Journal of Economic Dynamics & Control 37 (2013) 1500–1522

Contents lists available at SciVerse ScienceDirect

Journal of Economic Dynamics & Control

journal homepage: www.elsevier.com/locate/jedc

Leaning against boom–bust cycles in credit and housing prices

Luisa Lambertini [a,*], Caterina Mendicino [b], Maria Teresa Punzi [c]

[a] College of Management of Technology, École Polytechnique Fédérale de Lausanne, Station 5, CH-1015 Lausanne, Switzerland
[b] Research Department, Banco de Portugal, Avenida Almirante Reis 71, 1150-012 Lisbon, Portugal
[c] School of Economics, University of Nottingham Malaysia Campus, Jalan Broga, 43500 Semenyih Selangor Darul Ehsan, Malaysia

A R T I C L E I N F O

Available online 30 March 2013

JEL classification:
E32
E44
E52

Keywords:
Expectation-driven cycles
Macro-prudential policy
Monetary policy
Welfare analysis

A B S T R A C T

This paper studies the potential gains of monetary and macro-prudential policies that lean against house-price and credit cycles. We rely on a model that features Borrowers and Savers and allows for over-borrowing induced by news-shock-driven cycles. We find that policy that responds to changes in financial variables is socially optimal. Considering the use of a single policy instrument, both types of agents are better off when the interest rate optimally responds to credit growth. When we allow for the implementation of both interest-rate and LTV policies, heterogeneity in the welfare implications is key in determining the optimal use of policy instruments. The optimal policy for the Borrowers is characterized by a LTV ratio that responds countercyclically to credit growth, which most effectively stabilizes credit relative to GDP. In contrast, the optimal policy for the Savers features a constant LTV ratio coupled with an interest-rate response to credit growth. News-shock-driven cycles account for most of the gains from a policy response to changes in financial variables.

1. Introduction

The recent financial crisis, which was ignited by the bursting of the housing bubble in the United States, has forced central banks to reconsider their policy frameworks.[1] The traditional (micro) focus on the soundness of individual financial institutions has proved to be insufficient in limiting both economic volatility and the spreading of vulnerabilities from one financial institution to another. Hence, there has been a new emphasis on the need for a global macro-prudential approach to the supervision and regulation of the financial sector. In particular, the international debate has focused on the design of macro-prudential policies that lean against the financial cycle and aim at maintaining a "stable provision of financial intermediation services to the wider economy […] to avoid the type of boom and bust cycles in the supply of credit and liquidity that has marked the recent financial crisis."[2]

The Basel Committee on the Global Financial System identified the loan-to-value (LTV) ratio as one of the macro-prudential tools that may act as an automatic stabilizer if adjusted in a countercyclical manner around a pre-established cap.[3] According to the 2010 survey on macro-prudential tools conducted by the IMF on member countries, several country authorities have, indeed, introduced limits to LTV ratios for mortgages, in the aftermath of the recent financial crisis, in order

* Corresponding author.
E-mail address: luisa.lambertini@epfl.ch (L. Lambertini).

[1] A large body of evidence suggests that higher LTV ratios combined with higher risk mortgages contributed to the mortgage crisis. For example, Abraham et al. (2008) and Duca et al. (2011) document that LTV ratios above 80% were concentrated outside the prime sector. Mian and Sufi (2009) and Pavlov and Wachter (2009) document that during the latest boom, US house prices experienced a more rapid increase in areas where subprime and exotic mortgages were more prevalent.

[2] See Bank of England (2009).

[3] See Basel Committee on the Global Financial System (2010).

0165-1889/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jedc.2013.03.008

to mitigate "risks generated by strong credit growth and credit-driven asset price inflation".[4] Survey evidence also documents that LTV-ratio caps are adjusted more frequently than other instruments, and often at different phases of the cycle. Macro-prudential tools are generally used to complement other macroeconomic measures, such as monetary and fiscal policies. Still, little is known about the strength of the LTV ratio as macro-prudential tool, and its desirability in comparison with other macroeconomic measures.

The aim of this paper is to assess the effectiveness of alternative policies in mitigating booms (and busts) in housing prices and credit. Several factors can generate housing boom–bust episodes, among them loose mortgage-lending standards, bubble-like behavior stemming from imperfect knowledge, and optimism about future house price appreciation due to anticipated changes in fundamentals. While all these features may have contributed to the last run-up in US house prices, we model boom–bust cycles in credit and house prices as driven only by news shocks, namely by shifts in fundamentals anticipated by rational forward-looking agents. A housing boom emerges when agents expect a future increase in housing prices, which fuels current housing demand and lifts housing prices and debt immediately. In our model optimism about future house prices is related to current and expected macroeconomic developments, such as inflationary pressures, the conduct of monetary policy, productivity, and housing supply. For example, an anticipated reduction in the policy rate (relative to what stated by the policy rule) generates expectations of lower borrowing costs and higher house prices, thereby rasing immediately housing demand, mortgage debt and house prices. Housing booms are generated by news that put upward pressure on house prices, such as positive news on productivity in the non-durable or investment sector, negative news on productivity in the housing sector, or news about a reduction in the policy rate; busts follow if the news are not realized ex-post.

We rely on the model of the housing market developed by Iacoviello and Neri (2010) and extend it to incorporate news shocks.[5] In this model, a financial stability objective arises because anticipated innovations on a variety of fundamentals, such as productivity, investment costs, housing supply, inflation, the policy rate and the central bank's inflation target generate boom–bust dynamics in house prices and credit. Further, unrealized expectations about the future occurrence of shocks lead to a macroeconomic bust. Unrealized expectations distort consumption, borrowing and investment plans above the equilibrium level. Their sudden reversals have negative effects on economic and financial decisions, which are transmitted across sectors and generate a potential role for stabilization policy.

In the context of this model, we address four questions. First, we ask whether financial stability goals should be pursued by macro-prudential instruments, such as a countercyclical LTV ratio that responds to indicators of financial imbalance. Second, we investigate whether monetary policy should explicitly recognize financial stability goals by letting the interest rate respond directly to credit or house-price growth. Third, we ask whether booms and busts can be further mitigated by combining countercyclical LTV ratios with an interest-rate response to financial instability. Fourth, we quantify what fraction of the gains from such responsive policies are due to the presence of news-shock-driven cycles.

In order to address the first questions, we assess alternative policies in terms of their effectiveness in mitigating financial cycles and improving welfare. The analysis is conducted in three steps. First, we define macro-prudential policy as the use of the LTV ratio as a policy tool. We study whether countercyclical LTV-ratio policies can be effective in providing a stable supply of financial intermediation (i.e. loans to the household sector), so as to avoid spill-over into the macro-economy. We investigate the implications of countercyclical LTV rules that respond to output growth, credit growth, and house-price growth.[6] We find that the policy authority faces a trade-off between the welfare of two types of agents – Borrowers and Savers – when it allows the LTV ratio to respond to either house-prices or GDP growth. In contrast, an optimized LTV-ratio rule that responds to credit growth is a Pareto-improving policy compared to the use of a constant LTV ratio.

Second, we investigate whether interest-rate rules that respond to either credit or house-price growth can improve welfare by reducing the volatility of credit and house prices. An optimal interest-rate response to house prices, credit growth or GDP growth is Pareto improving. However, we find that an interest-rate rule that responds to credit growth better mitigates credit and housing cycles and improves welfare. Moreover, both the optimized interest-rate and LTV-ratio rules that respond to credit growth dampen out the volatility of credit relative to GDP, and slightly reduce the volatility of house prices without increasing the volatility of inflation. When we compare the alternative use of the optimized LTV ratio and the interest-rate rule that responds to credit growth in terms of welfare, we find that the interest-rate rule that responds to credit growth is preferred by both types of agents.

Third, we consider a combination of monetary and macro-prudential rules. We show that agents' heterogeneity prevents a uniform ranking among the alternative policy frameworks. The Borrowers benefit from the more stable supply of credit and the higher level of consumption that results from the use of a countercyclical LTV-ratio response to the credit cycle. In

[4] Active LTV-ratio policies have been introduced in Asia since the real-estate boom phase of the mid-2000s and in European countries since the recent global financial crisis. See Lim et al. (2011) for more detailed results.

[5] There are two reasons for adopting the model of the housing market developed by Iacoviello and Neri (2010). First, the model features credit flows at the household level and allows for the investigation of both interest-rate and LTV-ratio policies that lean against credit cycles. Second, its rich modeling framework allows us to consider sources of optimism about house price appreciation not only related to the housing market and the production sector but also to other developments in the economy, such as inflationary pressures and the conduct of monetary policy.

[6] The Basel Committee on the Global Financial System suggests: (1) the use of instruments "effective in leaning against both the upswing and the downswing [in the financial cycle]"; (2) the implementation of "predictable and transparent" policies that are set according to "easily observable and reliable indicators"; (3) [policies that] "might apply narrowly to sectors where systemically relevant imbalances are developing." See Basel Committee on the Global Financial System (2010).

contrast, Savers are better off under a constant LTV coupled with an interest-rate rule that responds to credit growth, which more effectively stabilizes their consumption. In the case of a social welfare function such that the planner equalizes utility across agent types for a given constant consumption stream, a countercyclical LTV ratio coupled with an interest-rate response to the credit growth is socially optimal.

Fourth, in order to investigate the importance of news shocks for the optimal design of policy rules, we quantify the welfare gains under alternative case scenarios, both with and without news shocks. We document that most of the gains from responding to financial variables are, indeed, due to the presence of news shocks. The reason is as follows. News shocks make house prices rise, which in turn increases leverage and inflates house prices still further. An increase in the LTV ratio during the boom phase of the cycle dampens this self-reinforcing dynamic. At the same time, a decline in the LTV ratio during the bust limits the decline in house prices and leverage and reduces the cost of the down phase. Thus, responding to credit growth reduces the amplitude of booms generated by news-shock-driven cycles and avoids the occurrence of busts, which results in a welfare improvement for both types of agents.

Robustness analysis also highlights some interesting results. First, our findings are not affected by the presence of monetary policy shocks, which may be interpreted as monetary reactions to changes in those macroeconomic and financial variables not included in the interest-rate rule, or may be interpreted as the exercise of judgment and discretion. We also show that the results are robust to the occasionally binding nature of the borrowing constraint. Following the previous literature, we solve a version of the model in which higher borrowing is feasible, but it is too costly to exceed the limit. Allowing agents to borrow less than the debt limit in a neighborhood of the steady state does not affect the optimality of responding to changes in financial variables. We also find an important role for heterogeneity in the welfare implications. Further, we explore the implications of social weighting criteria that assign equal weights to the two agents or, alternatively, weight the welfare of the agents by their labor-income share. Compared to the individual welfare-maximizing rules, the rule that maximizes the welfare function according to the two alternative criteria generates negligible welfare costs for the Savers and substantially larger ones for the Borrowers. We find less heterogeneity in the Savers' and Borrowers' welfare costs for not adopting their preferred rule under the rule that maximizes the benchmark social welfare function than under alternative social welfare criteria. Last, we report sensitivity analysis to Gomes and Mendicino (2011), who estimate the model of Iacoviello and Neri (2010) augmented by news shocks allowing for anticipated changes four and eight quarters ahead. Optimization over both interest-rate and LTV-ratio rules results in a strong countercyclical response of the LTV to credit growth, coupled with a moderate response of the interest-rate to the same variable. Further, our results suggest that revisions in expectations have no important role for ex-ante welfare measures.

The rest of the paper is organized as follows. In the next section we discuss the related literature. Section 2 briefly describes the model and Section 3 introduces news shocks and describes the transmission mechanism. Section 4 describes the method used for conducting welfare analysis. Section 5 investigates optimal interest-rate and LTV rules. Section 6 explores the role of news-shocks-driven cycles and Section 7 address some key issues. Section 8 discusses the results and some caveats of the analysis and Section 9 concludes.

1.1. Related literature

Despite a vast literature investigating the pros and cons of a policy response to asset-price movements, this remains an important but unsettled issue in macroeconomics. Earlier papers on this topic investigate optimal monetary policy in models of exogenous bubbles. See among others, Bernanke and Gertler (2001) and Gilchrist and Leahy (2002). In these models, the market price of an asset is the sum of its fundamentals, which are implied by competitive equilibrium, and an exogenous bubble component that stochastically emerges and disappears over time. Since the appearance, size and burst of the bubble are exogenously determined, these models do not allow for any feedback from the conduct of monetary policy to the occurrence and magnitude of boom–bust cycles in asset prices. Thus, unless asset prices signal changes in expected inflation, an anti-inflationary monetary policy is generally optimal in such an environment. Faia and Monacelli (2007) consider a model with credit frictions where the only sources of fluctuations are productivity and government spending shocks and they show that a strong inflation targeting is preferred in comparison with an interest-rate response to asset prices. Iacoviello (2005) concludes that an interest-rate response to house prices is not beneficial in terms of output and inflation stabilization. Environments characterized by imperfect knowledge and learning reinforce the need for a strong response to inflation and deemphasize the response to other real economic variables, as emphasized by Orphanides and Williams (2008). In contrast, a monetary policy response to asset prices has been shown to be beneficial in the presence of non-fundamental asset-price movements driven by expectation shocks, as in Dupor (2005). The same result holds in the presence of bubbles generated by a permanent increase in productivity growth that is only gradually learned by agents, as in Gilchrist and Saito (2008). Monetary policy can also eliminate the bubble by manipulating the interest rate in the case of asset-price bubbles that are the result of rational heard behavior, as in Loisel et al. (2012). More closely related to our paper is the work by Christiano et al. (2008) that introduces news on future productivity shocks as a source of fluctuations in asset prices in a model à la Bernanke et al. (1999). They find that, when credit growth is added to the interest-rate rule, the equilibrium response of the economy to news shocks is nearly optimal.

Recent literature investigates the design and implementation of macro-prudential policy in general equilibrium models. In particular, Bianchi and Mendoza (2011) consider a model in which asset prices determine debt dynamics and show that Pigouvian taxes, i.e. cyclical taxes on debt, may replicate the constraint-efficient allocations. Jeanne and Korinek (2011) show that, when the interaction between debt accumulation and asset prices exacerbates booms and busts, it is optimal to impose a Pigouvian tax to prevent over-borrowing. This tax responds to changes in parameter values in a non-trivial way. According to Benigno et al. (2013), considering the interaction between agents' behavior in normal and crisis times in this type of models leads to much larger welfare gains from ex-post policies than from ex-ante policies. In fact, imposing a tax on debt during normal times may reduce welfare. Bianchi and Mendoza (2012) document the effectiveness of macro-prudential policy in a model where agents learn about the transition probabilities of financial regimes and, in the short run, display optimism and pessimism depending on their initial priors and the observed market conditions. As for the comparison between monetary and macro-prudential policies, Benigno et al. (2012) study them in a small open economy that borrows from the rest of the world, which is subject to endogenous financial crises. They show that, from a welfare point of view, an interest-rate response to debt dominates a macro-prudential tax on aggregate borrowing. In a real business cycle model, Mendicino (2012) draws implications for the use of the LTV ratio as an alternative macro-prudential measure to monitor leverage and thus, dampen the magnitude of the financial cycle. Contrary to discretionary lower caps on LTV ratios, time-varying caps that countercyclically respond to indicators of financial imbalances dampen the severity of credit cycles, as well as business-cycle fluctuations driven by productivity shocks. Results in terms of ex-ante measures of welfare also tend to favor the use of a countercyclical LTV-ratio policy, since its stabilization effect is not coupled with a negative effect on the long-run performance of the economy, as in the case of discretionary lower LTV caps.

Regarding the housing market, Kannan et al. (2012) and Angelini et al. (2010) use ad hoc loss functions and measure the effects of monetary and macro-prudential policy in reducing the fluctuation of selected variables, such as output and inflation. Kannan et al. (2012) document that an interest-rate response to credit growth may be useful to mitigate the impact of financial shocks. However, they find no role for macro-prudential policy in booms generated by higher productivity. Angelini et al. (2010) show that, compared to capital-requirement rules, countercyclical LTV rules are more effective in reducing the variability of the debt-to-GDP ratio. Christensen and Meh (2011), extending Christensen et al. (2009) estimated model of the Canadian economy, study the implications of lowering the regulatory maximum LTV ratio below its long-run setting of 80% as a policy response to a credit boom. According to their results, changes in the maximum LTV ratio are a more effective tool to mitigate boom–bust cycles in house prices than monetary policy since they directly target the source of volatility.

Our paper is related to the literature on the role of news shocks in the business cycle. Since Beaudry and Portier (2006) showed that business-cycle fluctuations in the data are primarily driven by changes in agents' expectations about future technological growth, several authors have highlighted the importance of news shocks as a source of business-cycle fluctuations. Among others, Schmitt-Grohe and Uribe (2012) document that news on future neutral productivity shocks, investment-specific shocks, and government-spending shocks account for a sizable fraction of aggregate fluctuations in the United States since World War II. Kurmann and Otrok (2010) document that news shocks about future productivity can help explain swings in the slope of the term structure. Milani and Treadwell (2012) consider expectations about the policy rate and find that anticipated policy shocks play a larger role in the business cycle than unanticipated ones. Khan and Tsoukalas (2012) show that, in the presence of wage and price rigidities and a variety of news shocks, non-technology sources of news dominate technology news, with wage-markup news shocks in particular accounting for about 60% of the variance share of both hours and inflation.

Concerning the housing market, Lambertini et al. (2013) use a structural VAR model and data from the Michigan Survey of Consumers to study the transmission of innovations to news heard of favorable changes in business conditions and to expectations of rising house prices. A positive shock to the forward-looking survey variables generates hump-shaped responses in consumption, residential investment, households' credit and house prices. Gomes and Mendicino (2011) estimate the model of Iacoviello and Neri (2010) augmented with news. News shocks explain a large fraction of fluctuations in house prices, consumption and investment and contribute significantly to the housing boom episodes experienced in the United States since 1965. Anticipated cost-push shocks are important in explaining the housing boom of the early and late 1970s, whereas investment-specific news shocks were the major cause of the late 1990s cycle. Regarding the latest episode, expectations of housing productivity and investment-specific shocks contributed to the run-up in house prices. In terms of goodness of fit, the specification with news shocks outperforms that without news shocks. Other papers relate booms and busts in the housing market to expectations on future fundamentals. Kahn (2009) argues that perceived changes in trend productivity growth can explain a substantial portion of the behavior of housing prices since the 1960s. In particular, a regime-switching behavior of productivity growth coupled with imperfect information and learning about such regimes, can generate bubble-like house-price dynamics. Tomura (2010) documents that boom–bust cycles in house prices can be generated by uncertainty about the duration of a period of temporary high income growth only if the economy is open to international capital flows. Burnside et al. (2010) generate booms and busts in the housing market by relying on heterogeneous expectations about long-run fundamentals that drive house prices, as summarized by the flow of utility of holding a house. Adam et al. (2011) explain the joint dynamics of house prices and the current account deficits by relying on a model where agents form beliefs about how house prices relate to economic fundamentals.[7] In the case of *irrational*

[7] Regarding the joint dynamics of house-price appreciation and current-account deficits see also Ferrero (2012), Gete (2009), Pisani (2006), and Punzi (forthcoming).

exuberance Piazzesi and Schneider (2009) analyze data from the Michigan Survey of Consumers and find that more and more households became optimistic after having watched house prices increase for several years.

Self-fulfilling beliefs and imperfect information can also cause bubbles and credit crunches.[8] Considering specifically housing booms and crashes, Williams (2011) argues that models with imperfect information and learning endogenously generate bubble-like behavior. Granziera and Kozicki (2012) can generate a run-up followed by a sharp downturn in house prices, similar to the US experience between 2000 and 2006, relying on a Lucas-type asset pricing model with backward-looking, extrapolative expectations. Gelain et al. (forthcoming) show that agents' subjective forecasts may serve as an endogenous source of macroeconomic volatility that generate excess volatility in house prices and household debt. They evaluate alternative policies to dampen excess volatility and find that the most effective is a collateral constraint that takes into account the borrower's wage income. Gelain and Lansing (2013) match the volatility of the price–rent ratio in a model with near-rational agents and time-varying risk aversion.

While our paper focuses on the role played by expected future developments in housing and credit cycles, we acknowledge that several factors contributed to the latest housing boom and bust experienced in the United States.[9] Financial innovation changed dramatically the way in which the mortgage market worked during the housing boom. First, innovation in the form of private label securitization allowed lenders to sell loans to investors others than the GSEs, which require strict, standardized guidelines. As a result, the lenders' incentive to carefully screen borrowers was reduced. Second, innovation in the form of non-traditional mortgage contracts, such as short-term hybrid and option ARMs, gave subprime borrowers access to credit and to the housing market. Innovation in the financing of residential investment together with low long-term real interest rates due to the capital inflows from emerging economies, i.e. the global savings glut, contributed to strong growth in housing demand that drove up house prices.[10]

2. The model economy

The economy is populated by two types of households: the Saver and the Borrower. There is a continuum of measure 1 of agents in each group.[11] The two households differ in their discount factors, (β and β'). Borrowers (denoted by $'$) feature a relatively lower subjective discount factor that, in equilibrium, generates an incentive to anticipate future consumption to the current period through borrowing. Hence, the ex-ante heterogeneity induces credit flows between the two types of agents. This modeling feature has been introduced in macro models by Kiyotaki and Moore (1997) and extended by Iacoviello (2005) to a business-cycle framework with housing investment.

The model features three sectors of production: a non-durable goods sector, a non-residential investment sector, and a residential sector. Nominal price rigidities are assumed in final goods prices. Finally, the monetary authority follows an interest-rate rule.

Households. They both work in the production of consumption goods, $n_{c,t}$, and housing, $n_{h,t}$, consume, c_t, and accumulate housing, h_t.

The Borrowers maximize the utility function

$$U_t = E_t \sum_{t=0}^{\infty} (\beta')^t G_C^t z_t \left[\Gamma'_c \ln(c'_t - \varepsilon' c'_{t-1}) + A_{j,t} \ln h'_t - \frac{\tau_t}{1+\eta'} ((n'_{c,t})^{1+\xi'} + (n'_{h,t})^{1+\xi'})^{(1+\eta')/(1+\xi')} \right], \tag{1}$$

where G_C is the growth rate of consumption in the balanced growth path,[12] ϵ' measures habits in consumption, z_t and τ_t are shocks to inter-temporal preferences and to labor supply, respectively, the parameter $\eta' > 0$ is the inverse of the Frisch labor-supply elasticity; ξ' measures imperfect substitutability between work hours in the two sectors, the scaling factor Γ_c ensures a constant marginal utility of consumption, and $A_{j,t}$ is a housing preference shock, which behaves like a housing demand shock.[13] According to Iacoviello and Neri (2010) this shock explains a large fraction of house-price variability because it reconciles the high volatility of house prices with the lower volatility of consumption of non-durable goods. Gomes and Mendicino (2011) show that the housing preference shock remains an important source of fluctuations when they estimate the model in the presence of news.[14]

[8] See Lansing and LeRoy (2012) for a review of this literature.

[9] For an excellent review of these factors, see The Financial Crisis Inquiry Commission (2011) as well as in academic contributions by Brunnermeier (2009) and Keys et al. (2012).

[10] See among others, Bernanke (2010).

[11] A more realistic calibration of the distribution of financial wealth in the United States would imply a lower fraction of Savers than Borrowers.

[12] Since consumption grows at the rate G_C every quarter, the marginal utility of consumption falls at the same rate. For this reason, the model is transformed so that consumption is scaled by its growth rate G_C^t and the marginal utility of consumption is multiplied by the same rate. As a result, transformed consumption and scaled marginal utility of consumption are both constant in the steady state.

[13] Housing demand shocks can be given a broad interpretation. In addition to a shift in household's preferences toward housing services, they can also be interpreted as financial innovations that relax the borrowing constraint faced by agents experiencing idiosyncratic and uninsurable liquidity shocks—see Liu et al. (forthcoming), Favilukis and Ludvigson (2010), and Ferrero (2012) among others.

[14] Since preference shocks are important sources of fluctuation in consumption and other aggregate variables, it is not uncommon to study ex-ante optimal policy taking into account these shocks. See among others, Iacoviello (2005), Correia et al. (forthcoming), and Justiniano et al. (2013).

Borrowers maximize utility subject to the budget constraint

$$c'_t + q_t[h'_t - (1-\delta_h)h'_{t-1}] - b'_t \le \frac{w'_{c,t}n'_{c,t}}{X'_{wc,t}} + \frac{w'_{h,t}n'_{h,t}}{X'_{wh,t}} - \frac{R_{t-1}b'_{t-1}}{\pi_t}.$$

Except for the gross nominal interest-rate, R, all of the variables are expressed in real terms; π_t is gross inflation (P_t/P_{t-1}), $w'_{c,t}$ and $w'_{h,t}$ are the wages paid in the two sectors of production, and q_t is the price of housing in real terms. Houses depreciate at a rate of δ_h. Households set wages in a monopolistic way. $X_{wc,t}$ and $X_{wh,t}$ are markups on the wages paid in the two sectors. Wages are adjusted subject to a Calvo scheme with a given probability every period.

We allow Borrowers to collateralize the value of their houses

$$b'_t \le mE_t \frac{q_{t+1}\pi_{t+1}h'_t}{R_t}. \tag{2}$$

A limit on borrowing is introduced through the assumption that households cannot borrow more than a fraction m, of the next-period value of the housing stock. The fraction m should not exceed one and is treated as exogenous to the model. A higher m represents looser collateral requirements, while a lower m represents an economy subject to a higher degree of friction in the credit market. The borrowing constraint is consistent with standard lending criteria used in the mortgage and consumer-loan markets.

Similarly, the *Savers* choose how much to consume, how much to work and how much to invest in housing. However, they also invest in capital and receive the profits of the firms.

Firms. Final-good producing firms produce non-durable goods (Y) and new houses (IH). Both sectors face Cobb–Douglas production functions. The housing sector uses capital (k_h), land (l), intermediate inputs (k_b) and labor supplied by the Savers (n) and the Borrowers (n') as inputs of production

$$IH_t = (A_{h,t}(n_{h,t}^{\alpha} + n_{h,t}^{'1-\alpha}))^{1-\mu_h-\mu_b-\mu_l}(z_{h,t}k_{h,t-1})^{\mu_h}k_b^{\mu_b}l_{t-1}^{\mu_l}, \tag{3}$$

where the parameters μ_h, μ_b, μ_l are, respectively, the shares of capital, intermediate inputs, and land in the production function and z_h is capital utilization rate in the housing sector.

The non-housing sector produces consumption goods using labor and capital (k_c):

$$Y_t = (A_{c,t}(n_{c,t}^{\alpha} + n_{c,t}^{'1-\alpha}))^{1-\mu_c}(z_{c,t}k_{c,t-1})^{\mu_c}, \tag{4}$$

where z_c is capital utilization in the consumption good sector and μ_c is the share of capital in the production function, and α measures the labor income share of Savers and $(1-\alpha)$ of Borrowers.

Business investment is the increase in capital used in the two sectors

$$IK_{c,t} = k_{c,t} - (1-\delta_{k,c})k_{c,t-1}, \quad IK_{h,t} = \frac{k_{h,t} - (1-\delta_{k,h})k_{h,t-1}}{A_{k,t}}, \tag{5}$$

where $\delta_{k,j}$ is the rate of depreciation of capital in sector $j = h,\ c$ and $A_{k,t}$ is an investment-specific technology shock that affects only capital used in the non-housing sector. $A_{h,t}$ and $A_{c,t}$ are the productivity shocks to the housing- and goods-sectors, respectively. Firms pay wages to households and repay rented capital to the Savers. Retailers, owned by the Savers, differentiate final goods and act in a monopolistically competitive market. Prices can be adjusted with probability $1-\theta_\pi$ every period, by following a Calvo-setting. Monopolistic competition occurs at the retail level, leading to the following forward-looking Philips curve:

$$\ln \pi_t - \iota_\pi \ln \pi_{t-1} = \beta G_C(E_t \ln \pi_{t+1} - \iota_\pi \ln \pi_t) - \epsilon_\pi \ln(X_t/X) + u_{p,t} \tag{6}$$

where $\epsilon_\pi = ((1-\theta_\pi)(1-\beta\theta_\pi))/\theta_\pi$, X_t represents the price mark-up, ι_π is the indexation parameter, and $u_{p,t}$ is a cost-push shock. Housing prices are assumed to be flexible.

Monetary authority. As a baseline case, we assume that the central bank follows a Taylor-type rule as estimated by Iacoviello and Neri (2010)

$$R_t = R_{t-1}^{r_R}\pi_t^{(1-r_R)r_\pi}\left(\frac{GDP_t}{GDP_{t-1}}\right)^{(1-r_R)r_Y} rr^{(1-r_R)}\frac{u_{R,t}}{A_{s,t}}, \tag{7}$$

where rr is the steady state real interest-rate, r_R, r_π, r_Y are the responses of the interest rate to changes in the lagged interest rate, inflation and GDP growth, respectively, and $u_{R,t}$ is a monetary policy shock. The central bank's inflation target is assumed to be time-varying and subject to a persistent shock $A_{s,t}$. Thus, in contrast to the i.i.d. $u_{R,t}$ shock, the $A_{s,t}$ shock captures exogenous persistent deviations from the systematic policy rule.

GDP is defined as the sum of consumption and investment at constant prices

$$GDP_t = C_t + IK_t + qIH_t, \tag{8}$$

where q is real housing price in the steady state.[15]

[15] Notice that $IK_t = IK_{c,t} + IK_{h,t} + k_{b,t}$.

Table 1
Calibrated parameters.
Source: Iacoviello and Neri (2010).

Parameter	Description	Value	Parameter	Description	Value
r_Y	Saver's discount factor	0.9925	θ_π	Price stickiness	0.83
β'	Borrower's discount factor	0.97	ι_π	Price indexation	0.69
j	Housing preference shock	0.12	$\theta_{w,c}$	Wage stickiness in good sector	0.79
μ_c	Good capital share	0.35	$\iota_{w,c}$	Wage indexation in good sector	0.08
μ_h	Housing capital share	0.1	$\theta_{w,h}$	Wage stickiness in housing sector	0.91
μ_l	Land share	0.1	$\iota_{w,h}$	Wage indexation in housing sector	0.4
μ_b	Intermediate good share	0.1	ζ	Capacity utilization	0.69
δ_h	Housing depreciation rate	0.01	γ_{AC}	Growth rate in good sector	0.0032
δ_{kc}	Depreciation rate in good sector	0.025	γ_{AH}	Growth rate in housing sector	0.0008
δ_{kh}	Depreciation rate housing sector	0.03	γ_{AK}	Growth rate in business investment	0.0027
X	Price markup	1.15	ρ_s	AR of inflation target shock	0.975
X_{wc}	Wage markup in good sector	1.15	ρ_{AC}	AR of technology shock	0.95
X_{wh}	Wage markup in housing sector	1.15	ρ_{AH}	AR of housing technology shock	0.997
m	Loan-to-value	0.85	ρ_{AK}	AR of investment-specific technology shock	0.992
ε	Saver's habit consumption	0.32	ρ_j	AR of housing demand shock	0.96
ε'	Borrower's habit consumption	0.58	ρ_z	AR of intertemporal preference shock	0.96
η	Saver's labor supply elasticity	0.52	ρ_τ	AR of labor supply shock	0.92
η'	Borrower's labor supply elasticity	0.51	σ_{AC}	STD of technology shock	0.01
ξ	Saver's disutility of labor across sector	0.66	σ_{AH}	STD of housing technology shock	0.0193
ξ'	Borrower's disutility of labor across sector	0.97	σ_{AK}	STD of investment-specific technology shock	0.0104
$\phi_{k,c}$	Capital adjustment cost in good sector	14.25	σ_j	STD of housing demand shock	0.0416
$\phi_{k,h}$	Capital adjustment cost in housing sector	10.9	σ_R	STD of Policy Rate Shock	0.0034
α	Labor-income share of saver	0.79	σ_z	STD of intertemporal preference shock	0.0178
r_R	Monetary policy inertia	0.59	σ_τ	STD of labor supply shock	0.0254
r_π	Monetary policy inflation feedback	1.44	σ_p	STD of inflation shock	0.0046
β	Monetary policy output feedback	0.52	σ_s	STD of technology shock	0.0004

Shocks. Productivity in the consumption ($A_{c,t}$), investment ($A_{k,t}$), and housing sector ($A_{h,t}$) follows:

$$\ln(A_{z,t}) = t\ln(1+\gamma_{Az}) + \ln(Z_{z,t}),$$

where γ_{Az} is the net growth rate of technology in each sector

$$\ln(Z_{z,t}) = \rho_{Az}\ln(Z_{z,t-1}) + u_{z,t}.$$

$u_{z,t}$ is the innovation and $z=\{c,k,h\}$. The inflation target ($A_{s,t}$), inter-temporal preference ($A_{z,t}$), labor supply ($A_{\tau,t}$), and housing-preference ($A_{j,t}$) shocks follow $AR(1)$ processes. The cost-push shock ($u_{p,t}$) and the shock to the policy rule ($u_{R,t}$) are assumed to be *i.i.d*. We set the model parameters, persistence and standard deviation of the shocks equal to the mean of the posterior distribution estimated by Iacoviello and Neri (2010). These values are summarized in Table 1.

3. News shocks

Specification. We introduce expectations of future macroeconomic developments through news shocks. As in Christiano et al. (2008), we assume that the error term of the shock consists of an unanticipated component ($\varepsilon_{z,t}$), and an anticipated change n quarters in advance ($\varepsilon_{z,t-n}$)

$$u_{z,t} = \varepsilon_{z,t} + \varepsilon_{z,t-n}, \tag{9}$$

where $\varepsilon_{z,t}$ is i.i.d. and $z=\{c,h,k,p,R,s\}$. Thus, at time t agents receive a signal about future macroeconomic conditions that will occur at time $t+n$. If the expected movement does not occur, then $\varepsilon_{z,t} = -\varepsilon_{z,t-n}$ and $u_{z,t}=0$. Throughout this analysis, the news-shock horizon is assume to be four-periods ahead, i.e. $n=4$. Section 7.3 conducts an analysis of the model's sensitivity to the horizon assumption and considers the inclusion of revisions.[16]

We introduce news on productivity in the non-durable ($A_{c,t+n}$), housing ($A_{h,t+n}$) and investment-specific ($A_{k,t+n}$) sectors, on monetary policy ($u_{R,t+n}$), on the central bank's inflation target ($A_{s,t}$), and on cost-push ($u_{p,t}$) shocks; we do not consider news on housing preference ($A_{j,t}$) and time-preference (z_t) shocks. Anticipated changes in these fundamentals generate house-price and credit cycles in our model. Fig. 1 shows the impulse responses for the four-period-ahead ($n=4$) news shocks that materialize. More precisely, the left panel shows the responses to an anticipated positive innovation in A_c, A_k and a negative innovation in A_h; the right panel shows the responses to an anticipated negative innovation in u_R and a

[16] The benchmark results are based on the assumption that the anticipated component of the error term of each shock has the same variance as the unanticipated component as estimated in Iacoviello and Neri (2010). See Table 1. The results presented in Section 7.3 are instead based on Gomes and Mendicino (2011) joint estimates of the model's parameters and the standard deviations of the unanticipated and news components of each shock.

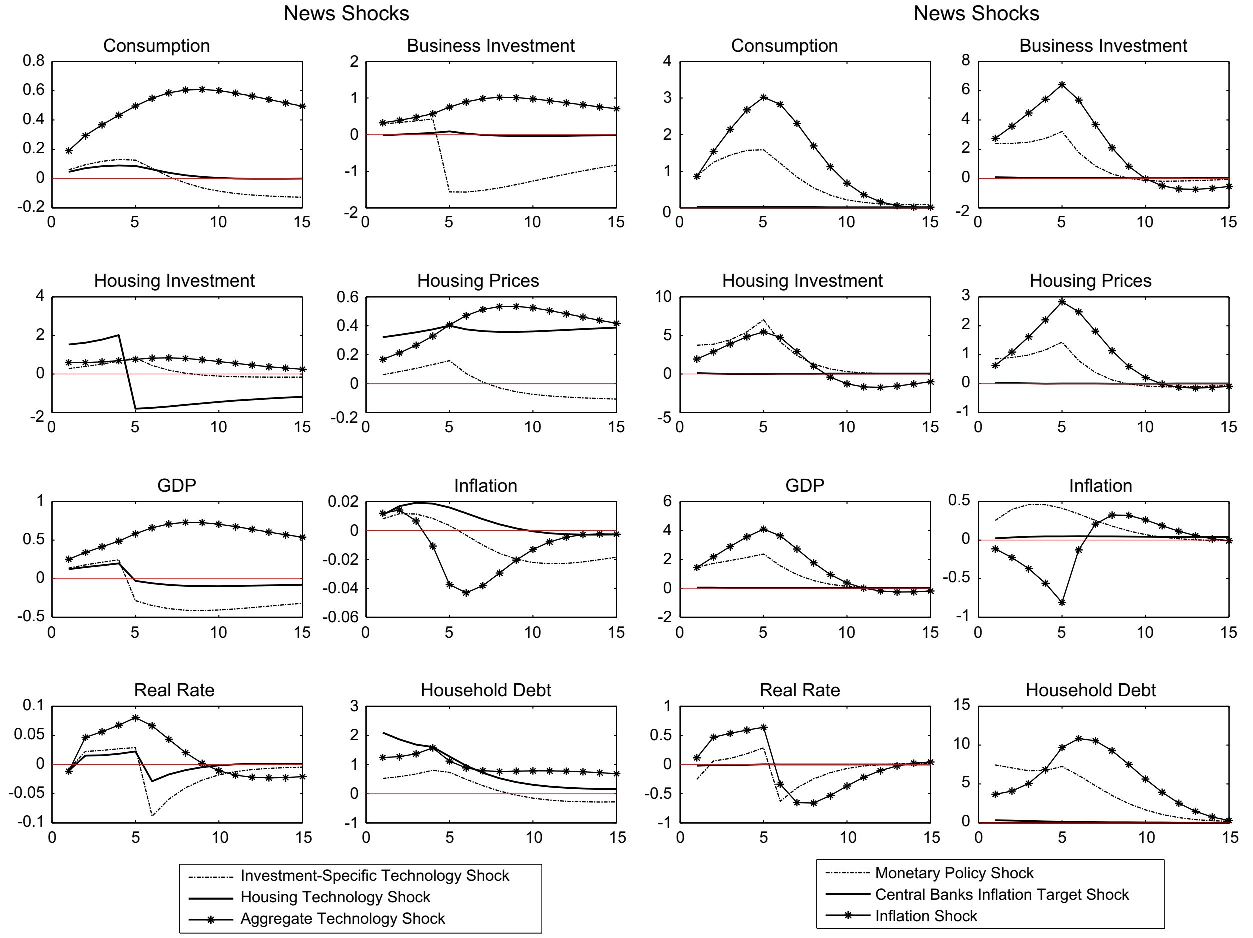

Fig. 1. Transmission mechanism news shocks: productivity shocks (left panel) and non-productivity shocks (right panel).

positive innovation in A_s and u_p. These news share the same feature: agents anticipate an increase in future house prices, which in turn raises leverage and causes a boom in the housing market. Fig. 2 shows the impulse responses in the case of news that do not materialize. In this case, the run-up in house prices and debt is followed by a bust. Hence, boom–bust cycles in the housing market can be plausibly related to expectations of future developments in different sectors of the economy and in the conduct of monetary policy.

Transmission mechanism. News shocks are plausible sources of optimism about future house-price appreciation and generate macroeconomic booms characterized by hump-shaped co-movement between house prices, consumption, residential investment, and mortgage loans.[17] To generate a boom in house prices and credit, it is necessary that agents expect a future increase in housing prices. Expectations about the future occurrence of shocks that lead to house-price appreciations fuel current housing demand and lift house prices immediately. Thus, the value of housing as a collateral increases, and the rise in house prices is coupled with an expansion in household credit. Second, unrealized expectations about future shocks generate boom–bust cycles in the housing market. Unrealized expectations distort consumption, borrowing and investment plans above the equilibrium level. Their sudden reversals have negative effects on economic and financial decisions, which are transmitted across sectors. Thus, the possibility of unrealized expectations gives a potential role to stabilization policy.

As an illustrative example, we describe the transmission mechanism of negative housing-productivity news shocks, i.e. expectations of lower future productivity in the housing sector. The left panel of Fig. 1 (solid line) shows the impulse responses for four-period-ahead ($n=4$) news on housing-productivity shocks. Expectations of lower future productivity in the housing sector generate expectations of future house-price appreciation. Thus, Borrowers increase their current housing demand for speculative purposes. Household indebtedness rises, reinforcing an increase in current housing and consumption expenditures. Due to an increased housing demand, current housing prices and housing investment rise.

[17] The transmission mechanism of news shocks in the model presented above is in line with the results of Lambertini et al. (2013) that estimate, using a VAR model and survey data, the effect of innovations to news heard of favorable changes in business conditions and to expectations of rising house prices.

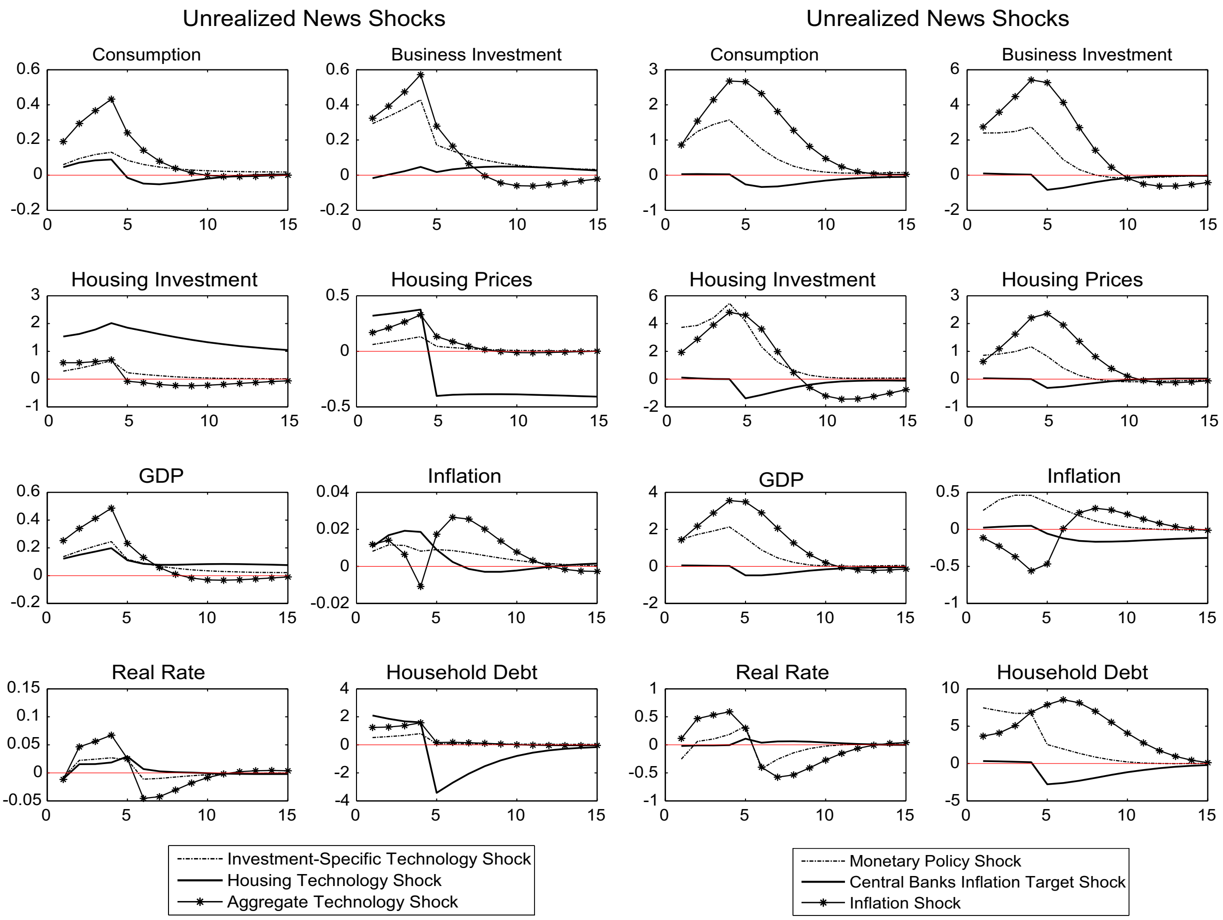

Fig. 2. Transmission mechanism unrealized news shocks: productivity shocks (left panel) and non-productivity shocks (right panel).

Moreover, due to credit limits, Borrowers increase their labor supply in order to raise internal funds for housing investments. Given the adjustment costs of capital, firms already start adjusting the stock of capital at the time in which news spreads. The stock of capital used as in input of production in the housing sector decreases over time. In contrast, it increases in the consumption-good sector of production, and current business investment slightly increases. As shown in the left panel of Fig. 1 (solid line) anticipated negative-housing supply shocks generate a boom in housing prices, housing investment, consumption, GDP, hours worked and households' credit.

In the following, we also describe the transmission of an anticipated reduction in the policy rate, i.e. news of future negative innovations of u_R. Lower future policy rates generate expectations of a decline in the future real interest rate. Borrowers anticipate this effect and increase their current consumption, as servicing loans will be less expensive. Demand pressure raises current inflation. The current ex-post real rate declines, reducing the debt service. The anticipation of expansionary monetary policy also creates expectations of higher future housing prices that further induce Borrowers to increase their current demand for housing and thus indebtedness. Due to limits on credit, impatient households increase their labor supply in order to raise internal funds for housing investments. Savers face a reduction in their current and expected interest income. Thus, for this group of agents, consumption increases by less, current housing investment declines and their labor supply increases significantly. As in the previous case, due to capital adjustment costs, firms already begin adjusting the stock of capital when news about a future reduction in the policy rate spreads. For the increase in investment to be coupled with an increase in hours, wages rise in both sectors. The increase in business and housing investment makes GDP increase at the time of the signal. As a consequence of the current increase in inflation and GDP, the policy rate increases at the time of the signal, to decline only at the time of the occurrence of the shock. In the case of an anticipated shock that is realized (Fig. 1), aggregate variables boom and then slowly decline. In contrast, if expectations are not realized, there is a dramatic drop in both quantities and prices (Fig. 2). Aggregate variables fall below their initial level. It takes about 10 quarters for GDP return to its initial level. Thus, unrealized expectations of loose monetary policy generate a macroeconomic boom–bust cycle followed by a recession.

A mechanism similar to the one described above holds for the transmission of other news shocks. In the case of anticipated shocks that do realize, aggregate variables boom and then slowly decline. The peak response in output corresponds to the time in which expectations realize. In contrast, if expectations do not realize there is a dramatic drop in both quantities and prices, with aggregate variables falling below their initial level.

4. Heterogeneity and welfare evaluation

Our paper studies interest-rate and macro-prudential policies in the presence of a rich stochastic structure that allows for both unanticipated and news shocks. We assume that the policymaker has the same information set as private agents. Thus, the ex-ante optimal policy is not dependent on a particular realization of the shocks. It is plausible that LTV and interest-rate rules that are conditional only on unfulfilled expectations would be successful in stabilizing boom–bust cycles. However, given the difficulty of identifying the source of fluctuations, we find it more interesting to characterize monetary and macro-prudential policy under a mixture of shocks and news that proxies changes into both current and expected economic conditions. All results are based on the nine unanticipated shocks and the six news shocks featured in the model.

We do not impose the optimality of stabilization policies by assuming an ad hoc loss-function that aims at minimizing the volatility of a chosen set of variables, typically inflation and output. To compare alternative policy rules in a meaningful way, without imposing any *a priori* conjecture on the optimality of reducing volatility, we rely on social welfare criteria. The policy authority maximizes households' welfare subject to the competitive equilibrium conditions and the class of interest-rate and LTV rules considered. The welfare analysis is based on the standard approach commonly used in the DSGE literature.[18] In the following, we briefly describe the methodology.

The welfare function for each agent is given by the conditional expectation of lifetime utility as of time t

$$V_t^i \equiv \max E_t\left[\sum_{j=0}^{\infty}(\beta^i)^j \tilde{U}(c_{t+j}^i, h_{t+j}^i, n_{c,t+j}^i, n_{h,t+j}^i)\right].$$

At the optimum

$$V_t^i = \tilde{U}(c_t^i, c_{t-1}^i, h_t^i, n_{c,t}^i, n_{h,t}^i) + \beta^i E_t V_{t+1}^i,$$

where $V_t^i = \{V'_t, V_t\}$ denotes the welfare of the Borrowers and Savers, respectively. Thus, we augment the set of equilibrium conditions of the model with two equations in two unknowns, V'_t and V_t. We explore the welfare performance of simple, optimal and operational rules that determine either the interest-rate (R_t) or the LTV ratio (m_t), as a function of observable macroeconomic variables that guarantee uniqueness of the rational expectations equilibrium. As it is common in the literature, we study ex-ante optimal simple rules based on the second-order approximate solution of the model.[19] We follow the rest of the literature and compute the welfare implied by the different rules conditional on the initial state's ($t=0$) being the deterministic steady state.[20]

Due to agents' heterogeneity, we explore the implications for group-specific welfare. However, we also aggregate individual welfare in a social welfare function. The social welfare function is a weighted average of the welfare of the two groups of agents (V_t^i)

$$\tilde{V}_t \equiv [\varphi' V'_t + \varphi V_t]. \tag{10}$$

As in Mendicino and Pescatori (2008) and Rubio (2011), we assume $\varphi' = (1-\beta')$ and $\varphi = (1-\beta)$ where the weights on households' welfare, β' and β, are such that, given a constant consumption stream, the Borrowers and the Savers achieve the same level of utility.[21] We maximize both individual and social welfare with respect to the parameters of each particular rule considered. Thus, optimized policy rules are characterized by the combination of parameters that delivers the highest welfare. We search over multidimensional grids of varying dimensions depending on the rule considered.

We compare the optimized rules with the estimated Taylor-type rule coupled with a passive macro-prudential policy that relies on a constant LTV ratio equal to 0.85, as calibrated by Iacoviello and Neri (2010). The social welfare under the estimated Taylor-type rule and a constant LTV ratio of 0.85 is −3.3001. See Table 2 (panel A). Alternative rules that maximize social welfare are compared both in terms of levels of welfare and in terms of a consumption-equivalent measure calculated

[18] See among others, Kim and Kim (2003), Faia and Monacelli (2007), Erceg et al. (2000), Schmitt-Grohe and Uribe (2005, 2007a, 2007b).

[19] As shown by the previous literature, first-order approximation methods are not locally accurate in evaluating the performance of different policies in terms of welfare. See among others, Kim and Kim (2003), Kollmann (2003a, 2003b), Schmitt-Grohe and Uribe (2004b, 2007a, 2007b).

[20] The rules considered in this paper do not have first-order effects. Thus, the deterministic steady state of the model is the same across the alternative regimes. Nevertheless, different policy regimes are associated with different stochastic steady states. The second-order approximation allows us to account for these differences. In the initial state agents' consumption, house holding and labor supply, $c_0^i = c_{-1}^i, h_0^i, n_{c,0}^i, n_{h,0}^i$, equal the deterministic steady state values. Since at time $t=0$ the deviation of the model's variables from the steady state is zero, the second-order approximate solution for the welfare functions, V_t^i, takes a simple form $V_t^i = f(\sigma^2)$, where σ^2 is the variance of the shocks. All sources of uncertainty play a role in the maximization of welfare. The coefficients on the variance of the shocks depend on the model parameters including the coefficients in the policy rules. See Schmitt-Grohe and Uribe (2004b) for further details. The maximization of the welfare function is based on the theoretical stochastic mean of the welfare delivered by the second-order approximation to the welfare and policy functions of the model. This means that we do not rely on simulations and our policy is independent of the certain realization of the unanticipated and news components of the shocks.

[21] It is important to highlight that defining the weights such that the planner equalizes utility across agent types given a constant consumption stream is only one of the possible criteria to define a social welfare function in this economy. See Section 7.3 for sensitivity to alternative weighting criteria.

Table 2
Conditional welfare.

Rules	Welfare values		
A. Baseline policy	Social	Savers	Borrowers
$m=0.85;\ r_R=0.59;\ r_\pi=1.44;\ r_Y=0.52;$	−3.3001	−44.0176	−98.9983
Social welfare maximization			
B. Optimized LTV rules			
$\nu_m=0.75;\ \nu_b=18.5$	−3.2964	−43.9572 (0.0455)	−98.8916 (0.3334)
$\nu_m=0.75;\ \nu_q=2$	−3.2996	−44.0199 (−0.0018)	−98.9803 (0.0563)
$\nu_m=0.75;\ \nu_y=0.5$	−3.3001	−44.0182 (−0.0005)	−98.9980 (0.0010)
C. Optimized interest-rate rules			
$r_R=0;\ r_\pi=1.1;\ r_Y=0.25$	−3.2970	−43.8639 (0.1160)	−98.9333 (0.2030)
$r_R=0;\ r_\pi=1.3;\ r_Y=0.25;\ r_q=0.8$	−3.2966	−43.9591 (0.0441)	−98.8958 (0.3203)
$r_R=0;\ r_\pi=1.4;\ r_Y=0;\ r_b=0.5$	−3.2940	−43.6610 (0.2694)	−98.8856 (0.3523)
D. Optimized interest-rate and LTV rule			
$r_R=0;\ r_\pi=1.1;\ r_Y=0.25;\ r_b=0.4;\ \nu_m=0.75;\ \nu_b=19$	−3.2937	−43.7807 (0.1789)	−98.8460 (0.4763)
E. Individual welfare maximization			
Savers' welfare			
$m=0.85;\ r_R=0;\ r_\pi=1.5;\ r_Y=0;\ r_b=0.6;$	−3.2941	−43.6572 (0.27462)	−98.8877 (0.3457)
Borrowers' welfare			
$r_R=0;\ r_\pi=1.1;\ r_Y=0.5;\ r_b=0;\ \nu_m=0.75;\ \nu_b=19$	−3.2945	−43.9405 (0.0582)	−98.8299 (0.526)

Second-order approximation. In parenthesis, individual welfare gains w.r.t. the baseline policy, i.e. estimated interest-rate rule coupled with a constant LTV ratio. Negative welfare gains indicate losses.

as the percentage increase in steady-state consumption that would make welfare under the baseline policy equal to welfare under the optimized rule.

5. Monetary and macro-prudential policy

In the following, we evaluate policies that make the LTV ratio respond to macroeconomic conditions and vary in a countercyclical manner. We also compare countercyclical LTV ratios to more standard policies, such as interest-rate rules, and assess the optimality of using both instruments.

5.1. Countercyclical LTV-ratio policy

We assume that the policy authority follows a Taylor-type rule as estimated by Iacoviello and Neri (2010) and allows the LTV ratio to vary in a countercyclical manner around it long-run setting of 85 percentage points.[22] We study the welfare implications of countercyclical LTV-ratio rules that respond to GDP, credit, and house price growth. In practice, we assume

$$m_t=\nu_m m_{t-1}+(1-\nu_m)m+(1-\nu_m)\nu_x(x_t-x_{t-1}), \tag{11}$$

where $m=0.85$ is the steady-state value for the LTV ratio, ν_m is an autoregressive parameter and ν_x is the response to alternative observable macroeconomic indicators, where $x_t=\{b_t,q_t,GDP_t\}$. We search over the $[-20,0]$ range for the parameter ν_x and the [0,0.75] range for the smoothing parameter ν_m.[23] A coefficient of $\nu_x=0$ corresponds to the case where the LTV ratio does not respond to the variable chosen as an imbalance indicator, and macro-prudential policy is non-active.

Table 2 (panel B) displays the parameters of each type of rule that maximize the social welfare function. It also reports the social and individual welfare levels, and the individual welfare gains relative to the baseline policy, i.e. the estimated Taylor-type rule coupled with a constant LTV of 0.85 (Table 2, panel A). All rules feature a high smoothing parameter.

[22] Iacoviello and Neri (2010) calibrate the parameter m equal to 0.85 percentage points over the period 1965–2006.

[23] The two-dimensional grid is based on a 0.01 step for each parameter. For values of ν_m higher than 0.85, the rational expectations equilibrium is indeterminate. Thus, in order to avoid policies that lead to proximity with indeterminate regions, we choose an upper bound for ν_m of 0.75. Higher values of ν_m (up to 0.85) do not yield sizable welfare gains.

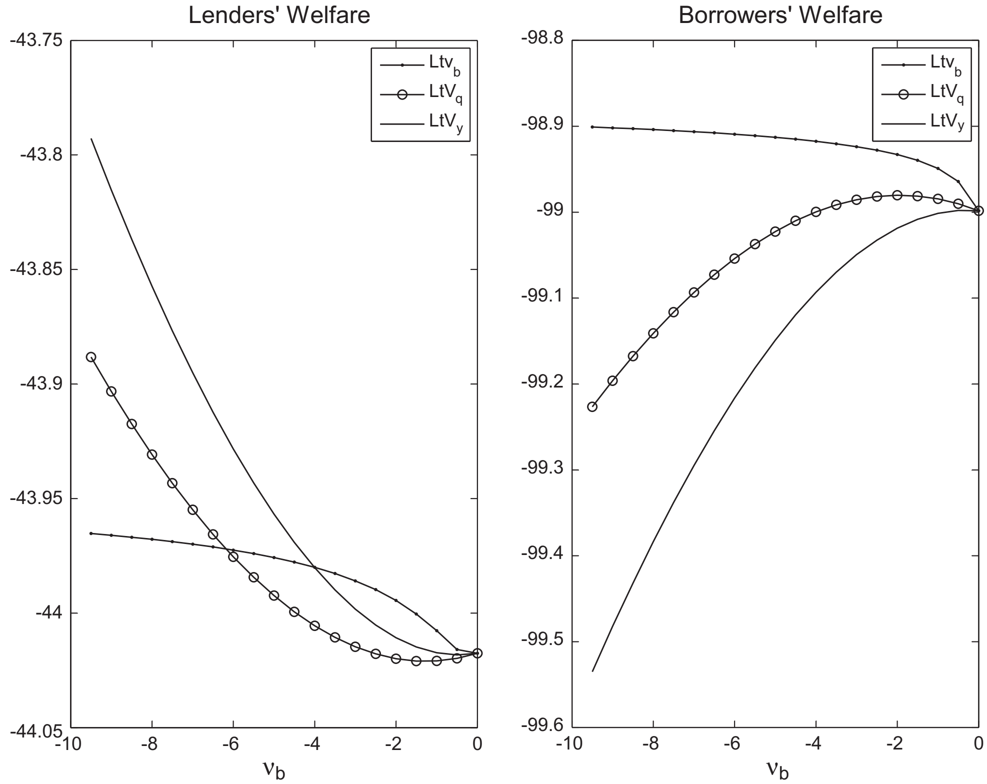

Fig. 3. Conditional welfare of LTV rules.

The optimal LTV rule that responds to credit growth features the largest value allowed in our search, whereas the other two rules react in a more moderate way to either house-price growth or GDP growth.[24]

Allowing for a countercyclical response of the LTV ratio to growth in macroeconomic variables improves upon a constant LTV ratio in terms of social welfare. However, this is not necessarily the case if we consider individual welfare. LTV rules that target either GDP growth or house-price growth face a trade-off between Savers' and Borrowers' welfare. In contrast, Savers and Borrowers are both better off under the optimized rule that responds to credit growth. Thus, allowing for the LTV ratio to respond countercyclically to credit growth is Pareto improving. Fig. 3 shows the welfare for Borrowers and Savers under the three alternative LTV rules for a range of values of ν_x between 0 and −10. Even though all LTV policies improve social welfare (relative to the baseline policy of a constant LTV ratio), only the LTV ratio that responds to credit growth improves the welfare of both groups of agents.

Table 3 reports the standard deviation of selected variables under alternative policies. Compared with the constant LTV policy, the three optimized LTV-ratio rules slightly reduce the volatility of house prices. However, the countercyclical LTV rule that responds to credit growth is more effective in reducing the volatility of the credit-to-GDP ratio, and thereby individual consumption and house holding. The intuition is as follows: since the optimal LTV rule that targets credit growth features a larger response to the targeted variable, it generates larger deviations of the LTV ratio (m_t) from its steady-state value, which effectively dampen out the dynamics of the credit-to-GDP ratio. In the absence of a countercyclical LTV policy, current shocks or news that lead to a credit expansion instead generate a reduction of the LTV ratio. As a result, loans are stabilized. This is not the case for LTV rules that target GDP or house-price growth because the smaller responses to these variables reduce the countercyclical variation of the LTV ratio and therefore the impact on credit volatility. The smaller responses to house-price growth and GDP growth in the LTV rules that maximize social welfare are dictated by the presence of the trade-off in the maximization of the welfare of the Savers and Borrowers.

5.2. *Interest-rate response to financial variables*

We assess alternative interest-rate rules that react to either credit growth or changes in house prices

$$R_t = R_{t-1}^{r_R}\pi_t^{(1-r_R)r_\pi}\left(\frac{GDP_t}{GDP_{t-1}}\right)^{(1-r_R)r_Y}\left(\frac{x_t}{x_{t-1}}\right)^{(1-r_R)r_x} rr^{(1-r_R)}\frac{u_{R,t}}{A_{s,t}}, \tag{12}$$

[24] Removing the upper bound for ν_b would imply a higher optimal response to credit growth. However, higher values of ν_b yield only marginal changes in welfare for both groups of agents (e.g. for $\nu_b = 25$ the improvement in V and V' relate to the 5th decimal number).

Table 3
Stabilization effect.

Rules	Savers' consumption	Borrowers' consumption	Savers' housing	Borrowers' housing	GDP	Housing prices	Debt/ GDP	Policy rate	Inflation
A. Baseline policy									
$r_R = 0.59$; $r_\pi = 1.44$; $r_Y = 0.52$	2.28	5.59	2.04	13.53	3.99	3.04	13.61	0.69	0.81
B. Optimized LTV rules and estimated interest-rate rule									
$\nu_m = 0.75$; $\nu_b = 18.5$	2.33	4.15	0.50	2.66	3.89	3.02	3.91	0.70	0.82
$\nu_m = 0.75$; $\nu_q = 2$	2.24	5.76	1.68	11.66	3.95	3.00	11.73	0.68	0.81
$\nu_m = 0.75$; $\nu_y = 0.5$	2.26	5.67	1.97	13.25	3.97	3.03	13.46	0.69	0.81
C. Optimized interest-rate rule and constant LTV									
$r_R = 0.59$; $r_\pi = 2.8$; $r_Y = 1.75$	1.94	4.23	1.60	10.58	3.06	2.70	11.42	0.50	0.77
$r_R = 0$; $r_\pi = 1.1$; $r_Y = 0.25$	1.98	4.68	1.86	12.33	3.61	2.81	12.58	1.19	1.04
$r_R = 0$; $r_\pi = 1.3$; $r_Y = 0.25$; $r_q = 0.8$	2.10	4.38	1.06	7.13	3.49	2.48	7.20	0.56	0.79
$r_R = 0$; $r_\pi = 1.4$; $r_Y = 0$; $r_b = 0.5$	1.53	2.63	0.67	3.40	2.45	2.17	4.25	1.20	0.95
D. Optimized interest-rate and LTV rule									
$r_R = 0$; $r_\pi = 1.1$; $r_Y = 0.5$; $r_b = 0.4$; $\nu_m = 0.75$; $\nu_b = 19$	1.78	2.75	0.54	1.89	3.06	2.49	3.09	1.21	1.09

Percentage standard deviations under the full set of shocks (both unanticipated and news) computed under the baseline policy, i.e. estimated interest-rate rule coupled with a constant LTV ratio (Panel A); the optimized countercyclical LTV-ratio rules (Panel B); the optimized interest-rate rules (Panel C); the joint maximization of the interest-rate and LTV rule (Panel D).
Both in A and B the interest rate follows the estimated Taylor-type rule of Iacoviello and Neri (2010).
Second-order approximation.

where $x_t = \{b_t, q_t\}$ and $r_x \geq 0$. We search over a four-dimensional grid over the parameters ranges [0,1] for r_R, [1.1,6] for r_π, [0,3] for r_Y, and [0,3] for r_x.[25]

Table 2 (panel C) reports the interest-rate rules that maximize social welfare. Some observations are in order. First, the optimal Taylor-type rule does not require interest-rate inertia, and features a moderate response to inflation and little or no response to GDP growth. Our model differs from the standard New-Keynesian model in three dimensions: heterogeneous discount factors, nominal household debt and news shocks. In the presence of heterogeneous agents it is suboptimal to stabilize inflation completely, as this would raise the volatility of the real interest rate and generate large unintended transfers from Borrowers to Savers or vice versa.[26]

Second, targeting financial variables improves both individual and social welfare. The information content of credit aggregates is such that an interest-rate rule that responds to credit growth is preferred by both agents. Among all optimized interest-rate rules, the rule that targets credit growth implies a lower volatility for all variables except inflation, which is only marginally more volatile (see Table 3). The stabilization effect of targeting credit growth implies that Borrowers' and Savers' welfare is highest under an interest-rate rule that responds to credit growth.

Comparing the optimized interest-rate rule that directly responds to credit growth with the optimized LTV-ratio rule that responds to credit growth in a countercyclical manner, we find that both rules: (a) lead to a Pareto improvement from the starting point of the benchmark policy; (b) are successful in reducing the volatility of credit relative to GDP, and also slightly reduce the volatility of house prices; (c) leave the volatility of inflation largely unchanged. When we compare the two rules in terms of social welfare, we find that the interest-rate rule that responds to credit growth is preferred. Even though both rules improve Borrowers' welfare, Savers accrue the largest welfare gains from an interest-rate response to credit growth coupled with a constant LTV ratio. Thus, social welfare maximization under (8) does not generate transfers that improve the welfare of one group of agents at the cost of a reduction in the welfare of the other. Notice that, in contrast to the optimized LTV rules that respond to the same macroeconomic variables, an optimal interest-rate response to house prices or GDP growth is also Pareto improving.

5.3. *On the use of both instruments*

We consider the possibility of allowing both the interest rate and the LTV ratio to respond to credit growth. Table 2 (panel D) shows that the optimization over both rules results in a strong reaction of the LTV to credit growth and a moderate reaction of the interest rate to the same variable. Compared with the estimated interest-rate rule coupled with a constant

[25] The grid step for each parameter is 0.1.

[26] Using a simpler model than ours, Mendicino and Pescatori (2008) study ex-ante optimal interest-rate rules and also show that, in the presence of nominal debt, monetary policy can avoid the welfare-reducing redistribution generated by nominal contracts by stabilizing the real interest rate, thereby allowing agents to share risk optimally. Monacelli (2006) shows that, in the presence of technology shocks, the Ramsey equilibrium is also characterized by some inflation volatility.

Table 4
Social welfare gains.

Optimized interest-rate and LTV rule vs…	Savers	Borrowers
(1) LTV rule max social welfare	0.1332	0.1423
(2) Interest-rate rule max social welfare	−0.0903	0.1236

Second-order approximation. In parenthesis, individual welfare gains w.r.t. the joint maximization of the LTV-ratio and interest-rate rule. Negative welfare gains indicate losses.

Table 5
Level and stabilization effect: individual welfare maximizing rules.

Rules	Stabilization and level effect						
	Savers' consumption	Borrowers' consumption	Savers' housing	Borrowers' housing	GDP	Housing prices	Debt/GDP
Optimized interest-rate and LTV rule	1.5061	0.3022	14.3766	2.3623	1.0161	1.0023	1.7517
	(1.78)	(2.75)	(0.54)	(1.89)	(3.06)	(2.49)	(3.09)
(1) Savers' welfare	1.5052	0.3017	14.3507	2.3495	1.0146	1.0037	1.7472
	(1.49)	(2.46)	(0.63)	(3.02)	(2.36)	(2.09)	(3.89)
(2) Borrowers' welfare	1.5068	0.3025	14.3866	2.3688	1.0169	1.0020	1.7547
	(2.25)	(3.71)	(0.54)	(2.43)	(3.79)	(2.99)	(3.8488)

Level effect: theoretical stochastic mean of the second-order approximation.
In parenthesis: standard deviations in percentage terms.

LTV (Table 2, panel A), both agents are better off under the policy that allows the optimal use of both instruments. Social welfare is higher when using both instruments relative than under any other rule. However, agents' heterogeneity fails to provide us with a uniform ranking among the alternative policy frameworks: Borrowers prefer the optimized rule that combine the use of both instruments, while Savers are better off under an interest-rate response to credit growth coupled with a constant LTV ratio.

Table 4 compares the performance, in terms of individual welfare, of the policy that optimizes the response of both instruments with respect to: (1) the estimated Taylor-type rule coupled with the optimized LTV ratio that responds to credit growth; (2) the optimized interest-rate response to credit growth coupled with a constant LTV ratio. In comparison with policy (1), the individual welfare gains of a policy that relies on the optimal response of both instruments to credit growth are of the same magnitude for both Savers and Borrowers.[27] In contrast, in comparison with policy (2), the Savers suffer some losses in terms of consumption. Thus, the use of a policy that allows both instruments to respond to credit growth turns out to be socially optimal, due to the large welfare gains accrued to Borrowers.[28]

Table 2 (panel E) reports the optimized rules that maximizes individual welfare. The rule that maximizes the welfare of the Borrowers requires an active countercyclical LTV policy and no interest-rate response to credit growth. In contrast, the rule that maximizes the welfare of the Savers features an interest-rate response to credit growth but a constant LTV ratio. Table 5 shows the level and the standard deviation of key variables under the policy that optimizes the response of both instruments and the individual welfare-maximizing rules.[29] Compared to the rule that maximizes social welfare, the policy preferred by Borrowers leads to higher levels of credit, consumption, house holding and GDP. On the other hand, the policy preferred by Savers reduces consumption volatility for this group.

[27] Table 2 compares the optimized rules with the baseline policy, whereas Table 4 compares directly the rule that allows for an optimal response of both instruments to credit growth with the rule that only allows a LTV-ratio response to credit growth or, alternatively, an interest-rate response to the same variable.

[28] For a discussion on the use of alternative weights in the social welfare function see Section 7.3.

[29] The policy that optimizes the response of both instruments is the one reported in Table 4, panel D, while the individual welfare maximizing rules are reported in Table 4, panel E.

Table 6
LTV ratio.

Rules	Relative frequency			LTV-ratio level statistics			
	$m_t > 0.85$	$m_t \geq 0.95$	$m_t \geq 1$	Average	$\min(m_t)$	$\max(m_t)$	$\text{stdv}(m_t)$
(1) Optimized LTV rule	0.58	0.02	0	0.88	0.74	0.98	2.36
(2) Optimized interest-rate and LTV rule	0.55	0.0067	0	0.87	0.76	0.96	1.72

5.4. Maximum LTV ratio and implied range

In the following, we assess the implications for the LTV ratio, m_t, under the optimized rules that feature an active LTV-ratio policy. In particular, we investigate whether the LTV ratio ever goes above 100%, and the implied LTV ratio range. See Table 6. The results are based on a sample size of a thousand observations of artificial data. Rule (1) denotes an optimal countercyclical LTV response to credit growth coupled with the estimated interest-rate rule. Rule (2) features an optimal LTV-ratio and interest-rate response to credit growth.[30]

Table 6 reports the relative frequency of LTV-ratio values higher than 85 percentage points and higher or equal to 95 and 100 percentage points, respectively. Both rules display more than a 50% probability of having a LTV ratio above 85 percentage points. In fact, the average LTV ratio is higher than the pre-established cap of 0.85 under both rules. The probability of having a LTV ratio equal to or greater than 95 percentage points is about 2% under rule (1). The same probability drops to 0.67 percentage points under rule (2). The LTV ratio never hits the 100% bound.

Table 6 also reports the minimum and maximum LTV-ratio levels that are in line with the two alternative policies. The implied LTV range is larger under rule (1) than under rule (2). Further, the policy that features both LTV-ratio and interest-rate responses to credit growth stabilizes the LTV ratio. However, the range implied by both policies is in line with the average and maximum LTV ratios in several industrialized countries.[31]

6. News shocks and welfare gains

The analysis conducted in this paper does not aim at designing optimal policies conditional on some particular shocks, but rather is based on the assumption that various sources of fluctuation, both expected and unexpected, can affect the economy. Hence, the policy authority does not target specific shocks or boom–bust cycles. However, we find it crucial to understand how the occurrence of news shocks in the economy relates to the welfare gains of various policy responses to changes in financial variables.

Table 7 documents the role of news-shock-driven cycles in the policy response to changes in financial variables. We compare the welfare performance of the three optimized rules under three case scenarios: (1) both news and unanticipated shocks, (2) no news shocks, (3) only news shocks.[32] Neglecting news shocks as sources of uncertainty unambiguously increases welfare for both groups of agents. However, it does not alter the individual ranking of the three optimized rules. Savers are better off under a constant LTV ratio (panel C) whereas Borrowers prefer a LTV ratio that responds countercyclically to credit growth (panel B).

News shocks turn out to be particularly important in determining the welfare gains of the Savers, but also account for a sizable fraction of the welfare gains accrued to the Borrowers. In particular, under the optimized rule that combines the use of both instruments, news shocks account for most of the Savers' welfare gains, and around 40% of the Borrowers' welfare gains, from a policy reaction to fluctuating financial variables (panel E). Similar results hold for gains under the other two optimized rules. Thus, the gains from a policy response to financial variables are significantly related to the assumption of news-shock-driven cycles.

Fig. 4 shows the responses of some key variables both under the baseline policy, namely the estimated interest-rate rule and constant LTV ratio (dashed line), and under the policy that optimally combines the use of both instruments (solid line). We consider the case of an unrealized four-quarter-ahead anticipated shock to housing productivity and monetary policy. Responses to credit growth tighten financial conditions during housing market booms, and loosen financial conditions during busts. As a result, the amplitude of the fluctuations generated by unrealized news shocks is reduced relative to the baseline policy. Boom–bust cycles are mitigated thanks to a stable provision of financial intermediation that improves welfare for both Savers and Borrowers.[33]

[30] The coefficients of the two rules are the ones reported in Table 2, panels B and D, respectively.

[31] Calza et al. (2013) document that typical LTV ratios imposed on new loans in the mortgage market vary significantly among OECD countries and range between 50 percentage points in Italy to 90 percentage points in The Netherlands and the United Kingdom.

[32] The welfare gains are computed with respect to the baseline policy, i.e. the estimated rule coupled with a constant LTV ratio, under each of the three cases (both news and unanticipated shocks, no news shocks, only news shocks), respectively. See Table 7, panel A.

[33] It is important to stress that boom–bust cycles are not completely offset by the policy authority, since we rely on ex-ante optimal policy that is not conditional on the realization of any particular unanticipated or news shock.

Table 7
Conditional welfare with and without news shocks.

	A. Baseline policy		B. Estimated interest-rate and optimized LTV rule		C. Optimized interest-rate and constant LTV rule		D. Optimized interest-rate and LTV rule	
	Savers	Borrowers	Savers	Borrowers	Savers	Borrowers	Savers	Borrowers
Welfare gains								
(1)								
All shocks	−44.0176	−98.9983	−43.9572 (0.0455)	−98.8916 (0.3334)	−43.661 (0.2694)	−98.8856 (0.3523)	−43.7807 (0.1789)	−98.846 (0.4763)
(2)								
No news	−43.7576	−99.2725	−43.7459 (0.0088)	−99.2114 (0.1908)	−43.6817 (0.0572)	−99.2052 (0.2102)	−43.7165 (0.0310)	−99.1754 (0.3034)
(3)								
Only news	−45.4343	−99.2762	−45.3857 (0.0367)	−99.2306 (0.1423)	−45.1536 (0.2120)	−99.2307 (0.1419)	−45.2386 (0.1478)	−99.221 (0.1723)

Second-order approximation. In parenthesis, individual welfare gains w.r.t. the baseline policy, i.e. estimated interest-rate rule coupled with a constant LTV ratio.

7. Key issues

7.1. On the importance of monetary policy shocks

In the analysis conducted above, we maximize social welfare always taking into account all sources of fluctuation in the model. Thus, we also include the inflation-targeting shock and the i.i.d. shock to the interest-rate rule. The inclusion of monetary policy shocks could be interpreted as a way to take into account the reaction of monetary policy to changes in macroeconomic and financial variables not included in the interest-rate rule, or as the exercise of judgement and discretion.[34]

We now explore the welfare implications of the optimized rules in the absence of monetary policy shocks. Table 8 reports the individual welfare levels under alternative rules and the welfare gains with respect to the estimated interest-rate rule coupled with a constant LTV ratio.[35] Disregarding monetary policy shocks increases individual welfare and reduces the welfare gains of the optimized rules. However, it does not alter the individual rankings of the three optimized policy rules. In fact, independently of the presence of monetary policy shocks, Savers get larger welfare gains under the optimized interest rate coupled with a constant LTV ratio whereas Borrowers are better off under an active use of both instruments.

The bottom panel of Table 8 reports the individual welfare levels in the model when we exclude the anticipated component or, alternatively, the news component of the monetary policy shocks. First, we evaluate all policies when including the unanticipated component and neglecting the news component. Then, we calculate the welfare implications considering the news component but ignoring the unanticipated component. It is worth noting that the two components have largely the same implications for the individual welfare levels and the implied welfare gains of the alternative policies.

7.2. Occasionally binding constraint

In the following, we report sensitivity to the occasionally binding nature of the borrowing constraint.[36] To this end, we solve an equivalent version of the model in which higher borrowing is feasible, but it is too costly to exceed the limit. Following the previous literature, we solve the model using a "barrier method."[37] Thus, we approximate the inequality constraint using a differentiable penalty function, $P(h_{i,t}, b_{i,t})$, that enters the utility function of the Borrowers

$$P(h'_t, b'_t) = \frac{\chi_1}{\chi_0}\exp\left\{-\chi_0\left(mE_t\frac{q_{t+1}\pi_{t+1}h'_t}{R_t} - b'_t\right)\right\}.$$

Unlike a constraint that is always binding, the penalty function does not prevent impatient agents from borrowing less than the debt limit in a neighborhood of the steady state. However, the penalty term, χ_0, is large enough to discourage Borrowers from violating the debt limit. We set χ_0 equal to 100 and χ_1 such that the two versions of the model have the same deterministic steady state.

[34] For a similar approach see among others, Reis (2009).

[35] Table 8, panel A reports the individual welfare level under the estimated rule coupled with a constant LTV ratio, both in the benchmark case and in the absence of monetary policy shocks.

[36] Following the approach commonly used in the literature, in previous sections we assume that the borrowing constraint is always binding in a neighborhood of the steady state. See among others, Campbell and Hercowitz (2004), Iacoviello (2005), Monacelli (2009), Iacoviello and Neri (2010), Sterk (2010), Calza et al. (2013), Andres and Arce (2012).

[37] For the use of "barrier methods", see Judd (1998). The same approach has been used to solve models with non-negativity constraints by, among others, Rotemberg and Woodford (1999), Preston and Roca (2007), Den Haan and Ocaktan (2009), Kim et al. (2010), Kim and Ruge-Murcia (2011) and Mendicino (2012).

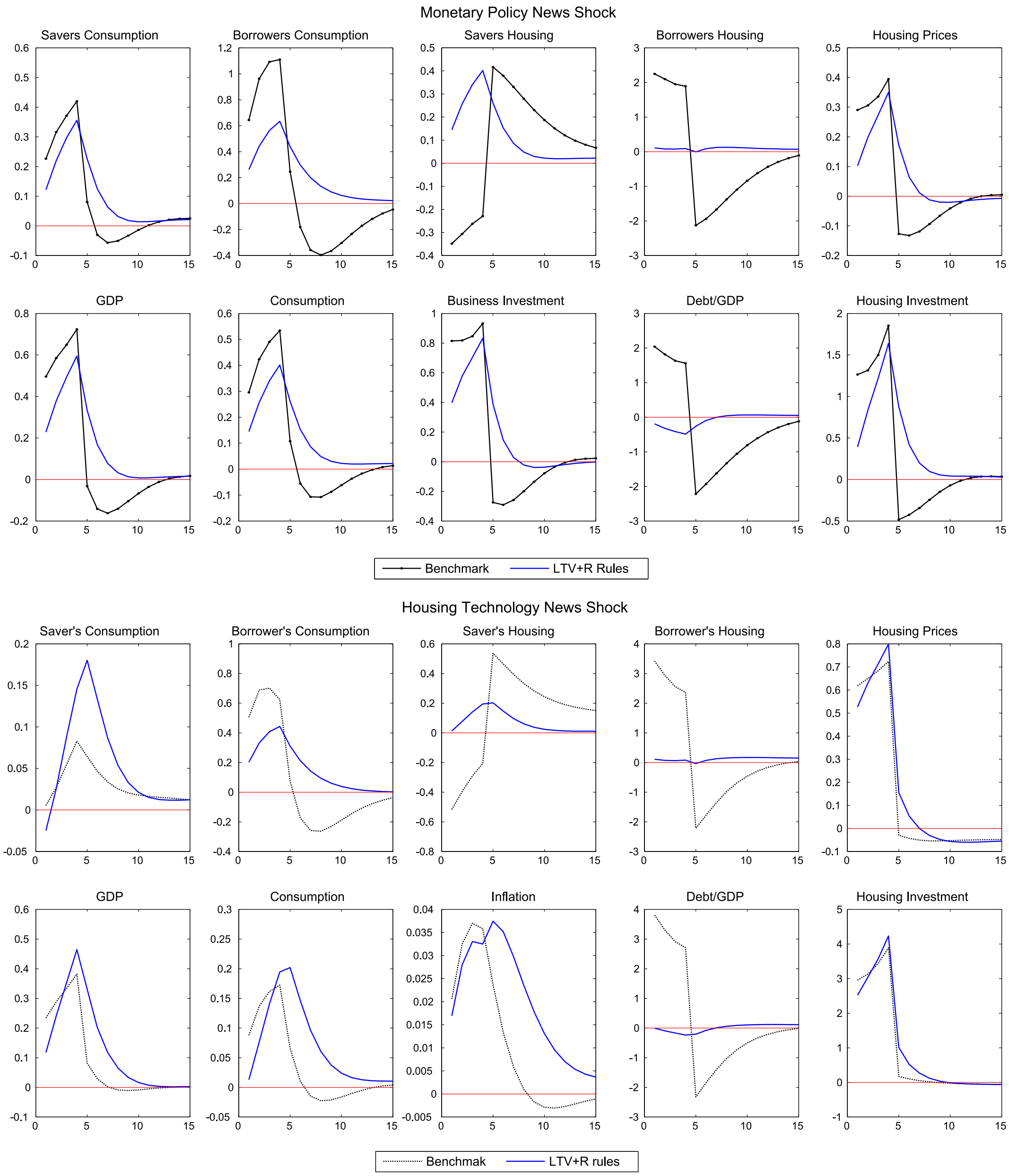

Fig. 4. Transmission of unrealized news on monetary policy shock (top graph) and housing technology shock (bottom graph) under benchmark and optimized interest-rate and LTV rule.

Table 9 reports the optimal coefficients of the rule that allows for both an interest-rate response to credit growth and a countercyclical LTV response to the same variable. Our findings confirm the optimality of responding to changes in financial variables. As in the case of an always-binding collateral constraint, the policy rule that maximizes the social welfare function features a strong countercyclical response of the LTV ratio to credit growth, a moderate interest-rate response to output and credit growth and a weak response to inflation. The welfare levels implied by the alternative rules are of the same magnitude as in the presence of always-binding collateral constraints. Further, we also find substantial heterogeneity in the implications for welfare. Savers are better off under a constant LTV ratio coupled with an interest-rate rule that responds to credit growth. In contrast, Borrowers' welfare is maximizes by an LTV ratio that countercyclically responds to credit growth, coupled with an interest-rate rule that responds only to output and inflation. No interest-rate response to credit growth is required to maximize the welfare of the two agents. Thus, taking into account the occasionally binding nature of the borrowing constraint does not alter substantially the main results of the paper.

Table 8
Conditional welfare relative to monetary policy shocks.

	A. Baseline policy		B. Estimated interest-rate and optimized LTV rule		C. Optimized interest-rate and constant LTV rule		D. Optimized interest-rate and LTV rule	
	Savers	Borrowers	Savers	Borrowers	Savers	Borrowers	Savers	Borrowers
Welfare gains								
All Shocks	−44.0176	−98.9983	−43.9572	−98.8916	−43.661	−98.8856	−43.7807	−98.846
			(0.0455)	(0.3334)	(0.2694)	(0.3523)	(0.1789)	(0.4763)
No MP shocks	−43.8979	−98.9389	−43.8565	−98.8638	−43.6483	−98.8832	−43.7267	−98.8353
			(0.0313)	(0.2344)	(0.1885)	(0.1738)	(0.1294)	(0.3235)
No MP news shocks	−43.957	−98.9788	−43.9051	−98.8813	−43.6538	−98.8845	−43.7476	−98.8399
			(0.0392)	(0.3046)	(0.2291)	(0.2946)	(0.1581)	(0.4341)
No MP unant shocks	−43.9585	−98.9584	−43.9086	−98.8741	−43.6555	−98.8843	−43.7597	−98.8414
			(0.0376)	(0.2633)	(0.2289)	(0.2314)	(0.1501)	(0.3657)

Second-order approximation. In parenthesis, individual welfare gains w.r.t. the baseline policy, i.e. estimated interest-rate rule coupled with a constant LTV ratio.

7.3. Social welfare

In Section 4, we define the weights of the social welfare function such that the planner equalizes utility across agent types given a constant consumption stream. In fact, for the same constant consumption stream $C=C'$, Savers' lifetime utility is $V=(1/(1-\beta))U(C)$, whereas Borrowers' is $V'=(1/(1-\beta'))U(C')<(1/(1-\beta))U(C)$. Given the parameter values assigned to β and β', the welfare of the Savers would be about four times higher than the welfare of the Borrowers. Weighting V_t by $(1-\beta)$ and V'_t by $(1-\beta')$ ensures the same level of utility across agent types for given $C=C'$. This is equivalent to having a weight on the Borrowers' welfare that is four times the weight for the Savers' welfare, for instance $\tilde{V}_t \equiv [0.8V'_t+0.2V_t]$, which can be interpreted as assuming a redistribution motive that favors Borrowers over Savers in the design of policy.

Now, we consider social welfare functions that weight the welfare of the two agents according to an alternative criteria. The top panel of Table 10 reports the rules that maximize social welfare under the benchmark weighting scheme (panel A) and when the welfare of the two agents is weighted equally (panel B). Compared to the rule that maximizes the benchmark social welfare, equal welfare weighting requires a constant LTV and a more aggressive interest-rate response to credit growth. The bottom panel of Table 10 reports the individual welfare costs implied by the social welfare maximizing rules compared to the rules that maximize the welfare of the Savers (2) and the Borrowers (3). The rules that maximize the individual welfare of the agents are independent of the weighting schemes used for the social welfare function and their coefficients are reported in Table 2 (panel E).

The benchmark rule (panel A) implies a welfare cost for the Borrowers of 0.0502 when compared with rule (3), which maximizes the welfare of this group of agents. The same rule implies a welfare cost for the Savers of 0.0932 compared with their preferred rule (2). Panel B reports the optimized policy rule that maximizes social welfare when we assume equal weights for the welfare of the two agents. This optimized policy rule is very similar to the policy rule that maximizes the welfare of the Savers and therefore implies a negligible welfare cost for this group. In contrast, the welfare cost for the Borrowers is much larger when compared to their preferred rule.[38] Overall, Savers' and Borrowers' welfare costs for not adopting their preferred rules are more similar under the rule that maximizes the benchmark social welfare function than under the rules that maximize a social-welfare criterion that assigns equal weights to the two agents.

7.4. Sensitivity to Gomes and Mendicino (2011)

This section reports sensitivity to the estimates of Gomes and Mendicino (2011). The authors estimate Iacoviello and Neri (2010) model, augmented by news shocks, and allowing for anticipated changes four and eight quarters ahead, as in Schmitt-Grohe and Uribe (2012). Thus, the innovation announced four quarters in advance can be viewed as a revision to the innovation announced eight quarters in advance.[39]

Optimization over both interest-rate and LTV rules results in a strong countercyclical response of the LTV ratio to credit growth, coupled with a moderate response of the interest-rate to the same variable. In contrast to results presented in Table 2 (panel D), the interest-rate rule in this version of the model features a more aggressive response to inflation and a mute response to GDP. Table 11 reports the coefficients of the optimized rule. The individual welfare levels are substantially

[38] Social welfare functions that weight Savers' welfare more than Borrowers', as it would be the case if the weights equal the labor-income shares, increase the welfare costs of the Borrowers but reduce the welfare costs of the Savers relative to their preferred rules.

[39] Strictly speaking, the error term of the shock consists of an unanticipated component ($\varepsilon_{z,t}$), and an anticipated change four and eight quarters in advance: $u_{x,t}=\varepsilon^0_{x,t}+\varepsilon^4_{x,t-4}+\varepsilon^8_{x,t-8}$. This assumption allows for revisions in expectations, e.g. $\varepsilon^8_{x,t-8}$ can be revised at time $t-4$ (up or down, partially or completely, in the latter case $\varepsilon^4_{x,t-4}=-\varepsilon^8_{x,t-8}$) and $\varepsilon^4_{x,t-4}+\varepsilon^8_{x,t-8}$ can be revised at time 0 (again, partially or completely, in the latter case $\varepsilon^0_{x,t}=-(\varepsilon^4_{x,t-4}+\varepsilon^8_{x,t-8})$ and $u_{x,t}=0$).

Table 9
Occasionally binding borrowing constraint.

		Welfare values		
	Baseline policy	Social	Savers	Borrowers
	$m=0.85$; $r_R=0.59$; $r_\pi=1.44$; $r_Y=0.52$; Optimized rule	−3.2961	−43.9822	−98.8745
Max social welfare	$r_R=0$; $r_\pi=1.1$; $r_Y=0.25$; $r_b=0.2$; $\nu_m=0.75$; $\nu_b=19$	−3.2936	−43.8129 (0.1278)	−98.8334 (0.1282)
Max Savers welfare	$r_R=0$; $r_\pi=1.4$; $r_Y=0$; $r_b=0.8$; $\nu_m=0$; $\nu_b=0$	−3.2951	−43.7425 (0.1810)	−98.8999 (−0.0794)
Max Borrowers welfare	$r_R=0$; $r_\pi=1.1$; $r_Y=0.5$; $r_b=0$; $\nu_m=0.75$; $\nu_b=19$	−3.2942	−43.9575 (0.0186)	−98.8159 (0.1827)

Second-order approximation. In parenthesis, individual welfare gains w.r.t. the baseline policy, i.e. estimated interest-rate rule coupled with a constant LTV ratio. Negative welfare gains indicate losses.

Table 10
Social welfare: alternative weighting schemes.

Social welfare criteria				
(1) Social welfare max rules	A $\tilde{V}_t \equiv [(1-\beta)V_t + (1-\beta')V'_t]$ $r_\pi=1.1$; $r_Y=0.25$; $r_b=0.4$ $\nu_m=0.75$; $\nu_b=19$		B $\tilde{V}_t \equiv [0.5V_t + 0.5V'_t]$ $r_\pi=1.4$; $r_Y=0$; $r_b=0.5$ $m=0.85$	
	Savers	Borrowers	Savers	Borrowers
Welfare level (1)	−43.7807	−98.8460	−43.6610	−98.8856
Welfare gains of (1) vs…				
(2) Savers welfare max rule $V=-43.6572$; $V'=-98.8877$;	−0.0932	–	−0.0029	–
(3) Borrowers welfare max rule $V=-43.9405$; $V'=-98.8299$;	–	−0.0502	–	−0.1736

Second-order approximation. In parenthesis, individual welfare gains w.r.t. the social welfare maximizing rules (as in panel (1)). Negative welfare gains indicate losses.

Table 11
Gomes and Mendicino (2011).

	Welfare values			
	Baseline policy $r_R=0.6552$; $r_\pi=1.5654$; $r_Y=0.8025$;		Optimized interest-rate rule and LTV rule $r_R=0$; $r_\pi=1.4$; $r_Y=0$; $r_b=0.4$ $\nu_m=0.75$; $\nu_b=19$	
	Savers	Borrowers	Savers	Borrowers
All Shocks	−47.3420	−100.8417	−46.0116 (1.0089)	−100.7531 (0.2767)
No UP (4&8) news shock	−46.9427	−100.8666	−45.8690 (0.8134)	−100.7699 (0.3018)
No UP (8) news shock	−46.9473	−100.8665	−45.8705 (0.8158)	−100.7697 (0.3022)
No AH (4&8) news shock	−47.3499	−100.8414	−46.0197 (1.0087)	−100.7534 (0.2750)
No AH (8) news shock	−47.3499	−100.8414	−46.0197 (1.0087)	−100.7534 (0.2750)

Second-order approximation. In parenthesis, individual welfare gains w.r.t. the baseline policy, i.e. estimated interest-rate rule (of Gomes and Mendicino, 2011) coupled with a constant LTV ratio.

lower than those reported in Table 2 (panel D). This result is plausibly due to the larger number of news shocks featured by this version of the model. Table 11 also reports the welfare gains with respect to the baseline policy, i.e. a constant LTV ratio of 0.85 coupled with the interest-rate rule of Gomes and Mendicino (2011). As for the welfare gains, the composition of the gains implied by the joint maximization of both policy rules is also substantially different. In fact, compared to the estimated interest-rate rule coupled with a constant LTV ratio, the welfare gains of adopting the optimized rule are lower for the Borrowers and considerably higher for the Savers than in the results presented in Table 2 (panel D).

According to Gomes and Mendicino (2011), news shocks in this model explain around 40% of business-cycle fluctuation in house prices and a sizable fraction of variations in consumption, residential and non-residential investment. The bottom panel of Table 11 reports the welfare implications of neglecting news on either cost-push shocks or housing-productivity shocks. As documented by Gomes and Mendicino (2011), news on cost-push shocks has been found to be important for the run-up in house prices and residential investment during the housing booms that occurred in the 1970s, whereas expectations of housing-productivity shocks and investment specific shocks contributed to changes in house prices and residential investment during the latest boom. In the absence of news on cost-push shocks, Savers experience a significantly higher welfare, whereas the welfare of the Borrowers is largely unchanged. As for the welfare performance of the optimized rule, the welfare gains accrued to the Savers are reduced by about 20%. In contrast, the Borrowers' welfare gains are slightly larger. In contrast, disregarding news on housing-productivity shocks does not yield significant differences in terms of welfare.

It is worth noticing that disregarding both components of each of the two shocks or only the eight-quarter-ahead component delivers very similar results for the cost-push shock, and no differences for the housing-productivity shock. This result suggests that revisions have no important role in terms of welfare. On the other hand, Gomes and Mendicino (2011) document that, among news shocks, the eight-quarter-ahead component accounts for most of the macroeconomic fluctuations in the model.

8. Discussion of the results and caveats

One of the contributions of our paper is to explore the implications of using the LTV ratio as a policy tool. It is fairly common in DSGE models of the housing market to consider a constant LTV ratio, equal to the typical or average LTV ratio for homebuyers or, alternatively, to calibrate it in order to match the ratio of flow-of-funds data on outstanding home mortgages to holdings of residential real estate during a selected sample period.[40] Our interest in countercyclical LTV-ratio policies arises from the current policy debate on the design of a macro-prudential policy whose goal is to moderate credit cycles and reduce financial imbalances. According to the 2010 survey on macro-prudential tools conducted by the IMF, two-thirds of the respondents have used macro-prudential tools since 2008. More than a third of the member-country authorities implemented LTV-ratio limits, and almost two-thirds considered it a possible policy tool. Making frequent adjustments of the LTV ratio at different phases of the cycle has recently become common practice internationally. Although our findings tend to favor the adoption of an active LTV policy adjusted countercyclically at different phases of the cycle, there are some caveats to be considered.

In the present paper, we focus on the benefits of LTV-ratio rules designed to mitigate the financial cycle by varying in a countercyclical manner around a pre-established cap. We abstract from other LTV policies, such as the occasional use of discretionary lower constant LTV caps, which have often been suggested to enhance the resilience of the financial system to macroeconomic shocks. In response to rapid mortgage growth and high household debt, some countries simply imposed discretionary lower caps on the LTV ratio. Whether adjusted over the cycle or not, tighter down-payment constraints on households' capacity to borrow may turn out to be effective in reducing the vulnerability of the economy to a credit crunch. However, as highlighted by Mendicino (2012), countercyclical LTV ratios, unlike discretionary lower caps, dampen credit-cycles without increasing the economy's sensitivity to real shocks or negatively affecting its long-run performance. The effectiveness of alternative credit-related policies in addressing the time-varying dimension of systemic risk in the presence of news shocks is left to future research.

Another issue not addressed in this paper is the optimal combination of macro-prudential instruments. As documented by the IMF survey, industrialized countries generally tend to favor credit-related measures over liquidity-related measures.[41] Nevertheless, the use of caps on the LTV ratio as a single macro-prudential instrument is rare. Countries generally prefer to use multiple instruments to target the same risk from different angles. Among the credit-related measures, limits on the LTV ratio are often coupled with limits on the debt-to-income ratio. However, there is still little known about the optimal combination of macro-prudential tools. The stabilization role of LTV-ratio policies could also be reinforced by the adoption of liquidity- and capital-related measures, such as reserves and capital requirements. But it is also possible that an appropriate use of countercyclical capital and reserve requirements could turn out to be more effective in addressing pro-cyclicality in the financial system, and thus overcome the need for time-varying LTV-ratio measures.

A particularly challenging task is the design of rules for the implementation of multiple tools. Optimally choosing macro-prudential targets is typically difficult, especially if countries operate a combination of tools that may interact or influence one another. Despite the fact that macro-prudential rules increase transparency, reduce regulatory uncertainty and overcome policy inertia, LTV-ratio adjustments in most countries are based on judgment and discretion rather than on rules. The comparison of rules and discretion may also warrant further research. More generally, a deeper understanding of

[40] See among others Campbell and Hercowitz (2009), Iacoviello and Neri (2010), Iacoviello (2008), Calza et al. (2013).

[41] The survey considers three types of measures: capital-related, liquidity-related and credit-related. Capital-related measures include countercyclical/time-varying capital-requirements, time-varying/dynamic provisioning, and restrictions on profit distributions. Liquidity-related measures consider limits on net open currency positions/mismatch, limits on maturity mismatch and reserve requirements. Apart from the LTV ratio and loan-to-income ratio, other credit-related measures include caps on foreign currency lending and ceilings on credit or credit growth.

the implementation and operational aspects of macro-prudential instruments also requires further analysis. The beneficial use of macro-prudential policy should be weighed against the costs of implementation, such as the regulatory burden. The effects on growth and on the long-run performance of the economy should also be taken into account.

The performance of alternative policies may be sensitive to the zero lower bound (ZLB) for the nominal interest rate. A criterion often imposed to avoid that the nominal interest rate not violate the zero bound is to require that, in the competitive equilibrium, the standard deviation of the nominal rate be less than a fraction of its steady-state value. In our model the steady-state annualized nominal interest rate is around three percentage points (with a gross steady-state rate of inflation of one percentage point). The standard deviation of the annualized interest rate (in nominal terms) under alternative policies is reported in Table 3. For the zero lower bound to be binding, the variation in the policy rate would need to be more than four times its standard deviation in case of the estimated interest-rate rule and the LTV rule that optimally responds to credit growth. In the case of the optimized interest-rate rule that reacts to credit growth and the optimal use of both instruments, the variation in the interest rate sufficient for the policy instrument to hit the zero lower bound is reduced to 2.5 times its standard deviation. Schmitt-Grohe and Uribe (2004a), for instance, require that the nominal interest rate be greater than two times its time standard deviation. However, we do not explicitly impose restrictions on the lower bound for the nominal interest rate, which we leave to future analysis.

A second contribution of this paper is to investigate the role of news-shock-driven cycles for the optimal design of policy rules. To this end, we introduce news shocks following the canonical assumption that the error term of the shock consists of both an unanticipated component and an anticipated change n quarters in advance.[42] However, as argued by Leeper and Walker (2011), the manner in which news shocks are modeled affects the way information flows impact equilibrium dynamics. Thus, the benefits of the optimized policy rules might be sensitive to assumptions about the news-shock process assumed.

Further, our results are based on a model populated by fully rational agents, which does not contemplate the possibility of bubbles as sources of excessive run-up in US house prices or credit. Despite the importance of news shocks as documented by a growing strand of the business-cycle literature, other factors, such as market sentiments, psychological factors, and shifts in beliefs that are independent of news shocks, may play a nontrivial role in generating expectation-driven macroeconomic fluctuations. There is a large literature on beliefs-driven cycles and excess volatility.[43] Allowing agents to depart from fully rational expectations into an otherwise standard model of housing does indeed generates excess volatility in house prices and household debt without requiring large and persistent shocks. The welfare implications of policy measures that aim at stabilizing financial and macroeconomic variables can be also sensitive to the nature of agents' expectations.

9. Conclusions

Our paper analyzes optimal monetary and macro-prudential policy in a model that allows (but do not impose) booms and busts cycles in housing prices and credit that arise in response to expectations of future changes on fundamental shocks. We investigate the design of ex-ante optimal policy rules by taking into account all possible sources of macroeconomic fluctuations. In order to avoid any *a priori* conjecture on the optimality of reducing the volatility of some particular variables, we evaluate alternative policies by using the welfare of the agents as a relevant criterion.

First, we explore the effectiveness of countercyclical LTV ratios as macro-prudential tools aimed at financial and macroeconomic stabilization. LTV rules face a trade-off between Savers' and Borrowers' welfare if they respond to GDP or house-price growth in a countercyclical manner. On the other hand, among the LTV-ratio rules, a response to credit growth is Pareto improving. Second, we compare the performance of countercyclical LTV rules and interest-rate rules in terms of welfare. We find that both the optimized interest-rate rule that responds directly to credit growth and the optimized LTV-ratio rule that responds countercyclically to credit growth lead to a Pareto improvement relative to the benchmark policy. Moreover, both rules are successful in reducing the volatility of credit and house prices without increasing the volatility of inflation. Using a countercyclical LTV policy in addition to an interest-rate response to credit growth is optimal in terms of social welfare because of the large gains that accrue to the Borrowers.

Last, we find that most of the gains from responding to changes in financial variables are due to the presence of news-shock-driven cycles. The amplitude of the financial cycles generated by varying news shocks is reduced under the social welfare maximizing policy.

Our results are robust to the exclusion of monetary policy shocks, to the occasionally binding nature of the borrowing constraint, and to the inclusion of revisions in the model.

Acknowledgments

We thank two anonymous referees, David Aikman, Jin Cao, Isabel Correia, Enrique Mendoza, Anella Munro, Stefano Neri, Christopher Otrok, Willi Semmler and Ignazio Visco, for valuable comments and suggestions. We are grateful to seminar

[42] See among others, Beaudry and Portier (2006), Christiano et al. (2008), Jaimovich and Rebelo (2009), Fujiwara et al. (2011), Milani and Treadwell (2012), and Schmitt-Grohe and Uribe (2012).

[43] See Section 1.1 for a review of the most related literature.

participants at the Banco de Portugal, the Bank of International Settlements, the Riksbank, the 2011 REPLHA International Conference, the BOK-BIS conference on *Macroprudential Regulation and Policy*, The Norges Bank workshop on *Interaction between Monetary Policy and Financial Stability*, the Reserve Bank of New Zealand conference on *Macro Policies After the Crisis* and the 1st ECB MaRS conference on *Macroprudential Policy* for useful feedbacks on this project. The opinions expressed in this paper do not reflect the position of the Banco de Portugal or the Eurosystem. Luisa Lambertini gratefully acknowledges financial support from the Swiss National Science Foundation, Grant CRSI11-133058.

References

Abraham, J., Pavlov, A., Wachter, S., 2008. Explaining the United States' uniquely bad housing market. Wharton Real Estate Review 12 (1), 24–41.
Adam, K., Kuang, P., Marcet, A., 2011. House price booms and the current account. In: NBER Macroeconomics Annual. MIT Press, pp. 77–122.
Andres, J., Arce, O., 2012. Banking competition, housing prices and macroeconomic stability. The Economic Journal 122, 1346–1372.
Angelini, P., Neri, S., Panetta, F., 2010. Macroeconomic stabilization policies: grafting macro-prudential tools in a macroeconomic framework. Manuscript.
Bank of England, 2009. The role of macro-prudential policy. Discussion paper.
Basel Committee on the Global Financial System, 2010. Macro-prudential instruments and frameworks: a stocktaking of issues and experiences. CGFS Publications 38.
Beaudry, P., Portier, F., 2006. Stock prices, news, and economic fluctuations. American Economic Review 96 (4), 1293–1307.
Benigno, G., Chen, H., Otrok, C., Rebucci, A., Young, E.R., 2012. Monetary and macro-prudential policies: an integrated analysis. Manuscript.
Benigno, G., Chen, H., Otrok, C., Rebucci, A., Young, E.R, 2013. Financial crises and macro-prudential policies. Journal of International Economic 89 (2), 453–470.
Bernanke, B., 2010. Monetary policy and the housing bubble. Speech at the Annual Meeting of the American Economic Association.
Bernanke, B., Gertler, M., 2001. Should central banks respond to movements in asset prices? American Economic Review Papers and Proceedings 91 (2), 253–257.
Bernanke, B., Gertler, M., Gilchrist, S., 1999. The financial accelerator in a quantitative business cycle framework. In: Taylor, J., Woodford, M. (Eds.), Handbook of Macroeconomics, Elsevier Science, North Holland, Amsterdam, pp. 1341–1393.
Bianchi, J., Mendoza, E., 2011. Overborrowing, financial crises and macroprudential policy. IMF Working Paper 11/24.
Bianchi, J., Mendoza, E., 2012. Macro-prudential policy in a fisherian model of financial innovation. IMF Economic Review 60 (2), 223–269.
Brunnermeier, M.K., 2009. Deciphering the liquidity and credit crunch 2007–2008. Journal of Economic Perspectives 23 (1), 77–100.
Burnside, C., Eichenbaum, M., Rebelo, S., 2010. Understanding booms and busts in housing markets. NBER Working Paper 16734.
Calza, A., Monacelli, T., Stracca, L., 2013. Housing finance and monetary policy. Journal of the European Economic Association 11 (Supplement s1), 101–122.
Campbell, J.R., Hercowitz, Z., 2004. Collateralized household debt in macroeconomic stabilization. NBER Working Paper 11330.
Campbell, J.R., Hercowitz, Z., 2009. Welfare implications of the transition to high household debt. Journal of Monetary Economics 56 (1), 1–16.
Christensen, I., Corrigan, P., Mendicino, C., Nishiyama, S., 2009. Consumption, housing collateral, and the Canadian business cycle. Bank of Canada Working Paper 2009-26.
Christensen, I., Meh, C.A., 2011. Countercyclical loan-to-value ratios and monetary policy. Manuscript.
Christiano, L., Ilut, C., Motto, R., Rostagno, M., 2008. Monetary policy and stock market booms. NBER Working Paper 16402.
Correia, I., Farhi, E., Nicolini, J.P., Teles, P. Unconventional fiscal policy at the zero bound. American Economic Review, forthcoming.
Den Haan, W.J., Ocaktan, T.S., 2009. Solving dynamic models with heterogeneous agents and aggregate uncertainty with dynare or dynare++. Manuscript.
Duca, J.V., Muellbauer, J., Murphy, A., 2011. Shifting credit standards and the boom and bust in US house prices. SERC Discussion Paper 76.
Dupor, B., 2005. Stabilizing non-fundamental asset price movements under discretion and limited information. Journal of Monetary Economics 52 (4), 727–747.
Erceg, C.J., Henderson, D.W., Levin, A.T., 2000. Optimal monetary policy with staggered wage and price contracts. Journal of Monetary Economics 46 (2), 281–313.
Faia, E., Monacelli, T., 2007. Optimal interest rate rules, asset prices and credit frictions. Journal of Economic Dynamics and Control 31 (10), 3228–3254.
Favilukis, J., Ludvigson, S.C., Van Nieuwerburgh, S., 2010. The macroeconomic effects of housing wealth, housing finance, and limited risk-sharing in general equilibrium. NBER Working Paper 15988.
Ferrero, A., 2012. House price booms, current account deficits, and low interest rates. Federal Reserve Bank of New York Staff Reports 541.
Fujiwara, I., Hirose, Y., Shintani, M., 2011. Can news be a major source of aggregate fluctuations? A Bayesian DSGE approach. Journal of Money, Credit, and Banking 43 (1), 1–29.
Gelain, P., Lansing, K.J., 2013. House prices, expectations, and time-varying fundamentals. Federal Reserve Bank of San Francisco Working Paper 03-2013.
Gelain, P., Lansing, K.J., Mendicino, C. House prices, credit growth, and excess volatility: Implications for monetary and macroprudential policy. International Journal of Central Banking, forthcoming.
Gete, P., 2009. Housing markets and current account dynamics. Manuscript.
Gilchrist, S., Leahy, J.V., 2002. Monetary policy and asset prices. Journal of Monetary Economics 49 (1), 75–97.
Gilchrist, S., Saito, M., 2008. Expectations, asset prices, and monetary policy: the role of learning. In: Asset Prices and Monetary Policy. National Bureau of Economic Research, Inc., pp. 45–102.
Gomes, S., Mendicino, C., 2011. Housing market dynamics: any news? Banco de Portugal Working Paper 21-2011.
Granziera, E., Kozicki, S., 2012. House price dynamics: fundamentals and expectations. Bank of Canada Working Paper 2012-12.
Iacoviello, M., 2005. House prices, borrowing constraints, and monetary policy in the business cycle. American Economic Review 95 (3), 739–764.
Iacoviello, M., 2008. Household debt and income inequality. Journal of Money, Credit and Banking 40 (5), 929–965.
Iacoviello, M., Neri, S., 2010. Housing market spillovers: evidence from an estimated DSGE model. American Economic Journal: Macroeconomics 2 (2), 125–164.
Jaimovich, N., Rebelo, S., 2009. Can news about the future drive the business cycle? American Economic Review 99 (4), 1097–1118.
Jeanne, O., Korinek, A., 2011. Managing credit booms and busts: a pigouvian taxation approach. Manuscript.
Judd, K.L., 1998. Numerical Methods in Economics. The MIT Press, Cambridge, MA.
Justiniano, A., Primiceri, G.E., Tambalotti, A., 2013. Is there a trade-off between inflation and output stabilization? American Economic Journal: Macroeconomics 5 (2), 1–31.
Kahn, J.A., 2009. What drives housing prices? manuscript.
Kannan, P., Rabanal, P., Scott, A., 2012. Monetary and macro-prudential policy rules in a model with house price booms. The B.E. Journal of Macroeconomics 12 (1).
Keys, B.J., Piskorski, T., Seru, A., Vig, V., 2012. Mortgage financing in the housing boom and bust. Manuscript.
Khan, H., Tsoukalas, J., 2012. The quantitative importance of news shocks in estimated DSGE models. Journal of Money, Credit and Banking 44 (8), 1531–1535.
Kim, J., Kim, S.H., 2003. Welfare effects of tax policy in open economies: stabilization and cooperation. Finance and Economics Discussion Series 51, Board of Governors of the Federal Reserve System.
Kim, J., Ruge-Murcia, F.J., 2011. Monetary policy when wages are downwardly rigid: Friedman meets Tobin. Journal of Economic Dynamics and Control 35 (12), 2064–2077.

Kim, S.H., Kollmann, R., Kim, J., 2010. Solving the incomplete matkets model with aggregate uncertainty using perturbation methods. Journal of Economic Dynamics and Control 34 (1), 50–58.
Kiyotaki, N., Moore, J., 1997. Credit cycles. Journal of Political Economy 105 (2), 211–248.
Kollmann, R., 2003a. Monetary policy uules in an interdependent world. CEPR Discussion Paper 4012.
Kollmann, R., 2003b. Solving non-linear rational expectations models: approximations based on Taylor expansions. University of Paris XII Working Paper.
Kurmann, A., Otrok, C., 2010. News shocks and the slope of the terms strucure of interest rates. Manuscript.
Lambertini, L., Mendicino, C., Punzi, M.T., 2013. Expectation-driven cycles in the housing market: evidence from survey data. Center for Fiscal Policy Working Paper 01-2013.
Lansing, K.J., LeRoy, S.F., 2012. Risk aversion, investor information, and stock market volatility. Federal Reserve Bank of San Francisco Working Paper 2010-24.
Leeper, E., Walker, T.B., 2011. Information flows and news driven business cycles. Review of Economic Dynamics 14 (1), 55–71.
Lim, C.H., Columba, F., Costa, A., Kongsamut, P., Otani, A., Saiyid, M., Wezel, T., Wu, X., 2011. Macroprudential policy: what instruments and how to use them? Lessons from country experiences. IMF Working Paper 11/238.
Liu, Z., Wang, P., Zha, T. Land-price dynamics and macroeconomic fluctuations. Econometrica, forthcoming.
Loisel, O., Pommeret, A., Portier, F., 2012. Monetary policy and herd behavior: leaning against bubbles. Manuscript.
Mendicino, C., 2012. Collateral requirements: macroeconomic fluctuations and macro-prudential policy. Banco de Portugal Working Papers 11-2012.
Mendicino, C., Pescatori, A., 2008. Collateralized household debt and monetary policy. Manuscript.
Mian, A., Sufi, A., 2009. The consequences of mortgage credit expansion: evidence from the US mortgage default crisis. Quarterly Journal of Economics 124 (4), 1449–1496.
Milani, F., Treadwell, J., 2012. The effects of monetary policy "news" and "surprises". Journal of Money, Credit and Banking 44 (8), 1667–1692.
Monacelli, T., 2006. Optimal monetary policy with collateralized household debt and borrowing constraint. In: Campbell, J. (Ed.), Asset Prices and Monetary Policy, University of Chicago Press, pp. 103–146.
Monacelli, T., 2009. New keynesian models, durable goods, and collateral constraints. Journal of Monetary Economics 56 (2), 242–254.
Orphanides, A., Williams, J.C., 2008. Learning, expectations formation, and the pitfalls of optimal control monetary policy. Journal of Monetary Economics 55 (Supplement), S80–S96.
Pavlov, A., Wachter, S., 2009. Mortgage put options and real estate markets. The Journal of Real Estate Finance and Economics 38 (1), 89–103.
Piazzesi, M., Schneider, M., 2009. Momentum traders in the housing market: survey evidence and a search model. American Economic Review Papers and Proceedings 99 (2), 406–411.
Pisani, M., 2006. House prices, consumption and trade balance in the US. Manuscript.
Preston, B., Roca, M., 2007. Incomplete markets, heterogeneity and macroeconomic dynamics. NBER Working Paper 13260.
Punzi, M.T. Housing market and current account imbalances in the international economy. Review of International Economics, forthcoming.
Reis, R., 2009. Optimal monetary policy rules in an estimated sticky-information model. American Economic Journal: Macroeconomics 1 (2), 1–28.
Rotemberg, J.J., Woodford, M., 1999. Interest rate rules in an estimated sticky price model. In: Monetary Policy Rules. National Bureau of Economic Research, Inc., pp. 57–126.
Rubio, M., 2011. Fixed and variable-rate mortgages, business cycles and monetary policy. Journal of Money Credit and Banking 43 (4), 657–688.
Schmitt-Grohe, S., Uribe, M., 2004a. Optimal operational monetary policy in the Christiano–Eichenbaum–Evans model of the US. business cycle. Manuscript.
Schmitt-Grohe, S., Uribe, M., 2004b. Solving dynamic general equilibrium models using a second-order approximation to the policy function. Journal of Economic Dynamics and Control 28 (4), 755–775.
Schmitt-Grohe, S., Uribe, M., 2005. Optimal fiscal and monetary policy in a medium-scale macroeconomic model. In: Gertler, M., Rogoff, K. (Eds.), NBER Macroeconomics Annual, MIT Press, pp. 383–425.
Schmitt-Grohe, S., Uribe, M., 2007a. Optimal inflation stabilization in a medium-scale macroeconomic model. In: Schmidt-Hebbel, K., Mishkin, R. (Eds.), Monetary Policy Under Inflation Targeting. Central Bank of Chile, Santiago, Chile, pp. 125–186.
Schmitt-Grohe, S., Uribe, M., 2007b. Optimal simple and implementable monetary and fiscal rules. Journal of Monetary Economics 54 (6), 1702–1725.
Schmitt-Grohe, S., Uribe, M., 2012. What's news in business cycles. Econometrica 80 (6), 2733–2764.
Sterk, V., 2010. Credit frictions and the comovement between durable and non-durable consumption. Journal of Monetary Economics 57, 217–225.
The Financial Crisis Inquiry Commission, 2011. The financial crisis inquiry report.
Tomura, H., 2010. International capital flows and expectation-driven boom–bust cycles in the housing market. Journal of Economic Dynamics and Control 34 (10), 1993–2009.
Williams, J.C., 2011. Monetary policy and housing booms. International Journal of Central Banking 7 (1), 345–355.