Expectations-Driven Cycles in the Housing Market

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Abstract

This paper analyzes housing market boom-bust cycles driven by changes in households' expectations. We introduce expectations-driven fluctuations into the housing-market model developed by Iacoviello and Neri (2009). We find that changes in expectations about the future state of productivity, investment cost, housing supply, inflation, the policy rate and the central bank's inflation target can generate macroeconomic boom-bust cycles in accordance with the data. Contrary to previous literature, we show that a strong anti-inflationary stance is detrimental both in terms of macroeconomic volatility and welfare. We also document that economies subject to a lower degree of credit friction experience higher volatility in both consumption household indebtedness.

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1 Introduction

Boom-bust cycles in asset prices and economic activity are a central issue in policy and academic debates. Particular attention has been given to the behavior of housing prices and housing investment. We document that, over the last three decades, housing prices boom-bust cycles in the United States have been characterized by co-movement in GDP, consumption, investment, hours, real wages and housing investment. This paper suggests a mechanism for modeling housing-market boom-bust cycles in accordance with the empirical pattern.

Modeling endogenous boom-bust cycles in macroeconomics is a major challenge. Our explanation builds on a "news shock" mechanism where public signals of future fundamentals cause business cycle fluctuations through changes in household expectations. Booms are generated by public signals; busts follow if the signals are not realized ex-post.

This work is related to the recent literature on expectations-driven business cycles. We review the literature in the next section.

This paper shows that expectations-driven boom-bust cycles in accordance with the empirical findings can be generated in a model of the housing market that features collateralized household debt and nominal price and wage rigidities. Iacoviello and Neri (2009) present an estimated model that is successful in explaining both the trend and short-run fluctuations in real housing prices and investment over the last four decades in the United States. We extend their model by including expectations of future macroeconomic developments. We show that changes in expectations about future productivity, investment costs, housing supply, inflation, the policy rate and the central bank's target can generate housing-market boom-bust cycles characterized by co-movement in GDP, consumption, investment, hours and real wages. In contrast, expectations of a future increase in housing demand or of a future tightening in the credit limit do not generate co-movement between business investment and all other aggregate variables and therefore fail to generate a boom-bust cycle. According to our findings, changes in the access to credit are not in accordance with the last boom in the housing market. However, we show that the degree of credit frictions plays a key role in the transmission of expectations-driven cycles. In particular, an economy with a lower degree of credit friction is characterized by higher volatility in aggregate consumption and household indebtedness.

Most of the previous literature on asset-price movements and monetary policy builds on models of exogenous bubbles. In this type of model, the market price of an asset is the sum of its fundamental implied by 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. As a result, an anti-inflationary monetary policy is optimal in such environments. Contrary to the previous literature, we show that a strict anti-inflationary stance is not optimal in our framework. In fact, strict inflation targeting delivers higher volatility of both GDP and hours and is detrimental to welfare.

The rest of the paper is organized as follows. Section 2 reviews the literature. Section 3 identifies four boom-bust episodes in the U.S. housing market in the last four decades and characterizes the behavior of several macroeconomic variables during such episodes. Section 4 describes the model. Section 5 to 7 investigate the occurrence of boom-bust cycles as a consequence of expectations on future macroeconomic developments. Section 8 analyzes the effect of changes in the degree of credit friction on boom-bust cycles. Section 9 investigates the role of monetary policy and section 10 concludes.

2 Literature on Expectations-Driven Cycles

Beautry and Portier (2004, 2007) show that a simple one-sector optimal growth model is unable to generate boom-bust cycles in response to news about a future improvement in technology. Consumption increases at the time of the signal thanks to a wealth effect. Hours worked fall because leisure is a normal good. Since technology has not improved yet, output decreases. The only way for consumption to increase as output falls is for investment to fall even more than output. Adding capital adjustment costs makes investment and therefore hours worked go up in response to the news. However, consumption falls because the increase in hours worked is not sufficient to raise output enough. Hence, the one sector model is unable to generate a boom in response to news about future technological improvements.

A two-sector model with consumption and capital goods is also unable to generate a boom in macroeconomic variables. News about productivity in the capital sector raises consumption but reduces hours worked. As a result, investment, capital and output fall. An announcement of future higher productivity in the consumption sector generates a boom in all macro variables except consumption for elasticities of intertemporal substitution above one; vice versa, it generates a bust in all macro variables but consumption when the elasticity is below one.

When a three-sector model is considered, Beaudry and Portier (2004, 2007) show that expectations-driven cycles can arise provided firms exhibit economy of scope or, in other words, internal cost complementarities between the production of different goods.

Jaimovich and Rebelo (2006) introduce three elements in an otherwise standard neoclassical growth model: Variable capital utilization; adjustment costs to investment; and a weak short-run wealth effect on the labor supply. This latter element is introduced by assuming a special class of period utility functions that makes preferences non-time-separable in both consumption and hours worked. A one-sector model displays co-movement of consumption, output, investment and hours worked in response to news about future total factor productivity or about investment-specific technology. The value of the firm, however, falls unless the production function features decreasing returns to scale as stemming from a factor of production in fixed supply. A two sector model is able to generate co-movement in response to news about future aggregate productivity, productivity in the consumption sector only, and productivity in the investment sector only provided the short-run wealth effects on the labor supply are very low, the elasticity of labor supply is high and the elasticity of capacity utilization is low. Jaimovich and Rebelo (2006) also explore a version of their two-sector model with adjustment costs to labor and find they are helpful to generate co-movement in response to news.[1]

Christiano, Ilut, Motto, and Rostagno (2008) show that a standard one-sector real business cycle model with habit persistence and costs of adjusting the flow of investment generates a boom-bust pattern in output, consumption, investment and hours in response to news on productivity that do not materialize. The price of capital, however, is negatively correlated with all other aggregate variables and therefore it falls and then increases. When they introduce inflation targeting and sticky nominal wages, the price of capital co-moves with the other aggregate variables and boom-bust dynamics emerges. More precisely, Christiano et al. represent monetary policy by an empirically estimated Taylor rule and embed it in a model with sticky nominal wages, habit persistence and adjustment costs of the flow of investment. When news spread about a future increase in productivity, aggregate variables increase because hours worked also increase. This increase in hours is possible because the real wage falls – hence producers are willing to raise labor demand – and because employment is demand-determined. Since nominal wages are sticky, a decrease in real wages occurs because prices fall faster than wages. The inflation-targeting central bank responds to this fall in inflation by cutting the nominal interest rate, which in turn raises investment and the price of capital. Two features are crucial for boom-bust dynamics in the model

[1] Other papers have focused on different mechanisms. Den Haan and Kaltenbrunner (2006) consider a labor market matching mechanism; Floden (2007) incorporates variable capital utilization and vintage capital; Kobayashi, Nakajima and Inaba (2007) and Walentin (2007) show that expectations-driven cycles can arise in models with credit constraints on firms.

of Christiano et al.: Sticky nominal wages and wages stickier than prices. As a result, real wages *fall* during most of the boom phase.

Our paper differs from the contributions above in a number of ways. We consider the effect of news in a model with housing. Unlike Jaimovich and Rebelo (2006), our model features nominal rigidities and a role for monetary policy and it generates boom-bust dynamics without the need for a non-standard utility function. Like Christiano et al. (2008), we consider a model where wages and prices do not adjust instantaneously, but we obtain boom-bust dynamics in all aggregate variables *and* real wages in response to news. This outcome arises independently of whether wages are stickier than prices or vice versa. Intuitively, the increase in housing demand and therefore housing prices in response to news allows for an increase in both real wages and hours in the housing sector that spills over the consumption sector.

3 Stylized Facts about Housing Boom-Bust Episodes

Figure 1 shows a number of macroeconomic variables in the United States over the period 1965:1 to 2009:2. These variables are: Consumption, GDP, residential investment, business investment, house prices, hours worked and wages in the consumption sector, hours worked and wages in the housing sector, inflation and the nominal interest rate. Appendix A describes the data in detail. Aggregate variables are log-transformed, real, per capita and have been normalized to 0 in 1965:1. Real house prices in the United States seem to trend upward over the sample period. From 1965:1 to 2009:2, real house prices increased by more than 66%. According to Iacoviello and Neri (2009), the positive trend in real house prices reflects faster productivity in the consumer-good sector relative to the construction sector.

Real house prices also display a number of boom-bust episodes, namely periods of faster-than-trend growth followed by periods characterized by falling prices. We define a peak as the centered maximum in real house prices in a twenty-one-quarters window, excluding end points. Using this definition, we identify four peaks in real house prices in the United States: 1973:3; 1979:4; 1989:2; 2006:2. The vertical lines in Figure 1 indicate the peak dates. A more stringent definition would require the peak to be the high of a longer centered window. For example, if we require the window to be twenty-five quarters, as in Ahearne et al. (2005), the 1973:3 high in real house prices would fail to be a peak. In general, upward trending house prices make it difficult to identify peaks in long, centered windows because prices do not fall all the way to the levels they had at the beginning of the boom. On the other hand, a shorter centered window of seventeen quarters would deliver an additional peak in 1969:4. Our definition of peak is robust to de-trending, either with a linear trend or with an Hodrick-Prescott filter.[2]

Interestingly, real house prices peaks are followed by recessions. The grey shaded areas in Figure 1 indicate recession dates according to the National Bureau of Economic Research.[3] Every housing peak as defined above has been followed by an economic downturn. Even the housing price high of 1969:4, which does not qualify as a peak according to our definition because real house prices rebound too quickly, is followed by a recession.

We are interested in characterizing the behavior of our macroeconomic variables during these four boom-bust episodes. First we consider the average behavior of these series over the four peak episodes. Figure 2 shows the average behavior of these variables in the twenty-one quarter window around a peak date. The vertical line indicates the peak in real house prices.

On average real house prices are pro-cyclical during boom-bust episodes. In fact, real house prices peak when real GDP reaches a maximum. Figures 4 to 7 illustrate the behavior of the macroeconomic variables of interest in *each* peak episode and we will discuss the differences among peak episodes later. Real personal consumption also increases during the boom in real house prices and peaks around the same time as the peak in real GDP and house prices.

Real private residential fixed investment reaches its maximum before the peak in house prices and falls rapidly afterward. On the other hand, real private nonresidential fixed investment raises during the boom period, peaks after the peak in housing prices and falls afterward. Hours worked follows closely the dynamics of real house prices, both in the construction and in the consumption-good sector. Hours rise during the boom phase and fall during the bust one.

The interest rate is the 3 months Treasury bill interest rate. It increases throughout the boom period, peaks around the time of or just after the peak in house prices, and then it falls rapidly. The empirical evidence therefore lends support to the hypothesis that housing price booms are fueled by low interest rates.

Inflation follows with some lags real house prices and other macroeconomic variables. On average, inflation increases before the peak in house prices, reaches a maximum after the peak in house prices and then falls. Real wages are also pro-cyclical during boom-bust episodes. Real wages in the consumption-good sector rise in the boom and fall in the bust phase. Real wages in

[2]Using the H-P filter and the twenty-one quarters definition of window would deliver a peak in 1969:2, the same peaks in 1973, 1979 and 1989, and it would put the most recent peak in 2007:1.

[3]At the time the paper was written, the National Bureau of Economic Research had dated the beginning of the recession in 2007:4 but not its end. Figure 7 assumes that the recession was not over yet as of the end of boom-bust window in 2008:4.

the construction sector have a similar pattern with a couple of differences: They peak before real house prices (and real wages in the consumption-good sector) and they fall much more rapidly after that.

Next we transform our variables in deviations from the Hodrick-Prescott filter and then calculate the average over the four housing-peak episodes. This allows us to see if housing boom-bust episodes are accompanied by below- or above-trend behavior of some variables. Figure 3 shows the data. A number of observations are in order. Real house prices, real GDP, private consumption and investment, both residential and nonresidential, fall below trend at the end of the bust phase. Models featuring unanticipated shocks that eventually die away cannot reproduce this feature of the data. The nominal interest rate is well below trend at the beginning of the boom phase, consistent with the evidence in Figure 2. Real wages start at or above trend, peak before the peak in real house prices and then fall well below trend. Christiano, Illut, Motto and Rostagno (2008) suggest that DSGE models with sticky nominal wages and monetary policy that follows a Taylor rule can generate boom-busts in asset prices following signals on future changes in productivity. In these models real wages fall during most of the boom phase and then increase shortly before the period when the shock is going to be realized (or not). The empirical evidence in Figure 3 seems to suggest that real wages are *not* below trend before a peak in house prices and that they increase throughout the boom phase. Notice also that the asset-price peak in the first quarter of the year 2000 was preceded by a rapid increase in real wages both in the consumption-good and in the housing sector – see Figure 1.

Figure 4 to 7 illustrate the behavior of our macroeconomic variables (not Hodrick-Prescott filtered) during the four housing peak episodes. These graphs show that the behavior of our "average" series represents well the four episodes. In all cases, real GDP, private consumption, real private residential and nonresidential fixed investment co-move with real house prices in a bell-shaped dynamics, with small differences in different housing price peaks. These differences, however, are worth commenting on. Inflation behaves differently in the 1973:3 boom-bust episode. Inflation decreases slightly in the ten quarters preceding the peak in real house prices and it increases from four to sixteen percentage points in the next six quarters, from 1973:3 to 1975:1. Notice, however, that inflation is already high at the beginning of the boom-bust episode as a consequence of the Vietnam War. Moreover, the first oil shock contributes to the sharp rise in inflation of 1975:1, the highest level since World War I. Real wages also behave differently in the last housing peak of 2006:2 relative to the previous ones. The peak in real house prices occurs roughly at the trough of real wages in both sectors in this housing boom-bust episode. In particular, it appears the nominal wages have not fallen at all in the construction sector and have fallen very little in the consumption-good sector since the beginning of the recession. We speculate that the real wage dynamics in the last boom-bust episode is driven by the combination of rapidly falling prices and sticky nominal wages that have not been adjusted yet.

Table 1 displays the correlation of our Hodrick-Prescott filtered variables with real house prices and the standard deviation. The first column reports the statistics over the entire sample, 1965:1 to 2009:2; The second column displays the same statistics over the four twenty-one quarter windows centered around the peaks identified earlier. GDP, consumption, business investment, hours and real wages become more positively correlated, or maintain the same correlation, with real house prices during boom-bust episodes. On the other hand, the nominal interest rate and inflation are less correlated with real house prices during boom-bust episodes. This evidence supports the idea that housing booms were fueled by low inflation and interest rates. All variables except business investment are more volatile during peak episodes. The increase in volatility is substantial for real wages, inflation, residential investment, the interest rate and consumption.

4 The Model

We adopt the framework developed by Iacoviello and Neri (2009). For completeness we report the main features of the model in the following. See Figure 8 for an illustration of the model.

The model's parameters are set according to the estimated values presented by Iacoviello and Neri (2009) for the U.S. economy.

4.1 Households

The economy is populated by two types of households: the Saver and the Borrower. They both work in the good- and housing-sector of production, consume and accumulate housing. They differ in their discount factor, (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 **Saver** maximizes the utility function with respect to :

$$U_t = E_t \sum_{t=0}^{\infty} (\beta G_C)^t \left[\Gamma_c \ln\,(c_t - \varepsilon c_{t-1}) + j_t\; ln\; h_t - \frac{\tau}{1+\eta} (n_{c,t}^{1+\xi} + n_{h,t}^{1+\xi})^{\frac{1+\eta}{1+\xi}} \right]$$

subject to:

$$c_t + q_t \left(h_t - (1-\delta_h) h_{t-1} \right) + \frac{k_{c,t}}{A_{k,t}} + \phi_{c,t} + k_{h,t} + \phi_{h,t} + k_{b,t} + p_{l,t} l_t - b_t + \frac{R_{t-1} b_{t-1}}{\pi_t} \leq$$

$$\frac{w_{c,t} n_{c,t}}{X_{wc,t}} + \frac{w_{h,t} n_{h,t}}{X_{wh,t}} + \left(\frac{1-\delta_k}{A_{k,t}} + R_{c,t} z_{c,t} \right) k_{ct-1} + (1-\delta_k + R_{h,t} z_{h,t}) k_{ht-1} + p_{b,t} k_{b,t} + (p_{l,t} + R_{l,t}) l_{t-1} + D_t$$

where c, h , n_c and n_h are consumption, housing services, hours worked in the good-sector and in the construction-sector, respectively. The parameter ξ defines the degree of substitution between the two sectors in terms of hours worked. For a high value of ξ hours worked in the two sectors are close to perfect substitutes, which means that the worker would devote most of the time to the sector that pays the highest wage. Small values of ξ imply, instead, that hours worked are far from perfect substitutes, thus the worker is less willing to diversify her working hours across sectors even in the presence of a wage differential.[4] j_t determines the relative weight in utility of housing services that follows an AR(1) process, R_t is the lending interest rate, δ_c and δ_h represent the depreciation rate for capital and housing stock, respectively. l_t is the land priced at $p_{l,t}$ and q_t is the price of the houses, all relative to the CPI. $z_{c,t}$ and $z_{h,t}$ are the capital utilization rates of transforming potential capital into effective capital in the two sectors. D_t are lump-sum profits, paid to households. The term $A_{k,t}$ is an investment-specific technology shock that follows an AR(1) process and captures the marginal cost of producing capital in the consumption sector.[5] G_C, G_{IK_c} and $G_{IK_h}$are the trend growth rates of real consumption and capital used in the two sectors of production. Γ_c and $\Gamma_c^{'}$ represents scaling factors of the marginal utilities of consumption. Wages are set in a monopolistic way and can be adjusted subject to a Calvo scheme with probability $1-\theta_w$ every period. $X_{wc,t}$ and $X_{wh,t}$ are markups on the wages paid in the two sectors.

The **Borrower** maximizes the utility function:

$$U_t = E_t \sum_{t=0}^{\infty} (\beta^{'} G_C)^t \left[\Gamma_c^{'} \ln\,(c_t^{'} - \varepsilon^{'} c_{t-1}^{'}) + j_t\; ln\; h_t^{'} - \frac{\tau}{1+\eta^{'}} ((n_{c,t}^{'})^{1+\xi^{'}} + (n_{h,t}^{'})^{1+\xi^{'}})^{\frac{1+\eta^{'}}{1+\xi^{'}}} \right]$$

[4]See Horvath (2000).

[5]$\phi_{c,t} = \frac{\phi_{kc}}{2G_{IK_c}} \left(\frac{k_{c,t}}{k_{c,t-1}} - G_{IK_c} \right)^2 \frac{k_{c,t-1}}{(1+\gamma_{AK})^t}$ is the good-sector capital adjustment cost, and $\phi_{h,t} = \frac{\phi_{kh}}{2G_{IKh}} \left(\frac{k_{h,t}}{k_{h,t-1}} - G_{IK_h} \right)^2 k_{h,t-1}$ is the housing-sector capital adjustment cost; γ_{AK} represents the net growth rate of technology in business capital, ϕ_{kc} and ϕ_{kh} indicate the coefficients for adjustment cost (i.e., the relative prices of installing the existing capital) for capital used in the consumption sector and housing sector, respectively.

subject to:

$$c_t^{'} + q_t\left[h_t^{'} - (1-\delta_h)h_{t-1}^{'}\right] - b_t^{'}$$

$$\leq \frac{w_{c,t}^{'} n_{c,t}^{'}}{X_{wc,t}^{'}} + \frac{w_{h,t}^{'} n_{h,t}^{'}}{X_{wh,t}^{'}} + D_t^{'} - \frac{R_{t-1} b_{t-1}^{'}}{\pi_t}$$

and

$$b_t^{'} \leq mE_t\left(\frac{q_{t+1} h_t^{'} \pi_{t+1}}{R_t}\right)$$

$\beta' \in (0, \beta)$ captures the Borrower's relative impatience.

Limits on borrowing are introduced through the assumption that households cannot borrow more than a fraction of the next-period value of the housing stock. The fraction m, referred to as the equity requirement or loan-to-value ratio, should not exceed one and is treated as exogenous to the model. It can be interpreted as the creditor's overall judicial costs in case of debtor default and represents the economy's degree of credit frictions in the economy. The borrowing constraint is consistent with standard lending criteria used in the mortgage and consumer loan markets.

Both households set wages in a monopolistic way.

4.2 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, land, l, and labor supplied by the savers, n, and the borrowers, $n^{'}$, as inputs of production.

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

The non-housing sector produces consumption and business capital using labor and capital.

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

$A_{h,t}$ and $A_{c,t}$ are the productivity shocks to the housing- and good-sector, respectively.

Firms pay the wages to households and repay back the rented capital to the Savers. Housing prices are assumed to be flexible.

The intermediate good-sector is populated by a continuum of monopolistically competitive firms owned by the Savers. Prices can be adjusted by each producer 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:

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

where $\epsilon_\pi = \frac{(1-\theta_\pi)(1-\beta\theta_\pi)}{\theta_\pi}$, X_t represents the price markup and $u_{p,t}$ is an i.i.d. cost shock $i.i.d. \sim N(0, \sigma_p^2)$.

4.3 Monetary Policy Rule

We assume that the central bank follows a Taylor-type rule as estimated by Iacoviello and Neri (2009)

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

where rr is the steady state real interest rate, $u_{R,t}$ is an *i.i.d.* monetary policy shock. The central bank's target is assumed to be time varying and subject to an AR(1) shock, s_t, as in Smets and Wouters (2003). GDP is defined as the sum of consumption and investment at constant prices. Thus

$$GDP_t = C_t + IK_t + qIH_t,$$

where q is real housing prices along the balanced growth path.

4.4 News Shocks

To introduce expectations of future macroeconomic developments 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, $\varepsilon_{z,t-n}$,

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

where $\varepsilon_{z,t}$ is i.i.d.and $z = \{h, c, R, s, p, j, k\}$. Thus, at time t agents receive a signal about future macroeconomic conditions at time $t + n$. If the expected movement doesn't occur, then $u_{z,t} = -\varepsilon_{z,t-n}$.

5 News and Boom-Bust Dynamics

Since the seminal contribution of Beaudry and Portier (2004) a growing literature has investigated the role of news about future productivity as a source of business cycle fluctuations. This section reports the dynamics of the model in response to news shocks to assess which of them is able to generate boom-bust cycles like those seen in the data.

First we consider the case of news about future productivity in the consumption sector and in investment-specific technology. We show that these news generate boom-bust dynamics. Next we consider news about future productivity in the housing sector and future housing demand. We show that news about future productivity causes boom-bust dynamics whereas news about future housing demand does *not*. Then we consider news about future monetary policy, future central bank's inflation target and future inflation, which generate boom-bust cycles.

At last, we consider the case both of a current unexpected and a future reduction in the credit friction, namely an increase in m. An often-heard explanation for the last housing boom is the increase in the loan-to-value ratio – in terms of our model, an increase in m. We show that neither a current nor an expected future temporary increase in m generate boom-bust dynamics in accordance with the empirical findings.

5.1 Productivity in the Consumption Sector and Investment-Specific Technology

Figure 9 reports the effect of anticipated future productivity gains, namely a shock to $A_{c,t}$ (starred line). It also illustrates the case in which the expected increase in productivity turns out to be wrong and at time t=4 there is no change in productivity (solid line). The dashed line displays the effects of a current unanticipated productivity shock.

Expectations of future productivity gains generate boom-bust dynamics in GDP, consumption, hours, investment and house prices. The intuition is as follows. Expectations of higher productivity in the future lead households to increase their current consumption expenditures. Due to demand pressures, inflation increases. At the same time, the anticipation of higher productivity in the future generates expectations of higher future housing prices. The decline in the current real rate coupled with higher expected housing prices leads to an increase in Borrowers' housing expenditure and indebtedness. Due to limits to credit, impatient households increase their labor supply in order to raise internal funds for housing investment.

Given the adjustment cost on capital, firms in the consumption sector start adjusting the stock of capital already at the time in which news about a future increase in productivity spreads. This way, when the increase in productivity occurs, capital is already in place. For the increase in business investment to be coupled with an increase in hours, wages must rise. GDP increases already at the time of the signal.

The model presented above features several real and nominal rigidities. In order to disentangle the contribution of the different modeling choices we introduce the frictions one at the time. Figure 10 displays the boom-bust response to news on productivity in the flexible-price version of the model. In the absence of adjustment costs on capital and when impatient households cannot borrow (dashed line), i.e. when $m = 0$, the wealth effect dominates and agents increase both consumption and leisure. Thus, investment (in all sectors) falls. When it is costly to adjust the stock of capital, the reduction in business investment and thus the increase in consumption is less pronounced (starred line). Allowing for borrowing against the value of collateral leads to a more pronounced increase in Borrower's housing demand (solid line). In this last case, Borrower's consumption increases by more in the boom phase and the decline in Borrower's hours (not shown in the graph) is more sizable. Saver's demand for housing declines. Since Savers account for about eighty percent of labor income, aggregate housing production declines and housing prices fall. To sum up, adjustment costs and the collateral effect are not enough to generate boom-bust dynamics in the absence of nominal rigidities.

Figures 11 shows the response of the economy with nominal rigidity in the price of the consumption good but no wage rigidities (dashed line). Expectations of higher future productivity lead to a decrease in expected inflation, which in turn reduces the expected real interest rate. The decline in the current real interest rate coupled with a higher expected real rate leads to an increase in current debt and thus the Borrower's consumption, Borrower's housing demand and Saver's consumption. On the contrary, Savers reduce their housing demand and increase their supply of labor. For a contemporaneous increase in business investment and hours, the rise in wages in the consumption sector needs to be significant. Aggregate housing investment first declines and then slowly increases; housing prices as well as current inflation increase. However, compared to the case with flexible price, inflation rises less, thereby allowing for a more pronounced increase in consumption.

In the additional presence of wage stickiness in the consumption sector, the wage in the consumption sector increases less (starred line), which raises the demand for labor and therefore hours in the consumption sector. Moreover, since the sectorial wage differential is more pronounced, Savers increase their labor supply in the housing sector as well. Thus, the model displays comovement of GDP, consumption, business investment and housing prices over the boom-bust cycle. Housing investment and hours in the housing sector, however, fall after the news because wages in the housing sector increase substantially, thereby reducing labor demand in the sector. To obtain a boom in investment and hours in the housing sector is therefore necessary to introduce wage stickiness in the housing sector.

Finally, we add wage stickiness in both sectors of production (solid line). Since we assume wage stickiness to be more sizable in the housing sector, the increase in wage in that sector is less pronounced. Due to a further reduction in the current income effect, agents increase their labor supply by more. Aggregate housing investment increases more so that housing prices rise less. Household debt increases less but aggregate consumption is barely affected relative to the case of no wage stickiness in the housing sector.

Figure 12 shows the effect of expectations of a future increase in the cost of transforming output into capital, A_k. Agents are willing to increase their labor supply in order to reduce the negative future effect of the shock. Consumption and housing expenditures increase. The increase in aggregate housing demand make housing prices rise as well. Housing investment increases. Thus, the stock of capital used as input of production increases in both the consumption- and housing-good sector and business investment goes up. As a result of the increase in the production of consumption goods, housing investment and business investment, GDP rises.

A four-period anticipated increase in the capital production cost generates a boom in housing prices, housing investment, consumption, GDP, hours and indebtedness. The peak response of all aggregate variables corresponds to the time in which expectations realize. After that all variables slowly return to their initial values. In contrast, if expectations do not realize there is a dramatic drop in both quantities and prices (solid line).

5.2 Productivity and Demand in the Housing Market

Iacoviello and Neri (2009) document that housing demand and supply shocks explain each one-quarter of fluctuations in housing prices and housing investment. We document that only expectations of a future reduction in the supply of houses generate boom-bust cycles in all aggregate quantities such as output, consumption, hours and investment. Expectations of a future increase in housing demand, on the other hand, reduces business investment and therefore fails to generate a boom-bust cycle.

Figure 13 shows that expectations of a future decline in productivity in the housing sector, $A_{h,t}$, makes agents increase their labor supply in order to reduce the negative future effect of the shock. Moreover, news of negative housing supply shocks generates expectations of a future increase in house prices. To take advantage of it, Borrowers increase their current housing demand. Thus, both indebtedness and consumption expenditures increase. Due to adjustment costs in capital, firms start adjusting the stock of capital already at the time of news. The stock of capital used as input of production in the consumption sector increases while it decreases in the housing sector. As a result, business investment slightly decreases. Despite this, GDP rises due to the increase in housing investment and consumption. A four-period anticipated decline in productivity (starred line) generates a boom in housing prices, housing investment, consumption, GDP, hours and indebtedness. Still, current business investment slightly falls.

Figure 14 shows the response of the model economy to expectations of a future increase in housing demand due to a housing preference shock, j. Anticipating a future increase in housing prices, Borrowers increase their current demand for houses and thus indebtedness and consumption. Firms in the housing sector start adjusting their capital holding at the time of the signal and housing investment increases. Due to an expected shift in preference for housing relative to consumption, firms in the consumption sector reduce their stock of capital. As a result, business investment falls. Despite the decline in business investment, GDP rises. Because of the reduction in business investment during the boom phase, news about a future increase in housing demand fails to generate boom-bust dynamics consistent with the data.

5.3 Monetary Policy and Inflation

According to Iacoviello and Neri (2009), monetary policy shocks account for between 15 and 20 percentage points of the variation in housing investment and housing prices over the last decades in the U.S. In the following we study the role of expectations of future monetary policy developments in driving business cycle fluctuations in the housing market. We document that expectations of a reduction of the policy rate or of a change in the central bank's inflation target generate macroeconomic booms that turn into a bust if agents' expectations are not realized ex-post. We also consider the effect of expected future pressure in inflation.

Expectations about the future state of monetary policy (news of a future negative shock to u_R) that do not realize can generate macroeconomic boom-bust dynamics. See Figure 15. The intuition is as follows. Signals of lower policy rates generate expectations of a decline in the future real interest rate. Borrowers anticipate this effect and increase their current consumption. Demand pressure rises current inflation. The current ex-post real rate declines, reducing the debt service. On the other hand, the anticipation of expansionary monetary policy creates expectations of higher future housing prices that further induce Borrowers to increase their current demand for housing and thus indebtedness. Due to limits to 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.

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 already at the time of the signal.[6]

In the case of an anticipated shock that realizes, 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. Thus, expectations of looser monetary policy that do not realize generate a macroeconomic boom-bust cycle (solid line).

Figure 16 documents the effect of expectations of a temporary but persistent upward deviation in the central bank's inflation target, a negative realization of u_s. The anticipation of a higher target for inflation means higher long-run expected inflation. Firms that can adjust their prices do so in the current period. Thus, expectations of higher future inflation increase inflation already in the current period. Expectations of a future reduction of the ex-post real interest rate coupled with a current reduction in the nominal interest rate induce an increase in household indebtedness, higher consumption and higher housing spending. Housing prices and housing investment increase. Due to adjustment costs to capital, firms start adjusting the stock of capital already at the time in which news spreads. Real wages and hours worked rise and the economy experiences a macroeconomic boom. After the shock is realized all variables slowly return to their initial levels. Figure 16 also displays the behavior of the model economy when news on future central bank's target do not realize (the target doesn't increase in period four). As expected at time t=5 quantities and prices drastically drop. Compared to the case of expectations of future expansionary monetary policy, expectations of a temporary upward shift in the inflation target generate a less sizable boom but a more pronounced bust.

Figure 17 documents how expected future downward pressure on inflation, namely a future negative shock to u_p, affects the dynamics of the model. Because of price stickiness, some firms already adjust their price downwards. Thus, expectations of lower inflation in the future reduce inflation instantaneously. Current consumption expenditure increases, as well as investment. Expectations of higher future housing prices induce Borrowers to increase their current demand for housing and therefore indebtedness. On the other hand, a reduction in inflation raises the rate of return on nominal assets and makes them more attractive. As a result, Savers demand less housing and invest more in nominal assets, namely they lend more to Borrowers. Hence, expectations of

[6] As a consequence of the current increase in inflation and GDP, the policy rate (not shown in the graph) increases at the time of the signal, to decline only at the time of occurrence of the shock.

a future decline in inflation generate a bifurcation in housing demand, with Borrowers demanding more while Savers demand less.

Compared to the previous cases, expectations of a future reduction in inflation leads to a more sizable boom but a milder bust. In contrast, during the bust all variables barely go below their initial values.

6 Credit Market and Boom-Bust Cycles

6.1 Credit Shocks

In the following we show that changes in the access to credit, either current or anticipated, do not generate boom-bust cycles.

To illustrate the effect of changes in the access to credit, we assume that m follows an AR(1) process with persistence equal to 0.5. The dotted line in Figure 18 shows the effect of a temporary increase in the access to credit, namely an increase in m. Borrower's debt and therefore consumption and housing demand increase, which leads to a rise in aggregate consumption, investment and GDP. Demand pressures make housing prices rise; inflation barely rises. However, the model's responses do not display the hump-shaped dynamics that typically emerges in boom-bust cycles. The shock leads to an initial increase in house prices, investment, consumption and GDP and a slow decline towards the initial level.

The starred line in Figure 18 shows the dynamics when agents expect a future increase in credit market access. The solid line corresponds to the case where expectations do not materialize. Lower expected credit frictions in the future reduce Borrowers' current demand for loans and housing. As a result, housing prices and housing investment initially fall. Borrowers substitute consumption for housing. In contrast, Savers' consumption and business investment decline due to a decrease in the real interest rate. The increase in Borrowers' consumption dominates and aggregate consumption rises as well as inflation and GDP. Hence, news about future increases in credit access do not generate boom-bust dynamics as seen in the data.

6.2 Credit Friction as a Transmission Mechanism

We now document the role of the degree of credit friction for the transmission of expectations-driven business cycles. We compare the transmission of news shocks in the case of the estimated loan to value ratio (m=0.85) with a lower (m=0.20) and a higher (m=0.95) value. As an example we show the effect of the degree of credit frictions for the transmission of news shocks on the policy rate. See Figure 19. Consumption and GDP are quite sensitive to the degree of credit frictions. In particular, both variables display larger booms and deeper busts for higher values of m. Other aggregate variables are only slightly affected by the loan-to-value ratio. A similar result holds for the other shocks.

The degree of credit friction has stronger implications at the individual level. In particular, a lower degree of credit frictions delivers larger sensitivity of Borrowers' consumption to the changes in expectations. In economies with a easier access to the credit market, the increase in indebtedness due to the anticipation of future monetary policy developments is larger. Thus, changes in Borrowers expenditures are more sizable. The rise in housing investment by Borrowers is particularly pronounced. In contrast, Savers' house holding is significantly reduced. Substituting housing with consumption makes Savers able to maintain the same increase in consumption independently of the loan-to-value ratio.

In economies with a lower degree of credit frictions Borrowers are more leveraged. When expectations do not materialize, the drop in Borrowers' consumption expenditure is more sizable, which in turn makes aggregate consumption more responsive to the loan-to-value ratio. Figures 20-21 show how the loan-to value ratio affects the response of Savers' and Borrowers' expenditure to different shocks.

Consistently with individual behavior, the volatility of consumption, household debt and GDP increases with an increase in the loan-to-value ratio. See Figure 22. In contrast, the volatility of housing prices, housing investment and business investment declines. Following Iacoviello and Neri (2009), GDP is defined as the sum of consumption and investment (business and housing) at steady-state prices. As a result, the volatility of GDP increases despite a reduction in the volatility of the relative price of housing and of the two investment components. Variations in GDP are only due to variations in quantities. In the following, we allow for changes in the relative price of investment to enter the measurement of GDP. Interestingly, the volatility of GDP declines with the degree of credit frictions – see Figure 23. Movements in relative prices play an important role in the transmission of shocks to GDP. The sensitivity of the other variables to the degree of credit frictions is not significantly affected by differences in the measurement of GDP in real terms.[7]

[7] In recent years, an increasing number of countries have changed from the constant price measure of GDP to the chain volume measure of GDP that takes into account movements in relative prices. See among others the United States, Canada, Australia, New Zealand, Japan, UK, Hong Kong and most European economies.

7 Monetary Policy and Boom-Bust Cycles

In what follows we investigate how the conduct of monetary policy affects the occurrence of expectations-driven boom-bust cycles. Standard models featuring nominal price stickiness imply that a strong anti-inflationary stance should increase economic activity and welfare by reducing price and wage dispersion.[8] Most literature on asset-price movements and monetary policy builds on models of exogenous bubbles.[9] In these models monetary policy does not play a central role in generating or bursting a bubble. As a result, a strong anti-inflationary monetary policy is optimal for the exactly the same reasons as in standard models with nominal stickiness.

We study boom-bust cycle formation under: a) an estimated Taylor rule; and b) a strict anti-inflationary stance. We assume that, under strict inflation targeting, the monetary authority credibly maintains inflation constant without deviating from the target. Thus, expectations on the policy rate and the central bank's target are supposed to be stabilized. Table 2 shows the standard deviation of aggregate variables conditional on the occurrence of productivity, investment-specific, housing supply and inflationary shocks, both current and in expectations. A strict anti-inflationary stance outperforms the estimated rule only under the investment-specific shock and news on this shock. Figure 24 shows that strict inflation targeting dampens the boom-bust dynamics of a future increase in the cost of transforming output into capital A_k and of a future decrease in productivity in the housing sector, A_h. In contrast, expectations of future productivity gains A_c or future downward pressures in inflation A_p generate larger and opposite responses with respect to transmission of the shock under the estimate rule. Thus, under strict inflation targeting, the same kind of expectations generate a bust instead of a boom and the economy is much more volatile. As shown by Table 3, the estimated rule delivers lower fluctuations in aggregate quantities such as business investment, consumption and inflation.

At the individual level, strict inflation targeting is accompanied by larger volatility of both consumption and hours - See Table 4. Thus, both Savers and Borrowers are better off under the

[8] See among others Woodford (1999), Erceg, Henderson and Levin (2000) and Schmitt-Grohé and Uribe (2006).

[9] For models of exogenous asset-price bubbles, see, among others, Bernanke and Gertler (1999), Cecchetti, Genberg and Wadhwani (2003) and Basant Roi and Mendes (2007).

estimated rule. A strict anti-inflationary stance is detrimental in terms of welfare in our model.[10]

For better understanding these results, we investigate how the central bank's responsiveness to inflation affects macroeconomic volatility in an economy with expectations-driven cycles. We take into account all shocks and expectations on future shocks. As seen in Figure 25, a stronger response to deviations of inflation from its target reduces the volatility of inflation. For a response to inflation below 1.1, it also reduces the volatility of GDP, hours worked, housing prices and housing investment. In contrast, a higher values of the response increases macroeconomic volatility. The rise in volatility is particularly sizable in housing investment and hours worked in the housing sector. Thus, strong inflation targeting is not beneficial in terms of macroeconomic stabilization.

To better understand the link between inflation targeting and volatility in our model, we consider the case of unrealized expectations of a future increase in productivity in the consumption sector, A_c. This is shown in Figure 26. A stronger reaction to inflation is undesirable because it reduces the boom but amplifies the bust on aggregate consumption, GDP, investment, housing prices and hours worked in both sectors.

We conclude this section with a comment on the transparency of monetary policy. Our analysis has shown that expectations of future shocks to the policy rate or to the inflation target generate boom-bust dynamics in the economy. Since volatility reduces welfare, the boom-bust dynamics generated by unrealized expected changes in monetary policy is detrimental to welfare. A high degree of transparency in monetary policy is likely to reduce the uncertainty about future monetary policy actions and therefore reduce the occurrence of unrealized changes in monetary policy. As such, a highly transparent monetary policy improves welfare.

8 Conclusions

We study the role of expectations-driven fluctuations in generating a macroeconomic boom. In particular, we are interested in explaining boom-bust cycle dynamics in the housing market. First, we document that the cyclical behavior of housing prices and housing investment is coupled with a similar pattern in GDP, business investment, consumption, hours and real wages. Then, we show that changes in expectations about the future state of productivity, investment cost, housing supply,

[10] We compute the conditional welfare implied by the different rules. Since alternative rules do not affect the deterministic steady state, to ensure that the economy under alternative rules, begins from the same initial point, we evaluate welfare conditional on the initial state being the deterministic steady state. Since first-order approximation methods are not locally accurate for comparing the welfare effects of implementable policy rules that have no first-order effects on the model's deterministic steady state, our results rely on second-order approximation.

inflation, the policy rate and the central bank's target can generate housing-market boom-bust cycles in accordance with the empirical findings. In contrast, expectations on future housing demand do not generate co-movement between business investment and all other aggregate variables.

We show that changes in the access to credit are not in accordance with the last boom in the housing market. Moreover, a lower degree of credit frictions generates larger sensitivity of consumption and household indebtedness to changes in expectations.

We also show that expectations on the conduct of monetary policy can be a source of fluctuations in the housing market. In fact, expectations of either a future reduction in the policy rate or a temporary increase in the central bank's inflation target that are not fulfilled can generate macroeconomic boom-bust cycle dynamics. Our results imply that good communication on monetary policy is essential for reducing the occurrence of expectations-driven cycles. However, as documented in this paper, monetary policy is only one of the mechanisms that can generate boom-bust cycles in the housing market. Contrary to previous literature our findings show that in the presence of boom-bust cycles, strongly targeting inflation is detrimental.

Investigating the effects of monetary policy on welfare is beyond the scope of this paper. The analysis of the conduct of optimal monetary policy as well as a quantitative assessment of the relative importance of each shock in generating boom-bust cycles requires separate consideration and it is left to future research.

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A Data

CC : Aggregate Consumption. Real Personal Consumption Expenditure (seasonally adjusted, billions of chained 2005 dollars, Table 1.1.6), divided by the Civilian Noninstitutional Population (CNP16OV, source: Bureau of Labor Statistics). Source: Bureau of Economic Analysis (BEA).

GDP : Gross Domestic Product. Real Gross Domestic Product (seasonally adjusted, billions of chained 2005 dollars, Table 1.1.6), divided by CNP16OV. Source: BEA.

IK : Business Fixed Investment. Real Private Nonresidential Fixed Investment (seasonally adjusted, billions of chained 2005 dollars, Table 1.1.6), divided by CNP16OV. Source: BEA.

IH : Residential Investment. Real Private Residential Fixed Investment (seasonally adjusted, billions of chained 2005 dollars, Table 1.1.6.), divided by CNP16OV. Source: BEA.

INFLQ : Inflation. Quarter on quarter log differences in the implicit price deflator for the nonfarm business sector, demeaned. Source: Bureau of Labor Statistics (BLS).

RRQ : Nominal Short-term Interest Rate. 3-month Treasury Bill Rate (Secondary Market Rate), expressed in quarterly units. (Series ID: H15/RIFSGFSM03_NM). Source: Board of Governors of the Federal Reserve System.

QQ : Real House Prices. Census Bureau House Price Index (new one-family houses sold including value of lot) deflated with the implicit price deflator for the nonfarm business sector. Source: Census Bureau, http://www.census.gov/const/price_sold_cust.xls.

NC : Hours in Consumption Sector. Total Nonfarm Payrolls (Series ID: PAYEMS in Saint Louis Fed Fred2) less all employees in the construction sector (Series ID: USCONS), times Average Weekly Hours of Production Workers (series ID: CES0500000007), divided by CNP160V. Source: BLS.

NH : Hours in Housing Sector. All Employees in the Construction Sector (Series ID: USCONS in Saint Louis Fed Fred2), times Average Weekly Hours of Construction Workers (series ID: CES2000000007), divided by CNP16OV. Source: BLS

RWCPC : Real Wage in Consumption-good Sector. Average Hourly Earnings of Production/ Nonsupervisory Workers on Private Nonfarm Payrolls, Total Private (Series ID: CES0500000008), divided by the price index for Personal Consumption Expenditure (Table 2.3.4, source: BEA). Source: BLS.

RWHPC : Real Wage in Housing Sector. Average Hourly Earnings of Production/Nonsupervisory Workers in the Construction Industry (Series ID: CES2000000008), divided by the price index for Personal Consumption Expenditure (Table 2.3.4, source: BEA). Source: BLS.

Note: In the figures and tables GDP, Consumption, Business Investment, Residential Investment, Hours in the Consumption Sector, Hours in the Housing Sector, House Prices, Real Wage in the Consumption Sector and Real Wage in the Housing Sector are log-transformed and normalized to zero in 1965:1.

B Tables and Figures

Correlation with QQHP		
	1965:1 to 2009:2	Boom-Bust Episodes
GDPHP	0.60	0.64
CCHP	0.54	0.60
IKHP	0.55	0.58
IHHP	0.49	0.53
NCHP	0.62	0.62
NHHP	0.71	0.71
RRQHP	0.50	0.44
INFLQHP	0.29	0.23
RWCPCHP	0.20	0.31
RWHPCHP	-0.10	0
Standard Deviation		
GDPHP	1.56	1.65
CCHP	1.85	2.13
IKHP	5.08	4.83
IHHP	10.23	12.41
NCHP	1.69	1.76
NHHP	4.38	4.60
RRQHP	0.31	0.37
INFLQHP	0.40	0.51
RWCPCHP	0.99	1.32
RWHPCHP	1.15	1.42
QQHP	2.23	2.31

Table 1: Descriptive Statistics for H-P filtered data: Full Sample and Boom-Bust Episodes

All series are detrended using the H-P filter. Standard deviation in percentage points.

	Productivity Shock		Investment-Specific Shock	
	Estimated Rule	Strict Inflation Targeting	Estimated Rule	Strict Inflation Targeting
Savers' consumption	0.0328	0.0373	0.0131	0.0122
Borrowers' consumption	0.0389	0.0616	0.0169	0.0157
Consumption	0.0337	0.0405	0.0136	0.0125
Business Investment	0.0481	0.0721	0.0722	0.0720
Housing Investment	0.03500	0.1420	0.0189	0.0075
Housing Prices	0.0283	0.0382	0.0116	0.0106
GDP	0.0371	0.0512	0.0257	0.0254
Inflation	0.0017	-	0.0011	-
Household Debt	0.0522	0.1868	0.0263	0.0214
Real Rate	0.0024	0.0258	0.0017	0.7842
Hours housing sector	0.0118	0.0255	0.0081	0.0069
Hours consumption sector	0.0394	0.1482	0.0216	0.0075
	Inflation Shock		**Housing Supply Shock**	
	Estimated Rule	Strict Inflation Targeting	Estimated Rule	Strict Inflation Targeting
Savers' consumption	0.0256	0.2306	0.0025	0.0019
Borrowers' consumption	0.0721	0.6266	0.0191	0.0126
Consumption	0.0330	0.2320	0.0043	0.0006
Business Investment	0.0637	1.1223	0.0038	0.0061
Housing Investment	0.0560	2.5873	0.3161	0.3163
Housing Prices	0.0272	0.5457	0.2328	0.2329
GDP	0.0420	0.6040	0.0200	0.0201
Inflation	0.0071	-	0.0008	-
Household Debt	0.1296	3.5888	0.1133	0.0943
Real Rate	0.0088	0.7842	0.0011	0.0006
Hours housing sector	0.0480	0.6508	0.1301	0.1292
Hours consumption sector	0.0649	3.1178	0.0048	0.0023

Standard deviation in percentage terms conditional on a particular shock (current and expectations).

Table 2: Stabilization Effect: Specific Shocks

	Estimated Rule	Strict Anti-Inflationary Stance
Consumption	0.0526	0.2358
Business Investment	0.1128	1.1269
Housing Investment	0.3299	2.6095
Housing Prices	0.2369	0.5946
GDP	0.0695	0.6071
Inflation	0.0147	-
Household Debt	0.2192	3.595
Real Rate	0.0104	0.7846
Hours housing sector	0.1705	3.124
Hours consumption sec.	0.0573	0.6514

Standard deviation in percentage terms. All shocks.

Table 3: Stabilization Effect: All shocks

	Estimated Rule	Strict Inflation Targeting
Savers' welfare	-0.11656	-0.326
Borrowers' welfare	-2.0174	-3.7015
$\sigma(c)$	0.0459	0.2339
$\sigma(c')$	0.0957	0.6299
$\sigma(nc)$	0.0625	0.6577
$\sigma(nc')$	0.0401	0.6681
$\sigma(nh)$	0.1731	3.1249
$\sigma(nh')$	0.1611	3.1216
$\sigma(h)$	0.2521	0.5599
$\sigma(h')$	0.3061	3.3780

Stochastic mean of agents' welfare w.r.t. an alternative monetary policy rule. For any variable, x, μ(x) represents the stochastic mean, and σ(x) the standard deviation as a percentage.

Table 4: Welfare and Volatility

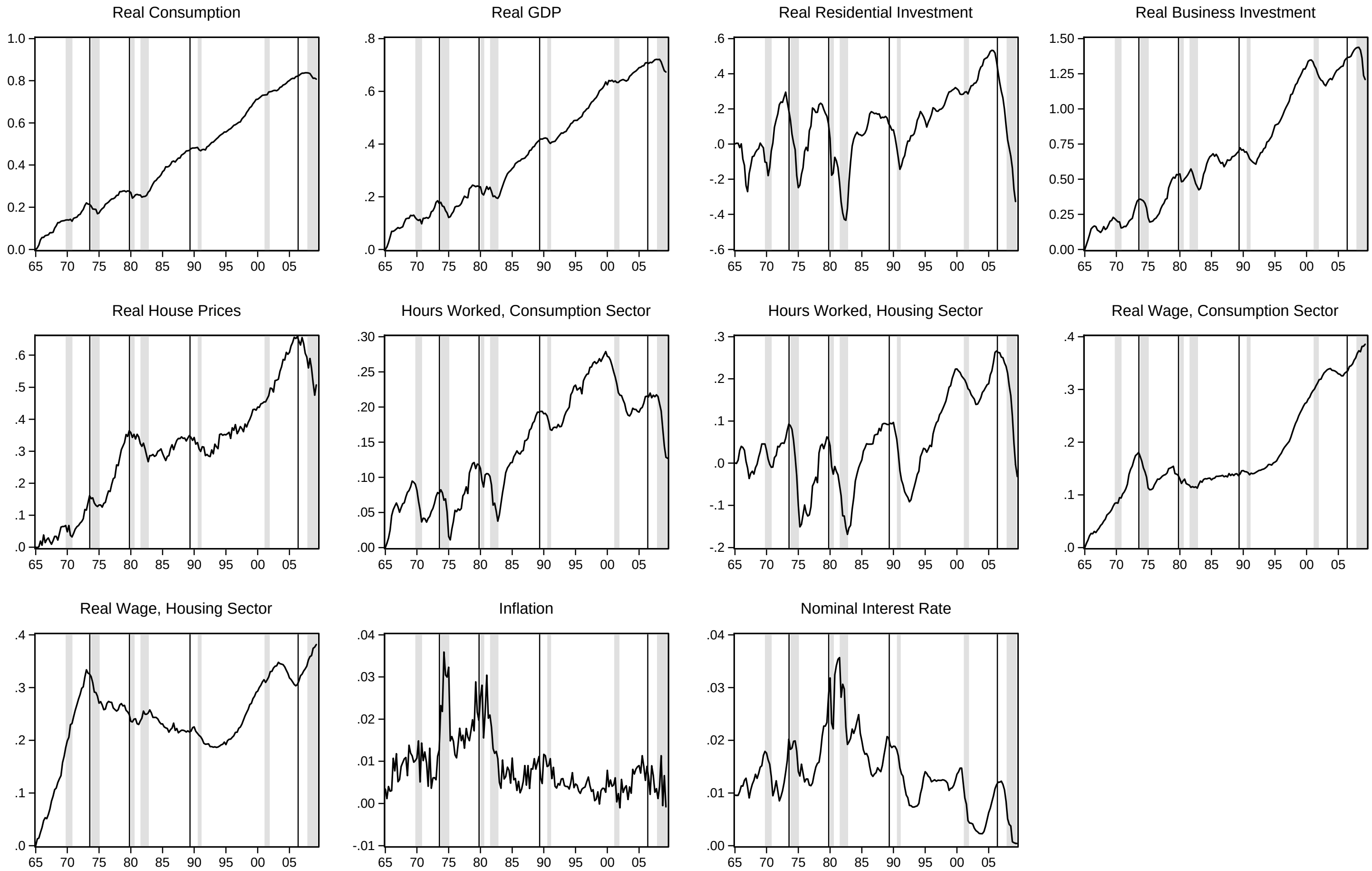

Figure 1: Macroeconomic Variables in the United States, 1965:1 to 2009:2

Note: Vertical lines indicate peaks in real house prices. Shaded areas indicate recessions according to the NBER.

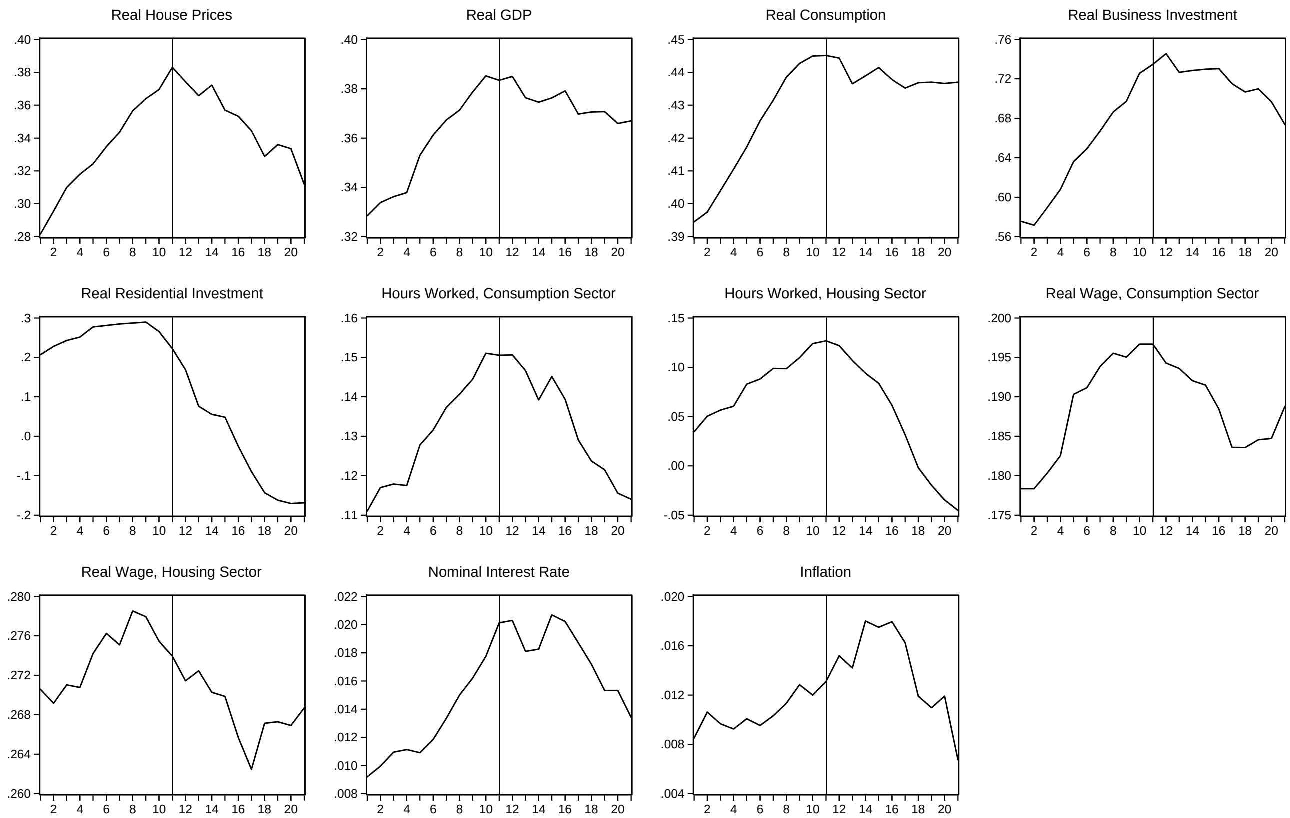

Figure 2: Macroeconomic Variables during Peaks: Average over all Peaks

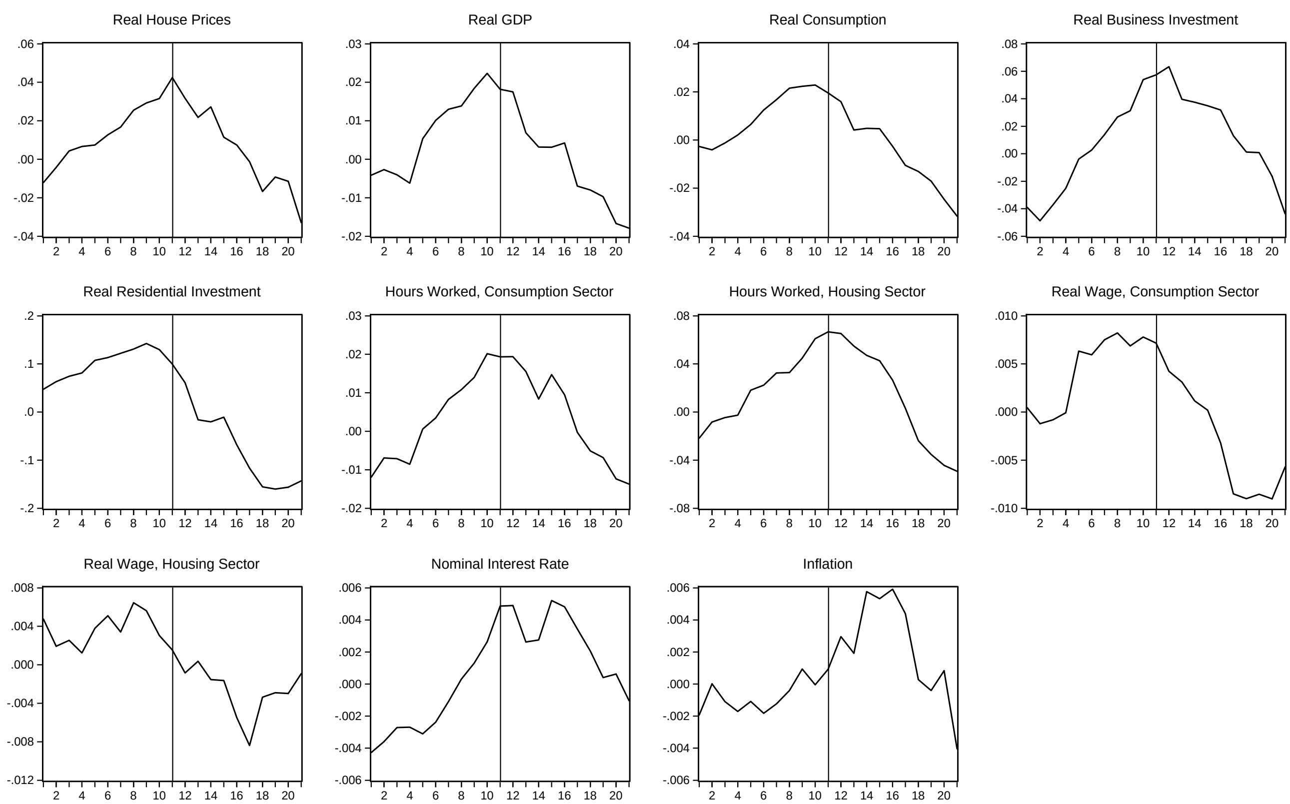

Figure 3: H-P-filtered Macroeconomic Variables during Peaks: Average over all Peaks

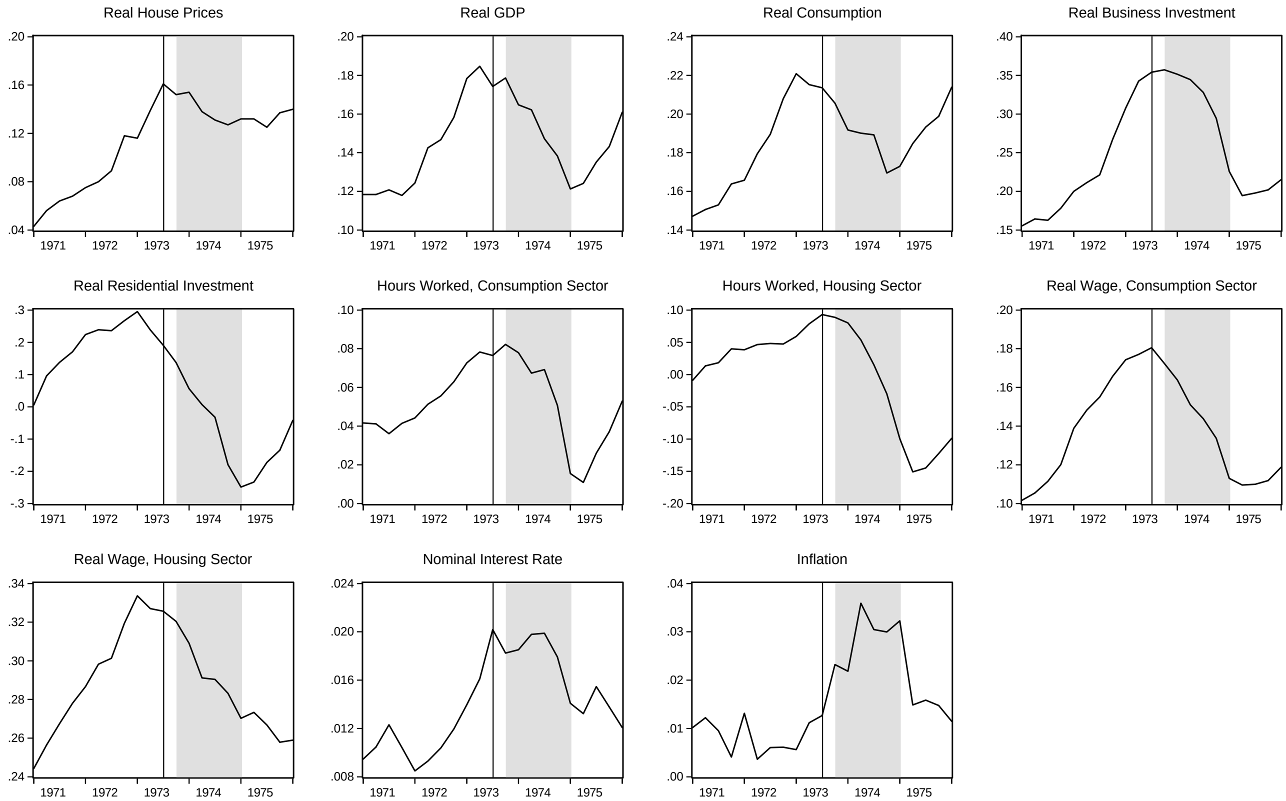

Figure 4: 1973:3 Peak

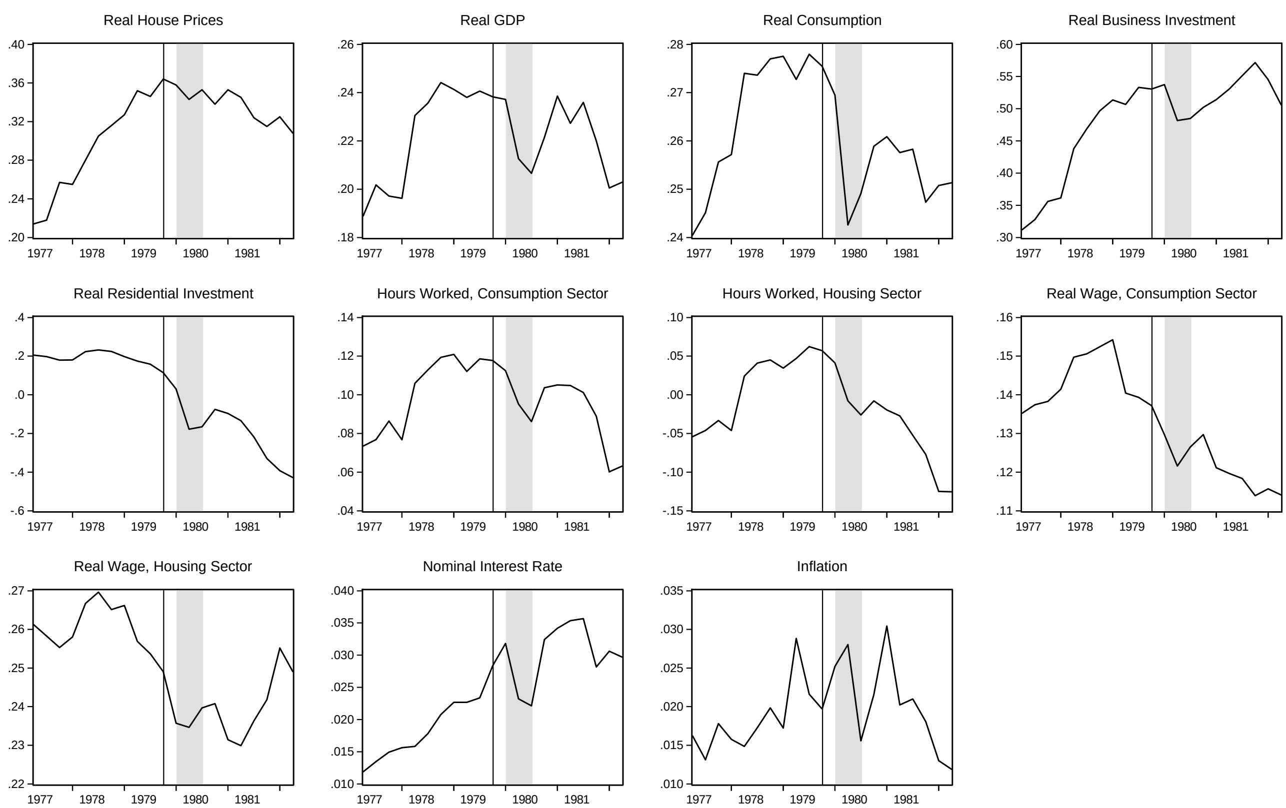

Figure 5: 1979:4 Peak

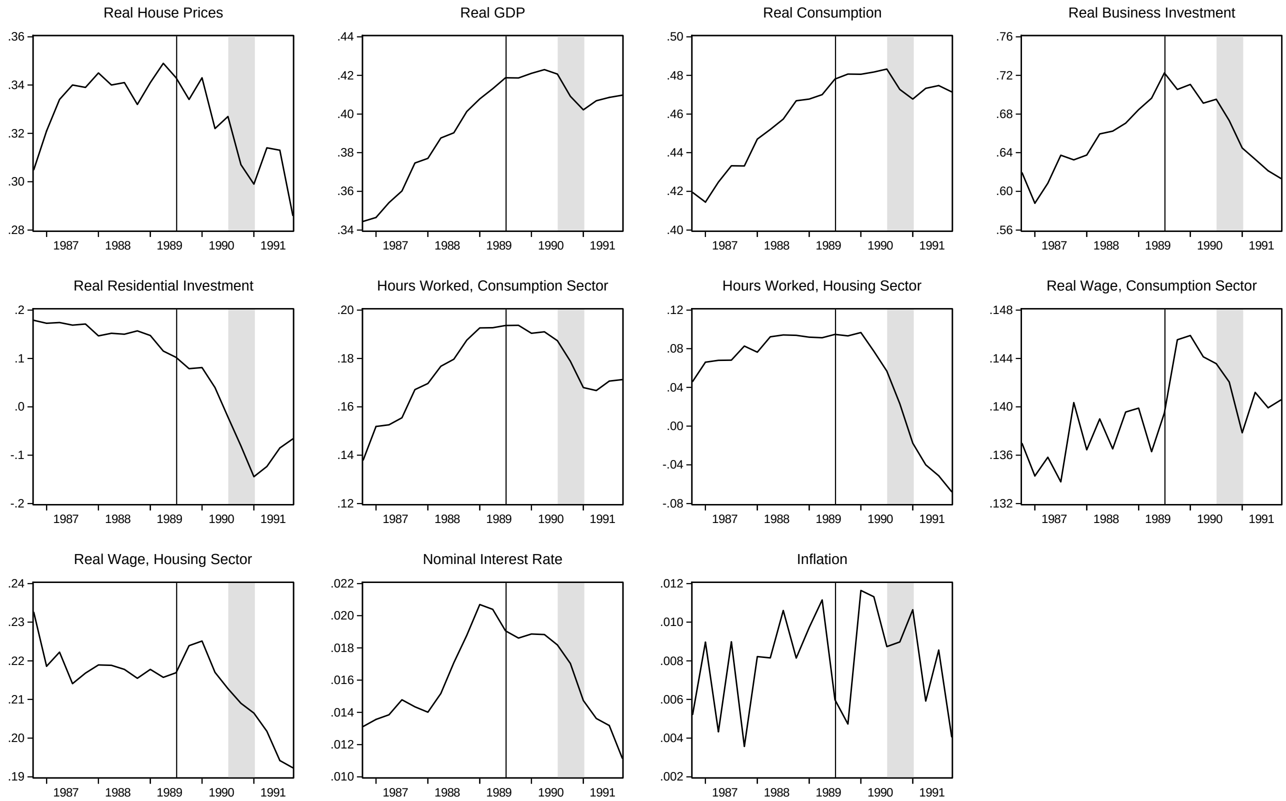

Figure 6: 1989:2 Peak

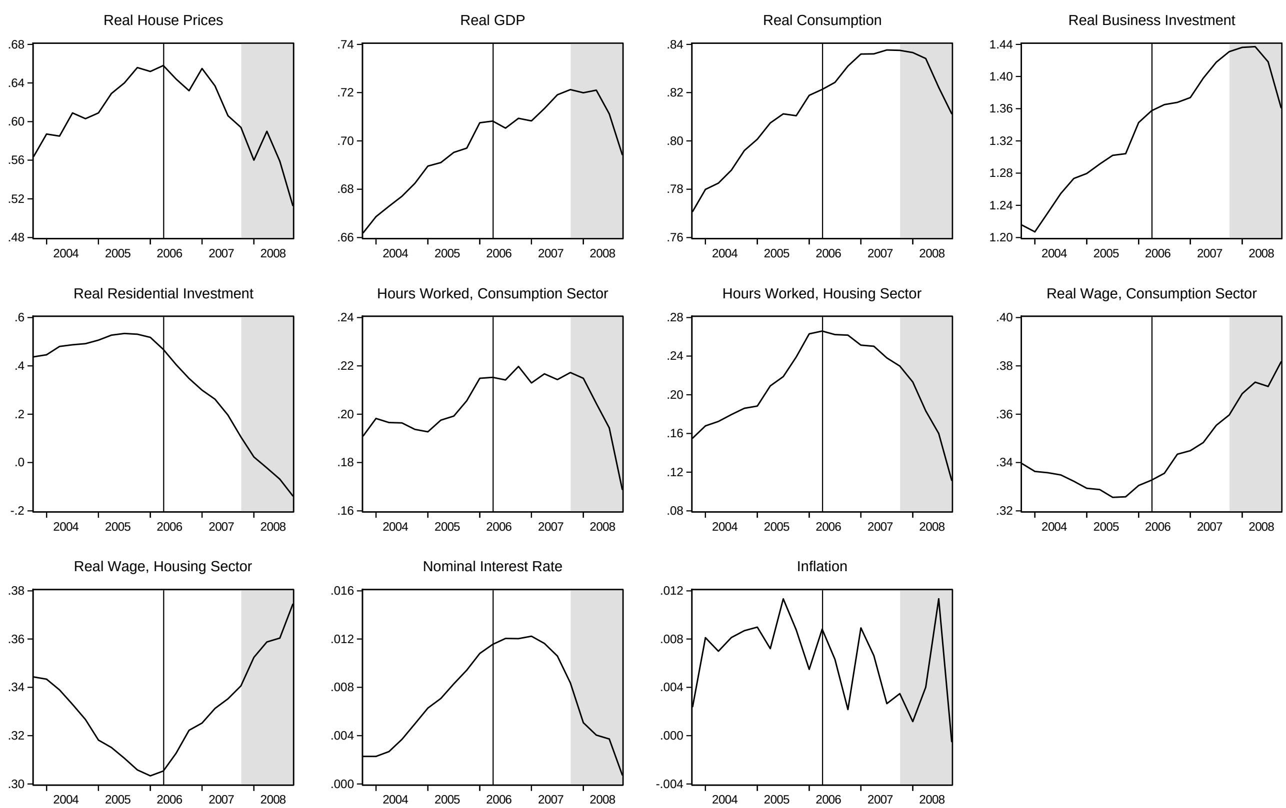

Figure 7: 2006:2 Peak

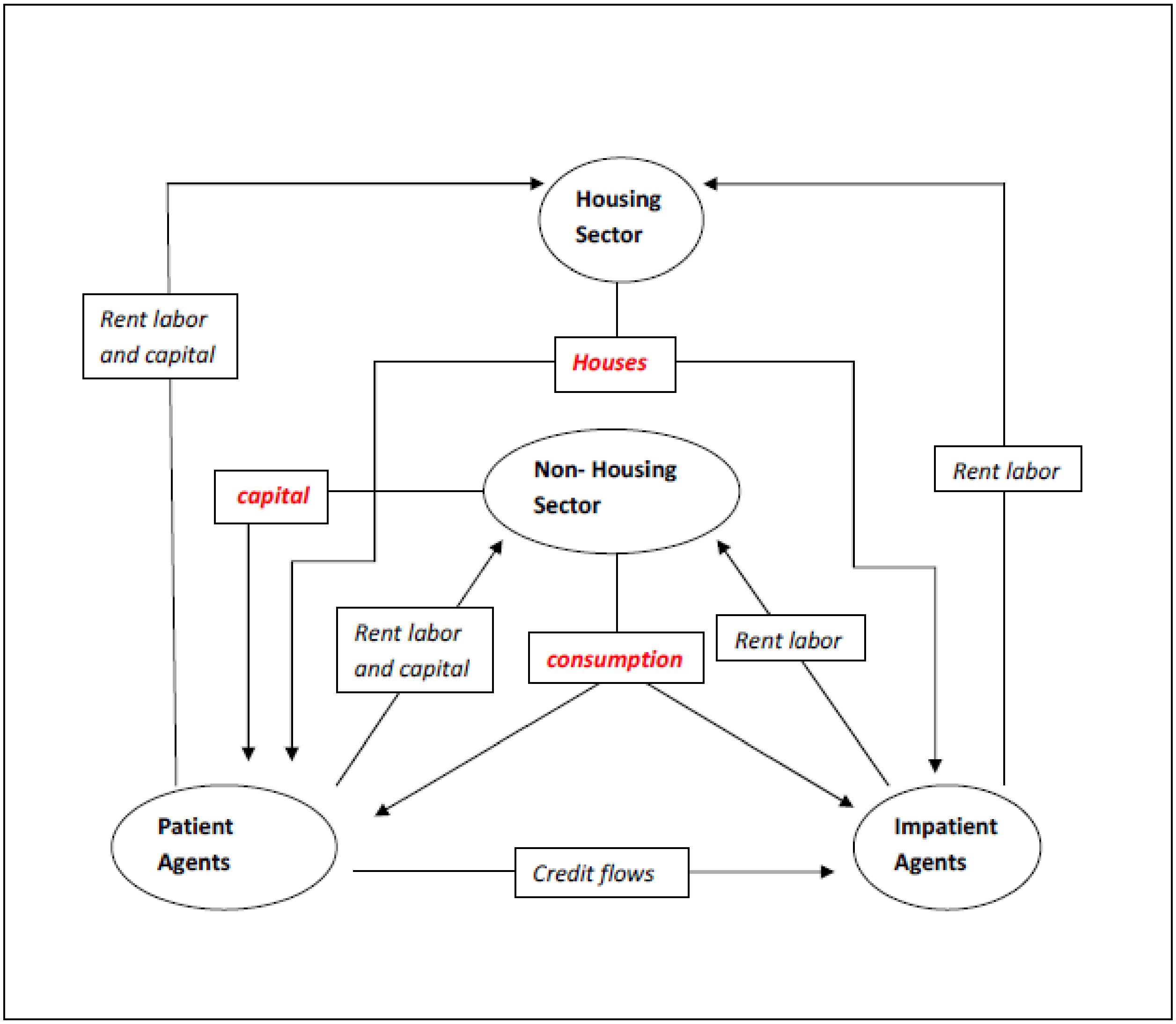

Figure 8: Model Economy

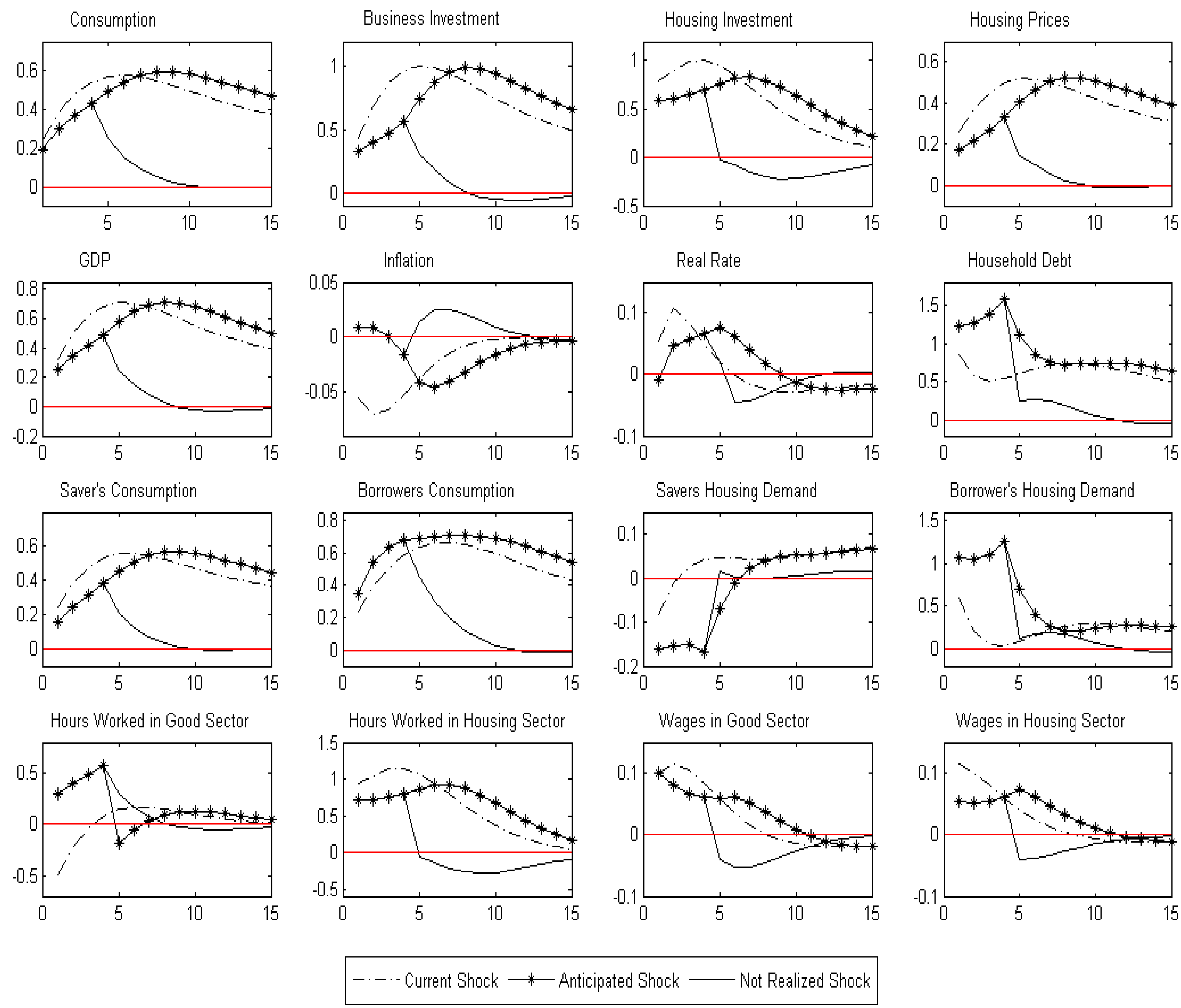

Figure 9: News on Technology Shock

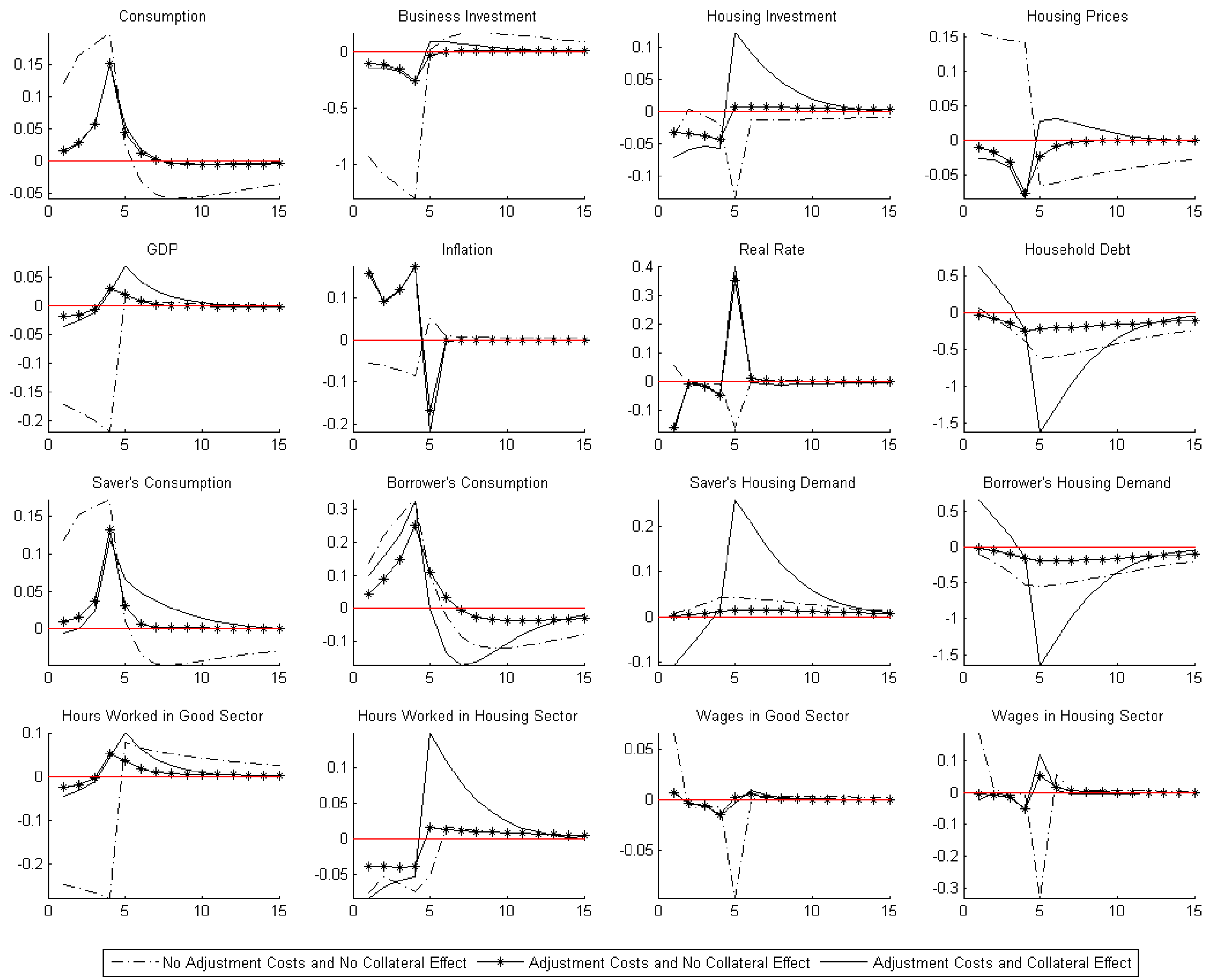

Figure 10: News on Technology Shock - Flexible-Price Case

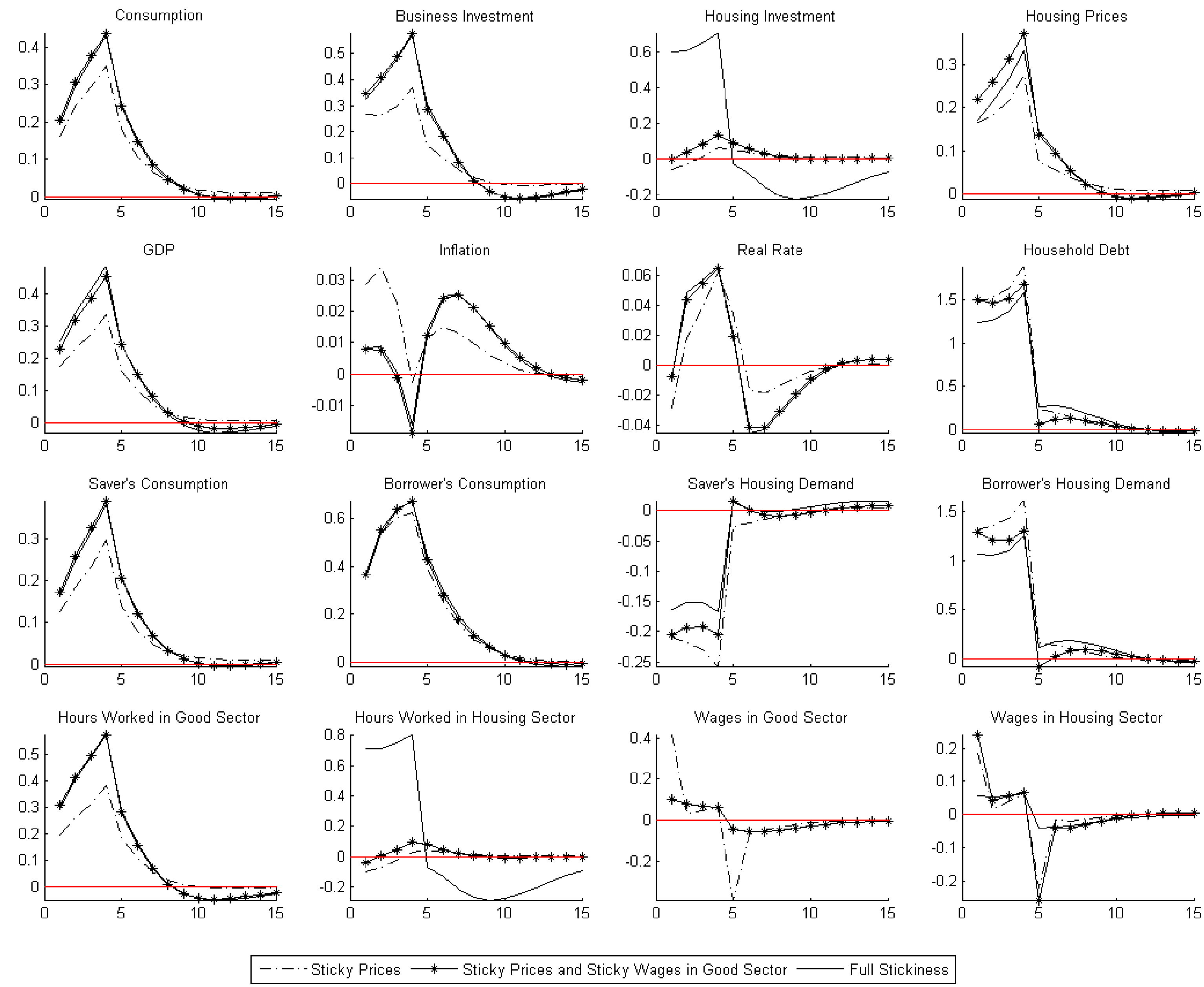

Figure 11: News on Technology Shock - Stickiness Case

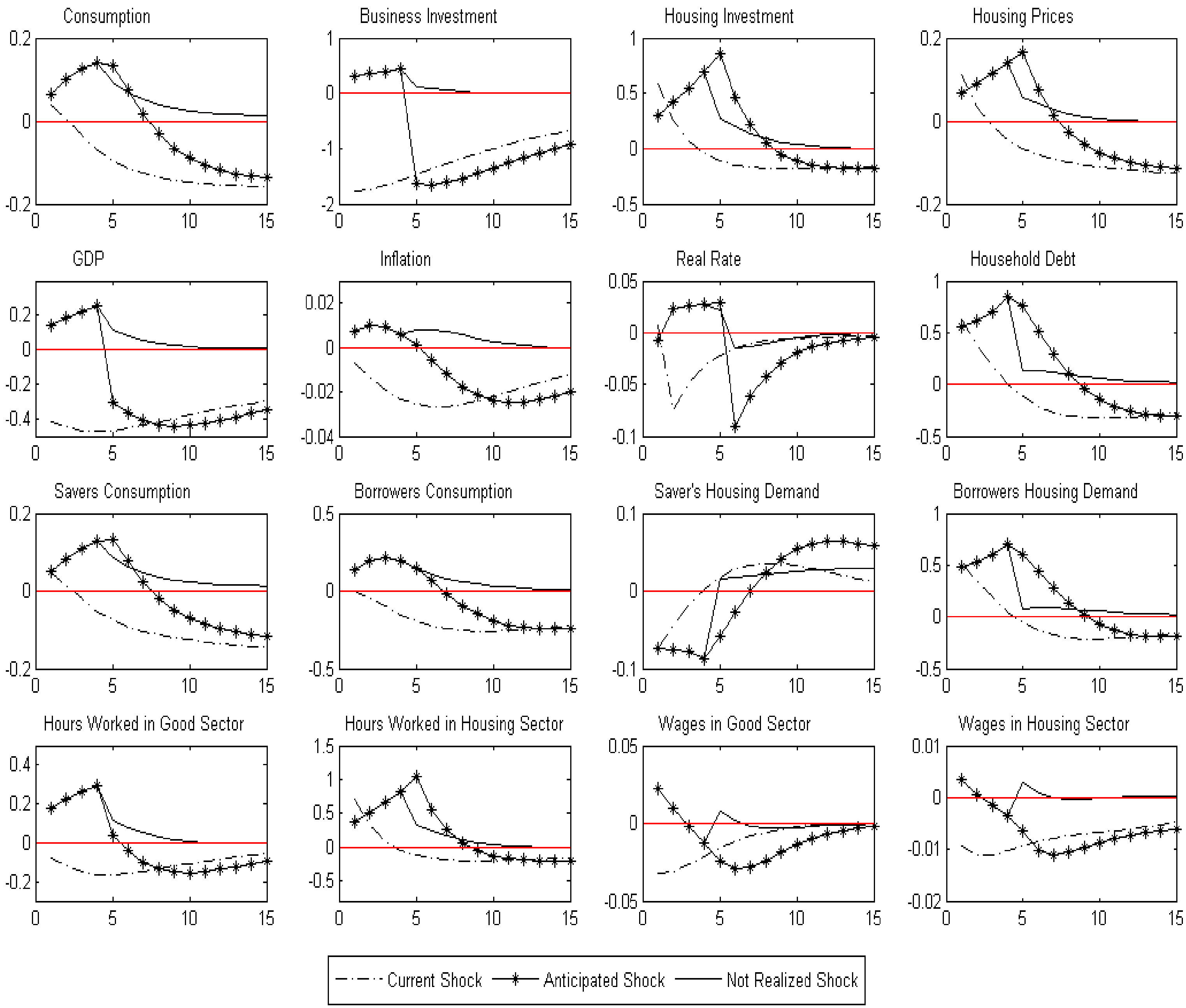

Figure 12: News on Investment-Specific Technology Shock

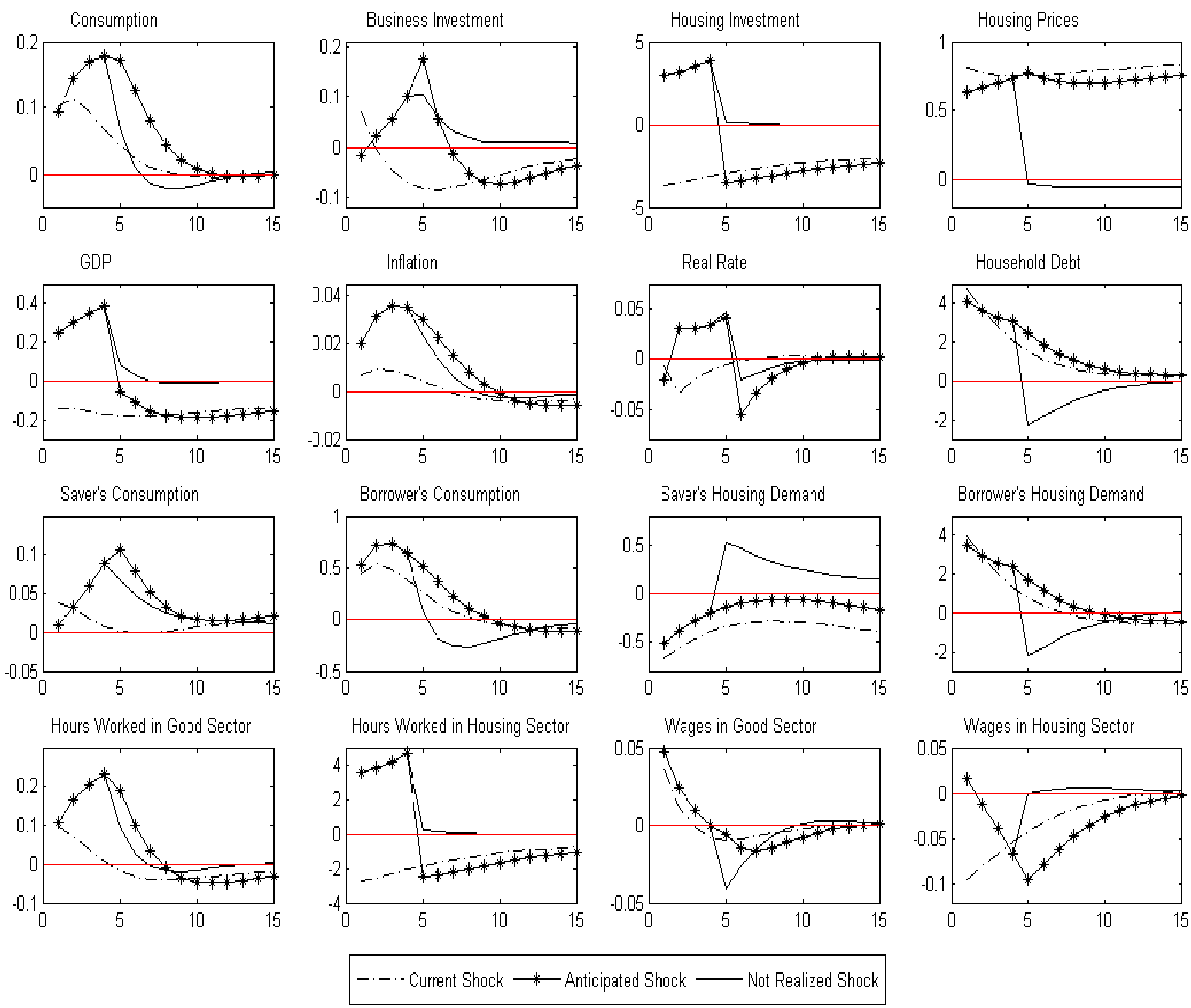

Figure 13: News on Housing Technology Shock

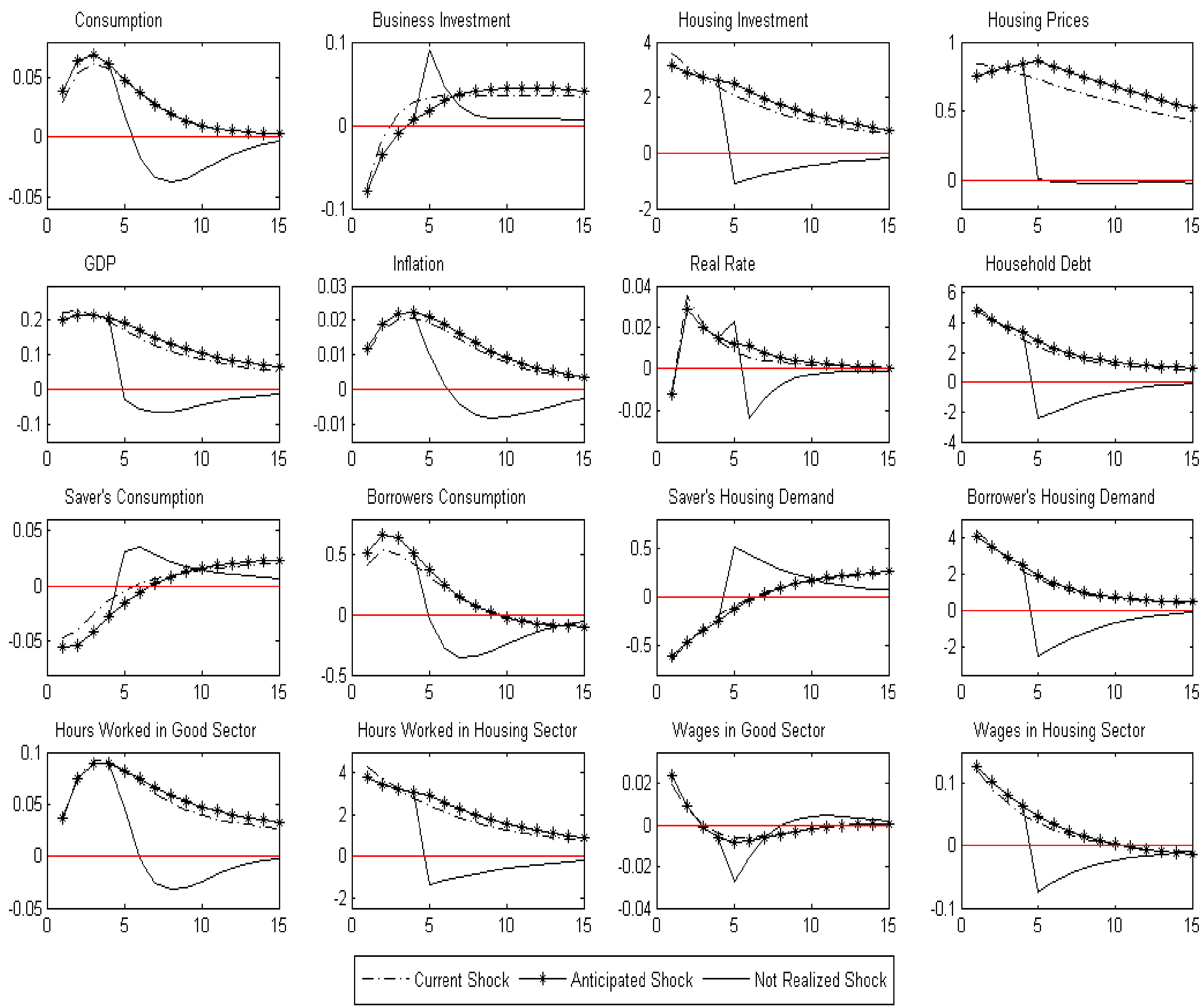

Figure 14: News on Housing Demand Shock

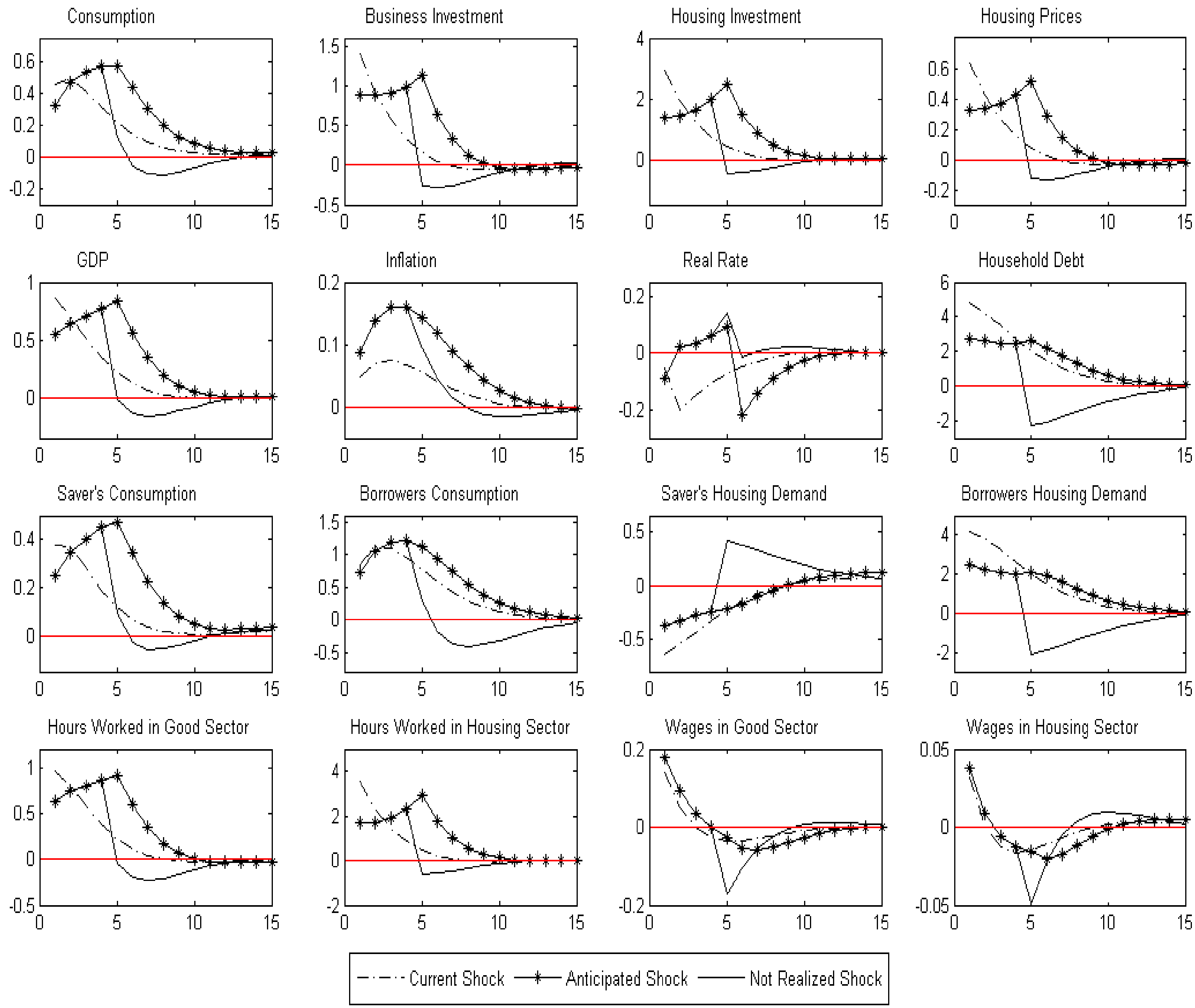

Figure 15: News on Monetary Policy Shock

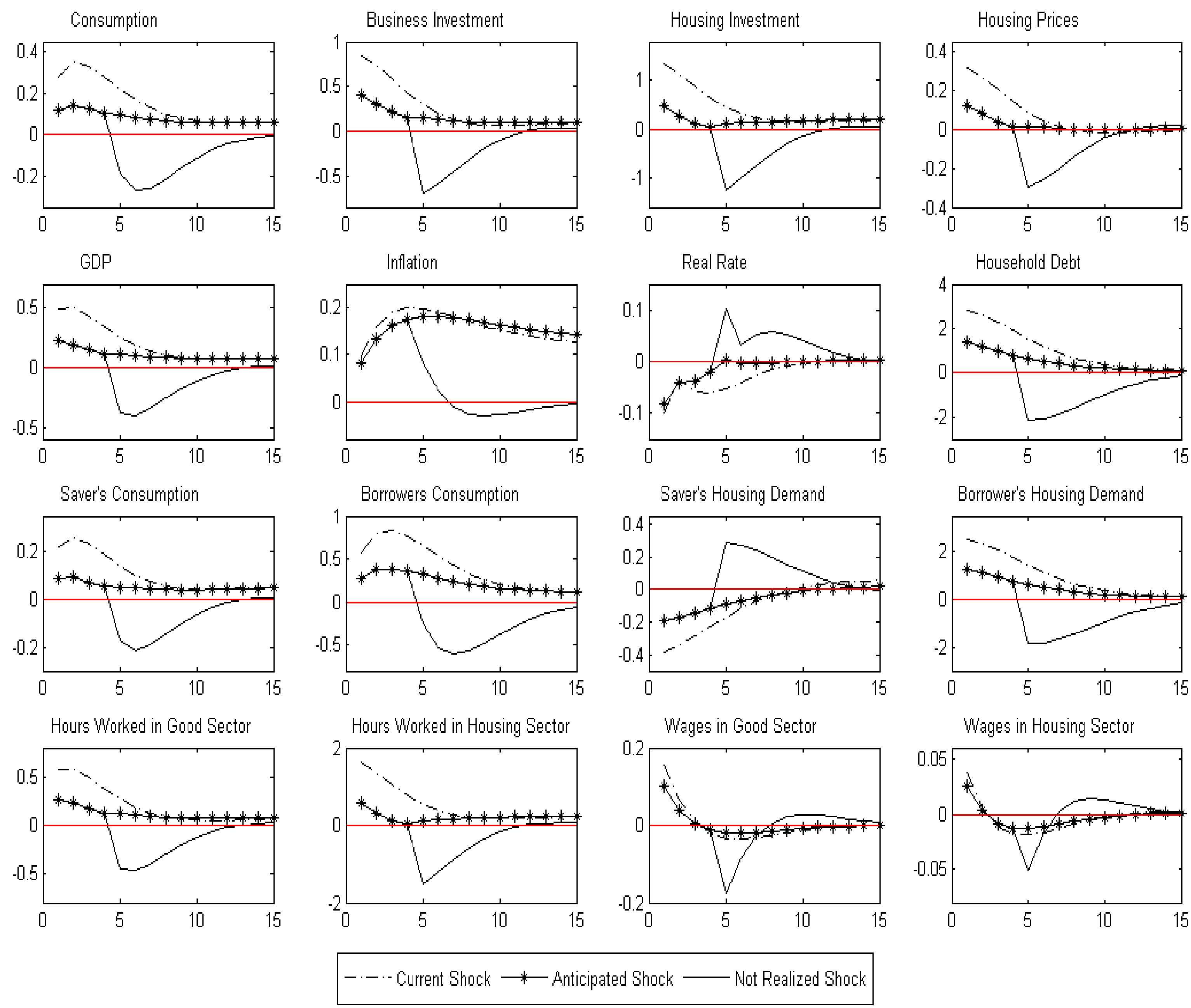

Figure 16: News on Central Bank's Inflation Target Shock

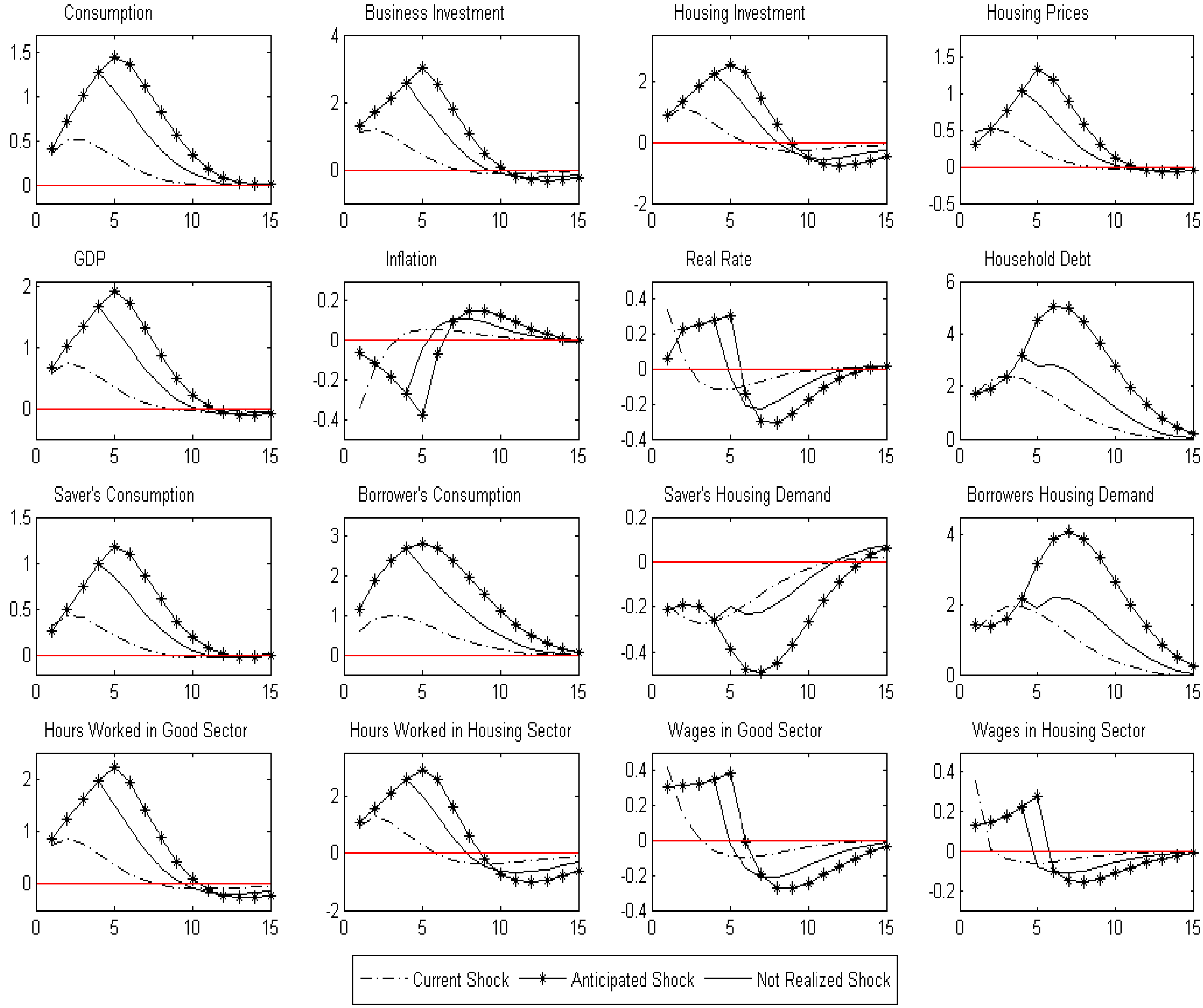

Figure 17: News on Inflation Shock

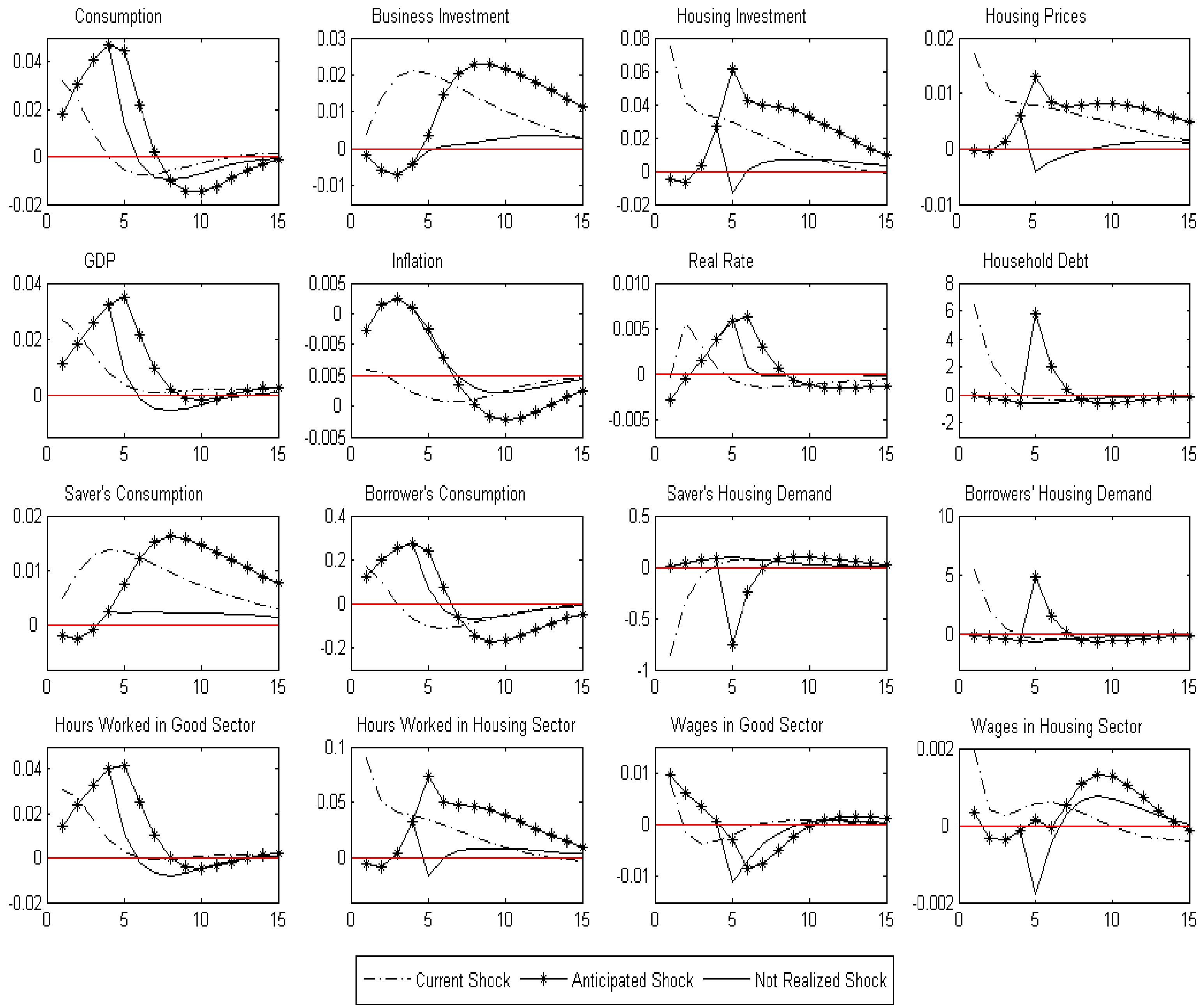

Figure 18: News on L-T-V Ratio Shock

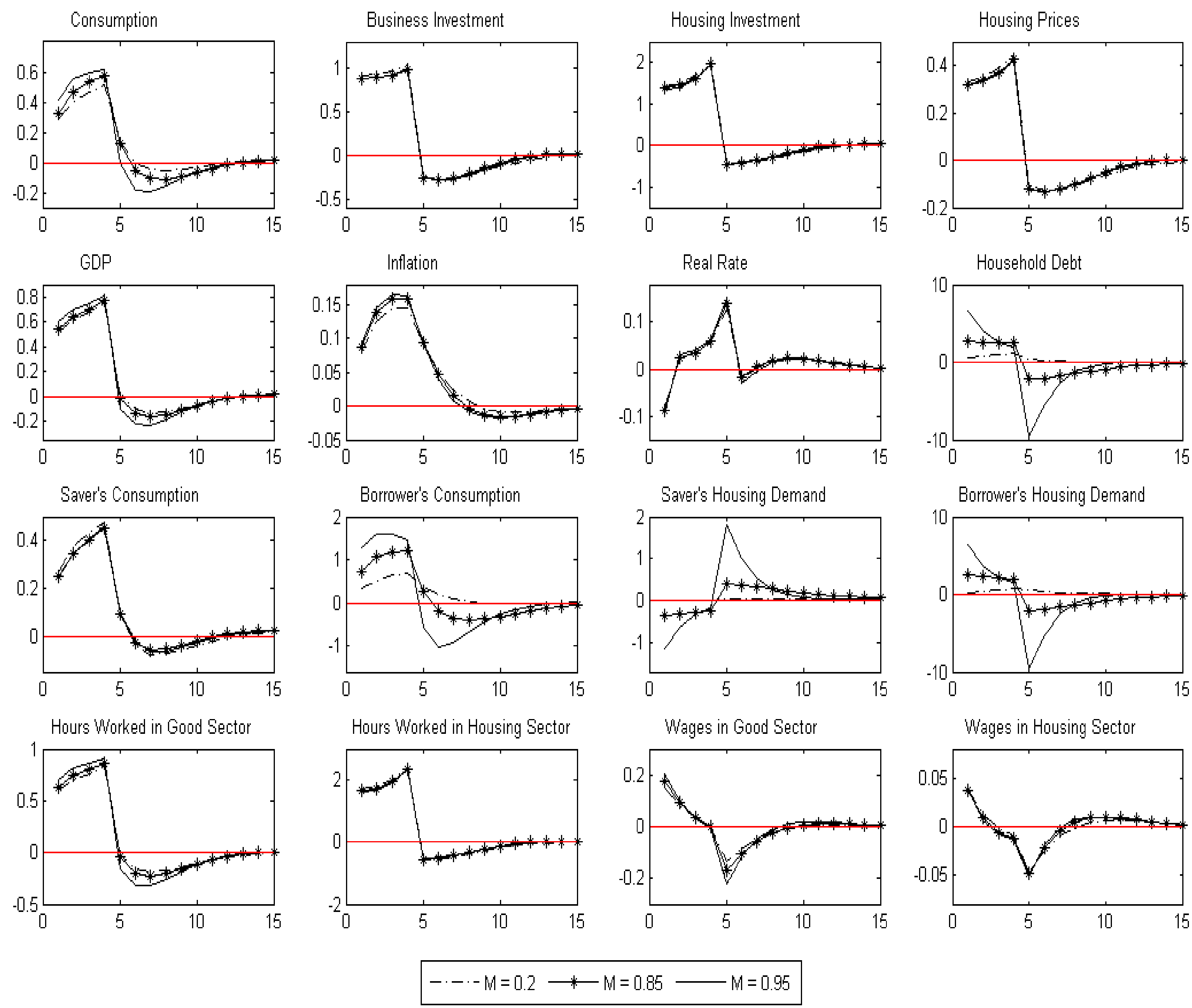

Figure 19: Collateral Effect on News on Monetary Policy Shock

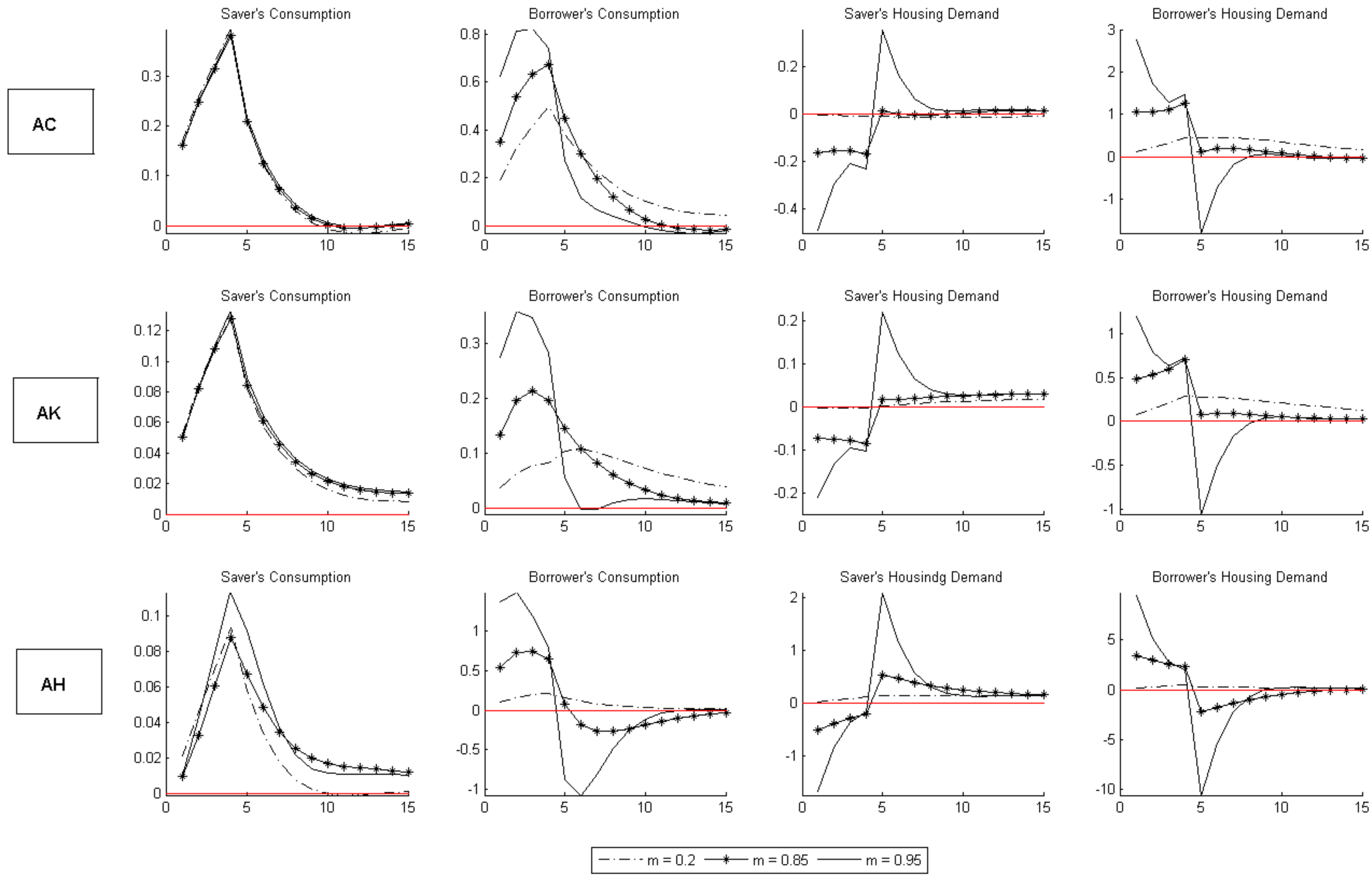

Figure 20: Collateral Effect on Individual Consumptions

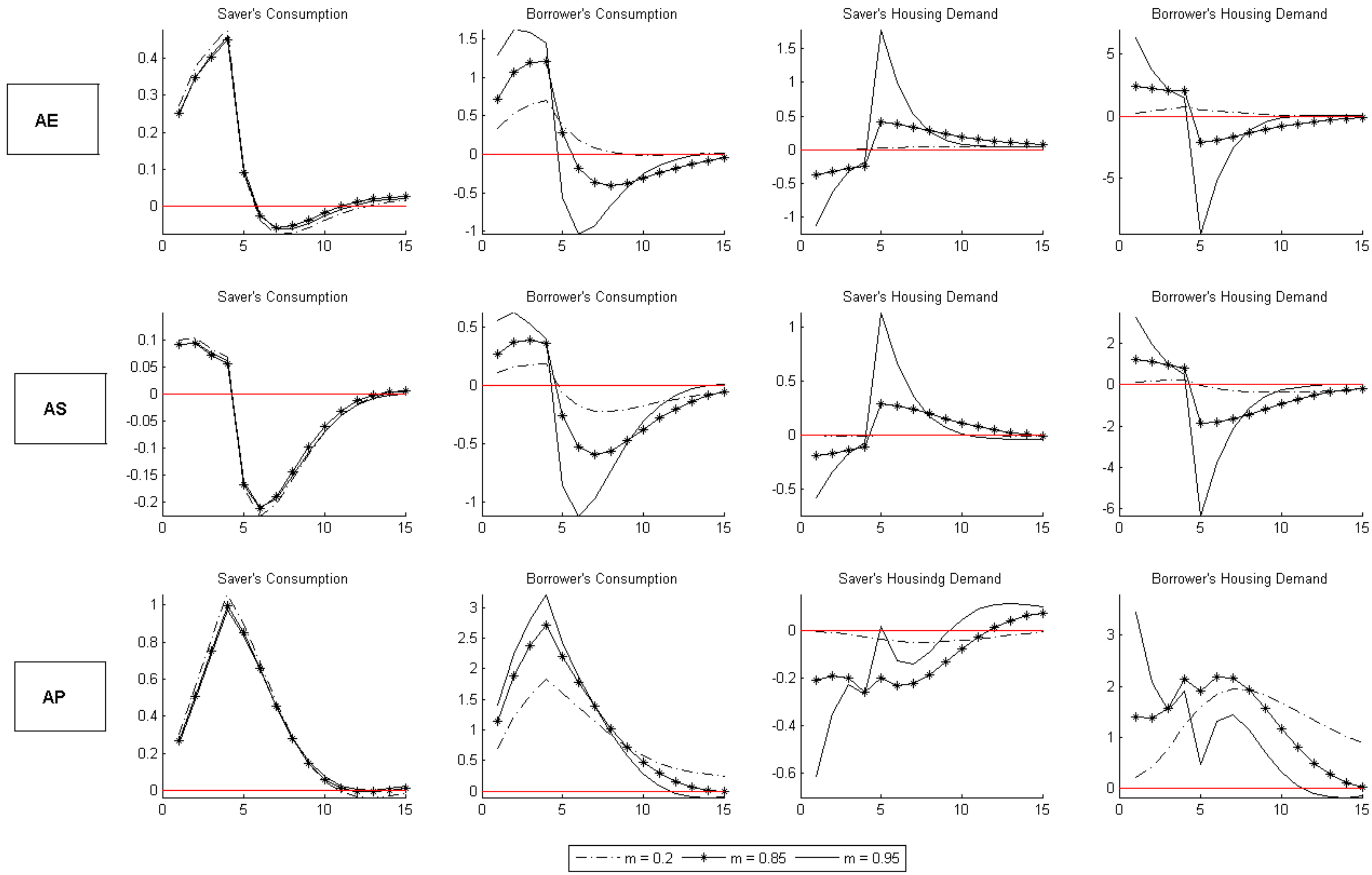

Figure 21: Collateral Effect on Individual Consumptions

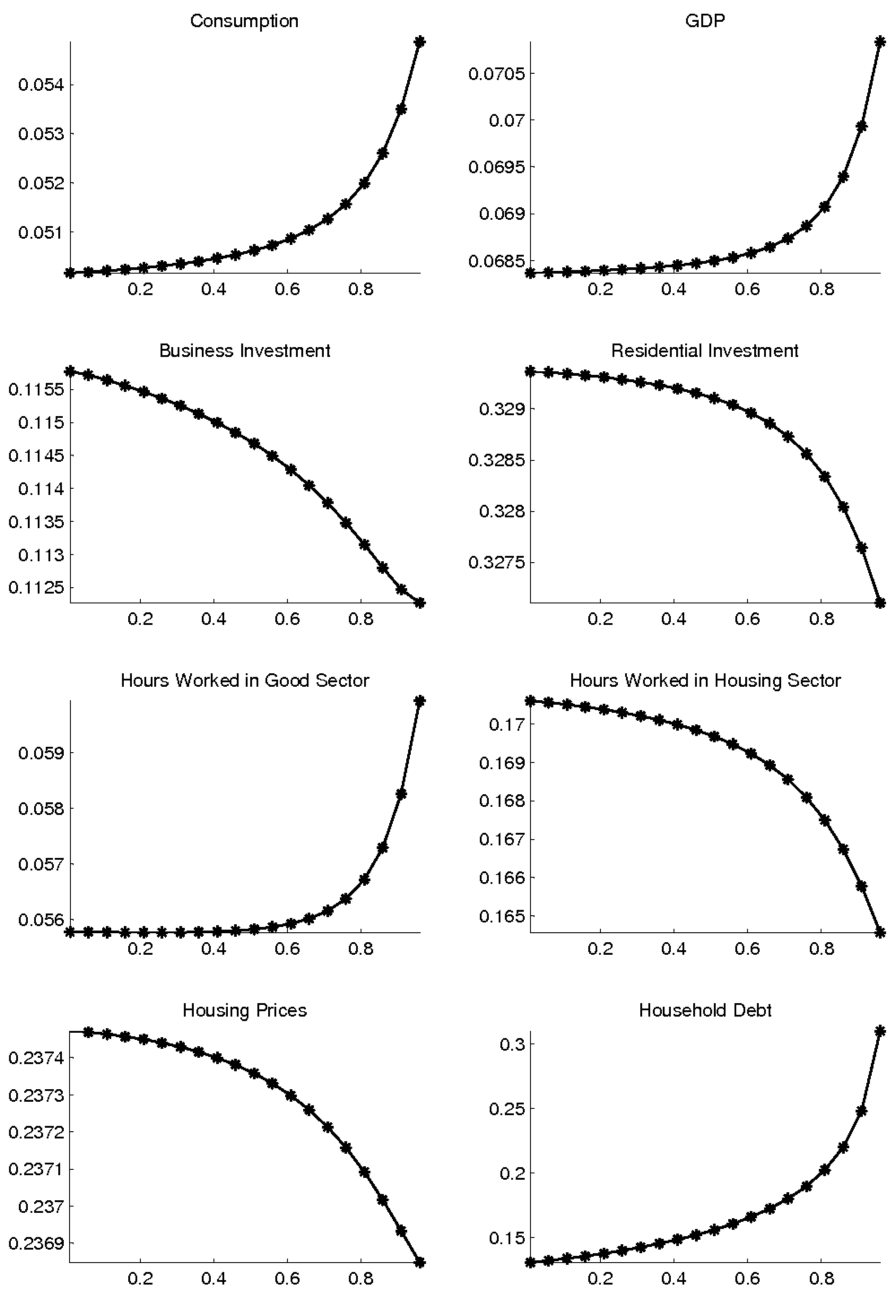

Figure 22: Volatility Change (%) and L-T-V Ratio

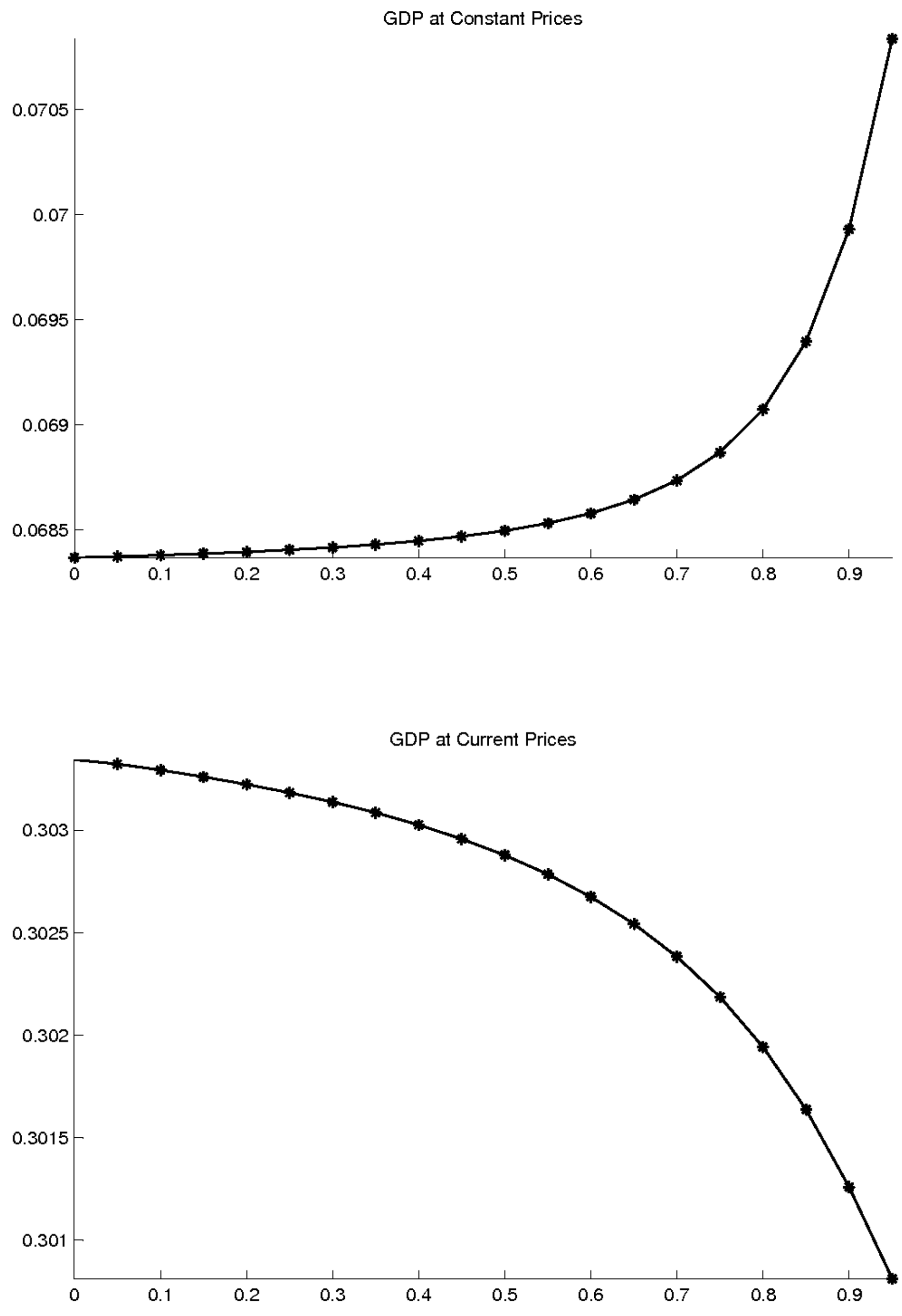

Figure 23: GDP Volatility Change (%) and L-T-V Ratio at Constant and Variable Prices

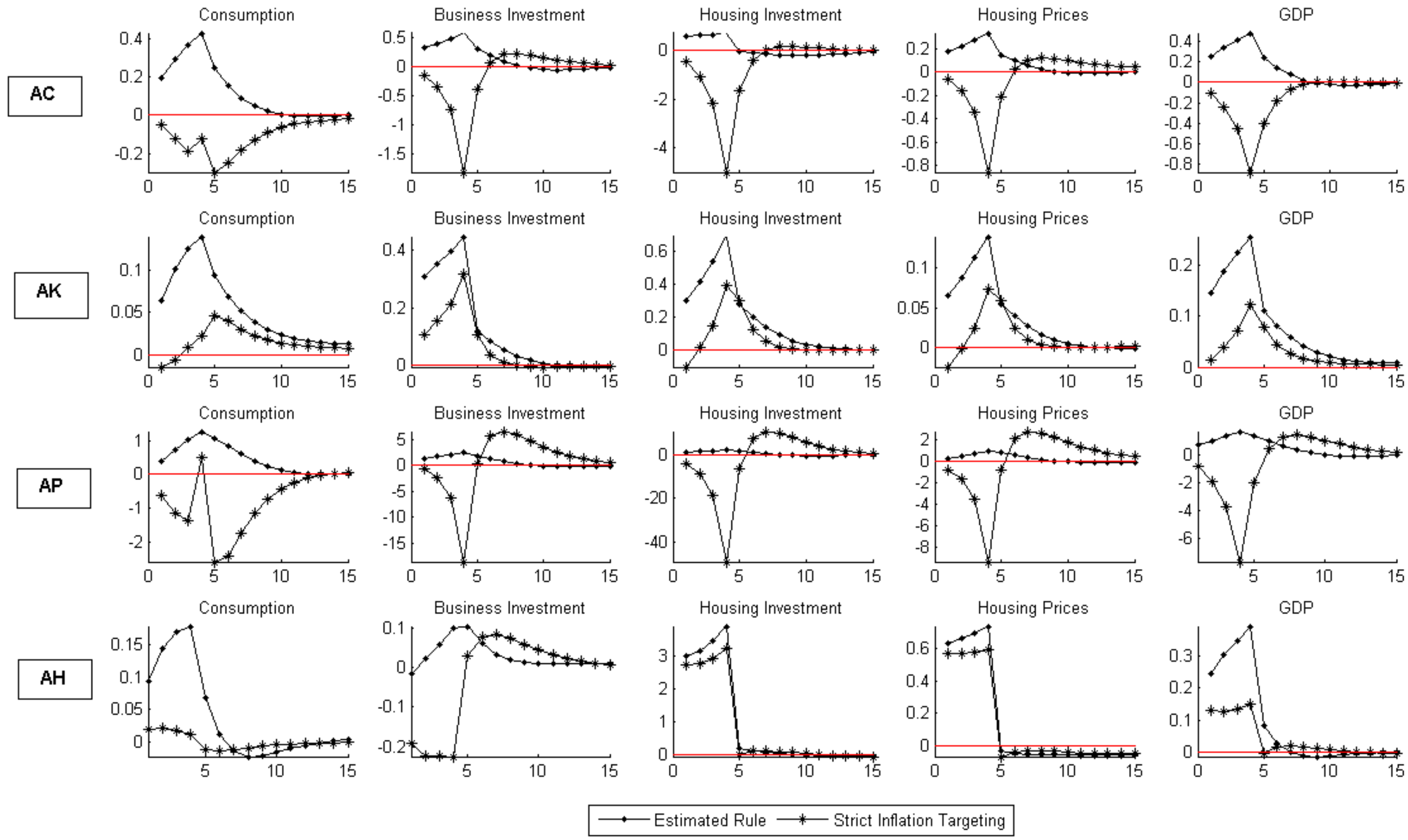

Figure 24: Estimated Rule versus Strict Inflation Targeting

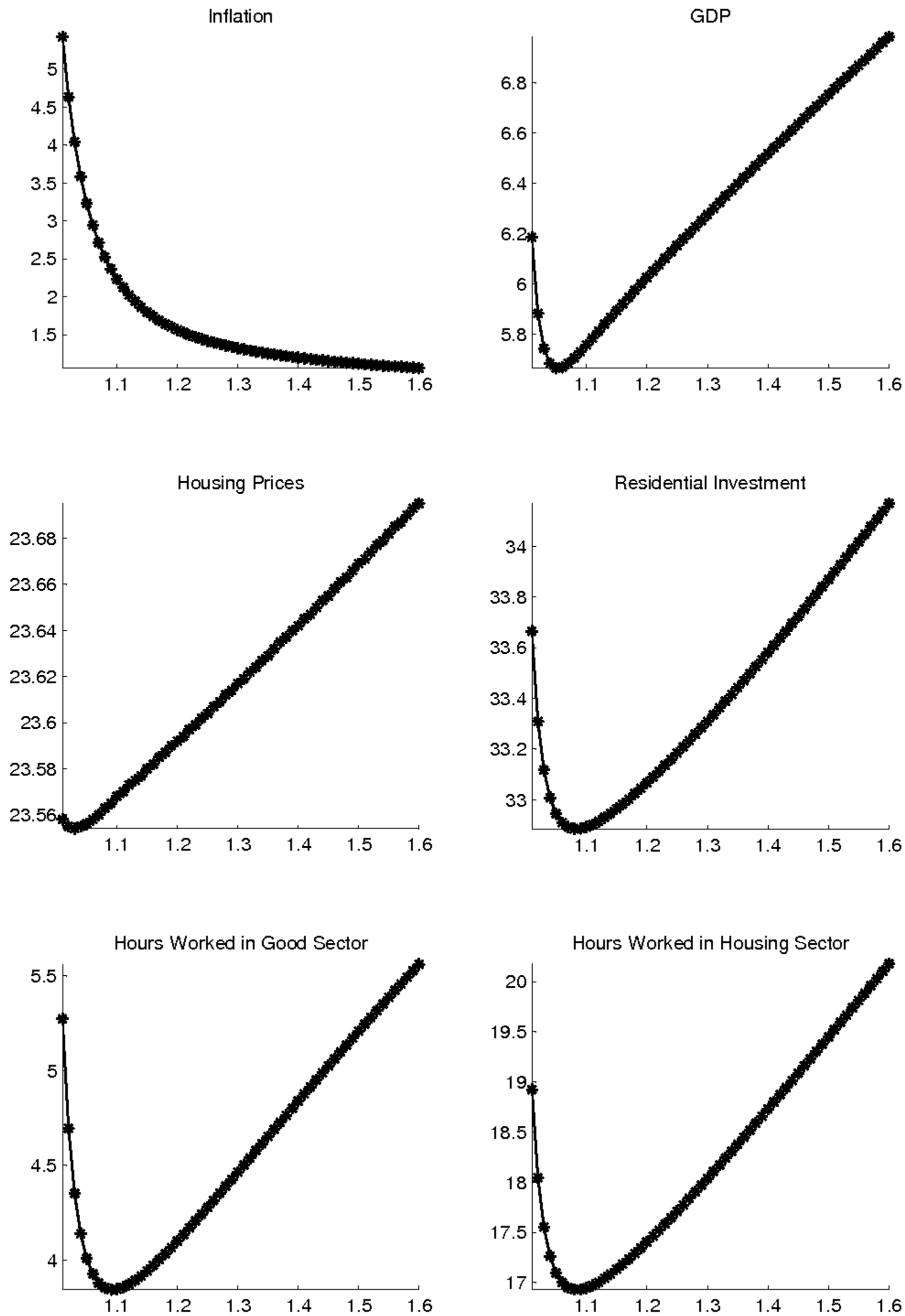

Figure 25: Volatility (%) and Responsiveness to the Inflation Target

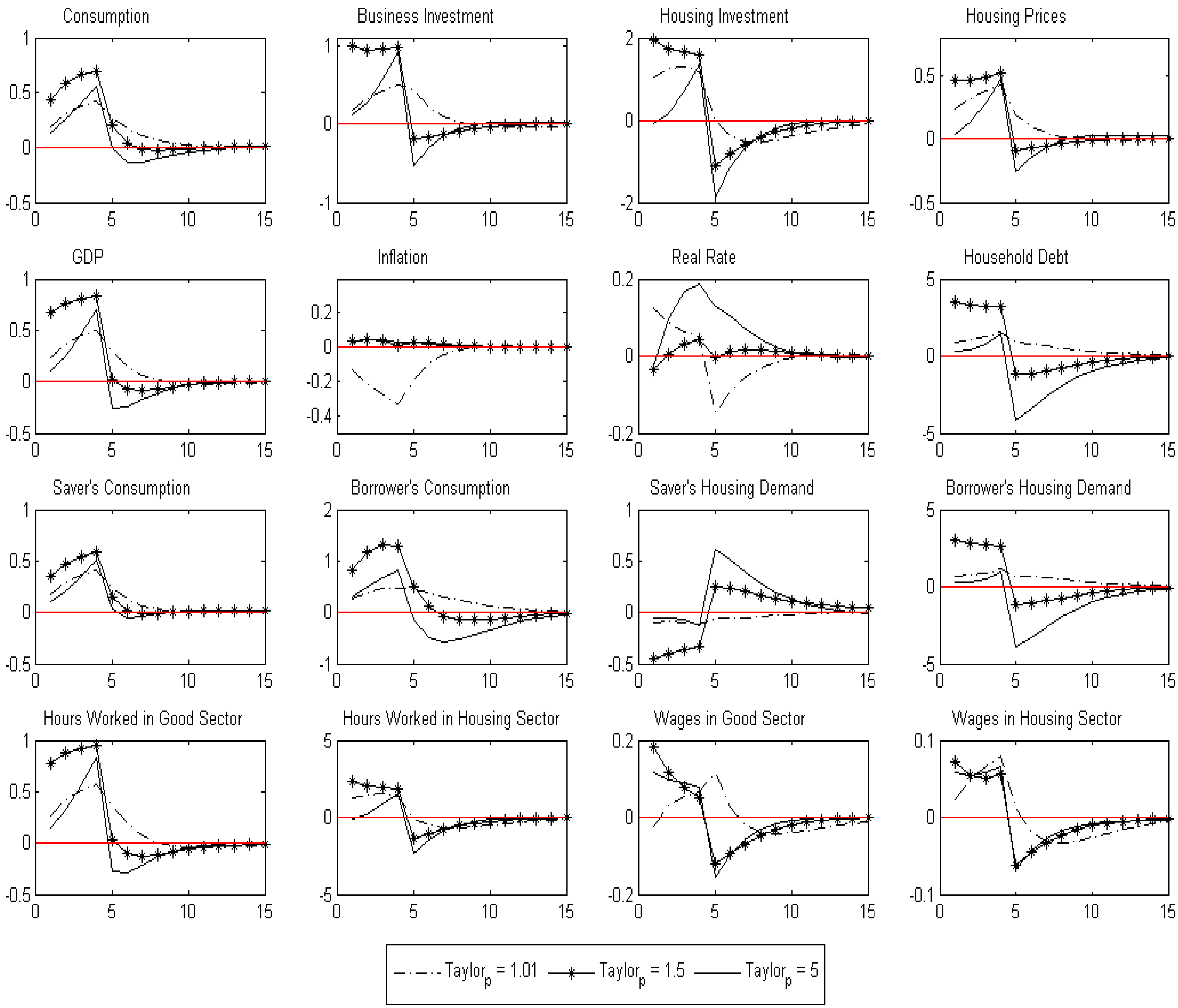

Figure 26: Responsiveness to the Inflation Target impact on News on Technology Shock