

Leaning Against Boom-Bust Cycles in Credit and Housing Prices*

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Abstract

This paper studies the potential gains of monetary and macro-prudential policies that lean against housing price and credit cycles. We rely on a model that features Borrowers and Savers and allows for over-borrowing induced by expectations-driven cycles. We find that responding to financial variables is socially optimal. Heterogeneity in the welfare implications is key in determining the optimal policy. Counter-cyclical Loan-To-Value (LTV) rules that respond to either GDP or house price growth face a trade-off between Borrowers' and Savers' welfare. On the other hand, responding to credit growth is Pareto improving. Borrowers are better off when both the LTV ratio and the interest rate respond to credit growth, which most effectively stabilizes credit relative to GDP. Savers are better off under an interest-rate response to credit growth coupled with a constant LTV ratio. Expectations-driven cycles account for most of the gains from a policy response to financial variables.

JEL classification: E32, E44, E52

Keywords: Expectations-driven cycles, macro-prudential policy, monetary policy, welfare analysis.

*We are grateful to seminar 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 first ECB MaRS conference on *Macroprudential Policy* for useful feedbacks on this project. We also thank David Aikman, Jin Cao, Isabel Correia, Enrique Mendoza, Anella Murno, Stefano Neri and Christopher Otrok for valuable comments and suggestions. The opinions expressed in this article do not reflect the position of the Banco de Portugal or the Eurosystem.

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1 Introduction

The recent financial crisis has demonstrated the need for a global macro-prudential approach to supervision and regulation of the financial sector. The traditional (micro) focus on the soundness of individual financial institutions has proved to be insufficient in limiting both the volatility and the spreading of vulnerabilities from one financial institution to another. Hence, there has been a new emphasis 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.”¹ However, little is known about macro-prudential policies, how they should be implemented and their potential gains. This paper contributes to the current debate on the implementation and effectiveness of macro-prudential tools by evaluating policies that make the Loan-to-Value (LTV) ratio respond to macroeconomic conditions and vary in a counter-cyclical manner. We compare the effectiveness of such policy tools against more traditional policies, such as interest-rate rules that respond to financial variables.

Optimism about house price appreciation has often been related to house price booms. Using data from the Michigan Survey of Consumers, Piazzesi and Schneider (2009) document that expectations of rising house prices increased during the last housing boom and that these expectations were related to optimism about economic conditions. In this paper, we consider news shocks as a source of optimism about future house price appreciation. We rely on the model of the housing market developed by Iacoviello and Neri (2010) and extend it to incorporate expectations-driven cycles which allow for booms (and busts) in housing prices and credit.² In this model, news shocks generate booms in house prices and credit characterized by co-movement in house prices, GDP, consumption, investment, household’s debt and hours worked, which is consistent with the data. Further, expectations about future economic conditions that are not matched with economic outcomes lead to a macroeconomic bust. Thus, unrealized news shocks distort borrowing above the equilibrium level. Its sudden reversals have negative effects on real and financial decisions and generate a potential role for stabilization policy. According to Gomes and Mendicino (2011) news shocks explain a sizable fraction of the variation in house prices and other macroeconomic variables.

¹See Bank of England, The role of macro-prudential policy, discussion paper November 2009.

²The model is characterized by a multi-sector framework and collateralized household debt. Several papers have explored the role of collateralized debt in different frameworks. See, among others, Campbell and Hercowitz (2004) for a model with durables and non-durables; Iacoviello (2005) for a business cycle model with residential and non-residential mortgages; Iacoviello and Minetti (2007) for a two-country model; Liu, Wang and Zha (2011) for a model on land-price dynamics.

News shocks were also shown to have significantly contributed to all episodes of housing booms in the United States over the last four decades.³

The goal of this paper is to assess alternative policies in terms of their effectiveness in mitigating financial cycles and improving welfare. The international policy debate is currently focused on the design of a macro-prudential policy whose goal is to moderate credit cycles and to reduce financial imbalances. The Basel Committee on the Global Financial System has identified the LTV ratio as one of the macro-prudential tools that may act as an automatic stabilizer if adjusted in a counter-cyclical manner around a pre-established cap. First, we define macro-prudential policy as the use of the LTV ratio as a policy tool.⁴ We study whether counter-cyclical 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 counter-cyclical LTV rules that respond to either output growth, credit growth, or housing price growth. We find that the policy authority faces a trade-off between Borrowers' and Savers' welfare when it allows the LTV ratio to respond to either house prices or GDP growth. However, responding to credit growth is a Pareto-improving policy relative to the use of a constant LTV ratio.

Second, we investigate whether interest-rate rules that respond to either credit or housing price growth can improve welfare by reducing the volatility of credit and house prices. We find that an interest-rate rule that responds to credit growth mitigates credit and housing cycles and is welfare improving. We compare the performance of the optimized interest-rate with the LTV-ratio rule, both responding to credit growth. We find that both policies dampen out the volatility of credit relative to GDP and slightly reduce the volatility of house prices without increasing the volatility of inflation.

Further, we consider using both monetary and macro-prudential policy. We show that a counter-cyclical LTV ratio coupled with an interest-rate response to the credit cycle are socially optimal. The social welfare improvement is mainly due to the gains accrued to the Borrowers through the

³Few other papers relate booms and busts in the housing market to expectations on future fundamentals. 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, Eichenbaum and Rebelo (2010) generate boom and bust in the housing market relying on heterogeneous expectations about long-run fundamentals that drive house prices, as summarized by the flow of utility of holding a house. Adam, Kuang and Marcet (2011) explain the joint dynamics of house prices and the current account by relying on a model where agents form beliefs about how house prices relate to economic fundamentals.

⁴According to Geanakoplos and Pedersen (2011): "Leverage and the asset level can be monitored by recording margin requirements, or, equivalently, loan-to-value ratios. This provides a model-free measure that can be directly observed, in contrast to other measures of systemic risk that require complex estimations [...] Margin requirements and down-payments are not just abstract terms in our model. They are negotiated every day in a variety of markets. The data we propose gathering exists."

use of active macro-prudential policy. The Borrowers benefit from a more stable supply of credit and the resulting higher level of consumption. Savers are better off under an interest-rate rule that responds to credit growth coupled with a constant LTV, which more effectively stabilizes their consumption.

Last, we document that most of the gains from responding to financial variables are due to the presence of news shocks. News shocks make house prices rise, which in turn increase leverage and further inflate house prices. An increase in the LTV ratio during the boom-phase of the cycle dampens this self-reinforcing dynamics. 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-driven cycles and avoids the occurrence of busts, which results in a welfare improvement for both types of agents.

Recent literature investigates the design and implementation of macro-prudential policy in models of the housing market. Among others, Angelini, Neri and Panetta (2010) use ad-hoc loss functions to show that, compared to capital requirement rules, counter-cyclical LTV rules are more effective in reducing the variability of the debt-to-GDP ratio. Kannan, Rabanal and Scott (2009) document that macroeconomic tools 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. Our analysis differs from the above studies in that we evaluate ex-ante optimal policies in response to a richer stochastic structure that allows for both current and expected shocks and is consistent with boom-bust dynamics in house prices. Moreover, we evaluate policy in terms of welfare implications rather than ad-hoc loss functions.

More recently, Bianchi and Mendoza (2011) and Jeanne and Korinek (2011) study macro-prudential policy in models of the credit cycle. In particular, Bianchi and Mendoza (2011) consider a model in which asset prices determine debt dynamics and show that Pigouvian taxes, namely 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. Unlike these other contributions, we focus on the use of the LTV ratio as an ex-ante macro-prudential measure to reduce amplification and improve welfare. Moreover, we focus on the feedback effects between house prices and mortgage loans that raise household leverage ratio as in the latest house price boom in many industrialized countries.

Our work is also related to the literature on asset-price movements and monetary policy.⁵

⁵For 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 implied by

Closely related to our paper is the work by Christiano, Ilut, Motto and Rostagno (2008) that introduces expectations about future productivity 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. Our paper analyzes optimal monetary policy in the presence of booms and busts in housing prices that arise in response to expectations of future changes not only about productivity but also about other shocks.⁶ Lastly, we consider macro-prudential policy and compare the effectiveness of interest-rate rules against LTV rules both in terms of welfare and in smoothing macroeconomic and financial cycles.

The rest of the paper is organized as follows. Section 2 briefly describes the model and section 3 introduces news shocks into the model. Section 4 describes the method used for conducting welfare analysis. Section 5 investigates optimal interest-rate and LTV rules. Section 6 concludes.

2 The Model

There are two primary 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. In this section we briefly describe the model economy.

Households. The economy is populated by two types of households: the Saver and the Borrower. 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 . They differ in their discount factor, (β and β'). Borrowers (denoted by ι) 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

competitive equilibrium and an exogenous bubble component that stochastically emerges and disappears over time. Since the insurgence, 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 the 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 environments. Cecchetti et al. (2000) analyze rules that minimize a weighted sum of output and inflation variability to find that macroeconomic stabilization can be improved by adjusting the interest rate also in response to asset price misalignments.

⁶Using simplified versions of the model of the housing market adopted in this paper that abstract from boom-bust cycles dynamics, Monacelli (2006) and Mendicino and Pescatori (2008) highlight the optimality of a certain degree of inflation volatility. These two studies analyze the Ramsey equilibrium and optimal simple rules, respectively.

introduced in macro models by Kiyotaki and Moore (1997) and extended by Iacoviello (2005) to a business cycle framework with housing investment.

The Borrowers maximize the utility function:

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

where G_C is the growth rate of consumption, c' measures habits in consumption, z_t and τ_t are shocks to inter-temporal preferences and to labor supply, and j_t is a housing preference shock. The parameter $\eta' > 0$ is the inverse of the Frisch labor supply elasticity; ξ' measures imperfect substitutability between hours in the two sectors, and the scaling factor Γ_c ensures a constant marginal utility of consumption.

Borrowers maximize utility subject to the budget constraint:

$$\begin{aligned} & c'_t + q_t \left[h'_t - (1 - \delta_h) h'_{t-1} \right] - b'_t \\ & \leq \frac{w'_{c,t} n'_{c,t}}{X'_{wc,t}} + \frac{w'_{h,t} n'_{h,t}}{X'_{wh,t}} - \frac{R_{t-1} b'_{t-1}}{\pi_t}. \end{aligned}$$

We allow Borrowers to collateralize the value of their homes:

$$b'_t \leq m E_t \frac{q_{t+1} \pi_{t+1} h'_t}{R_t}. \quad (1)$$

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 and j determines the relative weight in utility on housing services. 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 borrowing constraint is consistent with standard lending criteria used in the mortgage and consumer loan markets. 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.

The Savers choose how much to consume, to work and 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:

$$IH_t = \left(A_{h,t} \left(n_{h,t}^\alpha + n'_{h,t}{}^{1-\alpha} \right) \right)^{1-\mu_h-\mu_b-\mu_l} (z_{h,t} k_{h,t-1})^{\mu_h} k_b^{\mu_b} l_{t-1}^{\mu_l}, \quad (2)$$

where the parameters μ_h, μ_b, μ_l are, respectively, the share 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 and business capital using labor and capital (k_c):

$$Y_t = \left(A_{c,t} \left(n_{c,t}^\alpha + n'_{c,t}{}^{1-\alpha} \right) \right)^{1-\mu_c} (z_{c,t} k_{c,t-1})^{\mu_c}, \quad (3)$$

where z_c is capital utilization in the consumption good sector and μ_c is the share of capital in the production function.

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

$$IK_{c,t} = k_{c,t} - (1 - \delta_{k,c})k_{c,t-1}, \quad IK_{h,t} = \frac{k_{h,t} - (1 - \delta_{k,h})k_{h,t-1}}{A_{k,t}}, \quad (4)$$

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-sector 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:

$$\ln \pi_t - \iota_\pi \ln \pi_{t-1} = \beta G_C \left(E_t \ln \pi_{t+1} - \iota_\pi \ln \pi_t \right) - \epsilon_\pi \ln(X_t/X) + u_{p,t} \quad (5)$$

where $\epsilon_\pi = \frac{(1-\theta_\pi)(1-\beta\theta_\pi)}{\theta_\pi}$, 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. We assume that the central bank follows a Taylor-type rule as estimated by Iacoviello and Neri (2010):

$$R_t = R_{t-1}^{r_R} \pi_t^{(1-r_R)r_\pi} \left(\frac{GDP_t}{GDP_{t-1}} \right)^{(1-r_R)r_Y} r r^{(1-r_R)} \frac{u_{R,t}}{A_{s,t}}, \quad (6)$$

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 target is assumed to be time varying and subject to a persistent shock $A_{s,t}$. GDP is defined as the sum of consumption and investment at constant prices:

$$GDP_t = C_t + IK_{c,t} + IK_{h,t} + k_{b,t} + qIH_t, \quad (7)$$

where q is real housing price at the steady state.

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 (z_t), labor supply (τ_t), and housing preference (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 and Housing Market Dynamics

We introduce expectations of future macroeconomic developments through news shocks. As in Christiano et al. (2008) and Schmitt-Grohe and Uribe (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 ($\varepsilon_{z,t-n}$),

$$u_{z,t} = \varepsilon_{z,t} + \varepsilon_{z,t-n}, \quad (8)$$

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 $u_{z,t} = 0$. Since boom-bust cycles in the housing market can be plausibly related to expectations of future developments in different sectors of the economy, we introduce expectations about shocks originated in different sectors of the economy.

A rapidly-growing literature has shown that news shocks are a plausible mechanism for creating business cycle fluctuations. Among others, Schmitt-Grohe and Uribe (2008) document that news

Parameter	Value	Parameter	Value	Parameter	Value
β	0.9925	ξ	0.66	ρ_s	0.975
β'	0.97	ξ'	0.97	ρ_{AC}	0.95
j	0.12	$\phi_{k,c}$	14.25	ρ_{AH}	0.997
μ_c	0.35	$\phi_{k,h}$	10.90	ρ_{AK}	0.992
μ_h	0.10	α	0.79	ρ_j	0.96
μ_l	0.10	r_R	0.59	ρ_z	0.96
μ_b	0.10	r_π	1.44	ρ_τ	0.92
δ_h	0.01	r_Y	0.52	σ_{AC}	0.0100
δ_{kc}	0.025	θ_π	0.83	σ_{AH}	0.0193
δ_{kh}	0.03	ι_π	0.69	σ_{AK}	0.0104
X	1.15	$\theta_{w,c}$	0.79	σ_j	0.0416
X_{wc}	1.15	$\iota_{w,c}$	0.08	σ_R	0.0034
X_{wh}	1.15	$\theta_{w,h}$	0.91	σ_z	0.0178
m	0.85	$\iota_{w,h}$	0.40	σ_τ	0.0254
ε	0.32	ζ	0.69	σ_p	0.0046
ε'	0.58	γ_{AC}	0.0032	σ_s	0.0004
η	0.52	γ_{AH}	0.0008	$\sigma_{w,c}$	0.1218
η'	0.51	γ_{AK}	0.0027	$\sigma_{w,h}$	0.0071

Table 1: Calibrated Parameters

on future neutral productivity shocks, investment-specific shocks, and government spending shocks account for a sizable fraction of aggregate fluctuations in post-war United States. Christiano et al. (2008) show that expectations about future productivity can be a plausible mechanism to generate stock-market boom-bust cycles. Kurmann and Otrok (2010) document that news shocks about future productivity can help in explaining swings in the slope of the term structure. Milani and Treadwell (2010) consider expectations about the policy rate and find that anticipated policy shocks play a larger role in the business cycle than unanticipated ones. Gomes and Mendicino (2011) estimate two versions of the model presented above and show that the specification with news shocks outperforms the specification without news shocks in terms of overall goodness of fit. Further, news shocks turn out to explain a large fraction of fluctuations in house prices and significantly contribute to the boom episodes experienced in the United States since 1965.

In the model of the housing market that we rely on, the transmission of these news shocks has two important features. First, news shocks are plausible sources of optimism about future

house price appreciation and they generate macroeconomic booms characterized by hump-shaped dynamics. Further, news shocks generate the co-movement observed in the data during periods of housing booms, i.e. hump-shaped co-movement among house prices, consumption, residential- and non-residential investment, and hours worked in both sectors of productions.⁷ 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. Figure 1 and 2 show the impulse responses for the four-period ahead ($n = 4$) news shocks added to the model. In particular, we introduce expectations of future shocks to productivity ($A_{c,t+n}$), housing productivity ($A_{h,t+n}$), investment-specific technology ($A_{k,t+n}$), monetary policy ($u_{R,t+n}$), the central bank inflation target ($A_{s,t}$) and cost-push ($u_{p,t}$).⁸

Second, expectations about future shocks that are not realized generate boom-bust cycles in the housing market. Figures 3 and 4 consider the case of four-quarter ahead expectations of shocks that do not materialize. Expectations that are not fulfilled distort consumption, borrowing and investment plans above the equilibrium level. Their sudden reversals have negative effects on economic and financial decisions that transmit across sectors. Thus, the possibility of unrealized expectations gives a potential role to stabilization policy.

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 anticipated and unanticipated shocks. We assume that the policy-maker 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 in 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 welfare results and

⁷In this model unanticipated shocks generate responses that are strongest in the short run and eventually die away, thereby failing to generate co-movement among GDP, non-residential investment and hours worked. See Lambertini, Mendicino and Punzi (2010) and Gomes and Mendicino (2011) for the transmission of current shocks and news shocks in this kind of models.

⁸In the following we assume that the anticipated component of the error terms of each shock has the same variance as the unanticipated component as estimated in Iacoviello and Neri (2010). See Table 1.

simulations are based on the nine unanticipated 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.⁹ 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 :

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

At the optimum

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

where $V_t^i = \{V_t', V_t\}$ denotes the welfare of the Borrowers and the 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 common in the literature, we study ex-ante optimal simple rules based on the second-order approximate solution of the model.^{10, 11} We follow the rest of the literature and compute the welfare implied by the different rules conditional on the initial state ($t = 0$) being the deterministic steady state.¹²

Due to agents' heterogeneity, we explore the implications for the group-specific welfare while we also aggregate individual welfare in a social welfare function. As in Mendicino and Pescatori

⁹See among others, Kim and Kim (2003), Faia and Monacelli (2007), Erceg, Henderson and Levin (2000), Schmitt-Grohe and Uribe (2004, 2005, 2007a, 2007b).

¹⁰As shown by previous literature, first-order approximation methods are not locally accurate to evaluate the performance of different policies in terms of welfare. See among others, Kim and Kim (2003), Kollmann (2003a, 2003b), Schmitt-Grohe and Uribe (2004).

¹¹The rules considered in the 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.

¹²In 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. 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 (2004) for further details.

(2008) and Rubio (2010), the social welfare function is a weighted average of the welfare of the two groups of agents (V_t^i),

$$\tilde{V}_t \equiv \left[(1 - \tilde{\beta}')V_t' + (1 - \tilde{\beta})V_t \right], \quad (9)$$

where the weights on households' welfare, $\tilde{\beta}'$ and $\tilde{\beta}$, are such that, given a constant consumption stream, the Borrowers and the Savers achieve the same level of utility.¹³ We maximize social welfare with respect to the parameters of each particular rule considered. Thus, optimized policy rules are characterized by the combination of parameters which deliver the highest social 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).¹⁴ Alternative rules that maximize social welfare are compared both in terms of conditional welfare in levels and in terms of a consumption equivalent measure. The consumption equivalent is calculated as the percentage increase in steady-state consumption that would make welfare under the benchmark policy equal to welfare under the optimized rule.

5 Monetary and Macro-prudential Policy

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 framework. Should monetary policy give explicit recognition to financial stability goals? Or should financial stability goals be pursued by other instruments – such as LTV ratios?

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

5.1 Counter-cyclical LTV Ratio Policy

In this section we explore the effectiveness of counter-cyclical LTV ratios as macro-prudential tools aimed at financial and macroeconomic stabilization. Thus, we focus on the benefits of LTV ratios

¹³Where $\tilde{\beta}' = \beta' G_C$ and $\tilde{\beta} = \beta G_C$.

¹⁴The conditional welfare under the estimated Taylor-type rule and a constant LTV ratio is:

	Social	Savers	Borrowers
m=0.85; r _R =0.59;r _π =1.44; r _Y =0.52;	-3.3001	-44.0176	-98.9983

that vary in a counter-cyclical manner around a pre-established cap in order to mitigate the financial cycle. We abstract from the occasional use of lower LTV caps that have been often suggested to enhance the resilience of the financial system to macroeconomic shocks.¹⁵

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.”¹⁶ The Committee identified the LTV ratio as one of the macro-prudential tools that may act as an automatic stabilizer if adjusted in a counter-cyclical manner around a pre-established cap.

In the following 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 counter-cyclical manner around the steady-state cap.¹⁷ We study the welfare implications of counter-cyclical LTV-ratio rules that respond to GDP, credit, and housing price growth. In practice we assume

$$m_t = \nu_m m_{t-1} + (1 - \nu_m)m - (1 - \nu_m)\nu_x (x_t - x_{t-1}), \quad (10)$$

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 $[0, 0.75]$ range for the smoothing parameter ν_m and the $[0, 19]$ range for the parameter ν_x . $\nu_x = 0$ corresponds to the case where the LTV ratio does not respond to the variable chosen as imbalance indicator and macro-prudential policy is non-active.¹⁸

Table 2 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

¹⁵See Lambertini, Mendicino and Punzi (2010) for further discussion on the effects of discretionary changes, such as temporary lower LTV ratios, on macroeconomic volatility.

¹⁶See Basel Committee on the Global Financial System. 2010. Macro-prudential Instruments and Frameworks: a Stocktaking of Issues and Experiences. CGFS Publications No 38.

¹⁷The parameter m in the model can be interpreted as the average LTV ratio for households. Iacoviello and Neri (2010) calibrate this parameter equal to 0.85 percent in order to be consistent with the rest of the parameters of the model estimated over the period 1965-2006. Using limited information methods, Iacoviello (2005) estimates a business cycle model for the U.S. economy and reports a LTV ratio of 55 percent for the household real estate. The Finance Board’s Monthly Survey of Rates and Terms on Conventional Single-Family Non-farm Mortgage Loans reports a typical LTV ratio for home buyers in the United States of 0.76 percent between 1973 and 2006. Calza et al. (2010) document that typical LTV ratios imposed on new loans in the mortgage market vary significantly among OECD countries and range between 50 percent in Italy to 90 percent in the Netherlands and the United Kingdom.

¹⁸The 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 leads 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.

Optimized LTV Rules	Welfare Values		
	Social	Savers	Borrowers
$\nu_m = 0.75; \nu_b = 18.5$	-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)

In parenthesis: welfare gains in terms of consumption relative to the benchmark rule; Second-order approximation.

Table 2: Conditional Welfare of Optimized LTV Rules

a constant LTV policy ($m = 0.85$). Allowing for a counter-cyclical response of the LTV ratio to growth in macroeconomic variables improves upon a constant LTV ratio in terms of social welfare.¹⁹

All rules feature a high smoothing parameter. 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.²⁰ This is due to the fact that Savers and Borrowers are both better off under the optimized rule that responds to credit growth. Thus, allowing for the LTV ratio to respond counter-cyclically to credit growth is Pareto improving. However, LTV rules that target either GDP growth or house price growth face a trade-off between Savers' and Borrowers' welfare.²¹ Figure 5 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 these policies improve social welfare (relative to the benchmark case), only the LTV ratio that responds to credit growth improves the welfare of both groups of agents.

Table 3 reports the stochastic mean and, in parenthesis, the standard deviation of selected variables under alternative policies.²² Compared with the constant LTV policy, the three optimized LTV-ratio rules slightly reduce the volatility of house prices. However, the counter-cyclical LTV

¹⁹The social welfare under the estimated Taylor-type rule and a constant LTV ratio of 0.85 per cent is -3.3001. See Section 4, footnote 10.

²⁰Removing 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 (i.e. for $\nu_b = 25$ the improvement in V_1 and V_2 relate to the 5th decimal number).

²¹In Table 2, negative welfare gains indicate welfare losses.

²²*Stochastic mean* refers to the mean values of these variables delivered by the second order approximated simulation of the model (i.e. the stochastic steady state) under the full set of shocks (both current and expected). In what follows, we will use the terms standard deviation and volatility interchangeably. Panel A reports the values under the constant LTV ratio, while panel B reports the values under the optimized counter-cyclical LTV-ratio rules. Both in A and B the interest rate follows the estimated Taylor-type rule of Iacoviello and Neri (2010).

	Savers' Consumption	Borrowers' Consumption	Savers' Housing	Borrowers' Housing	Housing Prices	Debt/GDP	Inflation
A. Estimated Interest-Rate Rule and Constant LTV $r_R = 0.59; r_\pi = 1.44; r_Y = 0.52$	1.5064 (0.0228)	0.3019 (0.0559)	14.3996 (0.0204)	2.3090 (0.1353)	1.0020 (0.0304)	1.7126 (0.1361)	0.9999 (0.0081)
B. Optimized LtV Rules (and Estimated Interest-Rate Rule) $\nu_m = 0.75; \nu_b = 18.5$ $\nu_m = 0.75; \nu_q = 2$ $\nu_m = 0.75; \nu_y = 0.5$	1.5064 (0.0233)	0.3021 (0.0415)	14.3823 (0.0050)	2.3646 (0.0266)	1.0020 (0.0302)	1.7538 (0.0391)	0.9999 (0.0082)
C. Optimized Interest-Rate Rule (and Constant LTV) $r_R = 0.59; r_\pi = 2.8; r_Y = 1.75$ $r_R = 0; r_\pi = 1.1; r_Y = 0.25$ $r_R = 0; r_\pi = 1.3; r_Y = 0.25; r_q = 0.8$ $r_R = 0; r_\pi = 1.4; r_Y = 0; r_b = 0.5$	1.5064 (0.0226)	0.3019 (0.0567)	14.3996 (0.0197)	2.3094 (0.1325)	1.0020 (0.0303)	2.3120 (0.1346)	0.9999 (0.0081)
D. Optimized Interest-Rate and LTV rule $r_R = 0; r_\pi = 1.1; r_Y = 0.5; r_b = 0.4; \nu_m = 0.75; \nu_b = 19$	1.5052 (0.0194)	0.3016 (0.0423)	14.3636 (0.0160)	2.3252 (0.1058)	1.0035 (0.0270)	1.0563 (0.1142)	1.0000 (0.0077)
	1.5067 (0.0198)	0.3023 (0.0468)	14.4097 (0.0186)	2.3127 (0.1233)	1.0016 (0.0281)	1.7127 (0.1258)	0.9996 (0.0104)
	1.5059 (0.0210)	0.3019 (0.0438)	14.3681 (0.0106)	2.3559 (0.0713)	1.0035 (0.0248)	1.7504 (0.0720)	1.0000 (0.0079)
	1.5053 (0.0153)	0.3018 (0.0263)	14.3536 (0.0067)	2.3483 (0.0340)	1.0035 (0.0217)	1.7458 (0.0425)	0.9999 (0.0095)
	1.5064 (0.0201)	0.3023 (0.0307)	14.3751 (0.0055)	2.3655 (0.0222)	1.0026 (0.0272)	1.7540 (0.0345)	0.9998 (0.0100)

Table 3: Level and Stabilization Effect

rule that responds to credit growth is more effective in reducing the volatility of the loan-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 that effectively dampen out the dynamics of the loan-to-GDP ratio. Current shocks or news that would lead to a credit expansion in the absence of the macro-prudential policy generate instead a reduction of the LTV ratio. As a result, loans are stabilized. This is not the case for LTV rules that target GDP or housing price growth because the smaller responses to these variables reduce the counter-cyclical variation of the LTV ratio and therefore the impact on credit volatility.

5.2 Interest-Rate Response to Financial Variables

Should the monetary authority react to asset price or credit growth movements to avoid boom-bust cycles in the financial market? A high degree of transparency in monetary policy is likely to reduce the occurrence of unfulfilled news on monetary policy and thereby avoid boom-bust cycles driven by uncertainty in future monetary policymaking. In the following, however, we consider whether monetary policy can reduce the occurrence of cycles stemming from shocks and expectations about other (than monetary policy) types of future macroeconomic developments.

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

$$R_t = R_{t-1}^{r_R} \pi_t^{(1-r_R)r_\pi} \left(\frac{GDP_t}{GDP_{t-1}} \right)^{(1-r_R)r_Y} \left(\frac{x_t}{x_{t-1}} \right)^{(1-r_R)r_x}, \quad (11)$$

where $x_t = \{b_t, q_t\}$, where $r_x \geq 0$. 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 .²³

Table 4 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 null 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 completely stabilize inflation, as this would raise the volatility in the real interest rate and generate large unintended transfers from Borrowers to Savers or vice versa.²⁴

²³The grid step for each parameter is 0.1.

²⁴Using a simpler model than ours, Mendicino and Pescatori (2008) study ex-ante optimal interest-rate rules and 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 characterized by some inflation

Optimized Interest-Rate Rules	Welfare Values		
	Social	Savers	Borrowers
$r_R = 0; r_\pi = 1.1; r_Y = 0.25$	-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)

In parenthesis: welfare gains in terms of consumption relative to the benchmark policy; Second-order approximation.

Table 4: Conditional Welfare of Optimized Interest-Rate Rules.

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). Among optimized interest-rate rules, the debt-to-GDP ratio and Borrowers' housing are maximized under the rule that targets housing prices. On the other hand, nondurable consumption and Savers' housing are maximized under the rule that targets GDP growth. Nevertheless, the stabilization effect of targeting credit growth dominates over these level effects so that social, Borrowers' and Savers' welfare is highest under an interest-rate rule that responds to credit growth. See Table 3.

Comparing the optimized interest-rate rule that directly responds to credit growth (see Table 4 and Table 3, Panel B) with the optimized LTV-ratio rule that responds to credit growth in a counter-cyclical manner (see Table 2 and Table 3, Panel A) 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) do not increase the volatility of inflation. 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. Social as well as Borrowers' and Savers' welfare is highest with the optimized interest-rate rule that responds to credit growth. Even though Borrowers accrue the largest welfare gains from a policy response to credit growth, both rules improve Savers' welfare as well. Thus, social welfare maximization under (8) does not generate transfers that improve the welfare of one group of agents at the cost of a volatility.

Optimized Interest-Rate and LTV rule	Welfare Values		
	Social	Savers	Borrowers
$r_R = 0; r_\pi = 1.1; r_Y = 0.5; r_b = 0.4; \nu_m = 0.75; \nu_b = 19$	-3.2939	-43.8590	-98.8326
		(0.1197)	(0.5184)

In parenthesis: welfare gains in terms of consumption relative to the benchmark policy; Second-order approximation.

Table 5: Conditional Welfare of Using Both Instruments

reduction in the welfare of the other. Notice that only LTV rules that respond to either GDP growth or house price growth face a trade-off between Borrowers' and Savers' welfare.

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 5 shows that the optimization over both rules results in a strong reaction of the LTV to credit growth and a moderate response of the interest-rate to this variable. Such a policy improves social welfare compared to the benchmark policy (estimated Taylor-type rule coupled with a constant LTV ratio).

Table 6 compares the performance in terms of individual welfare of the policy that optimizes the response of both instruments with respect to: (a) the estimated Taylor-type rule coupled with a constant LTV ratio; (b) the estimated Taylor-type rule coupled with the optimized LTV ratio that responds to credit growth; (c) the optimized interest-rate response to credit growth coupled with the constant LTV ratio. The coefficients of the three optimized rules are reported in Table 2, Table 4 and Table 5 respectively. For the estimated Taylor-type rule coupled with a constant LTV ratio, see Section 4, footnote 11.

Compared with the benchmark policy (a), both agents are better off under the policy that allows

Welfare Gains		
Optimized Interest-Rate and LTV rule vs...	Savers	Borrowers
(a) estimated Taylor-type rule and constant LTV ratio	0.1197	0.5184
(b) estimated Taylor-type rule and optimized LTV rule	0.0742	0.1845
(c) optimized interest-rate rule and constant LTV ratio	-0.1431	0.1656

Second-order approximation.

Table 6: Welfare Gains of Optimized Rules

the optimal use of both instruments. Social welfare is higher when using both instruments relative to rules (b) and (c). 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 rule (c). For small volatility differences, Borrowers prefer the rule that allows both instruments to respond to credit growth since it leads to higher levels of credit, consumption, and housing. On the other hand, Savers are better off under the optimized interest-rate rule coupled with a constant LTV ratio (c), which reduces more their consumption volatility. The welfare gains accrued to Borrowers when using both instruments are large enough to make the use of both instruments socially optimal, even relative to policy (c).

5.4 Expectations-Driven Cycles and Welfare Gains

The analysis conducted in this paper does not aim at designing optimal policies conditional on some particular shocks but is based on the assumption that various sources of fluctuations can affect the economy, both expected and unanticipated. Hence, we do not target the smoothing out of specific shocks or boom-bust cycles.

Table 7 documents the role of expectations-driven cycles for the importance of a policy response to financial variables. We compare the welfare performance of the three optimized rules under three case scenarios: all shocks, no news shocks, only news shocks. News shocks account for most of the Savers' welfare gains and around 40 per cent of the Borrowers' welfare gains of a policy reaction to financial variables. Thus, the gains from a policy response to financial variables are mainly related to the assumption of expectations-driven cycles.

Figure 6 shows the responses of some key variables under the benchmark rule (dashed line), namely the estimated interest-rate rule and constant LTV ratio, and the policy that optimally combines the use of both instruments (solid line). We consider the case of a four-quarter ahead expected monetary policy shock that does not realize. Responding to credit growth tighten financial conditions during housing market booms and loosens financial conditions during busts. As a result, the amplitude of the fluctuations generated by unrealized news shocks is reduced relative to the benchmark policy. Boom-bust cycles are mitigated thanks to a stable provision of financial intermediation that improves welfare for both Savers and Borrowers.²⁵

²⁵It is important to stress that boom-bust cycles are not completely offset by the policy authority since we rely on ex-ante optimal policy.

Welfare Gains						
	Optimized Interest-Rate and LTV Rule		Estimated Interest-Rate and Optimized LTV Rule		Optimized Interest-Rate and Constant LTV Rule	
	Savers	Borrowers	Savers	Borrowers	Savers	Borrowers
full	0.1197	0.5184	0.0455	0.3334	0.2694	0.3523
no news	0.0096	0.3167	0.008	0.1907	0.0572	0.2100
only news	0.1100	0.2010	0.0367	0.1423	0.2120	0.1419

Second-order approximation.

Table 7: Conditional Welfare with and without News Shocks

6 Conclusions

We analyze the policy implications of expectations-driven cycles. We compare the performance of counter-cyclical LTV rules and interest-rate rules in terms of welfare. LTV rules face a trade-off between Savers' and Borrowers' welfare if they respond to GDP or house price growth in a counter-cyclical manner. On the other hand, a response to credit growth is Pareto improving.

We find that both an optimized interest-rate rule that directly responds to credit growth and the optimized LTV-ratio rule that responds to credit growth in a counter-cyclical manner 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 counter-cyclical LTV policy in addition to an interest-rate response to credit growth is optimal in terms of social welfare thanks to the large gains accrued to the Borrowers. Most of the gains from responding to financial variables are due to the presence of expectations-driven cycles.

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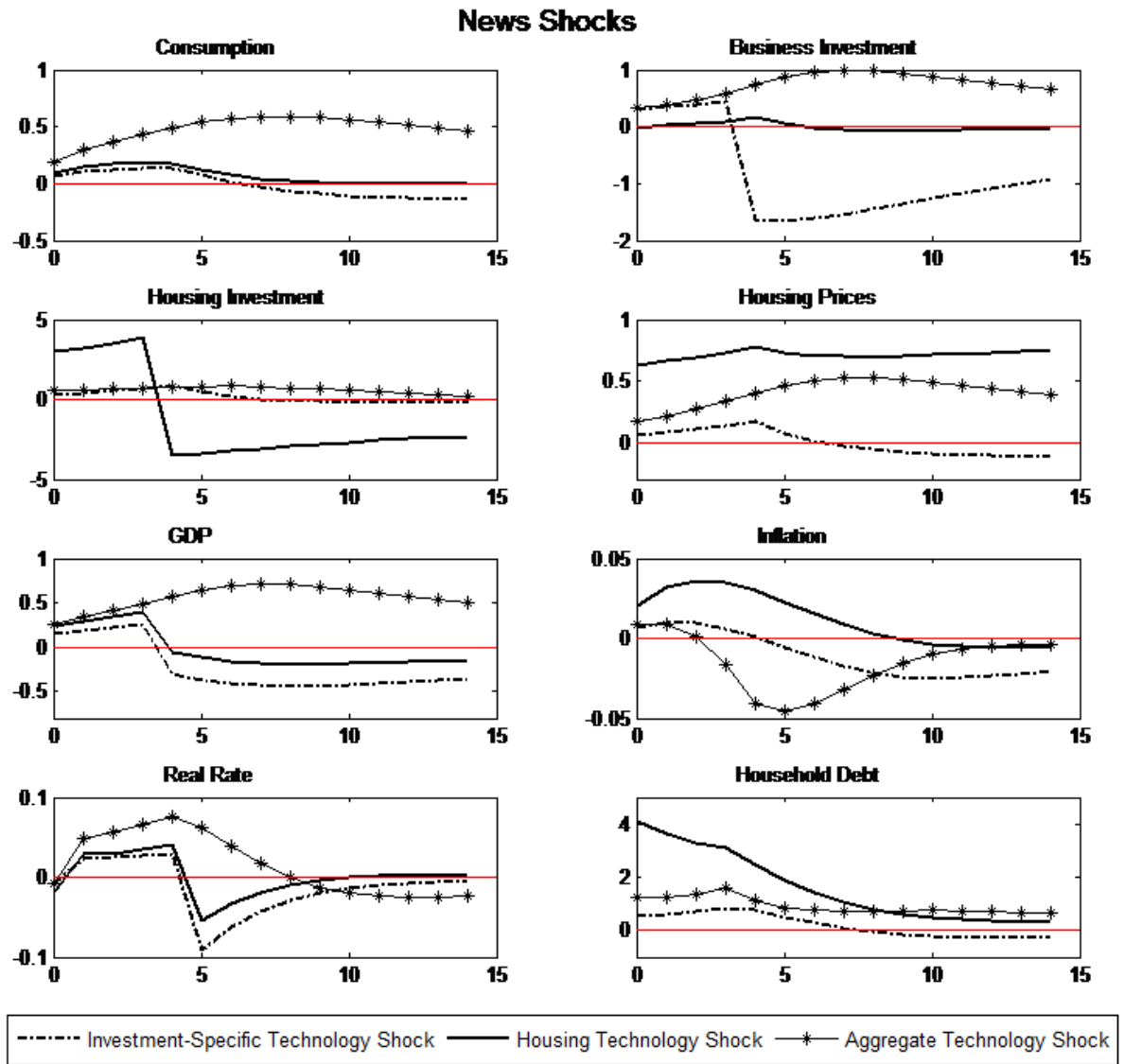


Figure 1: Transmission Mechanism News Shocks

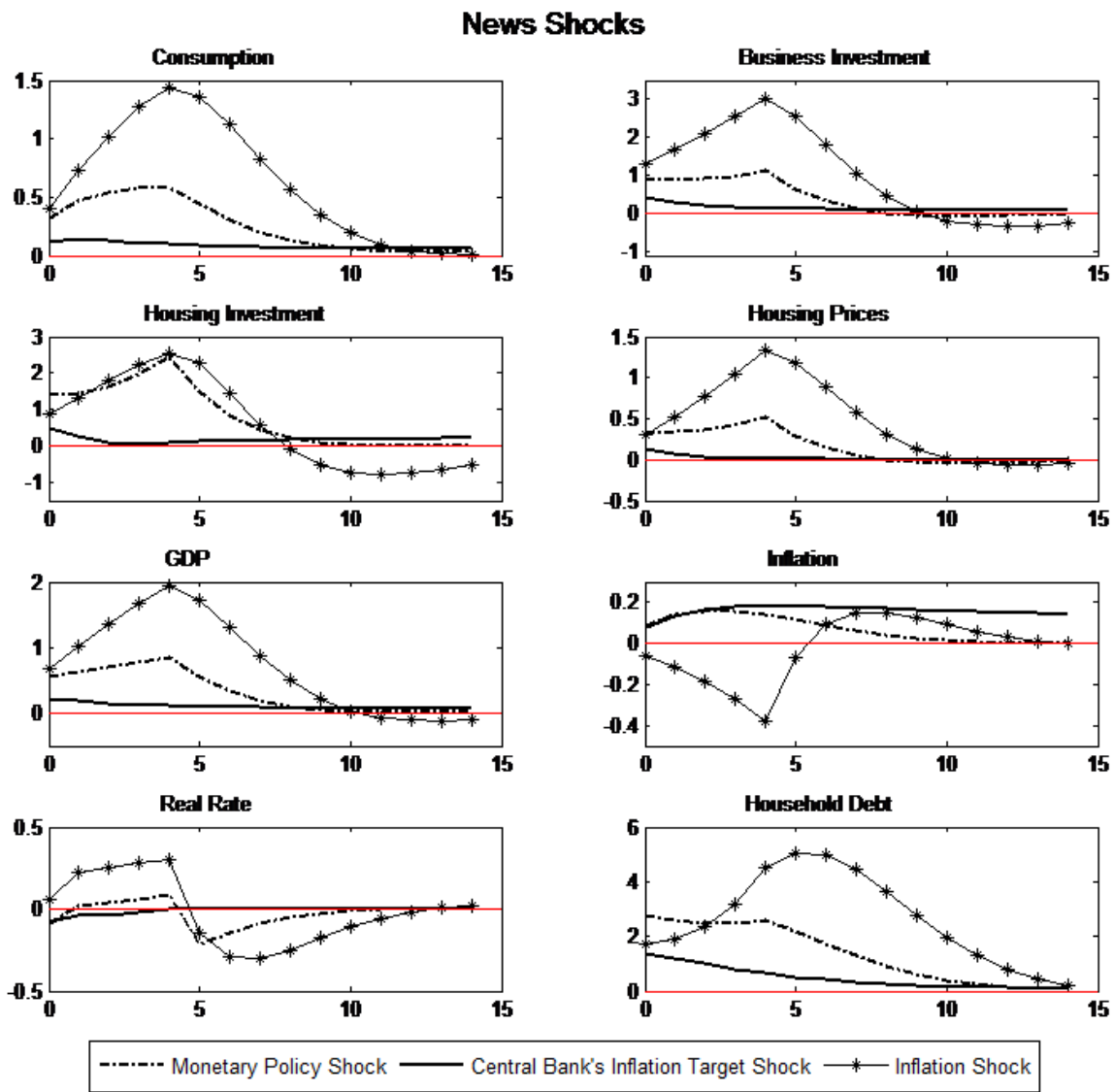


Figure 2: Transmission Mechanism News Shocks

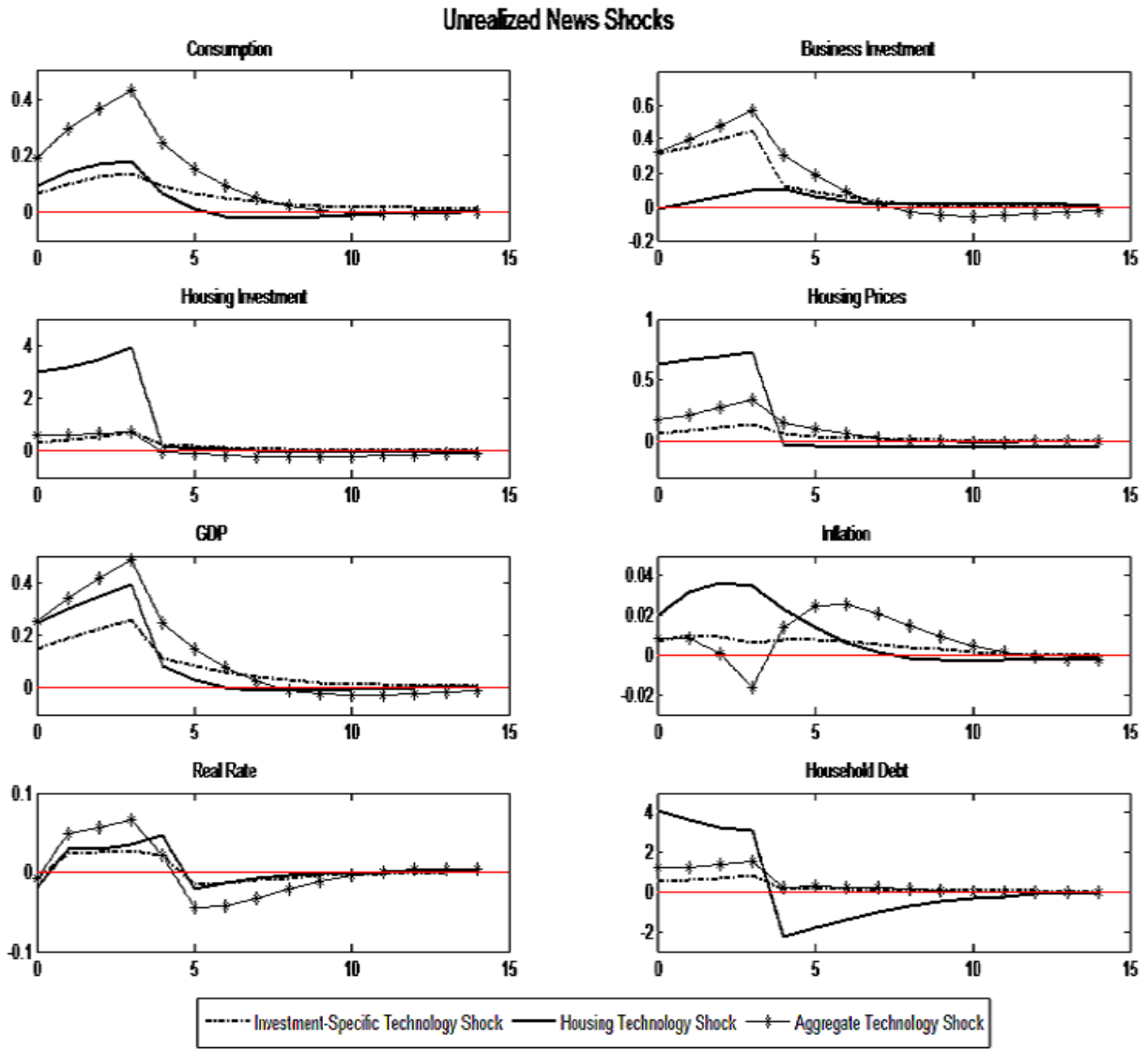


Figure 3: Transmission Mechanism Unrealized News Shocks

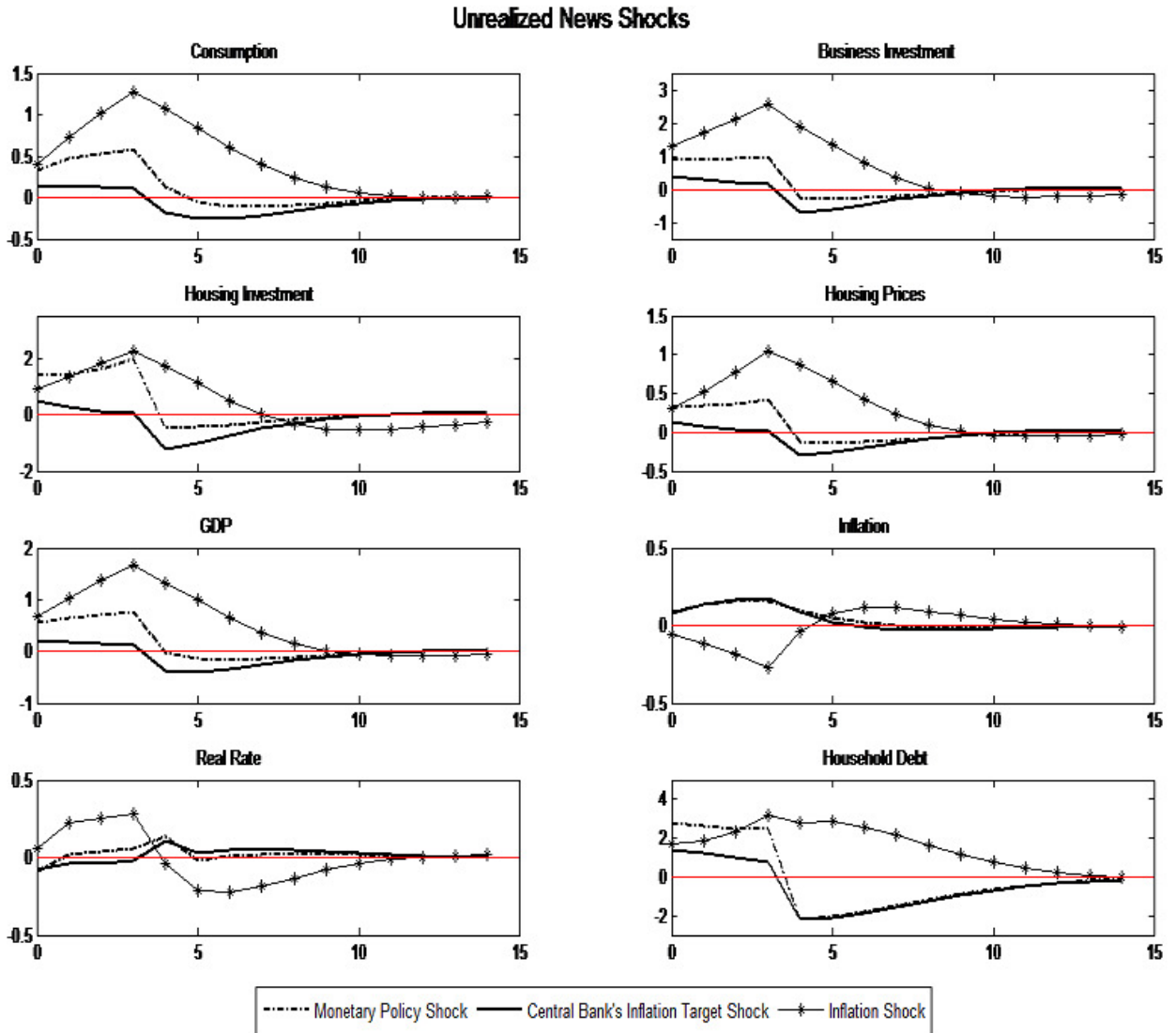


Figure 4: Transmission Mechanism Unrealized News Shocks

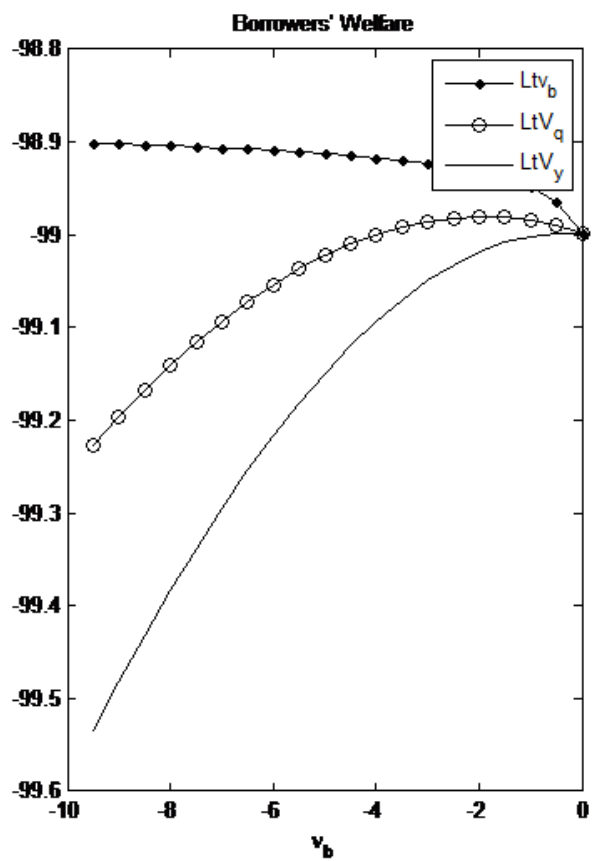
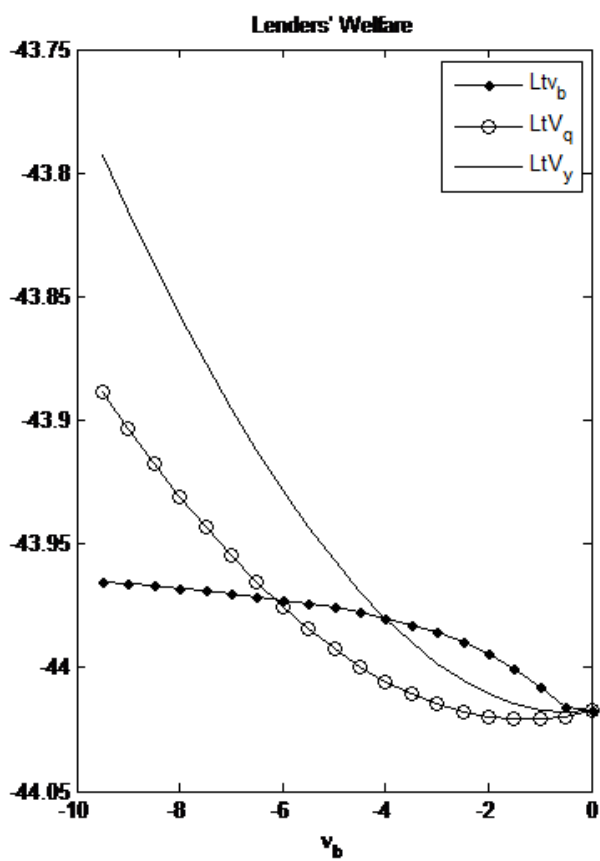


Figure 5: Conditional Welfare of LTV Rules

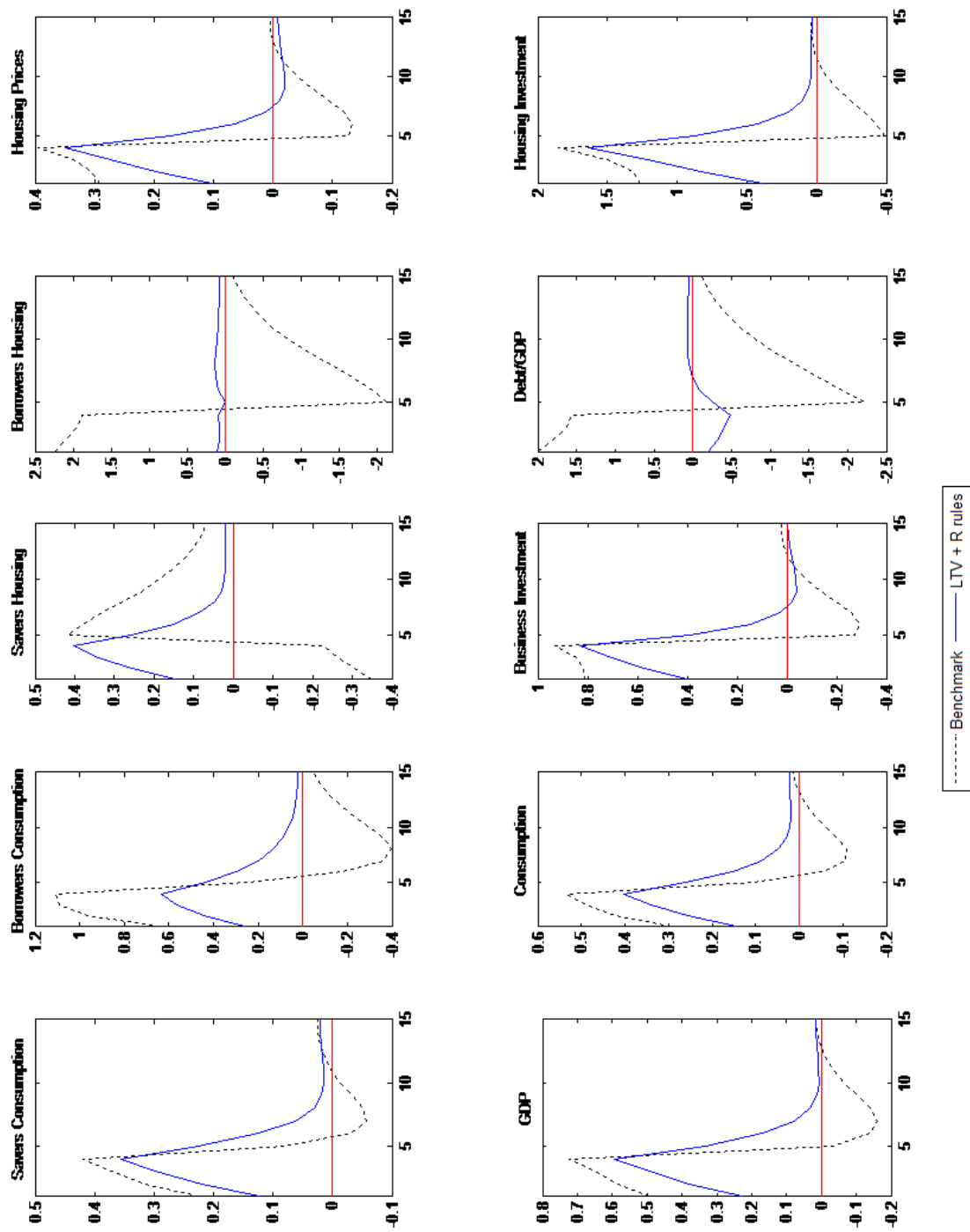


Figure 6: Transmission of Unrealized News on Monetary Policy Shock under Benchmark and Optimized Interest-rate and LTV Rule