supply and financial constraints, are key mediating factors in the relation between the supply of mortgages and property values.

The remainder of the paper is structured as follows. In Section 2 we describe the data and provide some descriptive evidence. In Section 3 we discuss the empirical strategy and the identification issues. Section 4 presents the results. Section 5 concludes the paper.

2. Data

Our dataset is based on two main data sources. First, outstanding mortgages are drawn from the Credit Register (CR) database, managed by the Bank of Italy (BoI). For each borrower, banks have to report to the Register, on a monthly basis, the amount of each credit position for all loans exceeding a minimum threshold (above 75,000 Euros until December 2008 and above 30,000 afterwards), plus all nonperforming loans. These data can be taken as a census of the outstanding mortgages to households. By using the residence of the borrower, we aggregate these individual-level data at the local labour market (LLM) level.[2] We have about 600 LLMs, which represent our (functional) definition of the city.

[2] Local Labour Markets (LLMs) are sub-regional geographical areas where the bulk of the labour force lives and works. LLMs are defined on a functional basis, the key criterion being the proportion of commuters who cross the LLM boundary on their way to work, and they are not designed to respect administrative boundary constraints.

Second, data on house prices per square metre are drawn from the Real Estate Archive (OMI is the Italian acronym). The OMI dataset is managed by the Italian Revenue Agency and includes the selling prices of properties twice a year, covering almost completely the entire national territory with a very detailed breakdown by location. Data availability starts from the beginning of the 2000s. Prices are a combination of data from various sources: the direct survey of actual prices quoted by market operators or detailed in administrative archives is combined with the assessments of local experts aimed at correcting imperfections in the survey of basic data and also at attributing a reference price whenever a low number of transactions limits the representativeness of the prices reported.[3] Data are provided at the sub-municipality level and we aggregate them at the LLM level, using the housing stock in 2001 as weight in the aggregation process.[4]

Both credit and house price variables are available on a biannual basis and cover the period 2003-I to 2015-II.

In the paper, we also show the heterogeneity of our results according to the (beginning-of-period) population density and local degree of bank dependence. Geographical and demographic data are drawn from the Italian Statistical Institute (ISTAT). Bank dependence is defined as the ratio between financial wealth per capita and cost of housing, assuming that cities with higher endowments of financial resources have less liquidity constraints and less dependence upon external finance. It is estimated by using proprietary information owned by the Bank of Italy on financial wealth at the local level.[5] In Table 1 we report the summary statistics of the main variables used in the paper.

The average growth rate of house prices was nearly 2% with divergent patterns over the housing market cycle (the growth rate was above 4% during the

[3] More precisely, house price values are based on individual transaction data taken from various sources, such as purchase and sale transactions (around 40% of cases), real estate agencies (around 30%), specialized magazines and other sources of information (the remaining 30%). If the number of transactions is less than 5, the OMI estimates the price, exploiting the expertise of local technicians specialized in real estate.

[4] For each zone, the OMI provides the price of each particular type of building (e.g. flats, villas, cottages, etc.) and quality status (whether very good, good or poor quality). In order to prevent house prices variations reflecting changes in the composition of the houses sold in a particular semester, we compute price changes using only those cells (defined by type, quality, etc.,) sold in two consecutive semesters. The main findings are confirmed if we do not take into account this composition effect and we compute simple (weighted) average prices of real estate transactions.

[5] See Albareto et al. (2008) for more details on the estimation of financial wealth at the regional level in Italy. These data are then translated at the city level using information on bank deposits at that level.

expansion phase and negative in the downturn). The average growth rate of outstanding mortgages was larger than that of house prices (6.4%) and it also diminished significantly moving from the boom period to the bust period (from nearly 11% to 1%; see also Figure 1).

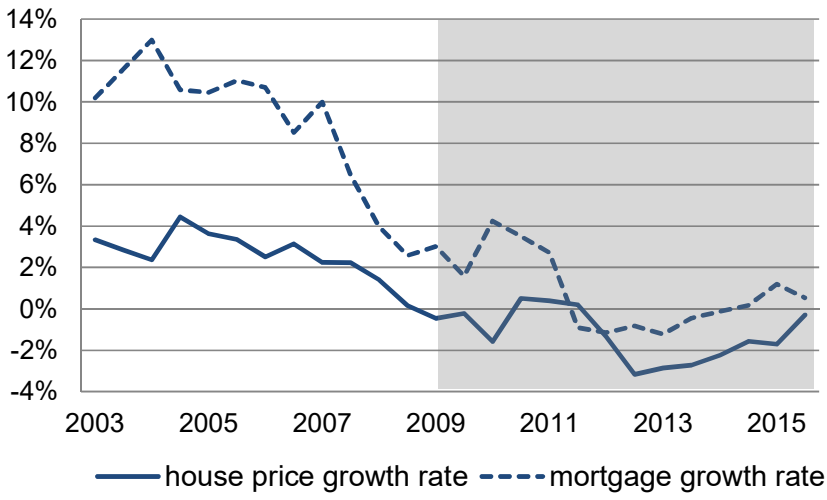
Table 1. Descriptive statistics

Variable: [Source]	Mean	St. dev.	10th pct.	90th pct.
Growth rate of house price [OMI]	0.019	0.057	-0.040	0.090
Growth rate of mortgages [BoI]	0.064	0.139	-0.046	0.183
Mortgage supply index	-0.004	0.054	-0.067	0.062
Population density [ISTAT]	2.070	2.940	0.342	4.270
Bank dependence [BoI]	0.364	0.156	0.186	0.565
Age index [ISTAT]	1.534	0.574	0.902	2.303

The table reports the main descriptive statistics of the main variables used in the analysis. For each variable, we report the name (with the corresponding data source in squared brackets), the mean, the standard deviation and the first and last decile. Figures for population density, bank dependence and the age index (i.e. ratio between population over 65 and under 15) are computed at the beginning of the period.

In the same period, the mortgage supply indicator moved from being positive to negative; interestingly, our mortgage supply index shows a huge variability, thus signalling that different cities in different periods are exposed to largely differentiated supply stances.

Figure 1. House price and mortgage dynamics



House price and mortgage growth rate; the shaded area indicates the bust period.

3. Empirical strategy

We estimate the effect of outstanding mortgage dynamics on the growth rate of house prices by running the following regression:

$$p_{lt} = \alpha + \gamma_l + \mu_t + \beta M_{lt} + \delta X_{lt} + \varepsilon_{lt} \quad (1)$$

where p_{lt} is the growth rate of house prices in LLM l at time (year-semester) t; γ_l and μ_t are LLM- and time-fixed effects (aimed at capturing local time-invariant structural differences and trends in prices common to all LLMs); M_{lt} is the outstanding mortgage growth rate and β the key parameters of interest; X_{lt} include time fixed effects interacted with city size (LLMs are grouped in 4 quartiles depending on the beginning-of-the-period population), and with geographical area (North-West, North-East, Centre and South). Standard errors are clustered at the LLM level to account for serial correlation.

The instrumental variable for M is built in the spirit of the "Bartik instrument" and leverages the fact that banks with different lending policies usually lend in many LLMs and, at the same time, each LLM is served by many banks whose market shares vary across LLMs.[6] The instrument is built in two steps. First, we isolate nationwide time-varying bank lending policies towards households from the following regression:

$$M_{blt} = \alpha + \gamma_{lt} + \rho_{bl} + \delta_{bt} + \varepsilon_{blt} \quad (2)$$

where b indexes banks and M_{blt} is the growth rates of mortgages at the bank-LLM-time level; γ_{lt} are the fixed effects capturing the variation in mortgages due to local economic factors (i.e. households' local demand); ρ_{bl} are the fixed effects capturing structural differences of the lending policies of the same bank across the different markets in which it operates (e.g. lending policies may differ in the LLM where the bank's headquarter is located); finally, δ_{bt} are the fixed effects capturing the (nationwide) banks' stance towards lending to households.

The identification of both γ_{lt} and δ_{bt} is guaranteed by the presence of multiple banks in each LLM (i.e. many banks exposed to the same local demand shock) and the presence of each bank in multiple LLMs (i.e. multiple areas exposed to the same bank supply conditions). Indeed, at the beginning of the period, each bank was active, on average, in 16 different LLMs. Those with a more limited geographical

[6] The classic reference is Bartik (1991), who combines the local industry composition with national changes in employment across industries to isolate local labour demand shocks. Since then, a similar shift-share strategy has been used in very different settings such as, for example, the impact of immigration (Card, 2001), trade shock (Autor et al., 2013) or credit supply (Greenstone et al., 2020; Barone et al., 2018; Berton et al., 2018).

radius were typically small, and therefore, accounted for a limited fraction of lending and credit supply. Using a different but complementary perspective, in each LLM there were on average 9 different banks.[7]

Second, we construct an LLM-time level mortgage supply index by aggregating the $\widehat{\delta_{bt}}$ estimated above using the beginning-of-the-period bank market shares in the LLMs as weights (ω_{blt_0}); formally:

$$S_{lt} = \sum_{b} \omega_{blt_0} \hat{\delta}_{bt} \tag{3}$$

therefore, S_{lt} captures the stance of the mortgage supply after purging any change in lending due to local economic factors as well as any bank-LLM idiosyncratic factors. Its source of variability is the substantial heterogeneity in lending standards across banks-times and the (initial) variation in bank market shares across LLMs.

Very importantly, bank-fixed effects used to build S in LLM l in equation (3) are estimated from equation (2) including all LLMs but l. This choice is aimed at preventing unobservable shocks in LLM l from affecting (nationwide) lending policies of banks operating in that local market. This may occur when an LLM is sufficiently large with respect to the national market of a certain bank (e.g. small banks are typically geographically concentrated in few municipalities) and, therefore, it may affect its lending policy.

4. Results

In this section, we first discuss the exogeneity of the mortgage supply indicator and show to what extent observed mortgage dynamics are driven by predicted lending policies (Section 4.1). Then we estimate equation (1) in a 2SLS framework using S_{lt} as instrument for M_{lt} (Section 4.2).

4.1 Predicted and actual mortgage supply

The validity of our instrument depends on two requirements: it must be exogenous – meaning that it has no direct effect on house price dynamics but that

[7] In an unreported analysis (available upon request), we find, as expected, that bank-time fixed effects carry significant information about observed mortgage patterns. Namely, the p-value of the F-test on the coefficients of the bank-time fixed effects being jointly different from zero is far below 0.01. Moreover, we find that bank-time fixed effects explain a non-trivial amount of the variation in mortgage patterns, and that their contribution to overall variation of mortgage patterns at the LLM-bank-time level is much higher with respect to those referred to LLM-bank and LLM-time fixed effects.

mediated by the variation in mortgages – and highly correlated with the observed mortgage growth rate.

Let us start with the former issue. Conditions under which Bartik-type instruments are credibly exogenous has been recently better understood (Borusyak et al., 2018; Goldsmith-Pinkham et al., 2018; Adão et al., 2019). Basically, the exogeneity of S_{lt} relies on the assumptions that both the beginning-of-the-period bank local market shares (ω_{blt_0}) and nationwide bank lending policies ($\hat{\delta}_{bt}$) are not correlated with house price trends at the city level. As to the first term, our assumption is that the lagged bank local market shares, once we have controlled for LLM-fixed effects, are not correlated with the outcome at the LLM level. As far as the second term is concerned, bank-fixed effects are very likely to be exogenous because (*i*) they are purged of any unobserved LLM-time factor, and (*ii*) are estimated excluding, for each LLM, the observations referred to the same LLM (see above). Another potential concern is that bank-fixed effects might be correlated with certain bank characteristics and these characteristics, in turn, might be correlated with the outcome variable. For example, if larger banks were more likely exposed to a negative shock (e.g. the liquidity drought in the interbank market after Lehman's collapse) and they were also more concentrated in more densely populated cities which have been characterized by different price dynamics with respect to the others (Glaeser et al., 2012), this would invalidate our identification strategy. To gain some insights on whether local mortgage supply shocks are as good as randomly assigned, we correlate the average *S* over the entire period (i.e. the overall exposure to mortgage supply stance) with some relevant LLM socio-demographic characteristics observed at the beginning of the period (Table 2, top panel). The results show that the latter are well balanced across quartiles of our credit supply index and the estimated correlation is not economically (and hardly statistically) different from zero. For a subset of (larger) cities (i.e., province capitals), we are able to examine whether the house price growth in the previous years was correlated with the exposure to the future credit supply shock (Table 2, bottom panel).[8] We compute the house price growth in the 5 and 10 years preceding the temporal window of our analysis and we find that it is not correlated with the exposure to the credit supply shock in the following years, thus suggesting that cities differently exposed to the credit supply shock did not display a divergent trend in the pre-treatment period.

[8] House prices are calculated using data from *Il Consulente Immobiliare*, a semiannual survey conducted for a review published by *Il Sole 24 Ore* media group (see Muzzicato et al., 2008).

Table 2. Balancing properties

Dependent variable:	Quartile of S				Regression coefficient	Standard error
	1	2	3	4		
Log of house price	6.960	7.000	7.028	6.918	0.000	0.001
Population density	2.263	2.029	2.295	1.651	-0.000**	0.000
Bank dependence	0.370	0.377	0.390	0.317	-0.003	0.003
South	0.471	0.392	0.320	0.658	0.001	0.001
Age index	1.610	1.516	1.566	1.442	-0.000	0.001
			Pre-trend			
House price growth 1998-2003	0.058	0.051	0.054	0.055	-0.010	0.018
House price growth 1993-2003	0.049	0.049	0.051	0.052	0.001	0.029

The table reports the mean values of each variable (observed at the beginning of the period) for different LLMs grouped on the basis of the quartiles of the mortgage supply index (averaged over the entire period considered in the empirical analysis); the last two columns report regression coefficients and standard errors of a regression with S as dependent variable and the variables reported in each row as regressor. The pre-trend analysis is restricted to the 103 province capitals for reasons of data availability. Standard errors clustered at the LLM level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

Following Greenstone et al. (2020), we also perform some further tests to examine whether banks with negative shocks are systematically sorted into areas with negative shocks. First, we calculate the correlation between LLM-fixed effects (the average over the period of $\hat{\gamma}_{lt}$ in equation 2) and the market share-weighted average fixed effect of banks located in that area (i.e., the average over the period of S_{lt}) and we find that they are almost uncorrelated (the correlation is 0.03 and is not statistically different from zero). This confirms our assumption that the cumulative supply response of banks in an LLM, as estimated by our model, is not affected by local economic shocks. Second, we examine (i) for each LLM l, the correlation between the fixed effect of the bank with the largest market share and the fixed effect of the bank with the second largest market share; and (ii) for each bank b, the correlation between the fixed effect of the bank and the (weighted) average of the fixed effects of other banks in each LLM in which the bank b operates (using as weights the loans extended by bank b in each LLM). In both cases we consider fixed effects as average over the entire time period considered in the analysis. The correlations are not different from zero both from an economic and a statistical point of view (the correlation is equal to -0.02 and 0.07, respectively).

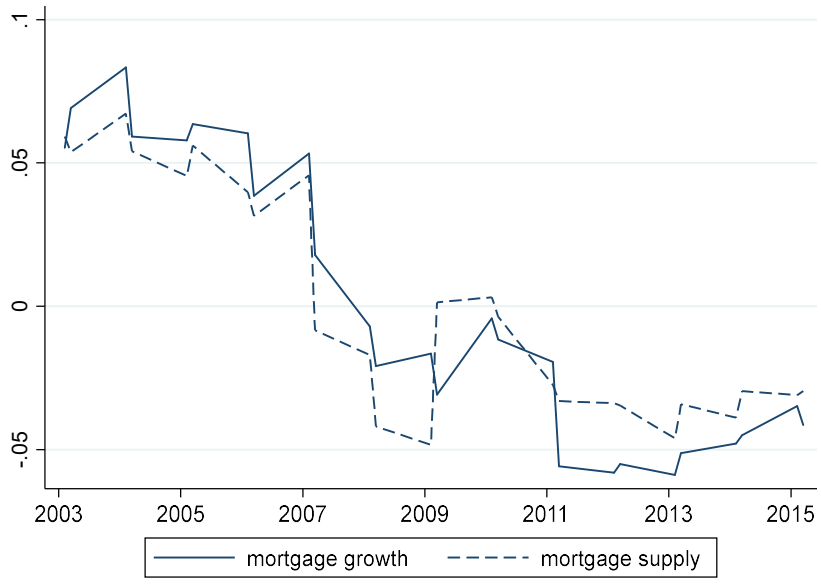
Concerning relevance, mortgage supply stance is very likely to affect the actual change in outstanding loans. Italy's mortgage market is characterized by a high degree of sluggishness, also due to the reduced financial education that impacts on the ability of borrowers to properly consider alternative choices with respect to

their financial debt (Bajo and Barbi, 2018). Finally, there are switching costs as for other bank products (Barone et al., 2011). However, in the case of Italy, the bank providing the mortgage requires the customer to have an account with it. Therefore, checking account-switching costs (Guiso et al., 2017), in addition to mortgage switching charges, have also to be considered.

On an empirical ground, we show that our credit supply indicator is predictive of actual change in outstanding loans; we start with a graphical analysis in which we show that, at the national level, the dynamics of outstanding mortgages for households closely mirrors the credit supply indicator (Figure 2).

Moving to a regression analysis, our LLM-time level credit supply index predicts fairly well the loan growth rate at the same level for the period 2003-2015 (Table 3, top panel). According to our findings, the elasticity of household mortgages to the credit supply is highly significant and is around 0.5. The coefficients are pretty stable to the inclusions of several group-time fixed effects aimed at capturing demand shocks that are common to clusters of LLM identified by their main geographical and demographic characteristics.

Figure 2. Actual mortgage growth rate and mortgage supply index



Dynamics of outstanding loans to households and the credit supply indicator at the national level. Both figures are measured as deviation from the mean.

4.2 The causal effect of mortgages on house price

Coming to the main equation, the mortgage growth rate is positively correlated with house price dynamics (Table 3, middle panel) while IV estimates revise upwardly this association and reveal a causal nexus between the two variables (Table 3, bottom panel). The first stage F statistics are largely reassuring in all specifications.

Our IV estimates indicate that the elasticity of house prices to mortgages is nearly 0.13 and it is significant at the 1 percent level. If we saturate the model with group-time fixed effects capturing time-varying demand shocks that are common to narrowly defined clusters of LLMs (based on beginning-of-the-period socio-demographic characteristics), the coefficient of interest remains positive and significant, even if its magnitude slightly decreases.[9]

Several factors might explain why the IV coefficient is larger than the OLS one. First, there might be a possible measurement error of the endogenous variable. For example, in our data the geographical location of a mortgage refers to the residence of the person requesting the loan; if she/he obtains the mortgage from her/his trusted bank, located in the city where she/he resides, to buy a second home in another place then we would have a measurement error which would result in an attenuation bias. An additional source of mismeasurement might have to do with the minimum loan threshold (see Section 2) envisaged for data collection. Second, there might be omitted variables leading to a downward bias. For example, a positive income or wealth shock might lead to a greater demand for houses and a lesser need to apply for a mortgage. Finally, IV estimate may be interpreted as a Local Average Treatment Effect (LATE), i.e. it measures the impact for the population mostly affected by the change in credit supply (the subset of "compliers"). In this case, one should be cautious about comparing IV estimates to those referring to the wider population that is considered under the OLS.

[9] It is also worth noting that the magnitude of our estimated elasticity is in line with Favara and Imbs (2015), whose estimates range between 0.12 and 0.14. Our results are not comparable with those in Di Maggio and Kermani (2017), who estimate a different functional form in which house price growth is regressed on log loans.

Table 3. House prices and mortgage supply

	First stage			
Dependent variable:	Mortgage growth rate (M)			
Mortgage supply index (S)	0.561***	0.541***	0.484***	0.464***
	(0.045)	(0.044)	(0.046)	(0.045)
	OLS estimates			
Dependent variable:	House price growth rate (p)			
Mortgage growth rate (M)	0.030***	0.028***	0.027***	0.025***
	(0.007)	(0.007)	(0.008)	(0.008)
	IV estimates			
Dependent variable:	House price growth rate (p)			
Mortgage growth rate (M)	0.125***	0.116***	0.103**	0.084**
	(0.035)	(0.035)	(0.043)	(0.043)
Time FEs	YES	YES	YES	YES
LLM FEs	YES	YES	YES	YES
City size-Time FEs	NO	YES	NO	YES
Area-Time FEs	NO	NO	YES	YES
First stage F statistics	278.5	248.0	192.7	170.0
Observations	14,527	14,527	14,527	14,527

The key variables are house price growth rate p (outcome variable), mortgage growth rate M (endogenous variable) and mortgage supply index S (instrumental variable). As control variables (interacted with time fixed effects) we include city size (LLMs are grouped in 4 quartiles depending on the beginning-of-the-period population), and geographical area (North-West, North-East, Centre and South). Standard errors clustered at the LLM level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

4.3 Heterogeneous effects

We have shown that an increase in mortgages due to banks' lending standards results in a rise in house prices. Now we investigate whether this result varies according to the point in the housing cycle and some relevant local features, such as the elasticity of housing supply and financial constraints.

The rather long time span allows us to test whether there are differences in the estimated elasticity according to the housing cycle. In our sample, we can distinguish between an expansionary and contractionary cycle, as discussed in Section 2. After splitting the sample according to the nationwide level housing cycles, our results show that the impact of mortgages on house prices is much larger during the boom periods (Table 4). This result suggests that lending standards have asymmetric impacts. Financial regulators should be aware that during a bust the

possibility of keeping house prices at a "safe" level might be severely impaired.

A number of empirical papers including Mian and Sufi (2009), Keys et al. (2010) and Mian and Sufi (2011) have stressed the role of mortgage finance in amplifying housing boom and bust cycles. For example, during booms, lending standards are more likely to be relaxed so allowing marginal borrowers, whose housing demand is more elastic, to enter the market (Dell'Ariccia et al., 2012). Mian and Sufi (2018) make a similar point by showing that credit supply expansion may induce speculative behaviours amongst households, fuelling boom-bust dynamics in the market. More specifically, they provide evidence that, during the 2003-2006 boom, U.S. ZIP codes more exposed to an acceleration of credit supply saw a relative increase in homes purchased with a mortgage, and that the increase was driven by riskier individuals.[10] Beyond reasons related to the behavioural reactions of agents, there is also a further accounting-based rule that can help rationalize why in our sample differences can emerge with respect to the housing cycle. Households usually finance house purchase with a mix of mortgage and available financial assets. During boom periods, external financial needs increase if the value of financial assets goes up *less* than that referred to housing. By the same token, during bust periods, dependence on mortgage supply decreases if the value of financial assets falls *less* than that referred to housing. This is exactly what occurred in our setting: the growth rate of the value of households' dwellings was higher than the corresponding figure for financial assets in the boom period, thus suggesting a larger need for external finance, and vice versa in the bust period.[11]

[10] In a similar vein, Mocetti and Viviano (2017) show that during the bust periods there is a weakening of (supply-driven) mortgage origination and a strengthening of the (positive) selection of borrowers.

[11] More precisely, between 2005 and 2009, the yearly average growth rate of the value of households' dwellings was 5.3%, much higher than the corresponding figure for financial assets (-0.8%). In the following bust period (up to 2015), on the contrary, both figures are -0.9% and 1.7%. Data are publicly available at https://www.bancaditalia.it/pubblicazioni/ricchezza-famiglie-societa-non-fin/2017-ricchezza-famiglie-societa-non-fin/index.html?com.dotmarketing.htmlpage.language=1.

Table 4. House prices and mortgage supply over the cycle

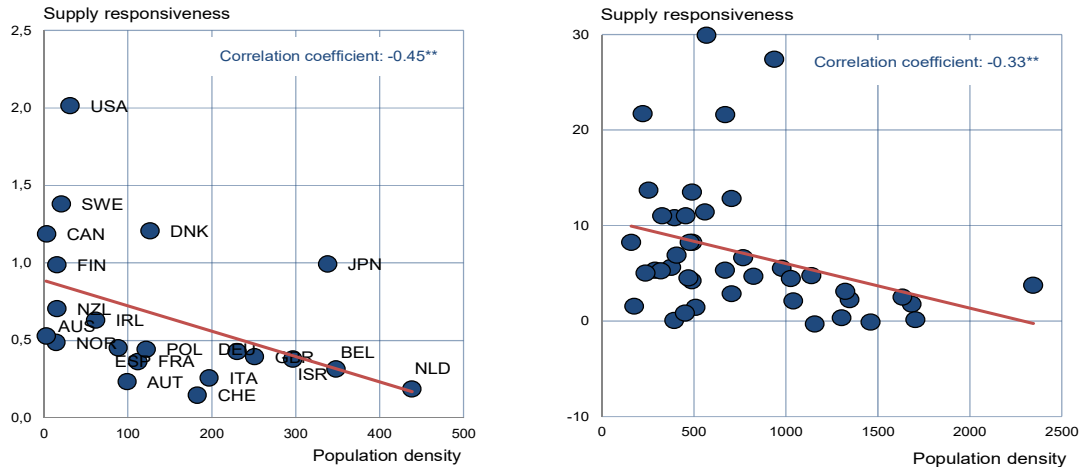
Dependent variable:	House price growth rate (p)			
Housing cycle	Boom		Bust	
Mortgage growth rate (M)	0.219***	0.179**	0.045	-0.008
	(0.071)	(0.077)	(0.039)	(0.071)
Time FEs	YES	YES	YES	YES
LLM FEs	YES	YES	YES	YES
City size-Time FEs	NO	YES	NO	YES
Area-Time FEs	NO	YES	NO	YES
First stage F statistics	67.7	47.5	197.4	63.3
Observations	7,228	7,228	7,255	7,255

The key variables are house price growth rate (outcome variable), mortgage growth rate (endogenous variable) and mortgage supply index (instrumental variable). As control variables (interacted with time fixed effects) we include city size (LLMs are grouped in 4 quartiles depending on the beginning-of-the-period population), and geographical area (North-West, North-East, Centre and South). Standard errors clustered at the LLM level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

Now we turn our attention to spatial heterogeneity and examine the role of the responsiveness of housing supply; the underlying idea is that the impact of mortgages on house prices is mediated by the elasticity of the supply curve in the housing markets: a more rigid supply schedule should imply larger effects on prices. We proxy housing supply elasticity with population density, under the plausible assumption that a lower extent of developable land corresponds to a lower elasticity of housing supply. In Figure 3, we provide evidence on the relationship between housing supply elasticity and population density, either at the cross-country level or across (US) cities.

After dividing cities according to the terciles of population density measured at the beginning of the sample, it turns out that, consistently with prior studies, the effect is larger in cities in which the housing supply curve is more rigid while the effect is smaller but still highly significant for the intermediate group (Table 5, top panel). On the other hand, in cities with very elastic supply, it reacts to upward shifts in the demand curve so that the impact of mortgages on house prices is positive but statistically indistinguishable from zero.

Figure 3. Housing supply elasticity and population density



Correlation between housing supply elasticity and population density. Figure on the left shows cross-country correlation using estimates of house supply responsiveness taken from Caldera and Johansson (2013), while figure on the right shows correlation across US cities using estimates of supply responsiveness taken from Green et al. (2005). *** p<0.01, ** p<0.05, * p<0.10.

Cities also differ in terms of financial constraints. More liquid households should be less sensitive to mortgage supply because they can, in principle, finance their purchase with their own funds. We proxy bank dependence at the city level with the beginning-of-period ratio between financial wealth per capita and housing cost and again divide our statistical units according to terciles. Table 5, bottom panel, shows that in the low-dependence subsample the estimate effect is smaller and has no statistical significance. Mortgage supply matters in cities hosting households more dependent on external finance, even if the relationship is not monotone.[12]

[12] In our sample the correlation between housing supply elasticity and bank dependence is very low (-0.13), signalling that the two spatial dimensions of heterogeneity we investigate are genuinely different. Results are qualitatively similar if we use the specification with city size-time and geographical area-time fixed effects.

Table 5. House prices and mortgage supply: spatial heterogeneity

Dependent variable:	House price growth rate (p)		
By extent of developable land:	Low	Medium	High
Mortgage growth rate (M)	0.180***	0.126**	0.056
	(0.069)	(0.059)	(0.055)
Time FEs	YES	YES	YES
LLM FEs	YES	YES	YES
First stage F statistics	127.2	93.3	92.1
Observations	4,855	4,820	4,408
By extent of bank dependence:	Low	Medium	High
Mortgage growth rate (M)	0.041	0.185***	0.126**
	(0.073)	(0.056)	(0.063)
Time FEs	YES	YES	YES
LLM FEs	YES	YES	YES
First stage F statistics	102.8	84.8	106.5
Observations	4,842	4,810	4.830

The key variables are house price growth rate (outcome variable), mortgage growth rate (endogenous variable) and mortgage supply index (instrumental variable). The cities are divided in terciles (low, medium and high) of the relevant variable. Standard errors clustered at the LLM level in parentheses. *** p<0.01, ** p<0.05, * p<0.10.

5. Implications and conclusions

Understanding the *causal* link between mortgage supply and house prices is a topic of the utmost importance that has gained increased attention, especially among urban economists but also monetary authorities and financial regulators. By using an exogenous and replicable measure of mortgage supply stance, the paper shows that mortgages do affect house prices. According to our estimates, a 10% increase in outstanding mortgages entails around a 1% rise in house prices. We also show that the impact is heterogeneous depending on the economic conditions of the housing market. Namely, the impact is larger during its expansionary phases. This aspect is relevant for policies aimed at mitigating the risk of financial instability. It suggests that regulators have to pay attention at the growth phase of property values, when their action can have a payoff in terms of cooling down market overheating. On the other hand, they might lack the ability to pursue the reverse course of action, that is stimulating property prices through credit supply during a housing downturn.

Our investigation can also provide additional useful insights on geographical areas characterized by significant heterogeneity. We have shown that a rigid

housing supply and high financial constraints act as factors that magnify house prices' response to mortgage supply. From a policy perspective, this suggests that a single monetary or regulatory policy affecting mortgage supply is likely to have spatial asymmetric effects, which could be mitigated by means of different local policy instruments.

Finally, our empirical framework has the advantage of being replicable, provided that the spatial structure of the credit market allows the implementation of our identification strategy. Basically, the requirement is likely to be satisfied: there must be intermediaries that serve different local markets and local markets differently exposed to intermediaries' lending policies. In contrast, replicability is not an option for studies that elaborate on country- and time-specific episodes of regulatory changes to derive exogenous source of variation for the supply of mortgages.

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