A Credit Anatomy of the U.S. House Price Boom*

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July 25, 2019

Abstract

The early 2000 U.S. house price boom-bust cycle can be largely understood through the lens of the mortgage credit market. Credit supply and demand theories play a complementary role in explaining the boom. Increased sound demand was overall the most important contributor to the mortgage credit boom which then spurred house prices. Loose credit supply plays a role, too, but only in the later phase of the house price boom.

Keywords: Credit, house price, boom-bust

JEL: E51, G01

1 Introduction

The role of credit in the runup to the Global Financial Crisis (GFC) is hotly debated. Various credit-related mechanisms at the root of the house price boom

*I am indebted to participants at the 1st Dolomiti Macro Meeting, and to Giorgio Primiceri and Raf Wouters for valuable suggestions. Correspondence: Department of Economics, KU Leuven. ferre.degraeve@kuleuven.be.

have been proposed and empirically validated. One can broadly classify the theories as either demand (e.g. Favilukis et al., 2017) or supply (e.g. Justiniano et al., 2019) driven, and as related to sound versus excessive credit.

Ample micro studies document the presence of each of the theories. But micro studies are limited in how much they can quantify aggregate effects, due to the use of diff-in-diff(-in-diff) identification techniques or abstracting from macro-effects through the use of time-dummies.

Macro versions of the theories have also been put to the test. Through calibrated/estimated DSGE models (e.g. Guerrieri and Iacoviello, 2017; Justiniano et al., 2019), reduced form regressions (Duca et al., 2011) or narrative data explorations (e.g. Justiniano et al., 2018), these verify if certain theories are qualitatively and/or quantitatively able to explain the boom-bust housing cycle.

Of course, the various theories are not mutually exclusive. The contribution of our analysis lies in the *joint quantification and timing* of the contribution of various credit-fueled housing boom theories. We structurally decompose the aggregate relation between the mortgage credit market and the house price boom. Our quantification is obtained relying only on aggregate mortgage credit market data, using relatively standard macroeconometric techniques (SVAR), with a twist. The twist lies in going beyond traditional identification of demand and supply using prices and quantities, by additionally exploring the quality dimension of credit. Crucially, the quality dimension enables disentangling sound from excessive credit supply and demand.

We find that most of the U.S. house price boom is linked to developments in the mortgage credit market. The early years of the boom (2000-2003) were primarily a result of increased demand in the mortgage market. This demand was sound in the sense that it is not associated with a reduction in the quality of the borrowers. It is only once the boom was well under way, in 2003, that increased

credit supply also became important in the mortgage credit market. Increased availability of credit to bad borrowers in particular, then assumed a primary role in fueling the late stages of the house price boom. The bust phase is the combined result of an early and gradual reduction in mortgage credit demand, coupled with a later, sudden and sharp reduction in credit supply.

We use our structural empirical model to answer a number of additional questions that permeate debates on the role of credit in the GFC. First, did the Fed contribute to the easy availability of credit? We find that the Fed contributed to increased sound mortgage demand and thereby also house prices, but actually leaned against excessive credit supply once it showed up. Second, credit aggregates have taken centre stage as a potential predictor of financial crises, e.g. Mian, Sufi and Verner (2017), Schularick and Taylor (2012). Adding to the evidence of Brunnermeier et al. (2018), our results help understand why early warning systems sometimes work, and other times not. We first document direct conditional evidence supporting the rationale behind early warning credit systems based on credit aggregates: excessive credit supply creates a boom-bust cycle in house prices. However, since excessive supply is only a partial driver of aggregate credit fluctuations, we suggest a more promising role for structural, conditional early warning systems, compared to the reduced form, unconditional ones currently in fashion.

2 Methodology

We estimate a reduced form VAR model on aggregate data comprising the mortgage credit market and house prices.

$$Y_t = \begin{pmatrix} \Delta \text{ (real mortgages)} \\ \text{mortgage delinquency rate} \\ \text{mortgage rate} \\ \text{mortgage-treasury spread} \\ \text{real house price} \end{pmatrix}_t = A(L)Y_{t-1} + \varepsilon_t \tag{1}$$

where $A(L)$ is a lag-polynomial and $\varepsilon_t \sim N(0, \Sigma)$. The system consists of aggregate measures that characterize the quantity of mortgage credit (real mortgage credit growth), the quality of mortgage credit (mortgage delinquency rate), as well as the price of mortgages (both the mortgage rate and the mortgage spread relative to Treasury rates).[1] To separate the different structural drivers of credit and house prices, we disentangle four types of structural mortgage credit market shocks. Theoretically motivated identification assumptions enable one to move from the reduced form system (1) to a structural system (2) in which orthogonal structural shocks $u_t \sim N(0, I)$ simultaneously (through C) determine all the endogenous variables in Y_t (e.g. Canova, 2007; Uhlig, 2005):

$$CY_t = B(L)Y_{t-1} + u_t. \tag{2}$$

Essential in our identification approach is information on the quality of loans, by means of the delinquency rate. This enables one to distinguish between different types of supply and demand shocks. It is exactly that distinction that allows us to map the crisis narratives to the aggregate data. The approach is a variation

[1] Following Justiniano et al. (2018), we use the mortgage spread over the treasury rate as the relevant price measure. The rationale being that a reduction in mortgage rates that merely passes through a reduction in treasury rates effectively leaves banks' decisions unchanged.

on the identification arguments of De Graeve and Karas (2014) and Meeks (2012) for deposit and corporate bond markets, respectively. It differs from broad measures of financial shocks (e.g. Eickmeier and Ng, 2015; Furlanetto et al., 2019; ...), which tend to ignore the quality dimension of credit.

Table 1 details the identification strategy. The first two rows separate demand and supply disturbances through a very traditional identification argument: supply shocks are those that drive quantity and price in opposing directions, while demand shocks have a same-signed impact on quantity and price.

A positive *sound supply* shock is a situation in which banks extend more mortgages, at lower interest rates, without jeopardizing quality. In other words, more cheap mortgages for good borrowers. Additional credit supply of this type will not cause additional delinquencies (hence a "-" in the bottom row, first column of Table 1).

A (positive) *bad supply* shock is a shock that facilitates more credit, at cheaper rates, but at the cost of higher (future) delinquencies. This captures the narrative that loose credit was extended to bad borrowers in the runup to the GFC: loose lending standards.

A (positive) *bad demand* shock sees both price and quantity, as well as delinquency increase. One can think of this as a situation in which bad borrowers wish to borrow more, another popular narrative of the house price boom: loose borrowing constraints. It contrasts with more traditional, sound demand shocks in that those would not lead to a reduction in quality (i.e. an increase in delinquency).

Importantly, our identifcation strategy puts strong restrictions on the various disturbances in the mortgage credit market. As a result, impulse response functions of these variables are not hugely informative. The spirit of the analysis is therefore not focussed on impulse response function (IRF) analysis. Instead, the

Table 1: Identification restrictions

	(Sound) supply	(Sound) demand	Bad supply	Bad demand
Quantity	+	+	+	+
Price ($R^M - R^T$)	-	+	-	+
Delinquency	-	-	+	+

timing of the identified shocks and their historical contribution to both restricted and unrestricted variables are all the more interesting. Crucially, the approach is fully agnostic about the shocks' impact on house prices. The setup allows asking, for each of the identified shocks, questions like: When were these events important in the mortgage credit market? Did they impact house prices?[2]

3 Data and estimation

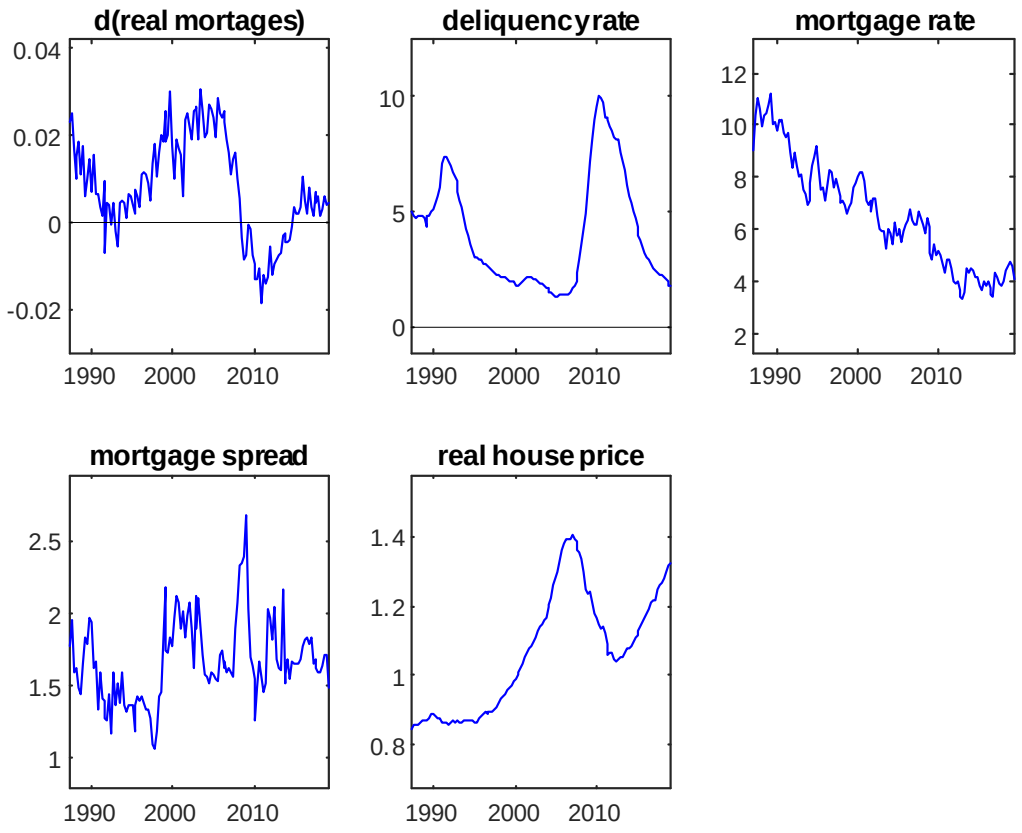
The sample covers the period 1987:Q1-2019:Q1. All data is available on FRED. The quantity of loans is Mortgage Debt Outstanding (All holders). Quality of mortgages is measured by the Delinquency Rate on Loans Secured by Real Estate (All Commercial Banks). House prices are the S&P/Case-Shiller US National Home Price index. To maximize sample length we use the 30-Year Fixed Rate Mortgage Average in the United States.[3] The long term risk-free interest rate

[2]Note that the identification disentangles different structural credit market disturbances, but remains silent on the possible macroeconomic shocks that might underlie them. This is, no doubt, a fruitful area for future research.

[3]Note that we use a conventional mortgage interest rate, which arguably does not capture the full breath of the mortgage market. However, our findings are fully in line with those based

is measured by 10-Year Treasury Constant Maturity Rate. In an extension with short term interest rates we use the 3-Month Treasury Bill: Secondary Market Rate. Mortgage credit and house prices are deflated by the GDP deflator.

Figure 1: Data



The results below are based on a VAR(4) estimated with Bayesian methods, using a Normal-Inverse Wishart prior centered on the OLS estimates. The horizon h for the restrictions imposed are $h = \{0, 1, 2\}$ for quantity and prices, while for

on the much broader conditional mortgage rate spread calculated in Justiniano et al. (2018).

delinquency we use $h = 1$ for sound demand and supply and $h = 16$ for bad supply and demand.[4] Results are presented as point-wise medians and 68% credible intervals based on 1000 posterior draws.

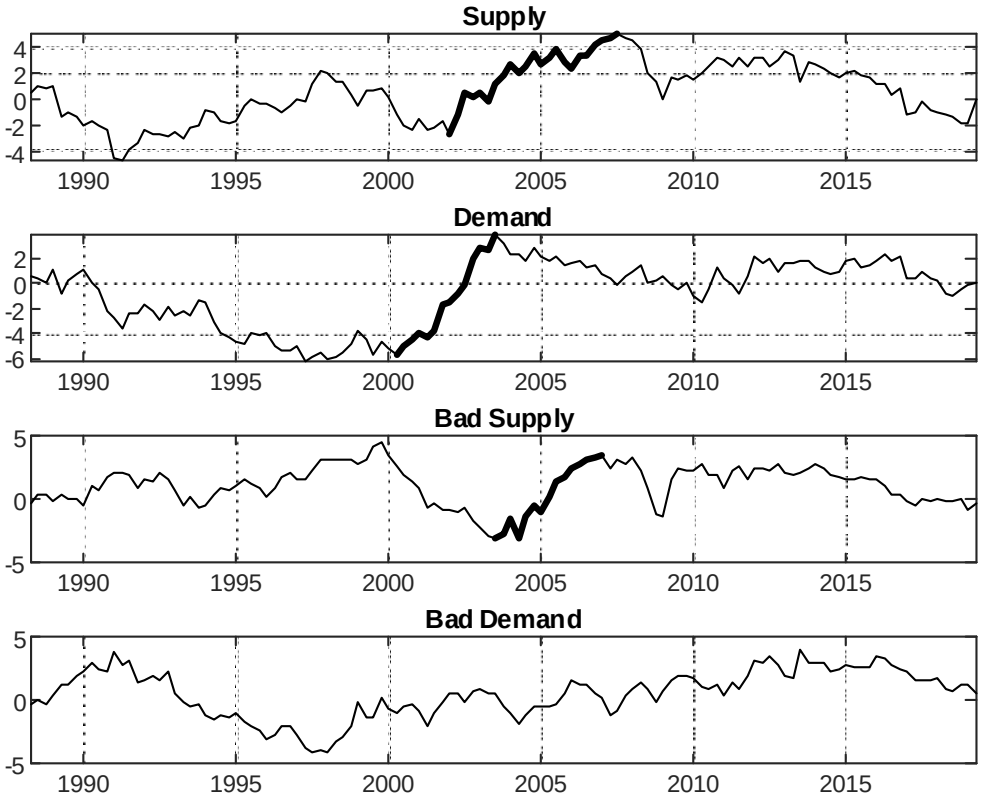
4 Decomposing the mortgage credit boom-bust

Figure 2 charts the cumulated sum of each of the identified credit shocks. Let us zoom in on the house price boom period 2000-2006. The model interprets the early years as one characterized by a sequence of positive demand shocks (thus pushing up the cumulated sum in the second panel). Demand shocks peak early 2003, after which the series gradually returns to fluctuate around zero. A few years into the boom period, in 2002-2003, both types of supply shocks start exhibiting a long-lasting upward crawl. That rise lasts until 2008, the onset of the GFC, at which point they both drop sharply. The time series estimate of bad demand shocks does not show any particularly strong pattern throughout the housing boom or bust.

Figure 3 details how the model interprets the evolution of the variables constrained in identification. The mortgage credit boom starts in the late nineties and lasts almost a decade. The majority of that credit growth is due to positive demand shocks. This high credit demand was associated with persistently falling delinquency rates, and a steady increase in the mortgage spread. Here too, it is apparent that demand peaks early 2003. The gradual and strong cutback in mortgage demand that follows is the main source behind the increase in delinquency during the GFC. Mortgage demand from good borrowers plummeted.

[4]The precise choice of these horizons is not essential for our results. Various perturbations to the horizons give very similar results, which is largely due to the very high persistence in the dynamic system (1). For instance, using equal horizons for traditional and bad shocks is effectively similar because the delinquency rate is so persistent.

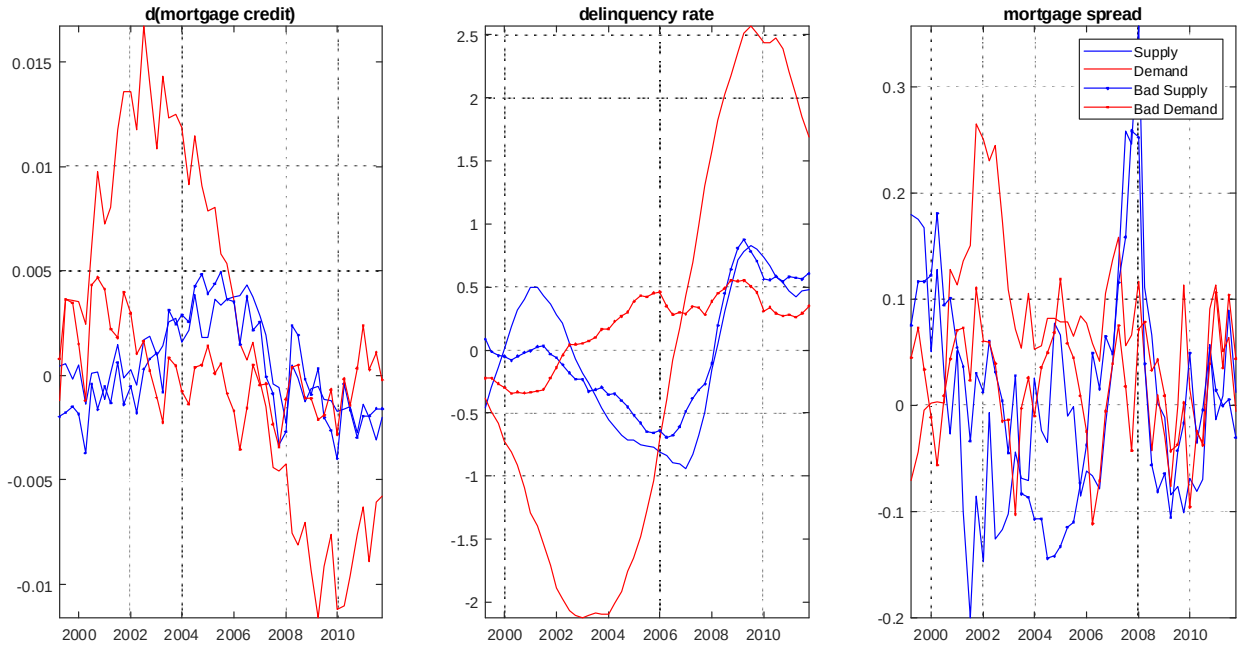
Figure 2: Structural shocks (period-wise median of cumulated sum)



While demand peaks early on, the supply of credit is picking up pace: there is a steady increase in credit growth due to both sound and bad supply shocks.

From 2003 onwards, there is a marked uptick in credit supply to bad borrowers (Figure 2). Bad borrowers are entering the market not because they are willing to pay higher rates (i.e. high demand), but because they are teased in by financial intermediaries' low interest rates. The increase in supply is not limited to bad borrowers; mid-2003 marks the start of a persistent positive contribution of both

Figure 3: Historical contributions to selected endogenous variables



types of supply shocks. These results are fully consistent with the findings of Justiniano et al. (2018) based on detailed micro-level mortgage data. They show the exceptionally low mortgage rates (relative to Treasury rates) are a phenomenon that (*i*) starts mid-2003, (*ii*) is very persistent, (*iii*) is not limited to any particular segment of the mortgage market. Despite the aggregate nature of data used here, our evidence corroborates each of the findings (*i*)-(*iii*).[5]

Importantly, the decomposition of the mortgage spread helps to reconcile the different views on the crisis. Justiniano et al. (2019), for instance, argue against

[5]In fact, one way of interpreting the identified structural shocks is that they, together, make up the (reduced form) aggregate time dummies or average residuals estimated in Justiniano et al. (2018).

demand interpretations of the credit boom because mortgage rates (and spreads) fell. Figure 3 shows that increased credit supply is the reason behind that fall. But at the same time, there was strong upward pressure on mortgage rates due to high demand. Both views on the boom phase are simultaneously at play.

The supply-led credit growth comes to a rather sudden halt at the start of the GFC. Delinquency shoots up during the crisis as a combined result of 1) the delayed effect of years of supplying credit to bad borrowers (consistent with the delayed impact in the IRF in Figure 8), and 2) the immediate effect of the cutback of supply to good borrowers (IRF in appendix Figure 9).

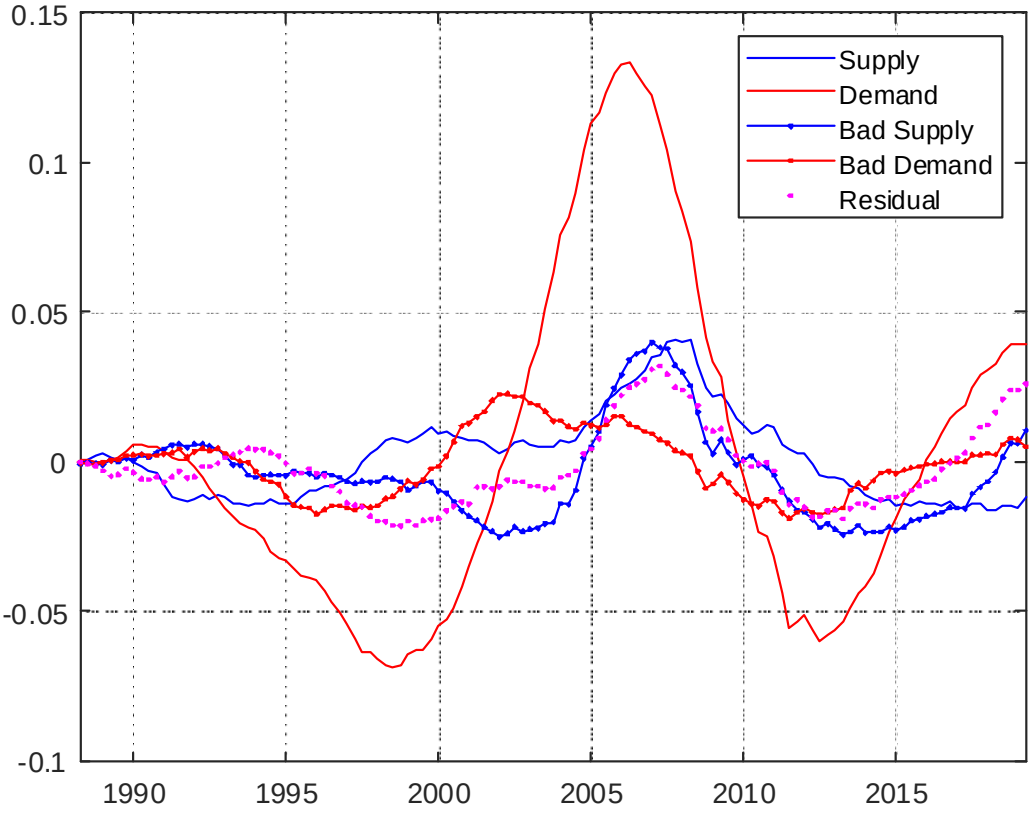
5 From credit to house prices

We are now ready to ask whether this credit boom was responsible for the dramatic surge in house prices that preceded the GFC. The estimated model decomposes fluctuations in the mortgage market into several structural forces, but imposes no a priori restrictions on the behavior of house prices. Figure 4 plots the estimated contribution of each of the identified shocks to the historical evolution of house prices.

By far the largest contribution to the house price boom (Figure 4) comes from credit demand shocks. Trough-to-peak this positive mortgage demand explains 20%-points of the real house price increase documented in Figure 1, larger than any of the other shock contributions.

Figure 4 supports the view that the increase in credit supply also contributed substantially to the house price boom. The increase in bad credit supply explains 6%-points of the house price boom; while markedly less than the contribution of increased demand, quite a significant contribution. Add to that the increase in sound supply which caused an additional 4%-points of the house price

Figure 4: Historical contributions to house price



appreciation. Combined, two thirds of the credit-fueled house price boom are demand-driven, while one third is due to increased credit supply.

The timing of the contributions also reveals an interesting pattern. Specifically, the contribution of demand shocks to house prices in Figure 4 peaks in 2006, substantially before that of bad (2007) as well as sound (2008) supply shocks. This confirms the narrative that especially the later stage of the house price boom was mostly driven by increased credit supply. It is also the dissipa-

tion of that credit supply which stands out in Figure 2: the bust is particularly noticeable by a sudden drop in both supply shock series.

6 Three questions

6.1 Is it all credit that explains the house price boom?

The restrictions in Table 1 identify four structural shocks in (2), a system of five shocks and five variables. Figure 5 shows the IRF to the non-identified shock (the IRF are normalized to a house price increase). It shows that this shock can explain changes in house prices, but is not systematically related to particular changes in the other variables. It is natural to ask just how much of the boom is explained by non-credit market factors. The answer is readily apparent in Figure 4. The contribution of the residual, non-credit-related shock is approximately 4%-points. It is worth noting that this number can change somewhat across various alternative specifications of the SVAR, but it never becomes a dominant force (while leaving all other conclusions on the relative contribution and timing of demand and supply unaffected).[6] This compares to a total observed increase in real house prices of 40%. Thus, while developments in the mortgage credit market do not explain the entirety of the house price boom, they easily explain the bulk of it.

[6]There are numerous variants of (2) that can be specified without necessarily being better or worse on econometric grounds. These include variations in the horizons at which restrictions are imposed, inclusion of variables in levels or growth rates, as interest rates or spreads, etc. It turns out the qualitative and most often all quantitative conclusions are similar across a wide range of specifications.

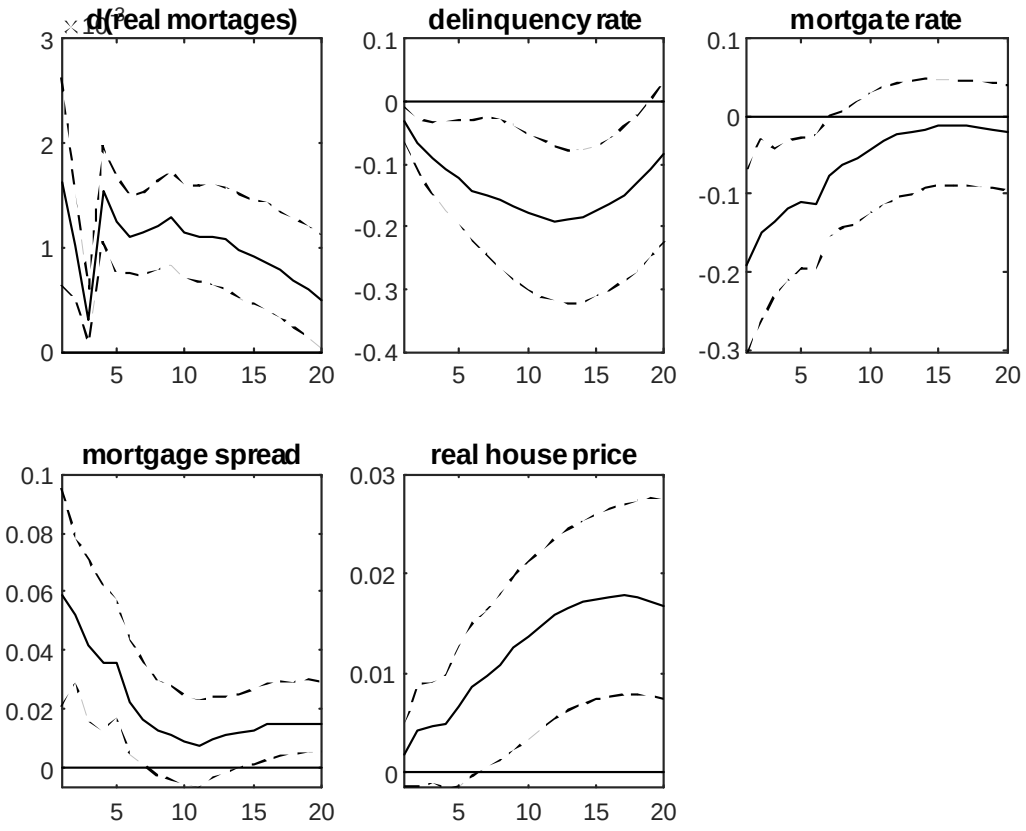
Figure 5: Impulse responses to the residual shock

6.2 Did the Fed cause the boom?

A prominent narrative for the causes for the house price boom is Taylor's (2007), which argues that the house price boom is a result of the Federal Reserve keeping its policy rate unduly low. Is there a role for monetary policy in the above credit decompositions? It turns out there is, some.

Figure 6 shows the impulse responses to a demand shock, the largest contributor to the house price boom. Observe what may seem a counterintuitive

Figure 6: Impulse responses to a positive credit demand shock

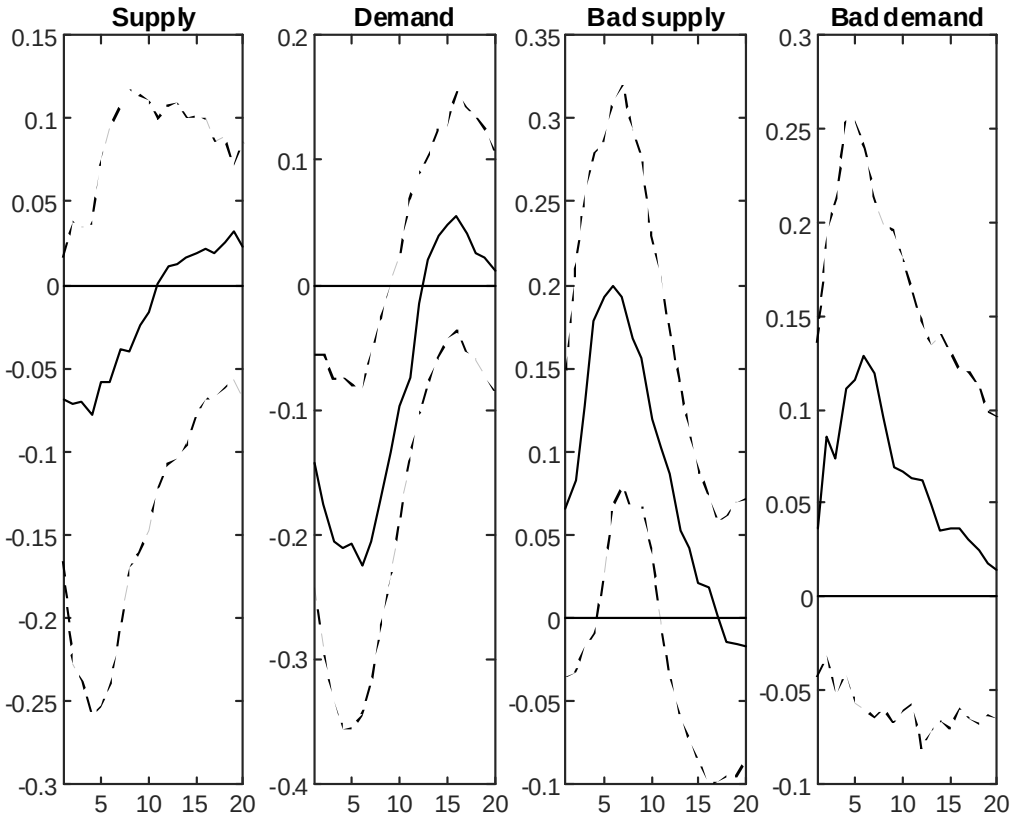


response of the mortgage rate: it falls in response to a positive demand shock, while the mortgage spread increases. This suggests the long term treasury rate must fall, which may well be due to low short term interest (or policy) rates. We can analyse this in more detail by extending the SVAR with the short rate as an observable variable.[7] The resulting IRF of the policy rate to the various

[7] We refrain from including the short term interest rate in the baseline model for two reasons. On the one hand, identifying monetary policy (shocks) in detail requires additional endogenous variables which would increase the size of the system too much. On the other hand, the near

credit market shocks are shown in Figure 7. The second panel documents a persistently negative IRF for the policy rate in response to a positive demand shock. Hence, since the credit demand boom is associated with persistently low short term interest rates, it is consistent with Taylor's view.

Figure 7: Impulse response of the short term interest rate



There are, however, two reasons one should not attribute the entire boom to

constant policy rate post-crisis is not easily explicitly incorporated into reduced form estimation of (1).

the Fed's behaviour. First, we find no negative response of the policy rate to any of the other shocks, and in fact a positive one to bad supply shocks. This is consistent with the observation that the Fed started increasing its policy rate in 2004, very soon after credit supply relaxed. Second, the increase in mortgage demand was already well under way before the period in which Taylor (2007) argues the Fed kept rates too low (i.e. during 2002-2003).

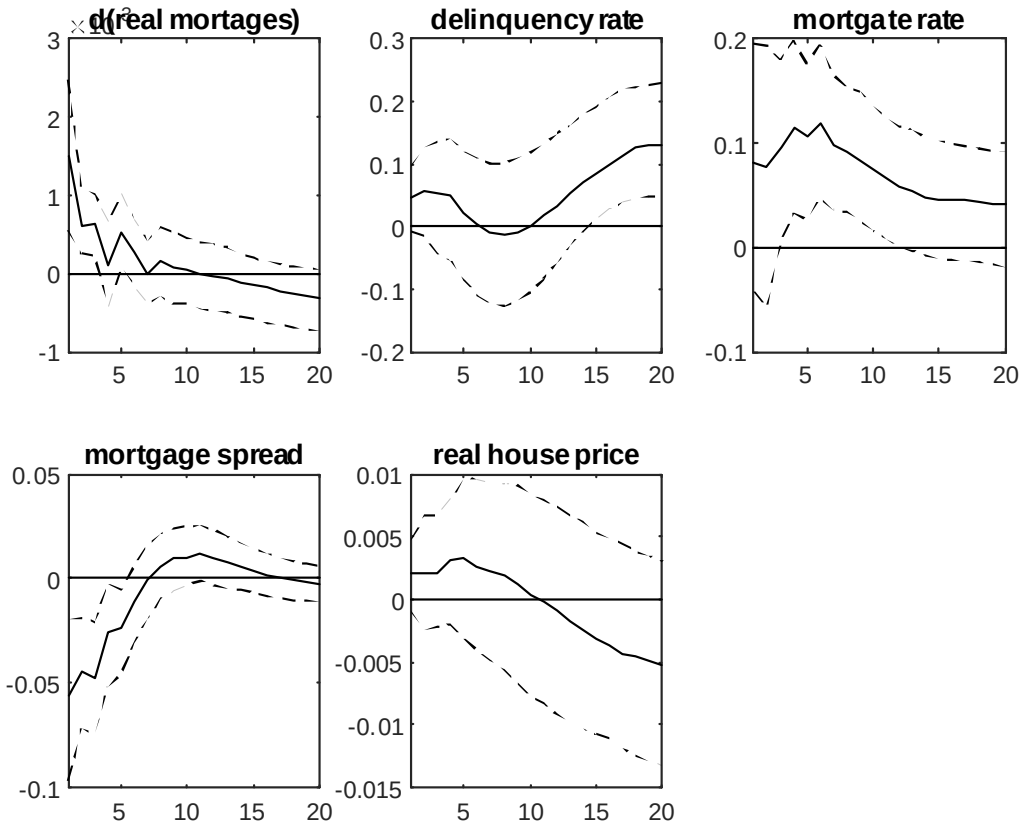
In sum, the low policy rate of the Fed has contributed to the house price boom. The channel through which it did was by stimulating borrower demand, but not by increasing credit supply. If anything, the Fed leaned against the increase in bad credit supply very soon after it showed up.

6.3 A role for credit aggregates in early warning systems?

The GFC has reinvigorated interest in so-called early warning systems. These aim to predict financial crises using various aggregate indicators, most notably credit aggregates, as predictors. The rationale is that credit can grow too big or too fast, leading to excess credit extension, granted to bad borrowers, which temporarily boosts asset prices, but ultimately leads to higher defaults and culminates in a financial crisis. The impulse response functions to a bad supply shock (Figure 8) corroborate such a rationale. A bad credit supply shock increases mortgage credit today, which initially fuels a house price boom, but then (endogenously) reverts into a significant house price bust. The historical contributions in Figure 4 tell a similar story, and show the not very statistically significant upward phase of house prices in the IRF (Figure 8) can cumulate to be quantitatively hugely significant.

On the one hand, this provides direct evidence on the rationale behind early warning systems. While Brunnermeier et al. (2018) find weak evidence for a link between credit aggregates and industrial production, the link from mortgage

Figure 8: Impulse responses to a bad credit supply shock



credit to house prices documented here is arguably a more direct (and easier to detect) channel. On the other hand, however, bad supply is but one of the drivers of credit, and historically not the most important one. As a result, any unconditional early warning system that does not condition on the structural source of variation in credit will have a hard time consistently predicting house price busts or their consequences. This need not imply that early warning systems as a whole should be discarded. As can be seen in Figure 4, the model attributes a

small but increasing fraction of the more recent house price boom to an increase in bad credit supply. This occurs despite the unconditional delinquency data (Figure 1) not (yet) showing a visible uptick in the last years of the sample. The results here therefore suggest promise for *structural, conditional* early warning systems, over and above unconditional ones.

7 Conclusion

The pre-GFC boom-bust cycle in U.S. house prices was largely credit-related. Factors outside the mortgage credit market have a limited role to play in explaining the boom. Our analysis underlines the necessity of *both* demand and supply theories in understanding the role of credit in the house price boom. The bulk of the boom and especially the early phase was a result of higher sound credit demand. Increased supply became an issue only halfway through the boom. These findings reconcile the different views in the literature, and can only be reached through a structural conditional analysis of the type performed here. These results add to hard-to-interpret reduced form evidence and tightly parametrized DSGE evidence available in the literature.

References

[1] Brunnermeier, M., Palia, D., Sastry, K.A., Sims, C.A., 2018. "Feedbacks: financial markets and economic activity," mimeo.

[2] Canova, F., 2007. *Methods for applied macroeconomic research*, Princeton University Press, 512 pp.

[3] De Graeve, F. Karas, A., 2014. "Evaluating theories of bank runs with heterogeneity restrictions," *Journal of the European Economic Association* 12 (4), 969–996.

[4] Duca, J. V., Muellbauer, J., Murphy A., 2011. "House prices and credit constraints: making sense of the US experience," *Economic Journal* 121, 533–551.

[5] Eickmeier, S., Ng, T., 2015. "How do US credit supply shocks propagate internationally? A GVAR approach," *European Economic Review* 74 (1), 128-145.

[6] Favilukis, J., Ludvigson, S.C., Van Nieuwerburgh, S., 2017. "The macroeconomic effects of housing wealth, housing finance, and limited risk sharing in general equilibrium," *Journal of Political Economy* 125, 140–223.

[7] Furlanetto, F., Ravazzolo, F. Sarferaz, S., 2019. "Identification of financial factors in economic fluctuations," *Economic Journal* 129, 311-337.

[8] Guerrieri, L., Iacoviello, M., 2017. "Collateral constraints and macroeconomic asymmetries," *Journal of Monetary Economics* 90, 28-49.

[9] Justiniano, A., Primiceri, G.E., Tambalotti, A., 2018. "The mortgage rate conundrum," mimeo.

[10] Justiniano, A., Primiceri, G.E., Tambalotti, A., 2019. "Credit supply and the housing boom," *Journal of Political Economy*, forthcoming.

[11] Meeks, R., 2012. "Do credit market shocks drive output fluctuations? Evidence from corporate spreads and defaults," *Journal of Economic Dynamics and Control* 36, 568-584.

[12] Mian, A.R., Sufi, A., Verner, E., 2017. Household debt and business cycles world wide, *Quarterly Journal of Economics* 132 (4), 1755–1817.

[13] Schularick, M., Taylor, A.M., 2012. "Credit booms gone bust: monetary policy, leverage cycles, and financial crises, 1870-2008." *American Economic Review* 102 (2), 1029–61.

[14] Taylor, J. B. (2007): "Housing and monetary policy," Proceedings - Economic Policy Symposium - Jackson Hole, 463–476.

[15] Uhlig, H., 2005. "What are the effects of monetary policy on output? Results from an agnostic identification procedure," *Journal of Monetary Economics* 52, 381-419.

Figure 9: Impulse responses to a supply shock

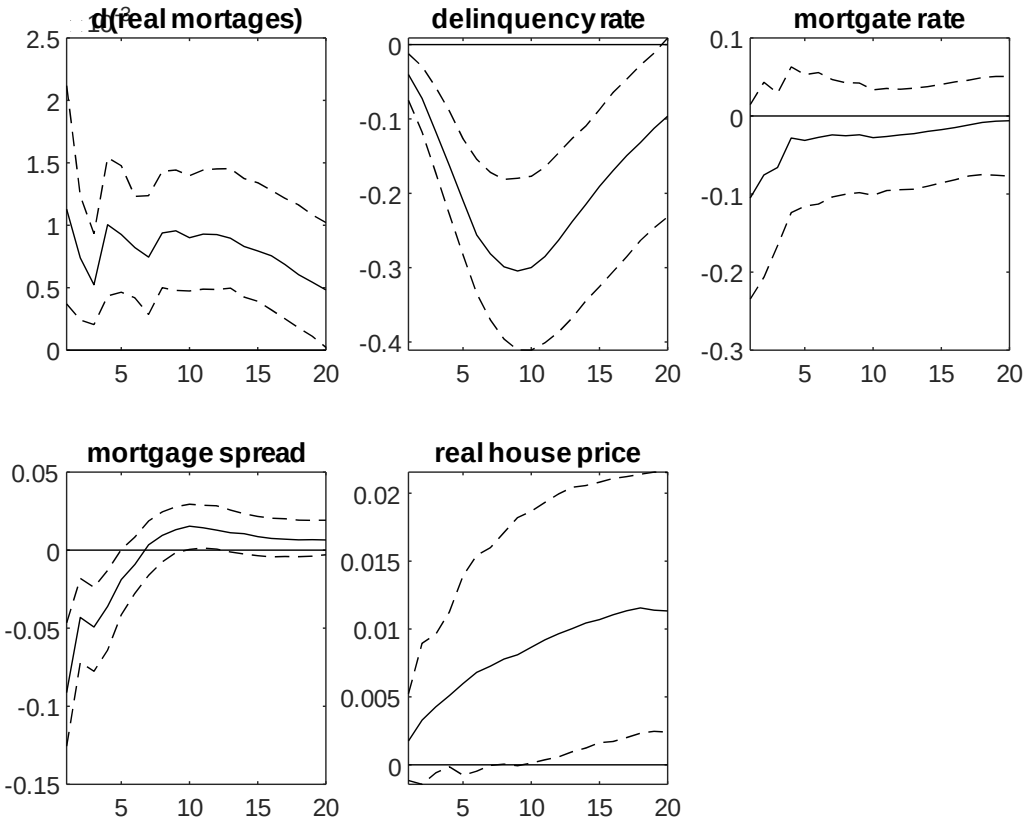


Figure 10: Impulse responses to a bad credit demand shock

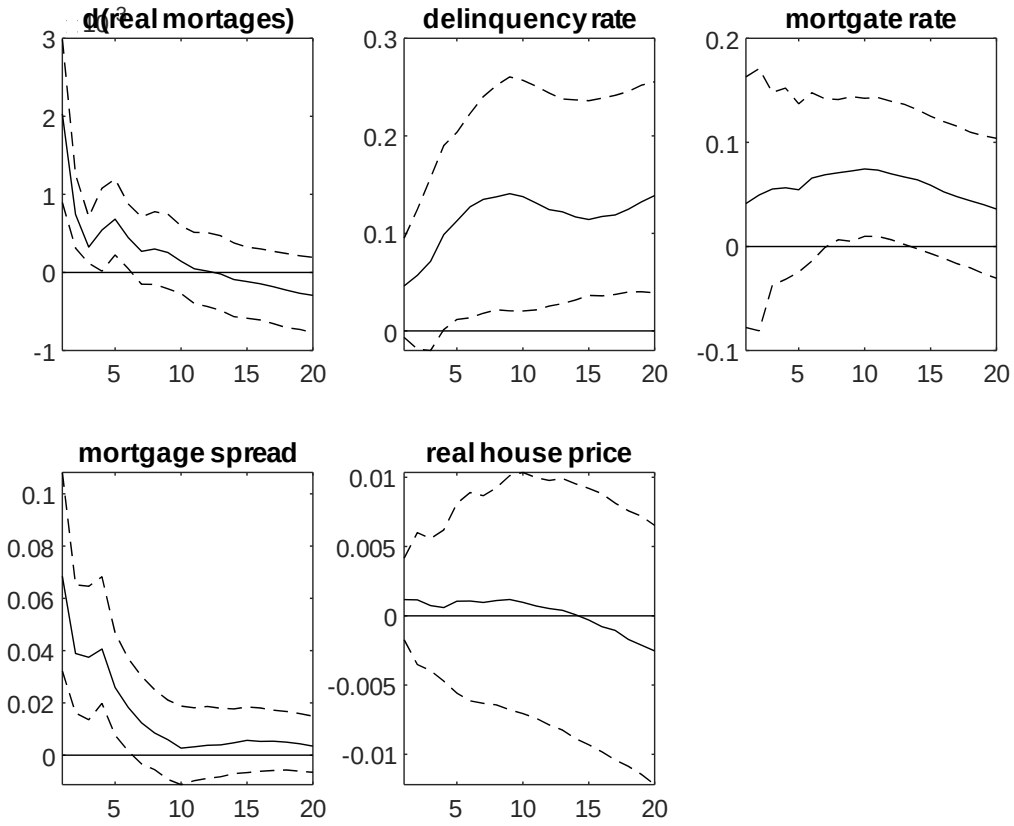


Figure 11: Historical contributions to other endogenous variables: full sample