The Financial Transmission of Housing Bubbles: Evidence from Spain*

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Abstract

What are the effects of a housing bubble on the rest of the economy? We show that if firms and banks face collateral constraints, a housing bubble initially raises credit demand by housing firms while leaving credit supply unaffected, and therefore crowds out credit to non-housing firms. If time passes and the bubble lasts, however, housing firms pay back their higher loans. This leads to an increase in banks' net worth and thus to an expansion in their supply of credit to all firms, so that crowding-out gives way to crowding-in. These predictions are confirmed by empirical evidence from the Spanish housing bubble of 1995-2008. In the early years of the bubble, non-housing firms reduced their credit from banks that were more exposed to the bubble, and firms that were more exposed to these banks exhibited lower credit and output growth. In its last years, however, these effects were reversed.

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1 Introduction

During the last two decades, many developed and emerging economies have experienced major boom-bust cycles in housing prices. These housing "bubbles", which have occurred for instance in the United States, the United Kingdom, Spain, Ireland and possibly in China, are widely believed to have important macroeconomic effects (see Zhu (2014) and Jordà et al. (2015a)). Understanding the channels through which they affect the rest of the economy has therefore become a key concern for economists and policymakers alike.

In this paper, we analyze the financial transmission of housing bubbles, that is, their transmission through the credit market. Despite its importance, the role of this market is a priori unclear. On the one hand, it has been argued that housing bubbles raise the demand for mortgages and credit to real estate and construction firms, reallocating credit towards the housing sector at the expense of non-housing firms (e.g., Chakraborty et al. (2017)). On the other hand, housing bubbles have also been identified as the source of credit booms extending to all sectors of the economy, including non-housing ones (e.g. Jimenez et al. (2014)).

Our paper makes two main contributions. First, we construct a macroeconomic model of housing bubbles and show that they have conflicting crowding-out and crowding-in effects through the credit market. Crucially, these effects play out at different moments in time. While a housing bubble initially crowds out non-housing credit and investment by reallocating credit to the housing sector, it eventually crowds them in by raising the net worth of the banking sector and thus credit supply. Second, we use a detailed bank and firm-level database to show that these theoretical predictions are in line with the Spanish experience during the recent housing boom and bust. These findings imply that the contrasting views outlined above are not mutually exclusive, but instead describe two sides of the same phenomenon.

Our theoretical analysis is based on an overlapping generations model of a small open economy that produces two goods, housing and non-housing. The economy is populated by housing entrepreneurs, non-housing entrepreneurs, and bankers. In order to invest in capital, entrepreneurs from both sectors borrow from bankers, which in turn borrow from an international financial market. Crucially, we assume that the borrowing of entrepreneurs and bankers is limited by a collateral constraint, as they cannot credibly promise to repay more than a fraction of their future income to their creditors.

Housing entrepreneurs are endowed with land, which is used in housing production and traded in a competitive market. At any point in time, the fundamental value of a unit of land equals the present value of its future marginal products. However, the market value of land can be subject to rational bubbles: in certain periods, housing entrepreneurs may be willing to buy land at a price exceeding its fundamental value because they expect to resell it at a high price in the future. We refer to such episodes as housing bubbles, and study how they are transmitted through the credit market.

When a housing bubble first appears, we find that it crowds out credit and investment in the non-housing sector. Indeed, the direct effect of the bubble is to raise the collateral of housing entrepreneurs, thereby enabling them to expand their credit demand. This leads to an increase in the domestic interest rate and to a reallocation of credit (and investment) from the non-housing to the housing sector.

As time passes and the bubble goes on, however, this crowding-out of credit to the non-housing sector is gradually reversed, eventually giving way to a crowding-in effect. Indeed, as long as the bubble lasts, housing entrepreneurs are able to take out and repay large loans. This raises the profits and thus the net worth of bankers, leading in turn to an expansion in the domestic credit supply. Therefore, the equilibrium interest rate falls and credit and investment in the non-housing sector start to increase again. If the bubble lasts long enough, we show that this crowding-in effect outweighs the initial crowding-out effect: the housing bubble eventually raises credit to all sectors, even the non-housing one.

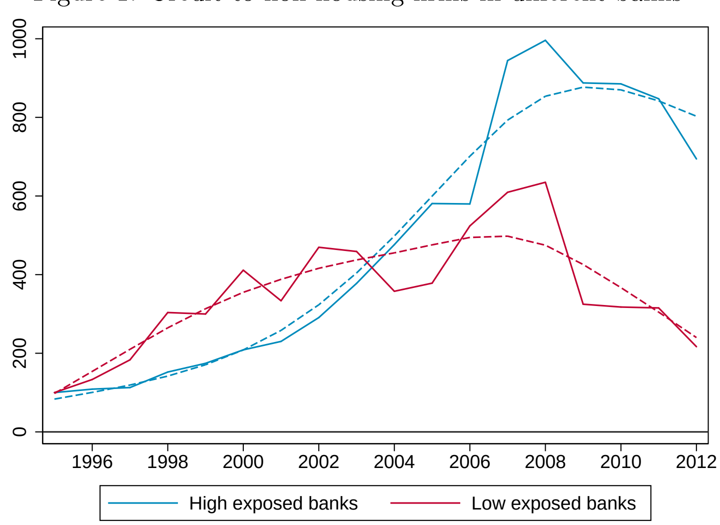
A key feature of bubbles, however, is that they are sustained only by market psychology. Housing bubbles, in particular, reflect the expectation of high land prices in the future. When these expectations change, the bubble bursts and land prices collapse. This wipes out the collateral of housing entrepreneurs, thereby reducing their credit demand. It also reduces loan repayments received by bankers, thereby reducing their net worth and contracting credit supply. Jointly considered, these effects trigger a sudden stop in borrowing from the international financial market, an increase in the domestic interest rate, and a fall in credit and investment both in the housing and non-housing sectors.

In order to test the pattern of crowding-in and crowding-out effects emerging from the model, we analyze empirical evidence from the massive boom-bust cycle in Spanish housing prices between 1995 and 2015. This episode is generally interpreted as the result of a housing bubble (see, for instance, Fernández-Villaverde et al. (2013), Akin et al. (2014), Santos (2017a)), and therefore provides an ideal laboratory to test our model's implications for financial transmission. However, it is important to stress that our predictions are not specific to bubbles, since the same pattern of crowding-in and crowding-out effects would arise in cycles driven by productivity shocks or financial innovations (e.g., changes in the extent to which income can be pledged to bankers) in the housing sector. Therefore, our empirical analysis is not designed to establish whether the housing cycle in Spain was driven by a bubble or not, but rather to understand the financial transmission of that cycle to the non-housing sector.

The boom-bust cycle in Spanish housing was spectacular. Between 1995 and 2008, Spain experienced a threefold increase in housing prices and in the number of new houses built. In 2008, this boom gave way to a prolonged bust: by 2015, house prices had fallen by a third from the 2008 peak, and there were essentially no new houses being built.[1] The housing bubble was accompanied by a credit and investment boom, and a surge in capital inflows. Its burst coincided with a long and deep recession (Baldwin et al. (2015)).

While our model is consistent with most of these aggregate developments, we aim to test its predictions more directly, using micro-level data from the Spanish Credit Registry (which contains information on all loans to commercial firms made in Spain). Our empirical strategy relies on the observation that not all banks were equally exposed to the housing bubble, because their business models did not give the same importance to housing credit. Using a simple extension of our model that incorporates bank heterogeneity, we show that the crowding-in and crowding-out effects can be observed at the bank level. Initially, higher exposure to the bubble reduces a bank's credit supply to non-housing firms. In later years, this pattern is reversed as the crowding-in effect takes hold, and higher bubble exposure raises credit supply to non-housing firms. Figure 1 shows that this prediction is in line with the evidence, by plotting the evolution of total credit to non-housing firms[2] for the Spanish banks with the highest and lowest exposure to the housing bubble. Exposure is measured by the ratio of mortgage-backed credit to total credit between 1992 and 1995, before the beginning of the bubble.[3]

Figure 1: Credit to non-housing firms in different banks



Source: CIR and authors' calculations (see Section 5 for details). High (low) exposed banks are above (below) the 90th (10th) percentile of the share of mortgage-backed credit before 1995. Dashed lines are HP trends of the original series.

In the first years after 1995, credit to non-housing firms grew less in high-exposure banks (above the 90th percentile of the exposure measure) than in low-exposure banks (below the 10th percentile). However, this

[1] These developments are discussed in greater detail in Section 2.
[2] Throughout, we define non-housing firms as firms which do not belong to the construction or real estate sectors.
[3] Most observers date the start of the bubble between 1996 and 1998 (e.g., Fernández-Villaverde et al. (2013)).

pattern eventually reversed and, by the end of the boom, credit to non-housing firms had actually grown more in high-exposure banks. Both types of banks reduced credit to non-housing firms during the crisis.

While the pattern shown in Figure 1 is suggestive, it could be due to systematic differences between the clients of high and low-exposure banks. To control for these factors, we use our rich micro data set. Following Khwaja and Mian (2008), we regress annual credit growth of non-housing firms at the loan level (that is, for any bank-firm pair) on bank exposure to the housing bubble and firm-time fixed effects. Firm-time fixed effects control for shocks to credit demand. Coefficients are thus identified by differences in the credit growth of the same firm with more or less exposed banks, and should only reflect changes at the bank-level. These regressions confirm the model's predictions: for the same firm, annual credit growth is significantly lower at more exposed banks during the first years of the boom, but then becomes significantly higher at these banks. During the crisis, credit growth at more exposed banks again becomes significantly lower.

Finally, we extend our analysis to the firm level. If non-housing firms can freely switch across banks, it is clear that banks' differential exposure to the housing bubble should have no differential effect on firms' access to credit. However, if there are frictions preventing firms from switching banks easily, the total credit obtained by a specific firm is likely to depend on its pre-existing relationships with different types of banks. To test whether these frictions are relevant in the data, we regress annual credit growth at the firm level on a weighted average of housing bubble exposure of all banks from which the firm borrowed in the beginning of the period. We find that indeed, firms which initially borrowed more from more exposed banks had lower credit growth during the first years of the boom, higher credit growth in its last years, and lower credit growth during the crisis. These results are confirmed when we consider growth in value added instead of credit growth, showing that the differences in credit growth had real effects.

Our paper contributes to the literature on the macroeconomic effects of housing bubbles, focusing specifically on their transmission through financial markets. A line of recent empirical papers provide evidence for an effect through the value of collateral, showing that higher housing prices in the United States increased the value of corporate headquarters for listed firms (Chaney et al. (2012)) and of private homes for small entrepreneurs (Adelino et al. (2015)), stimulating their credit and investment growth. Chakraborty et al. (2017), however, show that banks which were more exposed to the US housing boom reduced their loans to firms, as mortgages crowded out corporate credit. Finally, Jimenez et al. (2014) argue that access to securitization of mortgages increased the credit supply of Spanish banks during the housing boom, while Cuñat et al. (2014) and Hernando and Villanueva (2014) show that banks that were exposed to housing reduced their lending across the board when housing prices fell, both in the United States and in Spain. Our paper shows that these findings are not mutually incompatible, but capture different phases of the transmission of a housing bubble through the credit market. Most importantly, we show that the crowding-out of non-housing credit documented by Chakraborty et al. (2017) eventually gives way to a crowding-in effect. Although the latter is consistent with the findings of Jimenez et al. (2014), our interpretation is that crowding-in is driven by an increase in bank net worth rather than by access to securitization, and we provide some suggestive evidence for this net worth channel.

Our theoretical model is closest to Martin and Ventura (2012), who develop a framework for analyzing the interaction between rational bubbles and credit booms when the former provide collateral. Martin and Ventura (2015) extend this model to an open-economy setting, and use it to study the relationship between bubbles, credit and capital flows. Our model builds on their work by adding financial intermediaries, multiple sectors and bank heterogeneity, enabling us to study the role of bank net worth in the propagation of sectoral (bubble) shocks.[4] Our work is also related to Kaplan et al. (2017), who use a structural general equilibrium model to show that belief-driven changes in house prices can account for a substantial part of aggregate fluctuations in the United States, mainly through wealth effects in consumption (the empirical importance of which is also underlined by Mian and Sufi (2011)).

Finally, our paper adds to the large literature on credit booms and busts (including Jordà et al. (2015b), Mendoza and Terrones (2008, 2012), Reinhart and Rogoff (2009, 2014)). These studies document that credit booms tend to be accompanied by capital inflows and rising house prices, and increase the risk of financial crises. Our paper is consistent with these stylized facts, and provides additional details on Spain. The Spanish experience itself has also been the focus of extensive research (see, for instance, Fernández-Villaverde et al. (2013), Akin et al. (2014), Santos (2017a, 2017b)), investigating the origins of the housing bubble, the drivers of capital inflows and the flaws of the Spanish banking system. While we build on some of the insights of these studies, we do aim to provide a unified narrative for Spain's economic development during the period. For instance, we do not investigate whether the housing bubble was caused by the fall in Spanish real interest rates after the creation of the Euro, or decompose aggregate dynamics to see which part is explained by movements in the real interest rate and by the housing bubble.[5] Instead, we take the housing bubble as given and focus on its transmission to the rest of the economy through the credit market.

[4]Our model is also related to Basco (2014), who distinguishes between different types of bubbles and studies their relationship with financial liberalization. Ventura (2012) studies the interaction between bubbles and capital flows, but in his setting, bubbles affect the cost of capital and not the stock of credit. Finally, den Haan et al. (2003) propose a model of macroeconomic fluctuations in which lenders are financially constrained.

[5]We also abstract from the rising misallocation of capital during the period, documented by Garcia-Santana et al. (2015) and Gopinath et al. (forthcoming) and potentially responsible for Spain's low aggregate productivity growth. Basco et al. (2017) argue that the housing bubble was partly responsible for this increase in capital misallocation, because too many resources were channeled to unproductive firms with high real estate collateral, especially in municipalities with fast-growing housing prices.

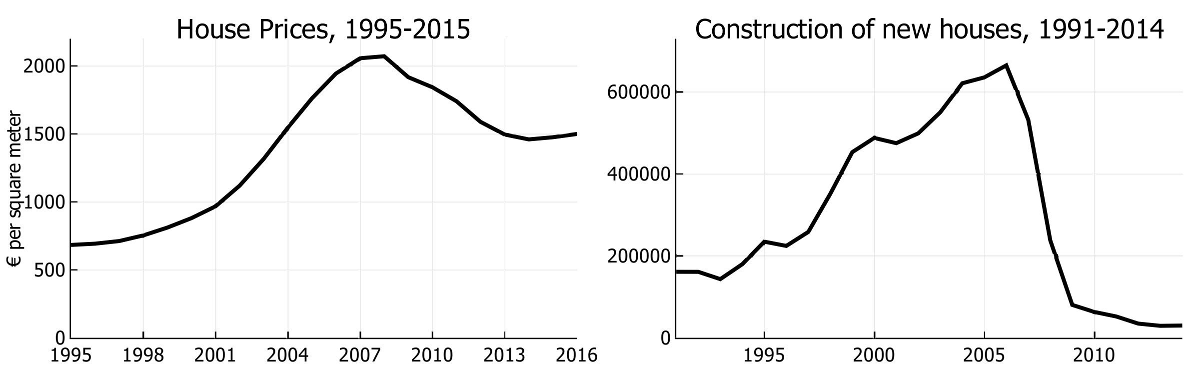
The remainder of the paper is structured as follows. Section 2 provides some background information about the Spanish boom and bust. Section 3 sets out our model, and Section 4 illustrates its results and predictions for a housing bubble. Section 5 tests the theoretical predictions with micro data, and Section 6 concludes.

2 The Spanish boom and bust

2.1 The housing bubble

In the middle of the 1990s, according to Jimeno and Santos (2014, P. 128), "*the Spanish economy [had] developed some characteristics that made it especially prone for a housing bubble*": the banking sector was able to attract capital inflows, construction firms had built up large capacities during earlier infrastructure projects, and the Spanish population was young and growing fast. As house prices started to rise, they were further sustained by changes in zoning and land use regulations in 1997 and 1998 (which decentralized and liberalized the granting of housing permits), and weak lending standards, especially in regional banks subject to capture by local political elites (Fernández-Villaverde et al. (2013), Akin et al. (2014)). As a result, both nominal house prices and the construction of new houses tripled between 1995 and 2008, as shown in Figure 2. The boom was followed by a spectacular collapse. Prices fell six years in a row, and in the years between 2010 and 2014, yearly housing construction represented only 6% of the pre-crisis peak.

Figure 2: House Prices and Housing Construction



Source: Ministry of Construction. See Appendix B for further details.

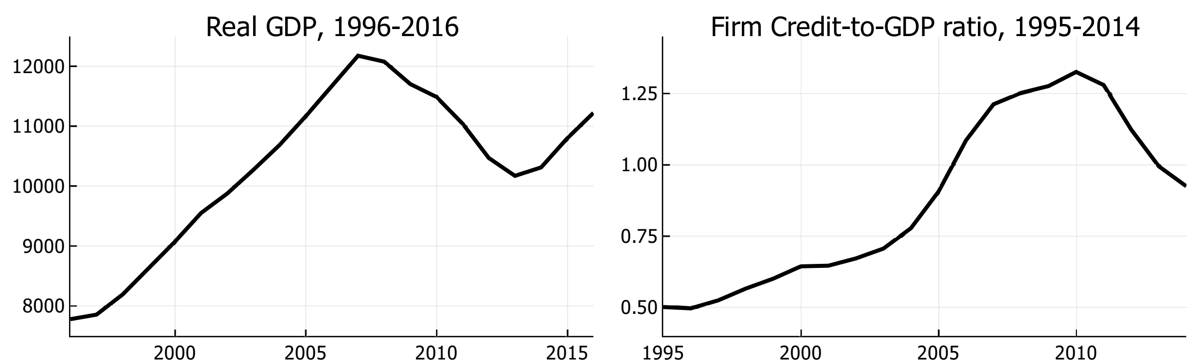
In our theoretical analysis, we assume these dynamics were caused by a rational bubble, during which housing prices exceeded their fundamental value because agents expected to be able to sell houses at even higher prices in the future. Indeed, most accounts of the Spanish experience affirm that there was a bubble on housing prices (see, for instance, Garcia-Montalvo (2008) and Santos (2017a)). However, our theoretical results do not depend on this formulation. For instance, they would be unchanged if we assumed that house prices were driven by belief shocks about future housing demand (as in Kaplan et al. (2017)).

In the next section, we provide some further details on the macroeconomic context in which the housing bubble took place.

2.2 GDP, credit, and capital inflows

Between 1995 and 2008, Spain experienced an economic boom, with real GDP increasing on average by 3.8% per year (see the left panel of Figure 3). This was followed by a deep crisis during which real GDP fell five years in a row. The expansion saw a credit boom, both in mortgage credit to households and in credit to firms.[6] The right panel of Figure 3 illustrates the latter point by plotting the ratio of firm credit to business-economy GDP, showing that this leverage ratio doubled between 1995 and 2008. Leverage continued to rise until 2010 (as credit fell more slowly than GDP), before deleveraging set in. The credit boom was financed by banks, which channeled capital inflows to firms and households. As a consequence, the external debt of Spanish banks almost tripled between 2002 and 2007.[7]

Figure 3: Real GDP and leverage of the Spanish business economy, 1995-2014



Source: INE and Bank of Spain. The right panel plots the ratio between credit to productive activities and business economy GDP (including all sectors except public administration, defense, social security, health, education, arts and entertainment).

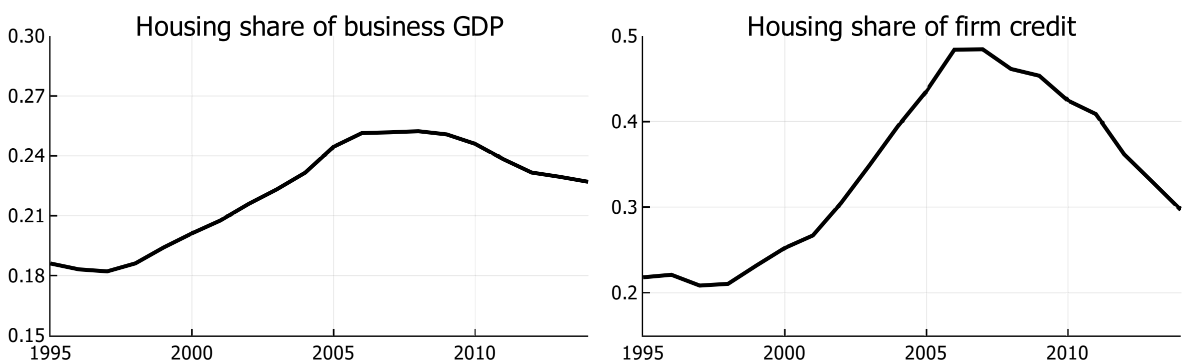
A simple accounting decomposition shows that housing sector dynamics contributed substantially to these aggregate developments, most of all for credit. Figure 4 shows that the share of housing (construction and real estate firms) in business sector GDP increased substantially during the boom, from 18% in 1997 to 25%

[6]This fact differentiates Spain from the contemporaneous experience of the United States, where firm leverage did not increase during the housing boom (Mian and Sufi (2011)).

[7]See the statistical bulletin of the Bank of Spain, Series 17.31 (https://www.bde.es/webbde/es/estadis/infoest/bolest17.html).

in 2007. The composition change for credit, however, was much more extreme: while housing made up 22% of firm credit in 1995, that share had increased to 48% in 2007. Had the GDP share of housing remained constant between 1995 and 2007, and had leverage increased by the same rate than in the rest of the economy, the overall increase in the Spanish firm leverage ratio shown in Figure 3 would only have been half as large (37 instead of 71 percentage points). Furthermore, the large increase in household credit during the boom was almost entirely driven by mortgage lending.

Figure 4: Composition of business GDP and firm credit, 1995-2014



Source: INE and Bank of Spain. See Appendix B for details.

The drivers of Spain's extraordinary boom-bust cycle have been widely debated. Clearly, productivity was not one of them, as Spain actually experienced negative growth in total factor productivity (TFP) throughout, particularly so in the housing sector.[8] Instead, the fall in real interest rates after the creation of the Euro and the housing bubble itself are generally regarded as the key drivers of aggregate dynamics.

These explanations are of course not mutually exclusive. Our aim in this paper is not to judge their relative importance, or to provide an exhaustive picture of all channels through which the housing bubble may have affected the rest of the economy. Instead, we take the housing bubble as given and analyze its spillover effects in the credit market: did the massive credit growth for housing firms shown in Figure 4 slow down credit and investment growth in other sectors, or did it actually stimulate it? In the next section, we present a simple model to study these questions more rigorously.

[8]According to the EU KLEMS database (http://www.euklems.net/), construction sector TFP declined by 24% between 1995 and 2007. However, the popular conception that misallocation of capital inflows to the low-productivity construction sector caused the aggregate TFP decline is inconsistent with the data. Indeed, housing accounts only for a small part of the aggregate decline, which was observed in virtually all sectors (Garcia-Santana et al. (2015), Fernández-Villaverde et al. (2013)). Gopinath et al. (forthcoming) argue instead that capital inflows were misallocated within manufacturing industries, helping only financially unconstrained firms (rather than the most productive ones) to expand.

3 A two-sector model of bubbles and financial intermediation

This section develops a model of a small open economy with two sectors, housing and non-housing. In both sectors, entrepreneurs borrow from domestic banks to finance capital accumulation. Banks, in turn, borrow from international financial markets. Crucially, all lending relationships are subject to collateral constraints. We model the housing bubble by introducing an additional asset, land. Land is used in housing production and held by housing entrepreneurs, who can use the income it generates as collateral. Importantly, land prices are prone to expectation-driven rational bubbles, that is, they may experience rapid increases because agents expect them to increase even more in the future. Bubbles increase the value of housing entrepreneurs' collateral and therefore their credit demand. However, the loan repayments sustained by this collateral eventually also raise the net worth of banks, allowing them to increase credit supply. This interplay between credit demand and supply is at the heart of our model.

3.1 Agents, preferences and technologies

Agents and preferences Time is discrete ($t \in \mathbb{N}$). We consider a small open economy populated by generations of agents that live for two periods. Agents are risk-neutral and derive utility from their old-age consumption of the economy's final good. Thus, for agent i born in period t, utility is given by

$$U_{i,t} = E_t\left(C_{i,t+1}\right), \tag{1}$$

where $C_{i,t+1}$ denotes the consumption of agent i in period $t+1$. Each generation of agents consists of three types: entrepreneurs in the housing sector, entrepreneurs in the non-housing sector, and bankers. We consider throughout symmetric equilibria in which all agents of a certain type are identical. This allows us to focus, without loss of generality, on the representative agent for each type and generation.

Agents derive their income either from their participation in the production process or from their role in credit intermediation. Therefore, we next describe the production structure.

Production The final good is assembled by competitive firms from two intermediate goods, housing (H) and non-housing (N), according to the CES production function

$$Y_t = \left[\tau\left(Y_{N,t}\right)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\tau)\left(Y_{H,t}\right)^{\frac{\varepsilon-1}{\varepsilon}}\right]^{\frac{\varepsilon}{\varepsilon-1}}. \tag{2}$$

The final good is tradable, and we normalize its price to 1. Intermediate goods, on the other hand, are not tradable. Letting $p_{N,t}$ and $p_{H,t}$ respectively denote the prices of the intermediate goods in period t, cost minimization by final goods producers implies

$$\frac{Y_{N,t}}{Y_{H,t}} = \left(\frac{\tau}{1-\tau}\frac{p_{N,t}}{p_{H,t}}\right)^{-\varepsilon}. \tag{3}$$

Furthermore, perfect competition implies that the price of the final good is equal to its marginal cost, so that

$$\left[\tau^{\varepsilon}\left(p_{N,t}\right)^{1-\varepsilon} + (1-\tau)^{\varepsilon}\left(p_{H,t}\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} = 1. \tag{4}$$

Intermediate goods are also produced by perfectly competitive firms. These firms use a Cobb-Douglas production function combining capital, labor and land, given by

$$Y_{j,t} = A_{j,t}\left(L_{j,t}\right)^{1-\alpha_j-\beta_j}\left(K_{j,t}\right)^{\alpha_j}\left(T_{j,t}\right)^{\beta_j} \text{ for } j \in \{N, H\}, \tag{5}$$

where $L_{j,t}$ stands for the labor employed by sector j in period t, $K_{j,t}$ for its capital stock and $T_{j,t}$ for its land use. $A_{j,t}$ denotes total factor productivity, and α_j and β_j are two positive parameters satisfying $\alpha_j + \beta_j < 1$. For simplicity, we assume that $\beta_N = 0$, implying that land is only used in housing production.

Factor supply All three production factors are supplied by entrepreneurs. Each generation of j-sector entrepreneurs inelastically supplies one unit of sector-specific labor when young. Furthermore, young entrepreneurs have access to a sector-specific investment technology, which allows them to convert one unit of the final good in period t into one unit of their sector's capital in period $t+1$.

Finally, young housing entrepreneurs are also endowed with one unit of land, which can be used in production when they are old. This implies that the aggregate stock of land grows over time, as a new land "vintage" is added in every period. We interpret this growth in the stock of land as capturing the granting of construction permits to housing entrepreneurs. As shown by Fernández-Villaverde et al. (2013), this was a key feature of the Spanish housing boom, and it plays an important role in our model as well.

Our assumptions entail that all production factors are sector-specific. This is convenient because, by eliminating all direct spillovers through factor markets, it enables us to isolate the transmission of housing bubbles through the credit market. However, factor specificity is not necessary for our results.[9]

We assume throughout that capital depreciates fully, and that land is productive for just one period. This last

[9] As we show in Appendix A, allowing for labor reallocation across sectors does not affect our main predictions.

assumption simplifies the model by ensuring that the stock of productive land at any given point is constant and equal to one. We show in Appendix A that none of our main results are driven by this assumption.

Factor markets and equilibrium production of intermediate and final goods As land and labor are specific factors, Equation (5) pins down the output of each sector for a given level of the capital stocks. Factor markets being competitive, the wage for each type of labor $j \in \{N, H\}$ equals its marginal product,

$$w_{j,t} = (1 - \alpha_j - \beta_j) \cdot p_{j,t} \cdot A_{j,t} \cdot (K_{j,t})^{\alpha_j} , \tag{6}$$

where we have already used the fact that in equilibrium, $L_{N,t} = L_{H,t} = T_{H,t} = 1$. Likewise, the rental rates of capital and land are also equal to their marginal products,

$$r_{j,t} = \alpha_j \cdot p_{j,t} \cdot A_{j,t} \cdot (K_{j,t})^{\alpha_j - 1} , \tag{7}$$

where $r_{j,t}$ denotes the rental rate of capital in sector j, and

$$m_t = \beta_H \cdot p_{H,t} \cdot A_{H,t} \cdot (K_{H,t})^{\alpha_H} . \tag{8}$$

where m_t denotes the rental rate of land. Thus, summing up, for a given level of capital stocks in both sectors, Equations (2) to (8) jointly determine the production and price of each intermediate good, the return to the three production factors, and the production of the final good.

Finally, there is also a land market, in which old housing entrepreneurs can sell their land holdings to young housing entrepreneurs. We assume that trade takes place after land has been used in production, and use V_t to denote the total market value of pre-existing (or "old") land traded in period t. As land is traded after being used in production, and because of our simplifying assumption that land is productive for only one period, old land is unproductive. This raises the question of how V_t is determined in equilibrium, which we postpone until Section 3.3. Here, it suffices to say that in principle, different "vintages" of land could have different market values. We denote by $V_{\tau,t}$ the market value at time t of land which has been created in period τ. Naturally,

$$V_t = \sum_{\tau=-\infty}^{t-1} V_{\tau,t},$$

where $V_{\tau,t} \geq 0$ for all τ and t due to free disposal. To simplify the terminology, in the following, we will refer to V_t simply as the value of land.

To complete the characterization of equilibrium, we now need to determine the laws of motion of the capital stocks in both sectors. To derive these, we turn to the credit market.

3.2 The credit market

Our small open economy is embedded in an International Financial Market (IFM), which is risk-neutral and willing to borrow or lend at the expected (gross) international interest rate R^*. However, we assume that only bankers have the know-how to collect the payments of domestic entrepreneurs, making them necessary intermediaries between domestic credit demand and the IFM. Thus, the domestic credit market equilibrium is determined by the behavior of entrepreneurs, who demand credit, and of bankers, who supply it.

As we explain below, we impose only one constraint on credit contracts: they need to be collateralized. Throughout, we focus on equilibria in which this constraint is binding, i.e., in which the return to capital exceeds the domestic interest rate, which in turn exceeds the international interest rate. Therefore, all domestic agents want to expand their borrowing, but their binding collateral constraints prevent them from doing so. Keeping this in mind, we now characterize the equilibrium of the domestic credit market by solving the optimization problem of entrepreneurs and bankers.

3.2.1 Credit demand

We assume that young entrepreneurs can trade state-contingent credit contracts with bankers. Repayments may be stochastic because, as will see shortly, land is used as collateral by housing entrepreneurs and its value may be prone to stochastic fluctuations in equilibrium.

Consider a credit contract that gives $Q_{j,t}$ units of credit in period t to the representative young entrepreneur of type j against the promise of a stochastic repayment $F_{j,t+1}$ in period $t+1$. We define the domestic interest rate R_{t+1} as the expected return to this credit contract, which must be equalized across both types of entrepreneurs in equilibrium:

$$R_{t+1} = \frac{E_t(F_{j,t+1})}{Q_{j,t}} \quad \text{for } j \in \{N, H\}. \tag{9}$$

Domestic entrepreneurs take the interest rate as given. Therefore, the budget constraints of an entrepreneur of type j during youth and old age are given by

$$K_{j,t+1} = w_{j,t} + \frac{E_t(F_{j,t+1})}{R_{t+1}} - \mathbb{1}_H \cdot V_t, \tag{10}$$

$$C_{j,t+1} = r_{j,t+1} \cdot K_{j,t+1} - F_{j,t+1} + \mathbb{1}_H \cdot (m_{t+1} + V_{t+1}), \tag{11}$$

where $\mathbb{1}_H$ is an indicator function equal to one if $j = H$ and zero otherwise.

Equation (10) shows that young entrepreneurs use their wage and the credit obtained from banks to invest in capital and, in the case of housing entrepreneurs, to purchase the economy's stock of pre-existing land. Note that entrepreneurs never save by lending to the IFM, because we focus throughout on equilibria in which entrepreneurs are constrained. Equation (11), in turn, shows that the old-age consumption of entrepreneurs equals their capital and land income, net of loan repayments.

Entrepreneurial borrowing is subject to a collateral constraint. In particular, we assume that the repayment promised by the representative young entrepreneur of sector j must satisfy

$$F_{j,t+1} \leq \lambda_j \cdot (r_{j,t+1} \cdot K_{j,t+1}) + \mathbb{1}_H \cdot (m_{t+1} + V_{t+1}), \tag{12}$$

where $\lambda_j \in (0,1)$. This implies that the entrepreneur cannot promise payments exceeding a fraction λ_j of her capital income and – in the case of housing entrepreneurs – whatever income is derived from land.[10] The collateral constraint can be interpreted as the result of imperfect contractual enforcement. For instance, if creditors can seize only a fraction λ_j of entrepreneurs' capital income, it will be impossible for the latter to pledge repayments exceeding this.

Since we focus on equilibria in which the credit constraints of entrepreneurs bind, the return to capital must exceed the domestic interest rate, i.e., $r_{j,t+1} > R_{t+1}$ for $j \in \{N, H\}$. Hence, it is optimal for young entrepreneurs to borrow as much as possible, and Equation (12) holds with equality in all states of nature. Taking this into account, we can combine it with Equation (9) and aggregate across both sectors to obtain the total credit demand by entrepreneurs,

$$Q_t^D = \frac{\sum\limits_{j\in\{N,H\}} \lambda_j \cdot r_{j,t+1} \cdot K_{j,t+1} + m_{t+1} + E_t(V_{t+1})}{R_{t+1}}. \tag{13}$$

Equation (13) is intuitive: it says that credit demand, denoted by Q_t^D, is increasing in the expected value of entrepreneurial collateral and decreasing in the domestic interest rate R_{t+1}. By combining this expression with Equation (10), we obtain the law of motion for the capital stock in sector j:

$$K_{j,t+1} = \frac{R_{t+1}}{R_{t+1} - \lambda_j \cdot r_{j,t+1}} \cdot \left(w_{j,t} + \mathbb{1}_H \cdot \left[\frac{m_{t+1} + E_t(V_{t+1})}{R_{t+1}} - V_t \right] \right) \tag{14}$$

[10]The assumption that land income is fully pledgeable is not essential for any of our results, but it greatly simplifies the algebra. See Martin and Ventura (2018) for a detailed discussion of this point.

Equation (14) shows that the future capital stock in each sector depends on the net worth of young entrepreneurs and on a financial multiplier that reflects the extent to which the net worth can be leveraged in the credit market.[11] The net worth includes wages and, in the case of housing entrepreneurs, whatever additional income is obtained from trading and using land. The financial multiplier, in turn, is decreasing in the interest rate R_{t+1} and increasing in the ability of the entrepreneur to pledge her future income λ_j.

3.2.2 Credit supply

Bankers intermediate funds between domestic entrepreneurs and the IFM. Thus, they supply credit domestically (by buying credit contracts from domestic entrepreneurs) and demand credit internationally (by selling credit contracts to the IFM). The IFM is risk-neutral and provides an infinitely elastic credit supply at the exogenous international interest rate R^*. Thus, young bankers can obtain $\frac{E_t(F_{B,t+1})}{R^*}$ units of credit in period t when promising the IFM a stochastic repayment $F_{B,t+1}$ in period $t+1$.

Just like young entrepreneurs, young bankers also receive labor income. In particular, we assume that old bankers alone can only collect a fraction $1-\phi$ (with $\phi \in (0,1)$) of the credit repayments they have been promised. To collect the remaining fraction ϕ, they need to hire young bankers. Assuming that young bankers have all the bargaining power in the resulting relationship, they will be able to extract a fraction ϕ of total repayments as a remuneration for their labor.

Taking this into account, the budget constraints of bankers during youth and old age are given by

$$Q_t^S = \phi \cdot (F_{N,t} + F_{H,t}) + \frac{E_t\left(F_{B,t+1}\right)}{R^*}, \tag{15}$$

$$C_{B,t+1} = (1-\phi) \cdot (F_{N,t+1} + F_{H,t+1}) - F_{B,t+1}. \tag{16}$$

As shown in Equation (15), the representative banker uses her labor income or net worth, plus whatever credit she obtains from the IFM, to purchase domestic credit contracts from entrepreneurs. We denote this purchase of credit contracts by Q_t^S, because it represents the domestic supply of credit to entrepreneurs. During old age, bankers consume their loan income, net of payments to young bankers and to the IFM.

Just like entrepreneurs, young bankers face a collateral constraint, given by

$$F_{B,t+1} \leq \lambda_B \cdot \left(F_{N,t+1} + F_{H,t+1}\right), \text{ with } 0 < \lambda_B < 1-\phi. \tag{17}$$

That is, bankers cannot promise payments that exceed a fraction λ_B of their revenues. This can be interpreted

[11] Note that in a constrained equilibrium, we necessarily have $\lambda_j \cdot r_{j,t+1} < R_{t+1}$ for $j \in \{N, H\}$. Indeed, if this were not the case, then entrepreneurs would be unconstrained (which would imply $r_{j,t+1} = R_{t+1}$).

as the result of imperfect contractual enforcement between bankers and the IFM, which enables the latter to seize only part of the former's profits.

As we had already anticipated, we focus throughout on equilibria in which bankers are constrained, i.e., in which Equation (17) holds with equality in all states of nature. By combining it with Equation (15), we can derive the domestic supply of credit,

$$Q_t^S = \frac{R^*}{R^* - \lambda_B \cdot R_{t+1}} \cdot \phi \cdot (F_{N,t} + F_{H,t}) . \tag{18}$$

Thus, domestic credit supply is increasing in both the domestic interest rate and in the labor income or net worth of bankers.

3.2.3 Credit market clearing

In equilibrium, domestic credit demand (given by Equation (13)) must equal domestic credit supply (given by Equation (18)). Thus, clearing of the credit market requires that

$$\frac{R_{t+1} \cdot R^*}{R^* - \lambda_B \cdot R_{t+1}} = \frac{\sum\limits_{j \in \{N,H\}} \lambda_j \cdot r_{j,t+1} \cdot K_{j,t+1} + m_{t+1} + E_t (V_{t+1})}{\phi \cdot (F_{N,t} + F_{H,t})} . \tag{19}$$

The left-hand side of Equation (19) is an increasing function of the domestic interest rate, whereas the right-hand side is the ratio of the collateral of young entrepreneurs to the net worth of young bankers. Thus, the expression shows that the equilibrium interest rate is increasing in entrepreneurial collateral, i.e., in domestic credit demand, and decreasing in bank net worth, i.e., in domestic credit supply.

Equation (19) also illustrates the role of collateral constraints in equilibrium. A tightening of entrepreneurs' collateral constraints (captured by a decline in λ_N and/or λ_H) reduces credit demand and thus the domestic interest rate, driving a wedge between the interest rate and the marginal product of capital. Without them, the marginal product of capital would equal the domestic interest rate in both sectors. A tightening of bankers' collateral constraints (captured by a decline in λ_B) instead restricts the supply of credit and raises the domestic interest rate, by driving a wedge between the domestic and the international interest rate. Without this collateral constraint, the domestic supply of credit would be perfectly elastic and the domestic interest rate would equal $R^* \cdot (1 - \phi)^{-1}$, independently of bankers' net worth.

Finally, note that both the value of entrepreneurial collateral and the net worth of banks depend on the expected and the current value of land, $E_t (V_{t+1})$ and V_t. What determines the equilibrium value of land? We turn to this important question next.

3.3 Bubbles and the value of land

At any point in time, the supply of land is perfectly inelastic because old entrepreneurs want to sell all the land that they own in order to consume. Even though it is unproductive, young entrepreneurs may be willing to purchase this pre-existing land to resell it during old age. Since all of the income generated by land can be pledged to bankers, these purchases can be fully financed with credit. This implies that, in equilibrium, the market value of existing land must grow at the domestic interest rate. Indeed, if its return were higher than R_{t+1}, the demand for land would be arbitrarily high: simply by purchasing it, young entrepreneurs could instantly loosen their collateral constraint. If instead its return were lower than R_{t+1}, there would be no demand for land: by purchasing it, young entrepreneurs would instantly tighten their collateral constraint. Therefore, for any vintage τ, it must hold that

$$V_{\tau,t} = \frac{E_t\left(V_{\tau,t+1}\right)}{R_{t+1}}, \tag{20}$$

Iterating this equation forward, we can write

$$V_{\tau,t} = E_t\left(\lim_{s\to\infty} \frac{V_{\tau,t+s}}{\prod_{k=1}^{s} R_{t+k}}\right). \tag{21}$$

Equation (21) says that the current market value of each vintage of land depends only on its expected value at infinity, i.e., on market psychology. This follows naturally because land is productive for only one period and therefore has no fundamental value. Thus, one possible equilibrium is the fundamental one, in which $V_{\tau,t} = 0$ for all t and $\tau < t$. But this need not be the only one. There are potentially also bubbly equilibria, in which the market value of land exceeds its fundamental value. In such equilibria, $V_{\tau,t} > 0$ for some t and $\tau < t$ and the value of each vintage of land can follow any stochastic process as long as it satisfies Equation (20), i.e., as long as the expected return to owning land equals the equilibrium interest rate.[12]

This discussion suggests that there are multiple sequences of land values, corresponding to different market psychologies, that are consistent with equilibrium. In the next section, we impose a particular stochastic process for market psychology, which we use to illustrate the macroeconomic effects of housing bubbles and to study the financial transmission mechanism.

[12] Because of this, it is well-known that bubbly equilibria can only arise if – on average – the interest rate is lower than the growth rate of the economy. Otherwise, the size of the aggregate bubble would eventually exceed the resources of bankers, which would not be consistent with equilibrium. Given our small open economy setting, here we simply assume that the international interest rate is low enough for bubbles to arise (see Martin and Ventura (2012) for a detailed discussion of this topic).

4 Bubbles and the financial transmission mechanism

4.1 Summary of equilibrium conditions and a process for the bubble

Equilibrium conditions As noted before, we restrict our attention to equilibria in which $r_{j,t} > R_t > \frac{R^*}{1-\phi}$ in every period t, so that both entrepreneurs and bankers are financially constrained. Then, given initial conditions for the value of existing vintages of land $\{V_{\tau,0}\}_{\tau<-1}$ and for capital stocks $\{K_{j,0}\}_{j\in\{N,H\}}$, a competitive equilibrium in our model is a sequence of values of land $(V_{\tau,t})_{t\geq 1}$, capital stocks $(K_{N,t})_{t\geq 1}$ and $(K_{H,t})_{t\geq 1}$, and interest rates $(R_{t+1})_{t\geq 0}$ such that Equations (14), (19) and (20) hold. All the other endogenous variables that appear in these equations only depend on the capital stocks in both sectors, as described in Section 3.1.

A bubble process To illustrate the financial transmission mechanism, we specify an explicit process for market psychology, assuming that it is characterized by a Markov process z_t which oscillates between a bubbly (B) and a fundamental (F) state of nature. z_t transitions from F to B with probability φ, and from B to F with probability ψ. Whenever the economy is in the fundamental state, the value of land is zero. In the bubbly state, however, new land vintages may have positive market values even after having been used in production. Formally,

$$V_{\tau,t+1} = \begin{cases} N & \text{if } z_t = z_{t+1} = B \\ 0 & \text{otherwise} \end{cases}, \text{ for } \tau = t \tag{22}$$

whereas

$$V_{\tau,t+1} = \begin{cases} V_{\tau,t} \cdot \dfrac{R_{t+1}}{1-\psi} & \text{if } z_t = z_{t+1} = B \\ 0 & \text{otherwise} \end{cases}, \text{ for } \tau < t. \tag{23}$$

Equation (22) indicates that bubbly episodes create a windfall for young housing entrepreneurs, who expect that – if the bubbly episode lasts during their old age – they will be able to sell their endowment of land at a price N after using it in production. Equation (23) in turn states that, during bubbly episodes, the expected return of purchasing and holding any vintage of land must equal the domestic interest rate. As there is a constant probability ψ that the bubbly episode ends and the value of each vintage becomes zero forever, the realized return to each vintage during a bubbly episode must equal $R_{t+1} \cdot (1-\psi)^{-1}$.

This process for the bubble entails two important and related assumptions. First, young housing entrepreneurs recieve a windfall during bubbly episodes, as they are endowed (for free) with land that is expected to be sold at a positive price. It is this windfall that relaxes their collateral constraint and allows them to increase their investment. Indeed, if there was no such "bubble creation" and young housing entrepreneurs were only be able to trade existing land, the bubbly episode would have no direct effect on their investment.[13] To see this, note that a young housing entrepreneur pays $V_{\tau,t}$ for a unit of land of vintage τ, but this unit also enables her to expand her borrowing by $\frac{E_t(V_{\tau,t+1})}{R_{t+1}}$. In equilibrium, however, it must hold that $V_{\tau,t} = \frac{E_t(V_{\tau,t+1})}{R_{t+1}}$ or young entrepreneurs would demand either zero or infinite units of land of vintage τ. This implies that, in equilibrium, the trading of existing units of land does not directly affect the amount of resources that young housing entrepreneurs can invest.

Second, the onset of a bubbly episode raises only the value of new vintages of land, but does not affect the value of pre-existing ones. Thus, the wealth initially created during a bubbly episode accrues entirely to young entrepreneurs and not to bankers. Although not essential for our results, this feature is in line with our interpretation of housing bubbles as sector-specific shocks.[14]

4.2 Bubble booms and busts

4.2.1 Aggregate effects

Given the bubble process set out in the previous section, we can now simulate a boom-bust episode to illustrate how bubbles are transmitted through financial markets. Figure 5 depicts such a simulation. In the figure, the economy initially finds itself in the fundamental steady state.[15] In period 4, it transitions into a bubbly state and remains there until period 38.

Throughout the bubbly episode, the total value of land rises for two reasons outlined in the market psychology of Equations (22) and (23): the value of new vintages is positive, due to the bubble component N, and the value of old vintages rises at a gross rate of $R_{t+1} \cdot (1-\psi)^{-1}$ in each period (see Panel 1). The positive value of land enables young housing entrepreneurs to expand their borrowing and investment: even though nothing fundamental has changed in the economy, there is a credit boom and the credit-to-output ratio steadily rises (see Panel 2). Fueled by this expansion in credit and investment, output itself also rises and the economy experiences a boom (see Panel 3). Finally, as the credit boom is ultimately driven by an expansion of collateral in the housing sector, the share of credit allocated to housing increases (see Panel 4). When the bubble bursts and the value of land collapses, the economy crashes as both credit and output collapse.

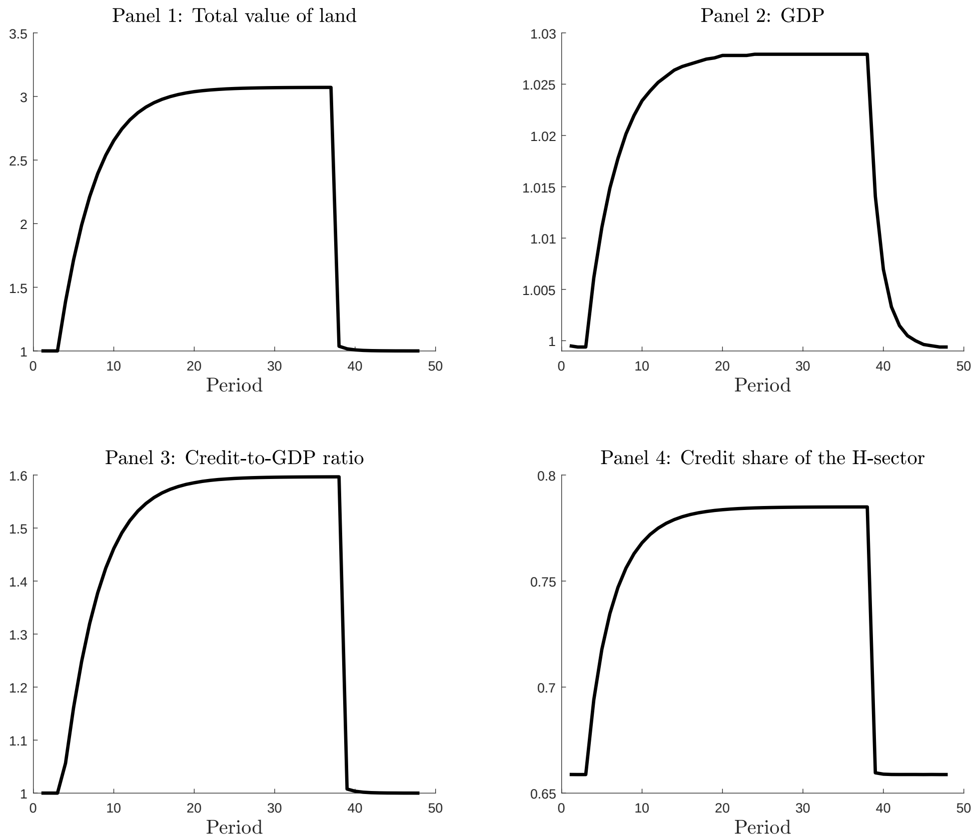
Figure 5 shows that, in a very stylized manner, our model can generate boom-bust episodes like the one

[13] There would be general equilibrium effects, as bubbles also affect investment through their effect on the interest rate.

[14] To be precise, our results would apply under more general market psychologies as long as the windfall created by the onset of a bubbly episode benefits housing entrepreneurs more than bankers.

[15] The fundamental steady state is the model's unique steady state in the fundamental equilibrium, when $z_t = F$ throughout.

Figure 5: The aggregate effects of a housing bubble



Notes: With the exception of the credit share of the H-sector, all variables are normalized to 1 in the fundamental steady state. The parameter values for the simulation shown in this figure are given in Appendix A.

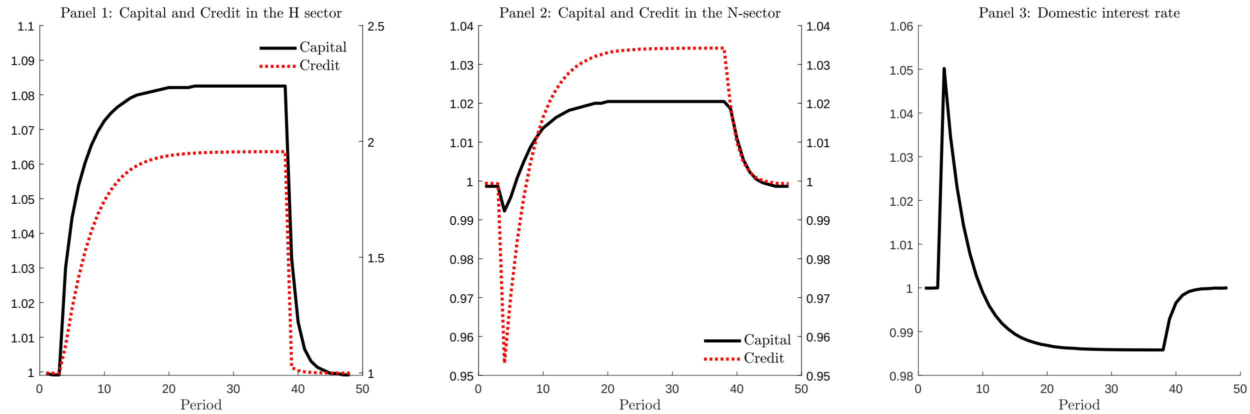
experienced by Spain and discussed in Section 2. Just like in Spain, the boom is not driven by TFP: in the model, productivity is constant and the boom is only due to an expectations-driven surge in land values. But the model can do more than this: it can also shed light on how the credit market acts as a transmission mechanism, generating spillovers from the housing to the non-housing sector, as we discuss in the next section.

4.2.2 Crowding-out and crowding-in of credit and investment in the non-housing sector

Figure 6 plots the evolution of credit and capital stocks in both sectors, as well as the domestic interest rate. Housing sector capital rises throughout the bubbly episode, as shown in Panel 1. This is due to the collateral effect of the bubble for housing entrepreneurs, allowing them to expand their credit and investment.

Most interestingly, the capital stock of the non-housing sector evolves non-monotonically, as shown in Panel 2. This is due to the financial transmission mechanism, which is summarized by the evolution of the domestic interest rate in Panel 3. On impact, the start of a housing bubble increases the collateral of housing

Figure 6: The sectoral effects of a housing bubble



Notes: All variables are normalized to 1 in the fundamental steady state. The parameter values for the simulation shown in this figure are given in Appendix A.

entrepreneurs and thus raises the domestic demand for credit. Credit supply, however, is not immediately affected. Thus, the housing bubble initially raises both the volume of domestic credit and the domestic interest rate. As Figure 6 shows, this crowds out credit and investment in the non-housing sector.

As the bubbly episode continues, however, things change. On the one hand, the value of the bubble rises, which continues to sustain collateral values and credit demand. On the other hand, though, the housing bubble also sustains higher loan repayments by the housing sector, and this raises the net worth of banks, so that the domestic credit supply curve also shifts out. Therefore, the path of the domestic interest rate is non-monotonic. In our simulation, the interest rate begins to fall shortly after the onset of the bubble. By period 30, moreover, it has fallen so much that both credit and the capital stock in the non-housing sector are higher than they were in the fundamental state: crowding-out has given way to crowding-in.

This pattern is not an artifact of one particular simulation. Instead, we can show that any bubble that lasts long enough must necessarily reduce the domestic interest rate below its value in the fundamental steady state. To see this, we can rewrite the credit market clearing condition of Equation (19) as

$$\frac{R_{t+1} \cdot R^*}{R^* - \lambda_B \cdot R_{t+1}} = \frac{\sum\limits_{j \in \{N,H\}} \left(\lambda_j \cdot r_{j,t+1} \cdot K_{j,t+1}\right) + m_{t+1} + E_t\left(V_{t+1}\right)}{\phi \cdot \left(\sum\limits_{j \in \{N,H\}} \left(\lambda_j \cdot r_{j,t} \cdot K_{j,t}\right) + m_t + V_t \right)}, \tag{24}$$

where we have taken into account that the net worth of banks in period t is a fraction of the repayment of loans by old entrepreneurs in that same period. In a fundamental steady state, $V_t = 0$ in all periods and the right-hand-side of the expression equals ϕ^{-1}. Consider instead a bubbly (pseudo) steady state, to which the economy converges if it stays in the bubbly state long enough. In such a state, we have $V_t = V_{t+1} = V > 0$,[16] while

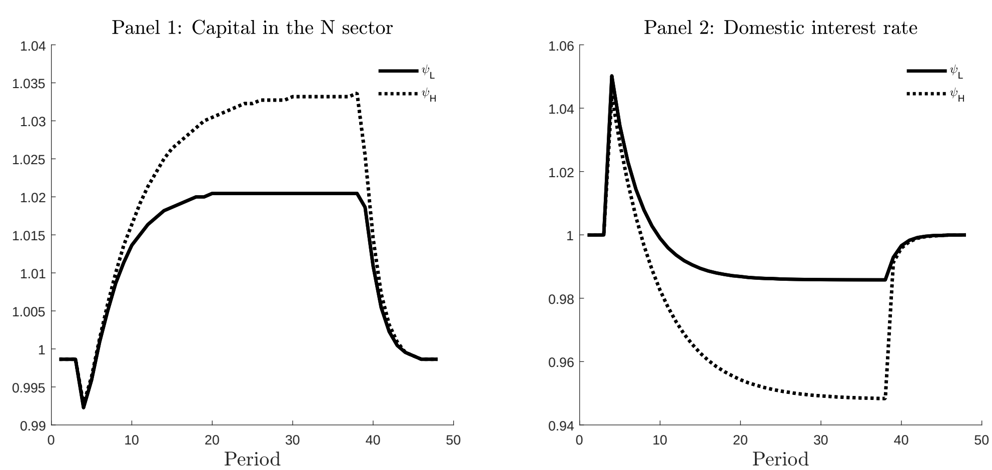
$$E_t\left(V_{t+1}\right) < (1-\psi)\cdot V < V.$$

Thus, the expected value of land is smaller than its realized value, because the former takes into account the possibility that the bubble may burst. Thus, the right-hand-side of Equation (24) is smaller than ϕ^{-1}. Since the left-hand side is an increasing function of the interest rate, it follows that – as long as $\psi > 0$ – the interest rate must be smaller in the bubbly (pseudo) steady state than in the fundamental one.

Intuitively, a housing bubble raises both credit demand, which crowds out credit to the non-housing sector, and credit supply, which crowds in credit to that sector. It is the relative strength of these two effects that determines the overall sign of financial transmission. Crucially, the expansion in credit demand is proportional to the increase in the collateral of housing entrepreneurs, i.e., to the expected value of land $E_t(V_{t+1})$. The expansion in credit supply is instead proportional to the increase in the actual payments made by housing entrepreneurs, i.e., to the realized value of land V_t. As long as $\psi > 0$ and the bubbly episode is risky, $E_t(V_{t+1}) < V_t$ because the former takes into account the probability of a crash. This is why bubbly episodes eventually raise the relative supply of credit and reduce the domestic interest rate.

This effect is stronger the riskier is the bubbly episode, i.e., the higher is ψ. This is illustrated in Figure 7, which reproduces the evolution of the interest rate and of the capital stock in the non-housing sector for the same bubbly episode of Figure 6 under two alternative values of ψ, ψ_H and ψ_L, with $\psi_H > \psi_L$.

Figure 7: The effect of bubble riskiness



Notes: All variables are normalized to 1 in the fundamental steady state. The parameter values for the simulation shown in this figure are given in Appendix A.

[16] The value of land must necessarily converge to a finite value V: if this were not the case, it would outgrow the economy and thus the net worth of banks, eventually violating feasibility. It is easy to show that $V = \frac{1-\psi}{1-\psi-R}\cdot N$.

As the figure shows, the riskier bubbly episode leads to a larger decline in the steady-state interest rate and to a larger credit and investment boom in the non-housing sector. Naturally, it also leads to a larger bust when the bubbly episode ends and the economy reverts to the fundamental state.

4.3 Testable predictions: the role of bank and firm heterogeneity

4.3.1 Taking the model to the data

Our model has three specific predictions regarding the financial transmission mechanism of a housing bubble to non-housing sectors. Initially, a housing bubble raises the demand of credit by the housing sector and crowds out credit to the non-housing sector. Over time, as the net worth of banks rises and the supply of credit expands, this gives rise to a crowding-in effect. Provided that it lasts long enough for the crowding-in effect to dominate, the bursting of a bubble reduces credit to the non-housing sector.

To test these predictions, we analyze the Spanish boom-bust cycle in housing prices between 1995 and 2015. Obviously, testing our predictions with aggregate data would be impossible, as it would require constructing a counterfactual time series for non-housing credit growth in the absence of the bubble. We therefore rely on cross-sectional evidence, exploiting the fact that not all Spanish banks were equally exposed to the housing bubble. Intuitively, we then expect the crowding-out and crowding-in effects to operate at the bank-level, and to be especially strong for highly exposed banks.

To analyze these issues in greater detail and derive more rigorous testable predictions, we now discuss a simple extension of our model that explicitly introduces heterogeneous banks. We provide only an intuitive discussion in the main text and refer the interested reader to Appendix A for a detailed derivation of all equilibrium conditions.

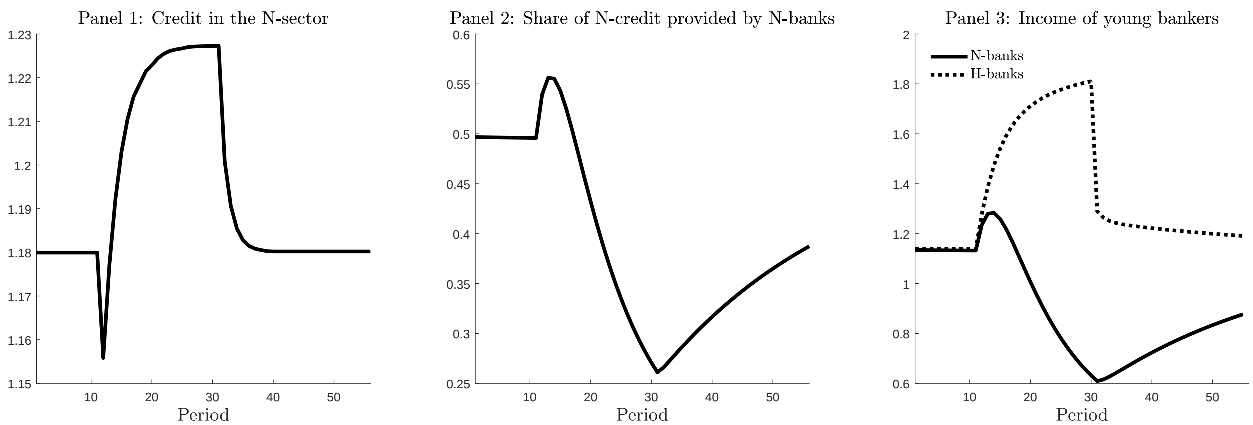
4.3.2 A model with bank and firm heterogeneity

Consider a slight variation of our model in which there are two types of bankers, which we call H- and N-bankers. While H-bankers can lend to all entrepreneurs, N-bankers can only lend to entrepreneurs in the non-housing sector. Thus, H-banks have a comparative advantage in housing, and are therefore better equipped to lend to this sector when a bubble appears.

All aggregate effects discussed in the previous sections are unchanged in this extended model. In particular, as shown in Panel 1 of Figure 8, total credit for non-housing entrepreneurs follows the same pattern of crowding-out, crowding-in and eventual bust described in the previous sections. However, there are now additional implications at the bank level. On impact, a housing bubble raises the demand for credit from

H-banks and thus the interest rate at which these banks lend. In response to this increase, non-housing entrepreneurs – who can borrow from both types of banks – shift their credit demand towards N-banks, as illustrated in Panel 2. The shift equalizes interest rates between both types of banks but, as Panel 1 shows, it cannot prevent a fall in total borrowing by non-housing entrepreneurs.

Figure 8: A housing bubble with heterogeneous banks



Notes: The parameter values for the simulation shown in this figure are given in Appendix A.

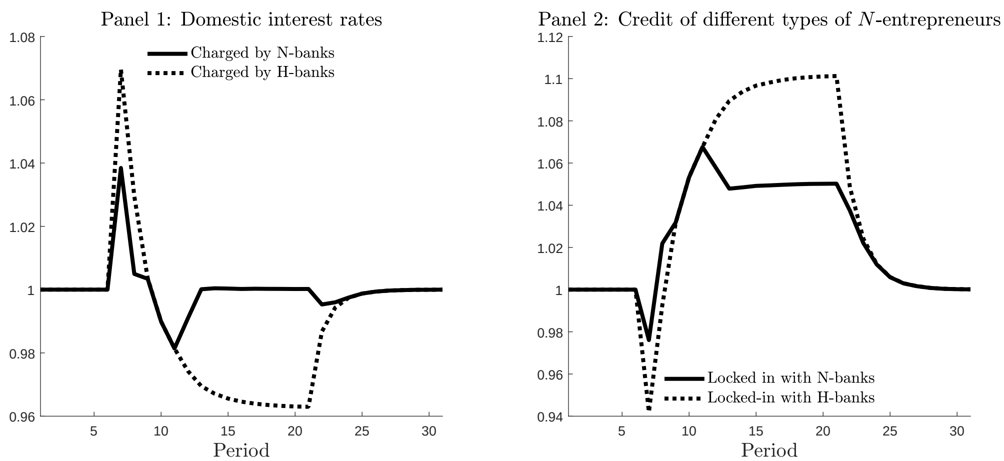
Over time, the bubble raises the supply of credit and the initial crowding-out effect gives way to crowding-in. Panel 3 shows that the increase in profits generated by the bubble is stronger for H-banks, because they are the only ones able to lend to housing entrepreneurs. Therefore, the relative credit supply of H-banks expands, and eventually raises these banks' share of lending to non-housing entrepreneurs (see Panel 2).[17] This analysis yields a first series of testable hypotheses. If banks differ in their exposure to a housing bubble, the effects of the bubble on their relative supply of credit should differ as well. During the first years of a bubble, we should observe a decline in the relative credit that non-housing firms obtain from more exposed banks.[18] In its later years, however, we should observe exactly the opposite pattern, with non-housing firms borrowing more from more exposed banks. Finally, the bubble burst should induce non-housing firms to switch back to less exposed banks again. If our mechanism is correct, moreover, these effects should be driven by the evolution of bank net worth: in particular, we should observe that the profits and net worth of banks that are highly exposed to the housing bubble grow more during the bubbly episode than those of banks with limited exposure to the bubble.

[17]The profits of N-banks evolve non-monotonically. Initially, they increase because non-housing entrepreneurs shift their demand of credit to N-banks, increasing the latters' interest rates and loan volumes. Eventually, as lending by H-banks expands alongside their net worth, the profits of N-banks fall, as they lose part of their clients. In general, note that the evolution of profits is driven by loan volumes rather than by profit margins. Profit margins for individual loans evolve non-monotonically, tracking the evolution of the equilibrium interest rate.

[18]The amount of credit that a single non-housing entrepreneur obtains from N-banks or H-banks is indeterminate, as all banks charge the same interest rate. For the average non-housing entrepreneur, though, the statement is true.

This extended model generates variation across banks, but it does not generate variation among non-housing entrepreneurs, because they all face the exact same credit supply. This changes if we assume that some entrepreneurs are locked into borrowing from their current bank, perhaps because changes in banking relationships are costly. An extreme version of this is illustrated in Figure 9, where we assume that only a fraction of non-housing entrepreneurs can borrow from both types of banks. The remainder is locked-in either with H- or with N-type banks and can only borrow from that particular type.

Figure 9: Bank heterogeneity and locked-in entrepreneurs



Notes: All variables are normalized to 1 in the fundamental steady state. The parameter values for the simulation shown in this figure are given in Appendix A.

As before, non-housing entrepreneurs that can borrow from both types of banks shift part of their borrowing from H- to N-banks during the beginning of the bubbly episode, and from N- to H-banks in later periods. However, these shifts may not be sufficient to equalize interest rates across banks. When this is the case, as in the simulation depicted in Figure 9, the start of a housing bubble raises the relative interest rate charged by H-banks (see Panel 1). This implies that non-housing entrepreneurs locked-in with these banks have lower credit (and investment) growth than non-housing entrepreneurs that are locked-in with N-banks (see Panel 2). This pattern is reversed in later periods: as the credit supply of H-banks increases, their relative interest rate falls and the non-housing entrepreneurs locked in with them exhibit higher credit (and investment) growth than non-housing entrepreneurs locked in with N-banks. Finally, when the bubble bursts, non-housing entrepreneurs locked in with H-banks suffer a larger contraction in credit.

This yields a second line of testable predictions. If there is a cost to switching banks, the pattern of crowding-in and crowding-out effects that we observe at the bank level should generate firm-level effects as well. Concretely, firms that are exposed to H-banks should exhibit lower credit growth during the first years of the bubble, but higher credit growth as time passes by. Finally, when the bubble bursts, these same firms should exhibit a larger drop in credit.

Summing up, this simple extension of our model shows how, in the presence of bank and firm heterogeneity, we can test for crowding-in and crowding-out effects using micro data.[19] We now turn to these tests.

5 Empirical evidence

In order to test our model's predictions, we focus on Spain's experience during the 1995-2015 housing boom and bust. We first describe the different databases that we use in Section 5.1. Section 5.2 then discusses our identification strategy, based on bank-firm level regressions. Our baseline results are presented in Section 5.3, together with some robustness checks as well as direct evidence on the net worth channel at the bank level. Finally, Section 5.4 documents evidence of financial transmission at the firm level.

5.1 Data

We use information from the following data sources:

Credit Registry data (CIR): CIR — *Central de Información de Riesgos* in Spanish — is maintained by the Bank of Spain in its role as primary banking supervisory agency, and contains detailed monthly information on all outstanding loans over 6,000 euros to non-financial firms granted by all banks operating in Spain since 1984.[20] Given the low reporting threshold, virtually all firms with outstanding bank debt appear in the CIR. For each loan, the CIR provides the identity of the parties involved, allowing us to match the loan-level data from CIR with administrative data on firm-level characteristics. For each month, we define each bank-firm relationship as a loan by aggregating all outstanding loans for the bank-firm pair.

Bank-level data: From 1991 onward, the CIR also contains information on banks' balance sheets. This data allows us to compute bank-specific measures of bubble exposure. Moreover, using this information we can also account for bank-specific characteristics such as size, capital and liquidity ratios, or default rates.

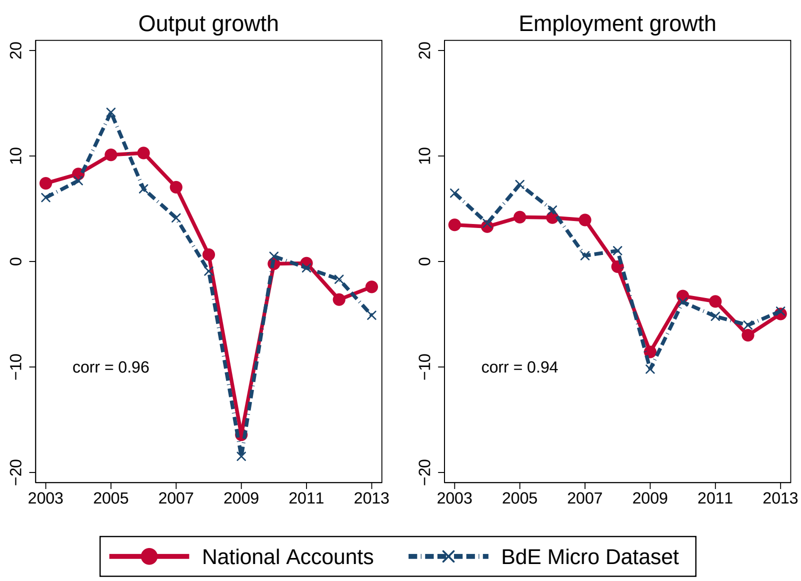
Firm-level data: Turning to the firm-level characteristics, we use administrative data taken from the Span-

[19] Of course, our results rely on strong assumptions: some entrepreneurs cannot borrow from certain types of banks, and there is no market for interbank lending. However, these assumptions can be relaxed. As long as some banks are better suited to lend to housing entrepreneurs than others and there are frictions that make bank lending relationships persistent, the effects of bubbles are bound to be different across banks and entrepreneurs. Furthermore, if these frictions were irrelevant in the data, we should just obtain insignificant results in all our regressions.

[20] In our analysis, we use total credit, which is the sum of promised and drawn credit lines. Our results do not change if we only consider drawn credit.

ish Commercial Registry, which contains the balance sheets of the universe of Spanish companies (as firms have a legal obligation to deposit their balance sheets at the Commercial Registry). For each firm, among other variables, it includes information on the firm's name, fiscal identifier, sector of activity (4-digit NACE Rev. 2 code), 5-digit zip code location, net operating revenue, material expenditures (cost of all raw materials and services purchased by the firm in the production process), number of employees, labor expenditures (total wage bill, including social security contributions) and total fixed assets.

Figure 10: Micro-aggregated output and employment growth



The final sample covers balance sheet information for a total of 1,801,955 firms with an average of 993,876 firms per year. The firm-level database covers around 85-90% of the firms in the non-financial market economy for all size categories in terms of both turnover and number of employees. Moreover, the correlation between micro-aggregated employment (and output) growth and the National Accounts counterparts is around 0.95 over the period 2003-2013 (see Figure 10). Since the coverage is high and stable from 2003 onward, we start our analysis in that year. Almunia et al. (2018) describe this database in greater detail.

Municipality-level data: We construct housing price indexes at the municipality level using the census micro-data on real-estate transactions. This dataset is provided by the Spanish Ownership Registry (Registro de la Propiedad) to the Bank of Spain since 2004, and contains the census of transactions on real-estate assets with information on prices, size of the assets in square meters and the geographic location (municipality) of each transaction. We calculate the price per square meter for each transaction and then aggregate those prices for all transactions made in a municipality during a natural year to create yearly median prices per square meter from 2004 to 2013. We keep only those municipalities with more than 25 recorded transactions in a given year.

Table A.8 in the Appendix provides summary statistics for all variables considered throughout the paper.

5.2 Identification strategy

In the presence of bank heterogeneity, our model has two distinct predictions regarding financial transmission during the boom. In the first years of the bubble, the crowding-out effect dominates, so that non-housing firms exhibit lower credit growth from banks with high exposure to the housing bubble. In later years, the crowding-in effect dominates, so that the opposite pattern is observed. The Spanish experience provides a great opportunity to test these predictions, as we have detailed data on the characteristics of banks and their credit to different firms.

However, there are still two key difficulties. First, we need to isolate the variation in bank-firm credit which is due to changes in the credit supply of banks. We do this by comparing the evolution of credit for the same firm by different banks, as in Khwaja and Mian (2008). Second, we need to isolate the changes in the credit supply of banks that are caused by exposure to the housing bubble. This requires finding an exogenous measure of exposure. We do this by considering banks' specialization in housing-related credit before the start of the bubble.

More formally, in order to address the first challenge, we estimate, for a sample of non-housing firms (covering both manufacturing and services) the following empirical specification:

$$\text{Credit\_growth}_{fbt} = \beta_t \text{E}_{b0} + \theta_t X_{bt-1} + \delta_t W_{fbt-1} + \eta_{ft} + u_{fbt} \tag{25}$$

where $\text{Credit\_growth}_{fbt}$ refers to credit growth of firm f with bank b in year t. E_{b0} measures bank b's bubble exposure (which we discuss in detail below). X_{bt-1} stands for a set of bank controls, namely the natural logarithm of total assets, capital ratio, liquidity ratio, and default rate. Finally, W_{fbt-1} refers to firm-bank controls, namely, the length of the firm-bank relationship in months and a dummy for past defaults.

Crucially, by having firms borrowing from several banks at the same time, we can also include time-variant firm fixed effects η_{ft} into Equation (25). These account for firms' credit demand, as in Khwaja and Mian (2008). More precisely, our identification compares the same firm borrowing from two different banks in a given period. Thus, as credit demand is kept constant, differences in credit growth can be attributed to the supply side, for instance, to differences in bubble exposure across the two banks.

This identification relies on the crucial assumption that firms' credit demand is the same for all banks and/or that banks' credit supply is not firm-specific. A recent contribution by Paravisini et al. (2017) suggests that this assumption may be violated in the presence of bank specialization. However, in our case, there are three points that alleviate this concern. First, we include bank-firm covariates in our regressions (W_{fbt-1}) and therefore control for relationship lending to some extent. Second, if bank exposure (E_{b0}) is exogenous, the β estimates would be unbiased even in the presence of bank specialization (see Amiti and Weinstein (forthcoming)). Third, a switch in the sign of the estimates for β during a bubbly episode (as predicted by our model) would be difficult to explain with bank specialization alone.[21]

Turning to the second challenge described above, we measure the exposure of a given bank b to the bubble by the ratio of mortgage-backed credit over total credit before the beginning of the bubble:[22]

$$\mathrm{E}_{b0} = \text{bubble exposure}_{b0} = \frac{\text{mortgage-backed credit}_{b,1992-1995}}{\text{total credit}_{b,1992-1995}} \tag{26}$$

This measure provides us with a source of variation in banks' bubble exposure that predates the beginning of the housing bubble, and can thus be considered as exogenous to the extent that the bubble was an unanticipated event. Of course, bubble exposure may still be correlated with some bank characteristics. To alleviate this concern, we introduce a large number of bank controls in Equation (25), and we also show that our results do not change if we use an alternative exposure measure.

5.3 Main results

5.3.1 Annual estimates

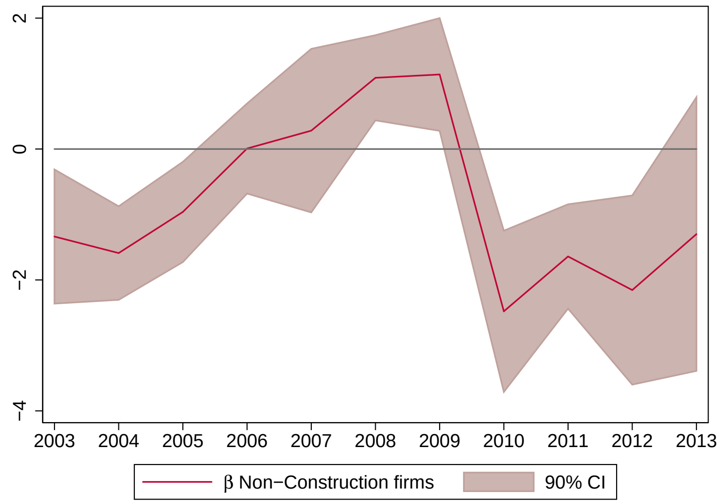
Figure 11 plots the estimated β_t coefficients estimated from Equation (25). As emphasized above, the inclusion of firm-year fixed effects ensures that we are comparing the difference in credit growth of the same firm with two different banks (with different bubble exposures) in each year.

The effect of bank bubble exposure on credit growth of non-housing firms is negative between 2003 and 2005, becomes positive in 2007-2009 and turns negative after the bubble burst in 2010-2013. This pattern supports the crowding-in and crowding-out effects described by our model, and allows us to identify their timing.

[21] We would expect bank specialization to be much more problematic if we performed the estimation on a sample of housing firms. In our model, changes in credit supply are the same for housing and non-housing firms. Thus, as we control for credit demand, estimating Equation (25) on a sample of housing firms should in principle give the same β coefficients than an estimation for a sample of non-housing firms. However, if the effects of the bubble are concentrated among some housing firms, one should be worried that this regression actually picks up a demand effect for banks specialized in lending to housing projects.

[22] Note that mortgage-backed credit includes loans to firms and households.

Figure 11: Bubble exposure and credit growth for non-housing firms.



Notes: This plot shows the OLS estimates of the β_t coefficient from Equation (25) in a sample of non-housing firms.

According to our estimates, the crowding-out effect dominates until 2006, while crowding-in takes over at the very end of the housing boom, from 2007 to 2009. This result may be surprising at first, given that Spain's economic crisis already started in 2008. However, our data (see Figure 2) indicate that house prices peaked in 2008. Furthermore, as discussed in much greater detail in Santos (2017b), the Spanish banking system still appeared relatively stable in 2008 and 2009. The share of non-performing loans for construction and real estate firms did not exceed 5% at the end of 2008 and 10% at the end of 2009 (it was to reach more than 35% at the peak of the crisis). Most bank balance sheets were still growing through 2009.[23] In this context, it is not surprising that we observe the crowding-in effect predicted by our model for the last stages of the bubble. Finally, a negative effect emerges from 2010 onward, when the banking crisis started in earnest.

In light of the annual pattern in Figure 11, Table 1 presents the estimates for three selected years. Columns (1) to (3) report our estimates for Equation (25) in 2004, 2008 and 2012. In 2004, crowding-out dominated. The same non-housing firm had lower credit growth with more exposed banks than with less exposed banks: a one standard deviation increase in banks' exposure reduced annual credit growth by 1.59 percentage points. However, in 2008, crowding-in dominated, and credit growth at more exposed banks became higher. Finally, during the bust in 2012, non-housing firms had lower credit growth at more exposed banks. These three effects are significant not only statistically but also economically: the estimated impact of banks' bubble exposure on bank-firm credit growth represents 18% of the average growth rate in 2004 (8.62), 31% in 2008 (3.51), and 75% in 2012 (-2.88).

[23] See Santos (2017b), Figure 1 (P.2) and Figure 2 (P.3). Only one small bank needed to be rescued before 2010.

Table 1: Bubble exposure and credit growth at the bank-firm level: baseline results

	Firm fixed effects			Firm controls			Firm controls (multibank)		
	2004	2008	2012	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bank bubble exposure	-1.59***	1.09***	-2.15**	-1.57***	1.18**	-2.32**	-1.74***	1.22**	-2.46**
(s.e.)	(0.48)	(0.43)	(0.96)	(0.60)	(0.55)	(1.03)	(0.64)	(0.57)	(1.15)
Average dep. variable	8.62	3.51	-2.88	11.30	5.58	-2.13	11.53	5.87	-1.58
Firm fixed effects	YES	YES	YES	NO	NO	NO	NO	NO	NO
Firm controls	NO	NO	NO	YES	YES	YES	YES	YES	YES
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry × municipality FE	NO	NO	NO	YES	YES	YES	YES	YES	YES
Multiple banks per firm	YES	YES	YES	NO	NO	NO	YES	YES	YES
Balance-sheet data	NO	NO	NO	YES	YES	YES	YES	YES	YES
R-sq	0.37	0.35	0.34	0.18	0.15	0.19	0.19	0.17	0.20
# observations	549,964	666,849	504,233	410,624	499,585	389,384	352,070	426,772	331,267
# firms	179,423	207,796	160,736	179,509	214,419	177,449	120,955	141,606	119,332
# banks	118	111	62	115	110	61	114	108	61

Notes: All regressions are based on Equation (25) and have annual credit growth at the bank-firm level as the dependent variable. Bank bubble exposure is proxied by the share of mortgage-backed credit (E_{b0}). Bank controls are the natural logarithm of total assets, capital ratio, liquidity ratio, and default rate. Firm-bank controls are the length of firm-bank relationship in months and a dummy for past defaults. Firm controls are total assets, number of employees, own funds over total assets, return on assets, a dummy for young firms (less than three years old), and an exporter dummy. To ease the interpretation, the bank bubble exposure regressor has zero mean and unit variance. Standard errors multi-clustered at the bank and firm level in parentheses.

In columns (4)-(6), we substitute firm fixed effects by a rich set of firm controls together with a set of industry-municipality fixed effects, as in Bentolila et al. (forthcoming). The firm controls included are total assets, number of employees, own funds over total assets, return on assets, a dummy for young firms (less than three years old), and an exporter dummy. This allows us to consider the universe of borrowing firms instead of only firms borrowing from more than one bank (multibank firms), with the firm-level variables controlling for credit demand. Finally, columns (7)-(9) report estimates from the same specification with firm controls but using the same sample of multibank firms used in columns (1)-(3). In both cases, the results remain virtually unchanged.[24]

Table A.2 in the Appendix presents the OLS and IV counterparts to these reduced-form regressions. More specifically, we regress annual credit growth on contemporaneous exposure (banks' share of mortgage-backed credit, E_{bt}) instrumented with initial exposure (E_{b0}). Looking at IV estimates in columns (4)-(6), the estimated effects are even larger. Moreover, the first-stage estimates reported in Panel B of Table A.2 confirm that our instrument is relevant, with F-statistics well above 10 in most specifications (Stock and Yogo (2005)).[25]

[24] Table A.3 in the Appendix also shows that our baseline estimates in Table 1 are robust to the exclusion of saving banks (*cajas de ahorros*) from the sample.

[25] As there are as many instruments as endogenous variables, we cannot test for overidentifying restrictions (see Hansen (1982)).

These results are consistent with the existing empirical literature, and enable us to reinterpret some of its findings. Jimenez et al. (2014) have used a similar measure of exposure of Spanish banks to real estate (although they interpret it as a proxy for access to securitization), and used it to analyze the (positive) effect of this exposure on credit supply. Despite there being some differences between their empirical specification and ours, their results are broadly in line with the estimates reported in Table 1: an initial negative effect of bank exposure on the credit growth of non-housing firms[26] and an eventual positive effect. Looking at the data through the lens of our model, however, enables us to interpret it differently. In our analysis, the ratio of mortgage-backed credit over total credit is a proxy for bubble exposure, and the empirically observed crowding-out and crowding-in effects are two manifestations of the same financial transmission mechanism. Indeed, the pattern uncovered in Figure 11 and Table 1 allows us to reconcile the apparently conflicting findings in Jimenez et al. (2014) and Chakraborty et al. (2017). While Jimenez et al. (2014) highlight the positive effect of banks' exposure to housing on credit of non-housing firms in Spain, Chakraborty et al. (2017) find that banks that were more exposed to housing prices growth in the United States reduced corporate credit. Our analysis suggests that crowding-out and crowding-in effects are not incompatible, but just operate at different points in time.

5.3.2 An alternative proxy for bubble exposure

Our baseline estimates use banks' shares of mortgage-backed credit as a proxy for their exposure to the housing bubble. In this section, we consider an alternative proxy, based on the geographical distribution of banks' activities. We follow the empirical strategy introduced in Saiz (2010) and adapted to Spain by Basco and Lopez-Rodriguez (2017), by using housing supply elasticities as an exogenous source of variation in housing prices at the municipality level. Their measure of housing supply elasticity is the ratio of potential plot surface over the built urban surface for a Spanish municipality, computed using census data from the Spanish Cadastre (Catastro) in 1995, before the start of the housing bubble and the soil liberalization laws.[27] We then construct a bank-specific exposure measure following the approach in Chakraborty et al. (2017), exploiting differences in the geographical distribution of banks' activities:

$$\mathrm{E}_b^{HSE} = \text{bubble exposure}_b^{HSE} = \sum_m \omega_{bm} HSE_m \tag{27}$$

[26] Note that their initial negative effect is not statistically significant. However, it is worth emphasizing that in their 2001-2004 regression (column 8 of Table V in their paper), there is an additional difference with respect to our baseline specification, as they do not include either bank controls or bank-firm controls.

[27] Within potential plot surface, Basco and Lopez-Rodriguez (2017) consider undevelopable total land, excluding protected non-urban areas (e.g. rivers or natural parks), plots classified as of rural use and public goods land (e.g. local surface occupied/covered by transport infrastructure and utilities).

where ω_{bm} refers to the share of total credit of bank b in municipality m in 1995[28] and HSE_m is the housing supply elasticity for municipality m in 1995. Note that the latter measure should be negatively associated with the housing bubble, as municipalities with more available land should have lower housing price increases. In order ease interpretation, we therefore change the sign of the elasticity measure, such that higher values (less land available for construction) correspond to higher bubble exposure (higher housing price increases). We label this variable land unavailability, as in Chakraborty et al. (2017).

Table 2: Bubble exposure and credit growth at the bank-firm level: an alternative exposure measure

	Firm fixed effects			Firm controls			Firm controls (multibank)		
	2004	2008	2012	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bank bubble exposure	-1.09**	0.73**	-1.24**	-1.08**	0.64*	-1.18*	-1.25**	0.68	-1.44**
(s.e.)	(0.48)	(0.34)	(0.53)	(0.52)	(0.39)	(0.64)	(0.58)	(0.46)	(0.70)
Average dep. variable	8.59	3.52	-3.21	11.28	5.59	-2.53	11.49	5.88	-2.07
Firm fixed effects	YES	YES	YES	NO	NO	NO	NO	NO	NO
Firm controls	NO	NO	NO	YES	YES	YES	YES	YES	YES
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry × municipality FE	NO	NO	NO	YES	YES	YES	YES	YES	YES
Multiple banks per firm	YES	YES	YES	NO	NO	NO	YES	YES	YES
Balance-sheet data	NO	NO	NO	YES	YES	YES	YES	YES	YES
R-sq	0.36	0.35	0.33	0.18	0.15	0.18	0.19	0.17	0.19
# observations	566,026	673,608	581,531	420,173	503,907	433,641	361,134	430,580	373,324
# firms	182,724	209,515	180,053	181,181	215,580	189,909	122,142	142,190	129,592
# banks	155	148	117	137	147	116	137	147	116

Notes: See notes to Table 1.

Table 2 reports the estimates using this alternative exposure measure in our baseline specification given by Equation (25). The structure of Table 2 is analogous to that of Table 1 and the estimated effects are also very similar, albeit slightly smaller in magnitude: -1.09 percentage points versus -1.59 in 2004, 0.73 versus 1.09 in 2008 and -1.24 versus -2.15 in 2012.

Panel A of Table A.4 in the Appendix presents the OLS and IV counterparts of the estimates in Table 2. In these estimations, we regress annual credit growth on a bank-specific measure of housing price growth defined as the weighted average of municipality-level housing price growth, where weights are given by the bank's exposure to those municipalities. That is,

$$\mathrm{E}_{bt}^{\Delta HP} = \sum_{mt} \omega_{bmt} \Delta HP_{mt} \tag{28}$$

[28] This share can be constructed by matching the CIR to the firm-level data from the Spanish Commercial Registry. The latter includes zipcodes of firms' headquarters.

where ΔHP_m refers to housing price growth in municipality m at year t, and ω_{bmt} is the bank-municipality credit share. IV estimates in columns (4)-(6) of Table A.4 confirm the pattern of the reduced-form estimates in Table 2. However, the first-stage tests reported in Panel B indicate that bank-specific land unavailability (E_b^{HSE}) is only weakly correlated with bank-specific housing price growth ($E_{bt}^{\Delta HP}$), casting doubt on the reliability of the IV estimates. In any case, we can conclude that our model's predictions are consistent with the data even when we consider a completely different exposure measure than that of our baseline results.

5.3.3 The extensive margin

The crowding-out and crowding-in pattern induced by the housing bubble may not only matter for the intensive margin of credit growth, but also for the formation or the termination of lending relationships. To analyze these effects, we substitute the dependent variable in Equation (25) by two measures for the extensive margin of credit.

Table 3: Bubble exposure and credit growth at the bank-firm level: the extensive margin

	Extensive_Credit_growth			Dropped_loan		
	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)
Bank bubble exposure	-1.50**	2.32***	-3.81***	0.002	-0.01***	0.01***
(s.e.)	(0.73)	(0.63)	(1.47)	(0.002)	(0.00)	(0.00)
Average dep. variable	8.51	-0.08	-4.11	0.13	0.13	0.15
Firm fixed effects	YES	YES	YES	YES	YES	YES
Bank controls	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES
Multiple banks per firm	YES	YES	YES	YES	YES	YES
R-sq	0.48	0.35	0.34	0.47	0.35	0.34
# observations	641,480	781,875	596,034	638,658	784,769	608,198
# firms	204,764	240,195	187,181	203,998	240,671	189,574
# banks	117	110	62	117	110	62

Notes: Bank bubble exposure is proxied by the share of mortgage-backed credit (E_{b0}). All regressions are based on Equation (25), but consider two alternative dependent variables, Extensive_Credit_growth and Dropped_loan. Bank controls are the natural logarithm of total assets, capital ratio, liquidity ratio, and default rate. Firm-bank controls are the length of firm-bank relationship in months and a dummy for past defaults. To ease the interpretation, the bank bubble exposure regressor has zero mean and unit variance. Standard errors multi-clustered at the bank and firm level in parentheses.

First, we follow Chodorow-Reich (2014) and consider a measure of credit growth of firm f with bank b in year t that incorporates the creation of new lending relationships and the termination of existent loans:

$$\text{Extensive\_Credit\_growth}_{fbt} = \frac{\text{Credit}_{fbt} - \text{Credit}_{fbt-1}}{0.5 \cdot (\text{Credit}_{fbt} + \text{Credit}_{fbt-1})} \tag{29}$$

This definition yields a growth measure that is symmetric around zero and bounded between -2 and 2, providing an integrated treatment of new loans, ended loans, and continuing loans.

Second, we analyze how banks' bubble exposure affects the probability of ending a credit relationship by considering as dependent variable a dummy that takes the value one if a given bank-firm (loan) pair was active in year $t-1$ but it is not active in year t ($\text{Dropped\_loan}_{fbt}$).

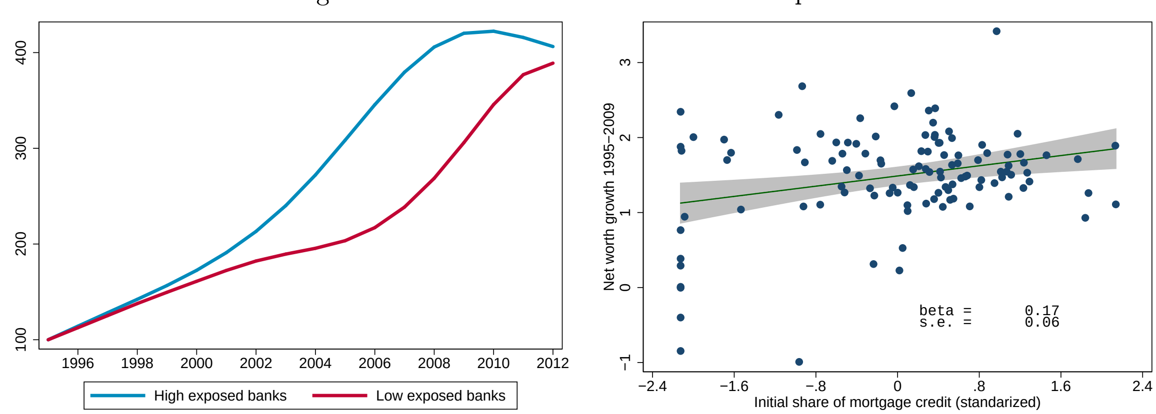
Table 3 presents the results. Columns (1)-(3) consider the extensive-margin growth rate defined in Equation (29) as dependent variable. The crowding-out estimate in column (1) is very similar to that of Table 1. However, the magnitude of the crowding-in effect is significantly larger now, which can be seen by comparing the coefficient estimate for 2008 with the average growth rate that is close to zero in that year. Finally, the negative effect of bank bubble exposure during the bust is also larger. Thus, taking into account the extensive margin of credit strengthens our results.

Columns (4)-(6) in Table 3 consider Dropped_loan as the dependent variable. Banks more exposed to the bubble are more likely to terminate a lending relationship with non-housing firms in 2004, even though the point estimate is not significant. In contrast, those banks are less likely to do so in 2008 and more likely again during the bust in 2012.

5.3.4 Bank net worth channel

In the model, the financial transmission mechanism documented above is driven by the evolution of bank profits as the bubble develops. In particular, the profits and net worth of banks more exposed to the housing bubble grow faster throughout the entire bubbly episode.

Figure 12: Banks' net worth and bubble exposure



Notes: In the left panel, high (low) exposed banks are those above (below) the 90th (10th) percentile of the share of mortgage credit before 1995. In the right panel, each dot represents a bank.

This pattern is confirmed in the data, as shown in the left panel of Figure 12. Moreover, the right panel of Figure 12 confirms that there is a positive and significant correlation between banks' bubble exposure (initial share of mortgage credit) and the growth of net worth over the 1995-2009 period. Table A.5 in the Appendix shows that this association is still positive and significant when controlling for other bank characteristics in the regression.

5.4 Firm-level analysis

5.4.1 Baseline

We now turn to the analysis at the firm level. As we have argued before, in the absence of costs for switching banks, non-housing firms which initially borrowed from banks exposed to the bubble should not behave any differently from non-housing firms which initially borrowed from other banks. When switching banks is costly, however, the crowding-out and crowding-in effects of financial transmission should also materialize at the firm level. In order to identify these effects, we consider the following regression:

$$\text{Credit\_growth}_{ft} = \beta_t \text{E}_{ft} + \theta_t X_{ft-1} + v_{ft} \tag{30}$$

where $\text{Credit\_growth}_{ft}$ refers to overall credit growth of firm f in year t. X_{ft-1} refers to a set of firm controls, namely, total assets, number of employees, own funds over total assets, return on assets, a dummy for young firms (less than three years old), and an exporter dummy. A set of industry-municipality fixed effects is also included. Finally, E_{ft} refers to exposure to the bubble of firm f computed as a weighted average of bank-level exposures as follows:[29]

$$\text{E}_{ft} = \sum_b \frac{\text{credit}_{fbt}}{\text{credit}_{ft}} \text{E}_{b0} \tag{31}$$

Table 4 present the estimated coefficients for Equation (30) for the three selected years. Columns (1)-(3) refer to the sample of all firms while columns (4)-(6) are based on a sample of multibank firms, as in our baseline specification in Section 5.3. In both cases, we find strong evidence in favor of the successive crowding-out and crowding-in predicted by the model, suggesting that non-housing firms are unable to fully undo the effects of bubble-induced credit supply shocks. This is consistent with the notion that switching banks is costly for firms. However, the estimated effects are lower than those at the bank-firm level shown in Table 1, pointing to some firms switching towards other banks.

[29] Ideally, weights should be measured before the bubble started in order to enhance exogeneity. However, the number of observations would be drastically reduced given that many bank-firm relationships active in 2004, 2008, and 2012 were not active in 1995. In any case, our estimates remain similar if we use lagged shares based on credit_{fbt-1} and credit_{ft-1}.

Table 4: Bubble exposure and credit growth at the firm level

	All firms			Multibank firms		
	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)
Firm bubble exposure	-1.03**	1.16***	-2.39***	-1.87**	1.07***	-3.06***
(s.e.)	(0.51)	(0.29)	(0.73)	(0.68)	(0.32)	(1.01)
Average dep. variable	19.11	10.65	4.21	26.93	16.39	11.64
Firm controls	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES
Industry × municipality FE	YES	YES	YES	YES	YES	YES
Only multibank firms	NO	NO	NO	YES	YES	YES
Balance-sheet data	YES	YES	YES	YES	YES	YES
R-sq	0.30	0.26	0.33	0.31	0.29	0.35
# observations	153,030	187,920	158,287	87,468	107,646	93,290

Notes: The dependent variable is annual credit growth at the firm level in all columns. Bank bubble exposure is proxied by the pre-boom share of mortgage-backed credit at the firm-level (E_{ft}). All regressions are based on Equation (30). Firm-bank controls are the length of firm-bank relationship in months and a dummy for past defaults. Firm controls are total assets, number of employees, own funds over total assets, return on assets, a dummy for young firms (less than three years old) and an exporter dummy. To ease the interpretation, the bank bubble exposure regressor has zero mean and unit variance. Standard errors multi-clustered at the main bank and industry-municipality level in parentheses.

The magnitude of the estimated effects is significant not only statistically but also economically, especially in the sample of all firms. In 2004, for instance, the crowding out effect of a one standard deviation increase in bubble exposure represents approximately -5% of the average credit growth in the sample. The crowding in is even larger in magnitude, representing 11% of the average sample credit growth.

Table A.6 in the Appendix reports the OLS and IV estimates, which corroborate the main conclusions from Table 4. Furthermore, in Table A.7, we consider an alternative proxy for a firm's bubble exposure, the bubble exposure of its main bank (i.e., the bank from which the firm borrows most). Again, these results corroborate our main findings in Table 4.

5.4.2 Cumulative effects

All our results so far have been based on year-to-year growth rates. In this section, we instead explore the overall effect of the housing bubble on non-housing firms. For that purpose, we consider a permanent sample including 28,709 non-housing firms that are observed in our data in every year between 2002 and 2012.

Using this sample, we first confirm that our baseline estimates at the firm level reported in Table 4 also hold in the sample of permanent firms. Then, we substitute the dependent variable in Equation (30) in order to consider the cumulative growth rate since 2002 instead of the annual growth rate.

Table 5: Bubble exposure and cumulative credit growth at the firm level.

	2004 (1)	2005 (2)	2006 (3)	2007 (4)	2008 (5)	2009 (6)	2010 (7)	2011 (8)	2012 (9)
Firm bubble exposure	-4.10**	-4.18*	-2.42	-0.04	-0.28	0.83	-0.44	-5.24**	-9.43***
(s.e.)	(2.01)	(2.40)	(2.69)	(3.41)	(3.21)	(2.69)	(2.89)	(2.70)	(3.80)
Average dep. variable	46.94	75.37	107.79	143.22	166.98	166.47	166.55	166.42	168.36
Firm controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry × municipality FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Only multibank firms	NO	NO	NO	YES	YES	YES	YES	YES	YES
Balance-sheet data	YES	YES	YES	YES	YES	YES	YES	YES	YES
R-sq	0.39	0.35	0.37	0.36	0.35	0.38	0.39	0.39	0.39
# observations	28,709	28,709	28,709	28,709	28,709	28,709	28,709	28,709	28,709

Notes. The dependent variable is cumulative credit growth at the firm level between the year 2002 and each of the years in columns (1)-(9). All other aspects are defined as in the notes to Table 4.

Table 5 presents the results. The negative effect induced by the initial crowding-out is statistically significant in cumulative terms until 2005. Afterwards, crowding-in starts and the negative impact of bubble exposure vanishes gradually, becoming positive (but not significant) in 2009. When the bubble bursts, the effect turns negative and significant in cumulative terms. Indeed, a one standard deviation increase in initial firm bubble exposure reduces cumulative credit growth by 9.43 percentage points. Therefore, the overall impact of the housing bubble on non-housing firms in this permanent sample turns out to be negative, as crowding-in is not large enough to compensate either the initial crowding-out by 2009 or the bubble burst by 2012.

5.4.3 Real effects

Finally, we analyze the real consequences of the credit-level results shown so far. Therefore, we estimate again Equation (30), but now use a firm's value added growth instead of credit growth as a dependent variable.[30] Following Chaney et al. (2012) we also saturate the specification with a set of firm fixed effects to account for unobserved heterogeneity that might blur the interaction between financial shocks and real outcomes at the firm level.[31]

Table 6 reports the estimated effects. In columns (1)-(3) we focus on the baseline measure of firm's bubble exposure. The estimated effects show that the differences in credit growth had real consequences: the value added of non-housing firms that borrowed more from more exposed banks grew less than that of their peers

[30] A firm's value added is defined as the difference between sales (net operating revenue) and material expenditures. Results are unchanged if we consider sales instead.

[31] Including firm fixed effects in equation (30) is equivalent to running a set of year-by-year regressions with the variables expressed in deviations from the firm-specific averages. Credit estimates in Table 4 are also robust to this specification.

borrowing from less exposed banks in 2004, while it grew more in 2008. Finally, value added growth was significantly lower in high-exposed firms when the bubble burst in 2012. This pattern remains unchanged when considering only the exposure of the firm's main bank (see columns (4) to (6)).

Table 6: Bubble exposure and value added growth at the firm level

	Baseline exposure			Main bank exposure		
	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)
Firm bubble exposure (E_{f0})	-0.28**	0.42**	-0.52***	-0.21**	0.36**	-0.47***
(s.e.)	(0.12)	(0.20)	(0.11)	(0.10)	(0.16)	(0.12)
Average dep. variable	1.57	-13.43	-6.86	1.56	-13.38	-6.80
Firm controls	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Balance-sheet data	YES	YES	YES	YES	YES	YES
R-sq	0.44	0.45	0.45	0.45	0.45	0.36
# observations	147,082	178,942	170,973	144,063	174,858	162,926

Notes: The dependent variable is annual value added growth at the firm level in all columns. Bank bubble exposure is proxied by the pre-boom share of mortgage-backed credit at the firm-level (E_{ft}). Firm-bank controls are the length of firm-bank relationship in months and a dummy for past defaults. Firm controls are total assets, number of employees, own funds over total assets, return on assets, a dummy for young firms (less than three years old) and an exporter dummy. To ease the interpretation, the bank bubble exposure regressor has zero mean and unit variance. Standard errors multi-clustered at the main bank and industry-municipality level in parentheses.

The magnitude of the real effects estimated in Table 6 is lower than that of the credit effects in Table 4, but still economically significant. For instance, a one standard deviation increase in firm's bubble exposure results in a 0.42 percentage point increase in value added growth, which represents 3% of the absolute value of average value added growth in 2008. This figure is even larger for 2004 (18%) and 2012 (7.5%).

6 Conclusion

Our analysis shows that the credit market plays an important role in transmitting housing bubbles to the rest of the economy. The direction of this transmission mechanism varies over time. Initially, a housing bubble increases credit demand for housing, and therefore crowds out credit and investment from non-housing firms. Eventually, however, the repayment of loans collateralized by the bubble increases banks' net worth and therefore their credit supply to all sectors. We also find that this financial transmission has real effects, as the output of non-housing firms tracks the crowding-out and crowding-in effects on credit.

On the policy front, our findings shed light on the costs and benefits of housing booms and busts. It may well be that housing expansions crowd out credit that is necessary for productive investment in other sectors, as many have argued. However, our findings suggest that this concern is likely to be temporary, because housing bubbles eventually raise credit to all sectors if they last long enough. Of course, housing booms driven by rational bubbles (as in our model) are also intrinsically fragile. Although this is well understood, our model shows that this cost is likely to be large – and to spread well beyond the housing sector – once the bubble makes up a substantial share of banks' net worth. This has natural macroprudential implications that are beyond the scope of this paper.

Finally, it is interesting to note that our results are not limited to housing bubbles, but can be generalized to a broad family of sectoral shocks. In this regard, our results highlight the role of the financial system as a transmitter of sector-level shocks. As long as the financial system faces collateral constraints, the expansion of one particular sector first reduces the availability of credit for other sectors, but eventually stimulates it. Thus, the financial transmission mechanism outlined in this paper can potentially help to explain more general comovement dynamics of economic sectors along the business cycle.

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A Theoretical Appendix

A.1 Labor reallocation and land depreciation

In this section, we relax two simplifying assumptions made in Section 3.1. First, we assume that labor is not sector-specific, but that young entrepreneurs can work in both sectors. Then, we analyze a model in which land does not fully depreciate during production.

A.1.1 A model with mobile labor

We now assume that young entrepreneurs can work both in the H and in the N-sector. To keep the aggregate stock of labor equal to 1, we assume that each of the two types of young entrepreneurs is endowed with 0.5 units of generic labor. In the following, we briefly describe the equilibrium conditions of this model, and then show that the financial transmission mechanism operates just as in our baseline model.

The goods market equilibrium conditions (described by Equations (3) and (4)) are identical to the ones in the baseline model. The situation in the labor market changes, however. Now, labor mobility implies that the wage must be equalized in both sectors, that is,

$$w_t = (1-\alpha_N) \cdot p_{N,t} \cdot A_{N,t} \cdot \left(\frac{K_{N,t}}{L_{N,t}}\right)^{\alpha_N} = (1-\alpha_H-\beta_H) \cdot p_{H,t} \cdot A_{H,t} \cdot \left(\frac{K_{H,t}}{L_{H,t}}\right)^{\alpha_H} \cdot (L_{H,t})^{-\beta_H} . \tag{32}$$

Together with the labor market clearing condition, which implies $L_{N,t} + L_{H,t} = 1$, Equation (32) pins down the equilibrium allocation of labor as a function of capital stocks in both sectors. The returns to capital and land are defined analogously to the baseline model, as

$$r_{j,t} = \alpha_j \cdot p_{j,t} \cdot A_{j,t} \cdot \left(\frac{K_{j,t}}{L_{j,t}}\right)^{\alpha_j - 1} (L_{j,t})^{-\beta_j} , \tag{33}$$

for each sector j, and

$$m_t = \beta_H \cdot p_{H,t} \cdot A_{H,t} \cdot (K_{H,t})^{\alpha_H} (L_{H,t})^{1-\alpha_H-\beta_H} . \tag{34}$$

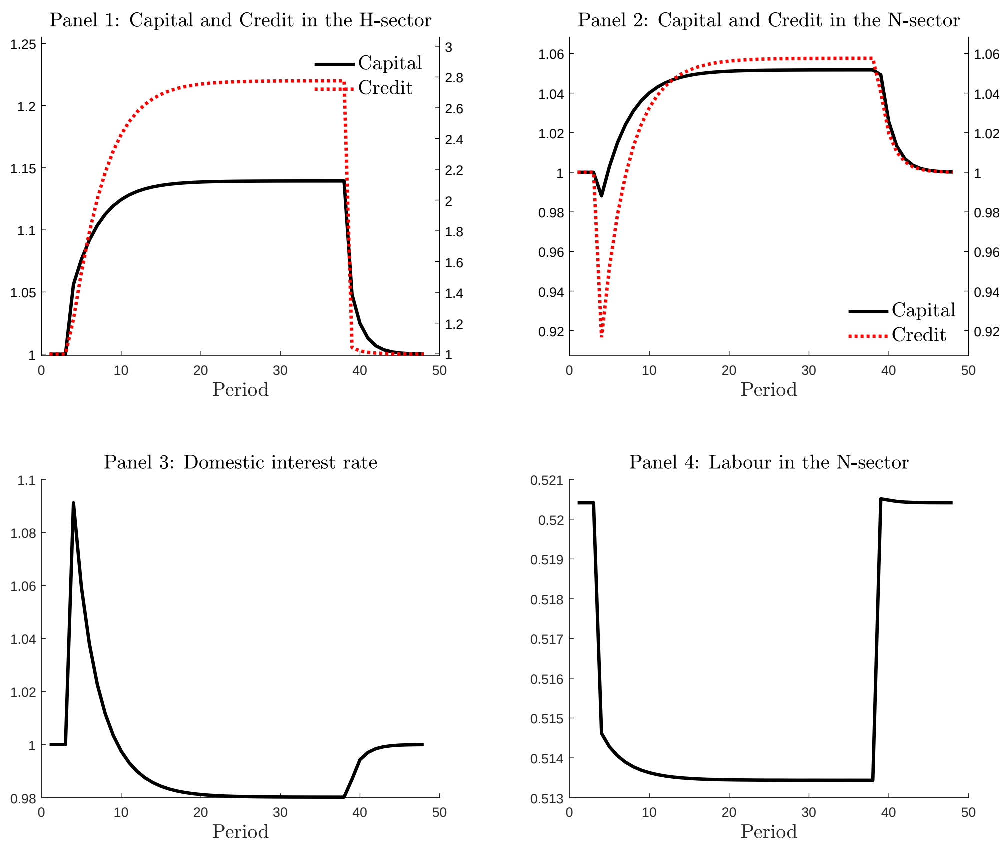
The credit market also works in the same way than in the baseline model. Thus, domestic credit demand is still defined by Equation (13), and the law of motion for the capital stock in sector j is

$$K_{j,t+1} = \frac{R_{t+1}}{R_{t+1} - \lambda_j \cdot r_{j,t+1}} \cdot \left(\frac{w_t}{2} + \mathbb{1}_H \cdot \left[\frac{m_{t+1} + E_t(V_{t+1})}{R_{t+1}} - V_t\right]\right) \tag{35}$$

Likewise, bankers' credit supply is still given by Equation (18). All other equations are unchanged, and the model can then be solved just as our baseline model in the main text.

Figure A.1 plots a bubbly episode in this more general model. Panels 1 to 3 show that all of the predictions described in the main text still hold: a bubble first crowds out credit and investment from the non-housing sector, and then crowds it in. Furthermore, Panel 4 shows that there is now an additional transmission channel through the labor market. As the bubble stimulates credit and investment in the housing sector most strongly, this sector attracts more labor. This, all else equal, lowers the marginal product of capital in the non-housing sector, and constitutes a drag on its capital accumulation that lasts until the bubble bursts.

Figure A.1: A bubbly episode with mobile labor



A.1.2 A model without full land depreciation

We now assume that land does not fully depreciate during the production process. Precisely, we assume that in every period, young housing entrepreneurs are endowed with η units of new land (where $\eta \in (0, 1)$, which can first be used in production in the next period. After production, a fraction $1 - \eta$ of this land remains productive, while the remaining fraction η becomes unproductive. This implies that the total stock of productive land in the economy is constant and equal to one. Formally,

$$T = \eta \cdot \sum_{k=0}^{+\infty} (1-\eta)^k = 1.$$

This does not change most of the model's equilibrium conditions, except for the equations pinning down the value of land. Now, as land does not fully depreciate, "old" vintages have some fundamental value, so V_t is different from zero even in the absence of a bubble. Precisely, we now have, for every vintage τ,

$$V_{\tau,t} = \frac{m_{t+1} \cdot \eta \cdot (1-\eta)^{t-\tau} + E_t\left(V_{\tau,t+1}\right)}{R_{t+1}}. \tag{36}$$

Iterating this equation forward, we get

$$V_{\tau,t} = \eta \cdot (1-\eta)^{t-\tau} \cdot E_t\left(\sum_{s=1}^{\infty} m_{t+s} \cdot \frac{(1-\eta)^{s-1}}{\prod_{k=1}^{s} R_{t+k}}\right) + E_t\left(\lim_{s\to\infty} \frac{V_{\tau,t+s}}{\prod_{k=1}^{s} R_{t+k}}\right). \tag{37}$$

Thus, the aggregate value of land now has both a fundamental and a bubble component. Indeed, we can write

$$V_t = \underbrace{E_t\left(\sum_{s=1}^{\infty} m_{t+s} \cdot \frac{(1-\eta)^{s}}{\prod_{k=1}^{s} R_{t+k}}\right)}_{V_t^F} + \underbrace{E_t\left(\lim_{s\to\infty} \frac{V_{t+s}}{\prod_{k=1}^{s} R_{t+k}}\right)}_{V_t^B}. \tag{38}$$

where V_t^F stands for the fundamental component of land prices and V_t^B for its bubble component. The competitive equilibrium in this model is defined analogously to the baseline, and the bubble process is also defined as in the main text (see Section 4.1). Then, it is clear that our main results will be unaffected: bubble creation still raises credit demand more than credit supply (thus increasing the interest rate and crowding out non-housing credit and investment), but this eventually increases loan repayments to bankers, expands their net worth and triggers a crowding-in effect.

A.2 Bank and firm heterogeneity

A.2.1 Assumptions

In this section, we derive the equilibrium conditions for the extended model with bank and firm heterogeneity described in Section 4.3. In this extension, we assume that there are two different types of bankers, N-

bankers and H-bankers, and three different kinds of entrepreneurs in the non-housing sector: a mass θ_N of entrepreneurs which can only borrow from N-banks, a mass θ_H of entrepreneurs which can only borrow from H-banks, and a mass $1-\theta_N-\theta_H$ of entrepreneurs which can borrow from both banks. Note that in Figure 8, we assume that $\theta_H = \theta_N = 0$, that is, all non-housing entrepreneurs are able to borrow from both banks. In Figure 9, instead, we consider the more general case in which we assume that $\theta_H > 0$ and $\theta_N > 0$, that is, some non-housing entrepreneurs are locked in with one type of bank.

We also assume in this extension that bankers of type j receive an exogenous endowment of x^j units of the final good when they are young. Indeed, without this technical assumption, the share of non-housing credit intermediated by one type of bankers (that is, the relative size of banks) would be indeterminate even in the absence of housing bubbles. This is due to the fact that banker income depends on loan volumes, which creates strong feedback effects: if N-bankers give a lot of credit to non-housing entrepreneurs in period t, young N-bankers in period $t+1$ have high income, which they can use again to lend to non-housing entrepreneurs. Introducing an exogenous endowment, even if it is arbitrarily small, slightly weakens this feedback and allows us to pin down the relative size of banks in the steady state without bubbles.

A.2.2 Equilibrium conditions

Individual optimization Intermediate goods and factor market clearing conditions are unchanged with respect to the baseline model, and therefore still given by Equations (3) to (8). Note that we have

$$K_{N,t} = K_{N,t}^{N} + K_{N,t}^{H} + K_{N,t}^{NH}, \tag{39}$$

where K_N^j stands for the capital stock of non-housing entrepreneurs which can borrow from j-type banks. Thus, the aggregate non-housing capital stock is the sum of the capital stocks held by the three groups of entrepreneurs. As all entrepreneurs supply the same capital, they all receive the same rate of return $r_{N,t}$. We continue to impose parameter conditions ensuring that the return to capital for all entrepreneurs is higher than the interest rate on their loans, which is in turn higher than the international interest rate. The budget constraint for young entrepreneurs of any type j is now

$$K_{j,t+1} = \theta_j \cdot w_{j,t} + \frac{E_t\left(F_{j,t+1}\right)}{R_{j,t+1}} - \mathbb{1}_H V_t, \tag{40}$$

where $R_{j,t+1}$ is the interest rate faced by entrepreneurs of type j. For housing entrepreneurs and non-housing entrepreneurs locked in with H-banks, this is $R_{H,t+1}$, the interest rate of H-banks. For non-housing entrepreneurs locked in with N-banks, it is $R_{N,t+1}$, the interest rate of N-banks. Finally, for non-housing entrepreneurs which can borrow from both banks, it is $\min(R_{N,t+1}, R_{H,t+1})$, as these entrepreneurs always borrow from the cheapest source. Note that it is now possible that the equilibrium interest rate at H-banks differs from the one at N-banks because some entrepreneurs are locked in (they would like to switch to a bank with a lower interest rate, but they cannot), and because banks are financially constrained.[32]

The collateral constraint then implies that credit demand for type j is given by

$$Q_{j,t} = \frac{\lambda_j \cdot r_{j,t+1} \cdot K_{j,t+1} + \mathbb{1}_H (m_{t+1} + E_t(V_{t+1}))}{R_{j,t+1}}, \tag{41}$$

Finally, the behavior of both types of bankers is exactly analogous to the one of the single banker in the model without heterogeneity.[33] Thus, the credit supply of a type-j banker is given by

$$Q^j_{B,t} = \frac{R^*}{R^* - \lambda_B \cdot R_{j,t+1}} \left(\phi \cdot F^j_{Bt} + x^j\right),$$

where $F^j_{B,t}$ denotes the repayments received by type-j bankers.

Credit market clearing Depending on parameter values, the equilibrium can be of three different types. If parameter values are such that $R_{H,t+1} > R_{N,t+1}$, then credit market clearing conditions are given by

$$Q^N_{N,t} + Q^{NH}_{N,t} = Q^N_{B,t} \quad \text{and} \quad Q_{H,t} + Q^H_{N,t} = Q^H_{B,t}. \tag{42}$$

If parameter values are such that $R_{H,t+1} < R_{N,t+1}$, then the credit market clearing conditions are given by

$$Q^N_{N,t} = Q^N_{B,t} \quad \text{and} \quad Q_{H,t} + Q^H_{N,t} + Q^{NH}_{N,t} = Q^H_{B,t}. \tag{43}$$

Finally, if parameter values are such that $R_{H,t+1} = R_{N,t+1} = R_{t+1}$, then there exists $s^N_{NH} \in [0,1]$ such that the credit market clearing conditions are given by

$$Q^N_{N,t} + s^N_{NH} Q^{NH}_{N,t} = Q^N_{B,t} \quad \text{and} \quad Q_{H,t} + Q^H_{N,t} + \left(1 - s^N_{NH}\right) Q^{NH}_{N,t} = Q^H_{B,t}. \tag{44}$$

[32]This is also the reason for why the domestic interest rate is higher than R^* in the model without heterogeneity: any bank would like to undercut the domestic interest rate and attract all borrowers, but it cannot do so, as it is constrained and therefore unable to serve more borrowers than it currently does.

[33]Bank competition prevents banks of the same type from price discrimination (e.g., charging higher interest rates to locked-in clients). This could not be an equilibrium because another bank could offer a slightly lower interest rate for the locked-in clients, attract them (and give up some low-return non-locked-in clients to respect the collateral constraint).

In each period t, we solve the model by first conjecturing that interest rates are equalized. Then, we can solve the model exactly as described in Section 4.1, and use Equation (44) to deduce s_{NH}^N. If this number is between 0 and 1, our initial conjecture was correct, and we have found the equilibrium. Otherwise, if this number is negative, it must be that the equilibrium interest rate at N-banks is higher than the one at H-banks. We can then solve for the equilibrium by combining Equation (43) with the other equilibrium conditions of Section 4.1 (and verify that the solution indeed holds $R_{t+1}^H < R_{t+1}^N$). Finally, if the computed s_{NH}^N is larger than 1, then the equilibrium interest rate at H-banks is higher than the one at N-banks, and we can solve for the equilibrium by combining Equation (42) with the other equilibrium conditions.

A.3 Parameter values

Table A.1 gives the parameter values used for drawing Figures 5 and 6.

Table A.1: Parameter values for the simulations

Parameter	Value	Parameter	Value
τ	0.5	ϕ	0.6
ε	2	λ_N	0.1
α_N	0.55	λ_H	0.1
α_H	0.55	λ_B	0.2
β_H	0.05	R^*	0.28
$A_{N,t}$	0.5	ψ	0.08
$A_{H,t}$	0.5	N	0.0004

Figures 8 and 9 largely use the same parameter values, just changing ϕ to 0.5, λ_B to 0.3, R^* to 0.23 and ψ to 0.25. In Figure 8, we set $\theta_H = \theta_N = 0$, while in Figure 9, we set $\theta_H = 0.44$ and $\theta_N = 0.48$. Furthermore, in both of these figures, $x^N = 0.00001$ and $x^H = 0.00005$.

B Data Appendix

B.1 Data sources for Section 2

House prices and the number of new houses built are taken from the Spanish Ministry of Construction.[34] We use the series “valor tasado de vivienda libre” (Table 1). Prices are defined as the average price per square meter of “free” (that is, non-subsidized) housing, and estimated every trimester by the ministry on the basis of data provided by valuation experts. We take a simple average to aggregate this data to a yearly series. The number of new houses instead refers to the number of new housing construction projects started in a given year (“Numero de viviendas libres iniciadas”, Table 3.1).

Series for real GDP and the GDP of the business economy are taken from the Spanish Statistical Institute (INE, www.ine.es). In line with the Eurostat definition, the business economy contains NACE sectors A to N, excluding only public administration and defense, social security, health and education, arts and entertainment.

Finally, credit series are taken from Table 8.9 of the Bank of Spain's economic bulletin.[35] These contain the overall credit given to firms (credit to productive activities), as well as the credit given to housing-related activities (construction and real estate).

[34] See http://www.fomento.gob.es/MFOM/LANG_CASTELLANO/ATENCION_CIUDADANO/INFORMACION_ESTADISTICA/Vivienda/

[35] See https://www.bde.es/webbde/es/estadis/infoest/bolest.html.

B.2 Additional results

Table A.2: Bubble exposure and credit growth at the bank-firm level.

PANEL A: Dep. variable is bank-firm credit growth ($\text{Credit\_growth}_{fbt}$)						
		OLS			IV	
	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)
Bank bubble exposure	-0.56	1.41***	-0.02***	-2.07***	1.52***	-4.44**
(s.e.)	(0.79)	(0.36)	(0.00)	(0.70)	(0.52)	(2.27)
Average dep. variable	8.71	3.50	-2.93	8.61	3.51	-2.88
Firm fixed effects	YES	YES	YES	YES	YES	YES
Firm controls	NO	NO	NO	NO	NO	NO
Bank controls	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES
Industry × municipality FE	NO	NO	NO	NO	NO	NO
Multiple banks per firm	YES	YES	YES	YES	YES	YES
Balance-sheet data	NO	NO	NO	NO	NO	NO
R-sq	0.37	0.35	0.34			
# observations	558,978	678,439	526,092	549,959	666,846	504,233
# firms	181,749	210,806	166,783	179,421	207,796	160,736
# banks	171	165	120	117	110	62

PANEL B: First-stage. Dep. variable is mortgage-backed credit at the bank level (E_{bt})						
Bank bubble exposure (E_{b0})	0.15***	0.16***	0.12***	0.15***	0.15***	0.10***
(s.e.)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.02)
Bank controls	NO	NO	NO	YES	YES	YES
F-stat	79.97	85.50	20.66	26.62	23.33	9.15
F-stat (p-value)	0.00	0.00	0.00	0.00	0.00	0.15
R-sq	0.40	0.43	0.24	0.54	0.51	0.43
# observations	121	116	66	121	116	66

Notes. See notes to Table 1 for Panel A. Year-by-year regressions at the bank level are reported in Panel B.

Table A.3: Bubble exposure and credit growth at the bank-firm level. Without cajas.

	Firm fixed effects			Firm controls			Firm controls (multibank)		
	2004	2008	2012	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Bank bubble exposure	-2.27***	1.16**	-1.57**	-2.23***	1.20*	-1.48*	-2.42***	1.27	-1.59*
(s.e.)	(0.52)	(0.59)	(0.78)	(0.66)	(0.73)	(0.81)	(0.72)	(0.80)	(0.90)
Average dep. variable	8.92	3.74	-2.10	11.62	5.71	-1.09	11.84	6.00	-0.41
Firm fixed effects	YES	YES	YES	NO	NO	NO	NO	NO	NO
Firm controls	NO	NO	NO	YES	YES	YES	YES	YES	YES
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry × municipality FE	NO	NO	NO	YES	YES	YES	YES	YES	YES
Multiple banks per firm	YES	YES	YES	NO	NO	NO	YES	YES	YES
Balance-sheet data	NO	NO	NO	YES	YES	YES	YES	YES	YES
R-sq	0.39	0.38	0.36	0.20	0.17	0.20	0.22	0.19	0.21
# observations	356,728	435,533	418,573	289,667	359,984	339,018	247,493	304,667	286,096
# firms	127,396	150,398	141,146	145,081	179,080	164,515	102,907	123,763	111,593
# banks	78	73	54	76	72	53	75	70	53

Notes: The dependent variable is annual credit growth at the bank-firm level in all columns. Bank bubble exposure is proxied by the share of mortgage-backed credit (E_{b0}). All regressions are based on Equation (25) but excluding saving banks (cajas) from the sample. Bank controls: log total assets, capital ratio, liquidity ratio, and default rate. Firm-bank controls: length of firm-bank relationship in months and past defaults. Firm controls: total assets, number of employees, own funds over total assets, return on assets, a dummy for young firms (less than three years old), and an exporter dummy. To ease the interpretation, the bank bubble exposure regressor has zero mean and unit variance. Standard errors multi-clustered at the bank and firm level in parentheses.

Table A.4: Bubble exposure and credit growth at the bank-firm level. HSE exposure.

PANEL A: Dep. variable is bank-firm credit growth ($\text{Credit\_growth}_{fbt}$)

	OLS			IV		
	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)
Bank housing price growth	-0.89*	0.13	-1.00	-3.30*	2.13*	-2.83**
(s.e.)	(0.47)	(0.30)	(0.95)	(1.75)	(1.66)	(1.25)
Average dep. variable	8.59	3.52	-3.22	8.59	3.52	-3.21
Firm fixed effects	YES	YES	YES	YES	YES	YES
Firm controls	NO	NO	NO	NO	NO	NO
Bank controls	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES
Industry × municipality FE	NO	NO	NO	NO	NO	NO
Multiple banks per firm	YES	YES	YES	YES	YES	YES
Balance-sheet data	NO	NO	NO	NO	NO	NO
R-sq	0.36	0.35	0.33			
# observations	565,900	674,169	583,236	565,900	673,484	581,375
# firms	182,688	209,698	180,667	182,688	209,79	180,004
# banks	146	141	120	146	110	62

PANEL B: First-stage. Dep. variable is housing price growth at the bank level ($E_{bt}^{\Delta HP}$)

Bank bubble exposure (E_b^{HSE})	0.010*	0.011*	0.012*	0.0167**	0.017*	.028**
(s.e.)	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Bank controls	NO	NO	NO	YES	YES	YES
F-stat	3.69	3.46	3.18	1.82	1.45	2.29
F-stat (p-value)	0.06	0.06	0.08	0.11	0.21	0.05
R-sq	0.02	0.02	0.03	0.06	0.05	0.12
# observations	165	153	118	147	140	89

Notes. See notes to Table 2 for Panel A. Year-by-year regressions at the bank level are reported in Panel B.

Table A.5: Banks net worth and bubble exposure — Regression analysis

	(1)	(2)
Bank bubble exposure	0.17***	0.12**
(s.e.)	(0.06)	(0.05)
Average Dep. Variable	1.48	1.48
Bank controls	NO	YES
R-sq	0.08	0.27
# observations	113	113

Notes. Dependent variable is the growth rate of banks net worth over the 1995-2009 period. Bank controls: log total assets, capital ratio, liquidity ratio, and default rate. In order to ease interpretation, bank bubble exposure refers to initial bank bubble exposure normalized to have zero mean and unit variance.

Table A.6: Bubble exposure and credit growth at the firm level.

PANEL A: Dep. variable is firm credit growth ($\text{Credit\_growth}_{ft}$)

	OLS			IV		
	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)
Firm bubble exposure	-1.13**	1.07***	-5.46***	-1.33**	1.57***	-4.69***
(s.e.)	(0.57)	(0.24)	(1.35)	(0.64)	(0.37)	(1.52)
Average dep. variable	19.11	10.65	4.21	19.11	10.65	4.21
Firm controls	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES
Industry × municipality FE	YES	YES	YES	YES	YES	YES
Only multibank firms	NO	NO	NO	NO	NO	NO
Balance-sheet data	YES	YES	YES	YES	YES	YES
R-sq	0.30	0.26	0.34			
# observations	153,973	189,235	164,544	153,030	187,920	158,287

PANEL B: First-stage. Dep. variable is mortgage-backed credit at the firm level (E_{ft})

Firm bubble exposure (E_{f0})	0.77***	0.74***	0.51***	0.77***	0.74***	0.52***
(s.e.)	(0.06)	(0.07)	(0.08)	(0.06)	(0.07)	(0.08)
Firm controls	YES	YES	YES	NO	NO	NO
Firm-bank controls	YES	YES	YES	NO	NO	NO
Industry × municipality FE	YES	YES	YES	YES	YES	YES
F-stat	29.37	16.75	10.37	178.98	115.18	42.99
F-stat (pvalue)	0.00	0.00	0.00	0.00	0.00	0.00
R-sq	0.73	0.68	0.55	0.72	0.67	0.53
# observations	153,030	187,920	158,287	205,354	261,945	

Notes. See notes to Table 4 for Panel A. Year-by-year regressions at the firm level are reported in Panel B.

Table A.7: Bubble exposure and credit growth at the firm level. Main bank exposure.

	All firms			Multibank firms		
	2004	2008	2012	2004	2008	2012
	(1)	(2)	(3)	(4)	(5)	(6)
Firm bubble exposure	-1.07**	1.07***	-1.68**	-1.89***	0.88***	-1.98**
(s.e.)	(0.44)	(0.30)	(0.79)	(0.56)	(0.33)	(1.00)
Average dep. variable	18.88	10.52	2.94	24.98	16.36	10.27
Firm controls	YES	YES	YES	YES	YES	YES
Firm-bank controls	YES	YES	YES	YES	YES	YES
Industry × municipality FE	YES	YES	YES	YES	YES	YES
Only multibank firms	NO	NO	NO	YES	YES	YES
Balance-sheet data	YES	YES	YES	YES	YES	YES
R-sq	0.2991	0.2616	0.3216	0.307	0.298	0.3428
# observations	149,900	183,575	147,597	84,526	103,505	83,198

Notes. See notes to Table 4.

Table A.8: Summary statistics.

Panel A: Year 2004	Mean	Std. Dev.	25th pctile	Median	75th pctile	# obs.
Bank-firm variables						
$Credit\_growth_{fbt}$	9.14	54.83	-17.34	0.00	15.24	1,157,114
Length of firm-bank relationship in months	55.12	47.49	17	42	83	1,539,256
Past defaults	0.16	0.36	0	0	0	1,539,256
Bank variables						
Share of mortgage-backed credit in 1995 (E_{b0})	0.34	0.20	0.18	0.35	0.49	123
Share of mortgage-backed credit (E_{bt})	0.52	0.22	0.45	0.57	0.65	179
log total assets	13.61	2.32	11.84	13.46	15.51	185
Capital ratio	0.12	0.17	0.06	0.07	0.10	185
Liquidity ratio	0.10	0.09	0.03	0.08	0.14	185
Default rate	0.022	0.105	0.005	0.009	0.014	179
Firm variables						
$Credit\_growth_{ft}$	63.39	1184.33	-15.32	0.00	27.04	614,236
Demand shock	17.52	552.14	-31.78	-16.75	5.82	609,777
Total assets (thousands euros)	3008.52	62328.45	149.79	386.68	1120.79	370,369
Number employees	17.25	232.55	3	5	12	370,369
Own funds over total assets	0.39	0.29	0.13	0.33	0.62	370,369
Return on assets	0.02	0.16	-0.01	0.02	0.07	370,357
Young dummy (age< 3 years)	0.06	0.24	0	0	0	370,369
Exporter dummy	0.05	0.22	0	0	0	370,369
Municipality variables						
Land unavailability	-0.59	1.28	-0.16	-0.35	-0.66	5,615
House price growth	14.72	18.73	6.19	14.57	23.14	2,247

Panel B: Year 2008	Mean	Std. Dev.	25th pctile	Median	75th pctile	# obs.
Bank-firm variables						
$Credit\_growth_{fbt}$	2.78	47.48	-18.72	-1.80	6.86	1,566,435
Length of firm-bank relationship in months	49.74	44.70	13	36	72	2,024,408
Past defaults	0.20	0.40	0	0	0	2,024,408
Bank variables						
Share of mortgage-backed credit in 1995 (E_{b0})	0.34	0.19	0.18	0.35	0.49	121
Share of mortgage-backed credit (E_{bt})	0.58	0.23	0.51	0.65	0.73	175
log total assets	14.13	2.42	12.23	14.02	16.07	181
Capital ratio	0.12	0.19	0.05	0.08	0.10	181
Liquidity ratio	0.07	0.07	0.02	0.06	0.11	181
Default rate	0.022	0.054	0.010	0.016	0.025	175
Firm variables						
$Credit\_growth_{ft}$	36.83	1176.45	-16.62	-1.43	11.27	798,273
Demand shock	1.92	412.28	-30.93	-16.40	-3.23	788,538
Total assets (thousands euros)	4120.04	155669.80	180.60	478.77	1401.90	460,173
Number employees	16.84	243.87	3	5	11	460,173
Own funds over total assets	0.41	0.30	0.14	0.36	0.67	460,173
Return on assets	0.00	0.17	-0.02	0.01	0.05	460,135
Young dummy (age< 3 years)	0.03	0.17	0	0	0	460,173
Exporter dummy	0.05	0.22	0	0	0	460,173
Municipality variables						
Land unavailability	-0.59	1.28	-0.16	-0.35	-0.66	5,615
House price growth	-2.25	20.06	-11.85	-2.67	7.50	2,391

Table A.9: Summary statistics — continued

Panel C: Year 2012	Mean	Std. Dev.	25th pctile	Median	75th pctile	# obs.
Bank-firm variables						
Credit_growth$_{fbt}$	-4.74	36.95	-19.18	-3.75	0.00	1,406,869
Length of firm-bank relationship in months	47.43	44.34	13	35	68	1,810,564
Past defaults	0.32	0.47	0	0	1	1,810,564
Bank variables						
Share of mortgage-backed credit in 1995 (E_{b0})	0.30	0.20	0.15	0.26	0.44	71
Share of mortgage-backed credit (E_{bt})	0.53	0.28	0.44	0.64	0.72	146
log total assets	13.80	2.46	12.07	13.46	15.44	168
Capital ratio	0.25	0.33	0.07	0.09	0.19	168
Liquidity ratio	0.14	0.13	0.01	0.12	0.20	168
Default rate	0.079	0.099	0.024	0.060	0.097	146
Firm variables						
Credit_growth$_{ft}$	16.49	938.91	-19.38	-3.06	7.85	734,387
Demand shock	-16.84	269.40	-10.14	-22.70	-8.64	726,801
Total assets (thousands euros)	4706.17	183728.20	193.67	504.51	1464.60	363,597
Number employees	16.49	262.73	2	4	9	363,597
Own funds over total assets	0.45	0.31	0.16	0.41	0.72	363,597
Return on assets	-0.02	0.16	-0.05	0.00	0.03	363,584
Young dummy (age< 3 years)	0.02	0.14	0	0	0	363,597
Exporter dummy	0.06	0.24	0	0	0	363,597
Municipality variables						
Land unavailability	-0.59	1.28	-0.16	-0.35	-0.66	5,615
House price growth	-12.77	25.63	-24.39	-12.61	-0.53	1,460