

Baldi, Guido

**Article — Accepted Manuscript (Postprint)**

## The economic effects of a central bank reacting to house price inflation

Journal of Housing Economics

*Suggested Citation:* Baldi, Guido (2014) : The economic effects of a central bank reacting to house price inflation, Journal of Housing Economics, ISSN 1051-1377, Elsevier, Amsterdam, Vol. 26, pp. 119-125,  
<https://doi.org/10.1016/j.jhe.2014.09.004> ,  
<https://www.sciencedirect.com/science/article/abs/pii/S1051137714000473>

This Version is available at:

<https://hdl.handle.net/10419/209697>

### Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

### Terms of use:

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

# The Economic Effects of a Central Bank Reacting to House Price Inflation

September 2014

## Abstract

What are the economic effects of a central bank that takes the evolution of house prices into account? In an attempt to answer this question, we use a New Keynesian dynamic stochastic general equilibrium model with a housing sector to explore the economic impacts of a central bank reacting to house price inflation. We examine this in the context of two different shocks that are associated with two factors cited as possible underlying sources of the recent bubble in the housing market and the ensuing financial crisis. First, we allow for a positive shock to the household borrowing constraint. Second, we analyze the effects of a preference shock to housing. Our results indicate that these two shocks lead to a more pronounced increase in house prices and an expansion of the housing sector if the central bank does not react to house prices. If the central bank reacts to house price increases, it must accept lower output growth rates over the business cycle. We also show that welfare decreases if a central bank reacts to house price inflation. Because of these effects, a central bank may be reluctant to react to house price inflation.

JEL CLASSIFICATION: E21, E22, E58, R21

KEYWORDS: Housing Demand, House Prices, Interest Rates, Consumption and Saving

# 1 Introduction

The recent economic crisis has led to a debate on whether central banks should assign greater weight to asset prices and, in particular, to house prices. Although it is difficult to empirically assess whether central banks have reacted to house prices in the past, there is some evidence that this might have been the case (see Finocchiaro and Heideken (2013)). In this paper, we apply a New Keynesian dynamic stochastic general equilibrium (DSGE) model with housing and banking sectors to assess the economic impacts of a central bank that reacts to the evolution of property prices. To this end, we will augment the standard Taylor rule by a term that determines the central bank's reaction to house price inflation. We analyze the impacts of such an augmented Taylor rule in the context of shocks to two factors that have been suggested as possible drivers of the recent housing boom in countries such as the United States, the United Kingdom and Spain. Our analysis focuses on temporary - though persistent - shocks and not on permanent changes to the equilibrium. We abstract from long-run housing price dynamics that may be related to long-run income and population growth.

The factors we consider include the following: The first is a temporary shock to the household borrowing constraint. This is included because, since the late 1990s, many homeowners in the United States and other countries were allowed to borrow a larger fraction of the values of their properties than before. In general, one can expect this to lead to a boom and higher prices in the housing sector that could spill over to the rest of the economy. The second shock is a temporary housing preference shock similar to that in Iacoviello and Neri (2010). Such a preference shock is, of course, difficult to identify in reality. We interpret a preference shock as the result of changes in the political and social environments that encourages an increase in home-ownership.

In a calibrated DSGE model, we illustrate how these two factors can contribute to higher house prices over the business cycle. We then investigate how a central bank reacting to price increases in the housing market affects macroeconomic variables. To this end, we develop a model that reflects the most important empirical findings regarding the effects of monetary policy on housing (see, for instance, Iacoviello (2005), Monacelli (2009) and Carlstrom and Fuerst (2006)). According to these results, a tightening of monetary policy leads to a decrease in spending on both housing and consumer goods. Thus, there is a positive co-movement between these two spending categories. In addition, spending on housing is more volatile than spending on consumer goods. Borrowing that is tied

to property values represents a further monetary policy transmission channel. In the presence of borrowing constraints, an increase in interest rates leads to higher borrowing costs for households. In addition, the price of housing decreases, which lowers the amount that households can borrow. This, in turn, will reduce their desired level of consumption. We also incorporate a cost channel into the monetary transmission mechanism, similar to Ravenna and Walsh (2006).

We show that a central bank reacting to house price inflation will have to accept economic growth rates that are below potential or even a recession. In addition, the reaction to house price inflation will also lead to lower welfare than under a conventional interest rate rule that does not include house prices. Because, in this paper, monetary policy reacts to house prices mechanically, the decisions made by the central bank will be independent of the type of shock. However, one should bear in mind that in practice central banks may attempt to identify the types of shocks affecting the business cycle, which involves a considerable degree of uncertainty.

This paper is organized as follows. In Section 2, we develop a two-sector New Keynesian DSGE model that contains housing and borrowing constraints. Section 3 describes how the parameter values of the model are selected. In Section 4, we investigate how the variables in our model respond to shocks to preferences and the borrowing constraint. Finally, Section 5 contains the conclusion.

## 2 The Model

### 2.1 The Representative Individual

We assume that there is a representative individual in the economy who maximizes the following utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\sigma}}{1-\sigma} + \phi_d \frac{D_t^{1-\theta}}{1-\theta} - \frac{(N_t^c + N_t^d)^{1+\chi}}{1+\chi} + \frac{\phi_m}{1-\tau} \left( \frac{M_t}{P_t} \right)^{1-\tau} \right) \quad (1)$$

where  $C_t$  denotes consumer goods and  $D_t$  housing. By including  $D_t$  in the utility function in this additive, separable form, we follow, among others, Iacoviello (2005), Monacelli (2009) and Aslam and Santoro (2008). The household provides labor services to the consumer goods sector ( $N_t^c$ ) and the construction sector ( $N_t^d$ ).  $M_t$  denotes the household's savings deposited at the country's banks and real savings ( $\frac{M_t}{P_t}$ ) enter the utility function.

Note that we interpret bank savings in a broad manner that includes all types of savings that a household has on deposit at a bank.

We assume that the housing stock evolves according to the standard process  $D_t = I_t + (1 - \delta)D_{t-1}$ . In addition, we follow the literature (see, for instance, Monacelli (2009)) and assume that individuals can obtain loans  $L_t^H$  up to the amount  $L_t^H = \mu_H E_t\{Q_{t+1}\}D_t(1 - \delta)$  where  $E_t\{Q_{t+1}\}$  denotes the expected future price of housing. Thus, loans are a fixed fraction  $\mu_H$  of the expected future price of the depreciated stock of housing. The individual has to pay the gross nominal interest rate  $R_t^d$  on these loans. As we will see below, this interest rate is determined by the banking sector and indirectly influenced by the central bank. In our analysis, the borrowing constraint is considered fixed and exogenous. Thus, we abstract from the occasionally binding borrowing constraints that can be found in Guerrieri and Iacoviello (2013) or Jensen, Ravn and Santoro (2013). Finally, we assume that bank savings are remunerated at the gross interest rate  $R_t^m$ . Our assumption of one representative household implies that it represents the average of all individuals in the economy. In this way, the representative household simultaneously holds savings and debt. This implies that the quantities of savings and debt chosen depend on the values of consumption, income and other aggregate variables for the average individual. Instead of netting them out, the simultaneous holding of savings and debt allows us to treat them as representing two different variables yielding different returns. In total, the parameter value will be chosen such that the representative individual holds more savings than debt. Following this reasoning, the nominal budget constraint is given by:

$$P_t C_t + Q_t(D_t - (1 - \delta)D_{t-1}) + R_{t-1}^d \mu^H (1 - \delta) E_{t-1}\{Q_t\} D_{t-1} + M_t \leq \mu^H (1 - \delta) E_t\{Q_{t+1}\} D_t + R_{t-1}^m M_{t-1} + W_t^c N_t^c + W_t^d N_t^d \quad (2)$$

The individual maximizes (1) subject to the budget constraint given in (2). The first-order conditions for  $C_t, N_t^c, N_t^d, \frac{M_t}{P_t}, D_t$  are given by:

$$0 = C_t^{-\sigma} - \lambda_t P_t \quad (3)$$

$$0 = -(N_t^c)^\chi + \lambda_t W_t^c \quad (4)$$

$$0 = -(N_t^d)^\chi + \lambda_t W_t^d \quad (5)$$

$$0 = \phi_m \left( \frac{M_t}{P_t} \right)^{-\tau} - \lambda_t + \frac{E_t \{ \lambda_{t+1} \}}{E_t \{ \Pi_{t+1} \}} \beta R_t^m \quad (6)$$

$$0 = \phi_d (D_t)^{-\theta} - \lambda_t Q_t + \lambda_t \mu_H E_t \{ Q_{t+1} \} (1 - \delta) \\ + \beta E_t \{ \lambda_{t+1} Q_{t+1} \} (1 - \delta) (1 - R_t^d \mu_H) \quad (7)$$

$\Pi_t = P_t/P_{t-1}$  denotes inflation in consumer goods prices and  $\lambda_t$  is the Lagrange multiplier. In the following, we write  $x_t = \log X_t$  for any variable  $X_t$  and  $\hat{x}_t = \frac{x_t - x_{ss}}{x_{ss}}$  to denote deviations around the steady-state. Log-linearizing (4), (5) and (6) using (3) yields:

$$\hat{w}_t^c - \hat{p}_t = \sigma \hat{c}_t + \chi \hat{n}_t^c \quad (8)$$

$$\hat{w}_t^d - \hat{p}_t = \sigma \hat{c}_t + \chi \hat{n}_t^d \quad (9)$$

$$\hat{r}_t^m = \frac{\hat{\lambda}_t}{u} - E_t \{ \hat{\lambda}_{t+1} \} + E_t \{ \hat{\pi}_{t+1} \} + \frac{(\hat{m}_t - \hat{p}_t)(1 - u)}{u} \quad (10)$$

$u = \beta R_{ss}^m < 1$  because real bank savings provide utility to consumers, which makes  $u$  smaller than 1. Equation (10) can be rearranged to derive a type of dynamic IS-curve:

$$\hat{c}_t = u E_t \{ \hat{c}_{t+1} \} + \frac{1}{\sigma} (u E_t \{ \hat{\pi}_{t+1} \} + u \hat{p}_{t+1} - \hat{p}_t - u \hat{r}_t^m + (\hat{m}_t - \hat{p}_t)(1 - u)) \quad (11)$$

The next step involves the log-linearization of (7):

$$0 = -\phi_d \theta F \hat{d}_t - (\hat{\lambda}_t + \hat{q}_t) + \mu^H (1 - \delta) (\hat{\lambda}_t + E_t \{ \hat{q}_{t+1} \}) \\ + \beta (1 - \delta) (E_t \{ \hat{q}_{t+1} \} + E_t \{ \hat{\lambda}_{t+1} \}) - \mu^H (1 - \delta) (E_t \{ \hat{q}_{t+1} \} + E_t \{ \hat{\lambda}_{t+1} \} + \hat{r}_t^d)$$

where  $F = \frac{P_{ss} D_{ss}^{-\theta}}{Q_{ss} C_{ss}^{-\sigma}}$  depends on the steady-state expenditures on housing and consumer goods. This expression can be further simplified and rearranged to obtain:

$$\hat{d}_t = \frac{1}{\phi_d \theta F} (\sigma \hat{c}_t + \hat{p}_t - \hat{q}_t) + \beta (1 - \delta) E_t \{ \hat{q}_{t+1} - \sigma \hat{c}_{t+1} - \hat{p}_{t+1} \} \\ - \mu^H (1 - \delta) \left( E_t \{ -\sigma \hat{c}_{t+1} - \hat{p}_{t+1} \} + \sigma \hat{c}_t + \hat{p}_t + \hat{r}_t^d \right) \quad (12)$$

This expression determines the evolution of investment in housing  $\hat{i}_t$ :

$$\hat{i}_t = \frac{1}{\delta} \left( \hat{d}_t - (1 - \delta)\hat{d}_{t-1} \right).$$

## 2.2 Firms in the Consumer Goods Sector

There is a consumer goods sector with a continuum of firms with a measure of 1. Each firm produces a differentiated good using the simple production function  $Y_t(i) = ZN_t(i)^c$ . Thus, the production function exhibits constant returns to scale in the privately provided input  $N_t^c$ .  $Z$  denotes total factor productivity, which is held constant. We assume that firms have to borrow a fixed fraction  $\mu_B$  of their wage bill from banks at an interest rate of  $r_t^d$ , which equals the interest rate on mortgages faced by households. Loans to firms thus equal  $L_t^c = \mu_B W_t^c N_t^c$  and the labor costs of firms can be written as  $(1 + \mu_B r_t^d) W_t^c N_t^c$ . In so doing, and similar to Ravenna and Walsh (2006), we introduce a cost-channel for the monetary transmission mechanism. Independent of the nature of the price setting process, the average real marginal costs expressed in logs are given by:

$$mc_t^c = w_t^c - p_t + \log(1 + \mu_B r_t^d) \quad (13)$$

Log-linearizing this expression and using  $\hat{w}_t^c - \hat{p}_t = \sigma \hat{y}_t + \chi \hat{n}_t^c$  and  $\hat{y}_t = \hat{z}_t + \hat{n}_t^c$  yields:

$$\hat{m}c_t^c = \hat{y}_t(\sigma + \chi) + \mu_B \hat{r}_t^d \quad (14)$$

where we used the approximation  $\log(1 + \mu_B r_t^d) = \mu_B r_t^d$ , as in Gali (2008). Following a large body of the New Keynesian literature, we use the Calvo-pricing assumption (Calvo (1983)) and assume that in every period a firm faces a constant probability to reoptimize its price. This leads to the following equation for inflation (see, for instance, Gali (2008)), which is typically called the New Keynesian Philips (NKPC) curve:

$$\pi_t = \beta E_t \{\pi_{t+1}\} + \omega^c \hat{m}c_t^c \quad (15)$$

where  $\omega^c = \frac{(1-\tau^c)(1-\beta\tau^c)}{\tau^c}$  and  $\tau^c$  is the probability that a firm cannot reset its price in any given period.

## 2.3 The Production Sector for Housing

For housing, we assume the same functional form as for consumer goods. There is a continuum of firms with measure 1, which use the production function  $Y_t^d(j) = AN_t^d(j)$  where  $Y_t^d$  is equal to household demand  $I_t$  and  $A$  is total factor productivity. As with firms in the consumer goods sector, the producers of housing also have to borrow a fraction  $L_t^D = \mu_B W_t^d N_t^d$  of their wage bill. Log-linearized marginal costs are then given by:

$$\hat{m}c_t^d = \hat{w}_t^d - \hat{q}_t + \mu_B \hat{r}_t^d$$

Recall that the log-linearized FOC of the household with respect to  $n_t^d$  can be written as:  $\hat{w}_t^d - \hat{p}_t = \sigma \hat{c}_t + \chi \hat{n}^d$  and the log-linearized production function can be expressed as  $\hat{n}_t^d = \hat{i}_t$ . We use these two expressions and the resource constraint ( $\hat{c}_t = \hat{y}_t$ ) to derive an expression for marginal costs in the housing sector:

$$\hat{m}c_t^d = \hat{p}_t - \hat{q}_t + \sigma \hat{y}_t + \chi \hat{i}_t + \mu_B \hat{r}_t^d \quad (16)$$

Using the same procedure as for consumer goods prices, one can derive a separate NKPC for housing prices:

$$\pi_t^d = \beta E_t \pi_{t+1}^d + \omega^d \hat{m}c_t^d \quad (17)$$

where  $\omega^d = \frac{(1-\tau^d)(1-\beta\tau^d)}{\tau^d}$  and  $\tau^d$  is the probability that a firm cannot reset its price in any given period. Next, we use the definition  $\hat{\pi}_t^d = \hat{q}_t - \hat{q}_{t-1}$  to substitute for  $\hat{q}_t$  in (16).

## 2.4 Banks

Banks are modeled in a relatively simple manner in this paper. On the asset side of their balance sheets, banks hold loans to households and firms, required liquidity reserves at the central bank, and additional liquidity reserves as assets. The only liabilities are bank savings  $M_t$  from households. Formally, we assume that  $L_t + V_t = M_t$ , where  $V_t$  denotes liquidity reserves and  $L_t$  denotes total loans, which are given by  $L_t = L_t^H + L_t^C + L_t^D$ . This modeling strategy follows the simple industrial organization model of banking (as explained in Freixas and Rochet (1997)).  $V_t$  is assumed to be a fraction  $\eta$  of  $M_t$ . The interest rate for  $V_t$  is given by  $R_t^{cb} = (1 + r_t^{cb})$  and is determined on the interbank market. It is assumed to be entirely under the control of the central bank and is the central bank's



target interest rate. This implies that the central bank attempts to influence the other interest rates and the economic variables through  $R_t^{cb}$ . For individual savings, banks pay  $R_t^m$  and from loans, they receive  $R_t^d$ . Granting loans and holding deposits are both associated with costs for the banks. To ensure that the model is as simple as possible, we consider the simple linear cost function  $C(L_t, M_t) = eL_t + fM_t$ , where  $e$  and  $f$  denote marginal costs of granting loans and holding deposits, respectively. We assume that  $e > f$ . Following this, a bank maximizes profits  $\Pi$  by solving the following maximization problem:

$$\max_{L_t, M_t, S_t} \Pi = R_t^d L_t + R_t^{cb} V_t - R_t^m M_t - eL_t - fM_t \quad (18)$$

subject to the constraint:

$$L_t + V_t = (1 - \eta)M_t \quad (19)$$

Using the constraint to substitute for  $V_t$  in the objective, we can derive the log-linearized first-order conditions:

$$\hat{r}_t^d = \hat{r}_t^{cb} \quad (20)$$

$$\hat{r}_t^{cb}(1 - \eta) = \hat{r}_t^m \quad (21)$$

Finally, we log-linearize the balance sheet constraint  $L_t = (1 - \eta)M_t$  to obtain:

$$\hat{l}_t = k_1(1 - \eta)\hat{m}_t \quad (22)$$

where  $k_1 = \frac{m_{ss}}{l_{ss}}$ .

## 2.5 The Evolution of Aggregate Loans

Aggregate loans are determined by  $L_t = L_t^H + L_t^C + L_t^D$ . Log-linearizing this sum yields:

$$\hat{l}_t = \frac{\gamma_1 \hat{l}_t^h + \gamma_2 \hat{l}_t^c + \gamma_3 \hat{l}_t^d}{\gamma_1 + \gamma_2 + \gamma_3} \quad (23)$$

where  $\gamma_1, \gamma_2$  and  $\gamma_3$  are the shares of the respective loan categories in relation to total output. Log-linearizing  $L_t^H = \mu^H E_t\{Q_{t+1}\}D_t(1 - \delta)$ ,  $L_t^C = \mu_B W_t^c N_t^c$ , and  $L_t^D = \mu_B W_t^d N_t^d$  and inserting into (23) yields:

$$\begin{aligned} \hat{i}_t = & \frac{\gamma_1(E_t\{\hat{q}_{t+1}\} + \hat{d}_t) + (\gamma_2 + \gamma_3)(\hat{p}_t + \sigma\hat{y}_t)}{(\gamma_1 + \gamma_2 + \gamma_3)} \\ & + \frac{(1 + \chi)(\gamma_2(\hat{y}_t) + \gamma_3(\hat{i}_t))}{(\gamma_1 + \gamma_2 + \gamma_3)} \end{aligned} \quad (24)$$

## 2.6 Monetary Policy

We assume that monetary policy is determined by a version of a Taylor rule, by which the central bank reacts to expected future inflation. Two types of Taylor rules are considered. The rule we call type 1 is a rule, by which the central bank only reacts to the expected future inflation of consumer goods:

$$\hat{r}_t^{cb} = \rho_r \hat{r}_{t-1}^{cb} + \rho_c E_t\{\pi_{t+1}^c\} \quad (25)$$

The type 2 rule considers the case in which the central bank also reacts to expected future house price inflation:

$$\hat{r}_t^{cb} = \rho_r \hat{r}_{t-1}^{cb} + \rho_c E_t\{\pi_{t+1}^c\} + \rho_d E_t\{\pi_{t+1}^d\} \quad (26)$$

It should be noted that the central bank acts under uncertainty. It reacts to expected consumer price inflation (and house price inflation, if it is a type 2 central bank). In our model, the central bank cannot identify which type of shock causes inflation. The simulation results presented in the next section can be used to assess whether this might constitute a problem for the central bank.

## 3 Choice of Parameter Values

The values selected for the parameters are reported in Table 1. Note that one period corresponds to one quarter. The values of  $\sigma, \beta, \theta, \chi$  and  $\delta$  are within the range of the standard values in the literature. The intertemporal elasticity of substitution for consumer goods  $\sigma$  is set equal to 1 and the same value is chosen for  $\theta$  in accordance with

Iacoviello (2005). The Frisch elasticity of labor supply is also chosen to be 1, the inverse of which is given by  $\chi = 1$ . The rate of depreciation of housing is set at 0.025.

For  $u$ , we select a value of 0.995. We further assume a depreciation rate for the housing stock of 0.025. For the loan-to value ratio  $\mu^H$ , we select a value of 0.75, which is similar to that in Iacoviello (2005) and Gerali, Neri, Sessa and Signoretti (2010). The weight of housing services in the utility function  $\phi^d$  is chosen to be 0.1, as in Iacoviello (2005).

We set the degree of nominal rigidity of consumer prices equal to  $\tau^c = 0.75$ , implying a price adjustment frequency of four quarters. For consumer goods prices, we follow Bils and Klenow (2004) and assume a lower parameter value of  $\tau^d = 0.5$  to reflect their findings that housing prices are more flexible than consumer goods prices. For the monetary policy rule, we choose standard values of  $\rho_r = 0.7$  and  $\rho_c = 1.5$ . For the case in which the central bank also reacts to house price movements, we set  $\rho_d = \rho_c = 1.5$ . The persistence parameters for the shocks of the exogenous processes are chosen to be 0.85.

The value for  $F = \frac{P_{ss}D_{ss}^{-\theta}}{Q_{ss}C_{ss}^{-\sigma}}$  is derived as follows. If, as discussed above,  $\sigma = \theta = 1$ , then  $F = \frac{P_{ss}C_{ss}}{Q_{ss}D_{ss}}$ . As  $I_{ss} = \delta D_{ss}$ ,  $F$  can be written as  $F = \frac{\delta P_{ss}C_{ss}}{Q_{ss}I_{ss}}$ . If we approximately follow OECD data and set the share of consumption expenditures in GDP equal to 0.65 and the share of housing to 0.05, we obtain a value of  $F = 0.325$ . The ratio of total loans to output is set equal to 3, which approximately corresponds to private debt levels before the crisis in the United States. However, one should bear in mind that the debt level did not behave in a stationary manner during that period. The ratio of household debt is set to 0.7, which yields  $\gamma_1 = 0.7$ . This leaves a fraction of 2.3 to firms. If, as discussed above, the consumer goods sector is approximately 13 times larger than the housing sector, we obtain approximately  $\gamma_2 = 2.1$  and  $\gamma_3 = 0.2$ .

Table 1: Choice of Parameter Values and Steady-State Values

Parameter	Value	Parameter	Value
$\beta$	0.99	$\delta$	0.025
$\sigma$	1	$u$	0.995
$\theta$	1	$k_1$	0.95
$\phi^d$	0.1	$\tau^c$	0.75
$\chi$	1	$\tau^d$	0.5
$\eta$	0.05	$F$	0.325
$\gamma_1$	0.7	$\rho_z$	0.85
$\gamma_2$	2.1	$\rho_a$	0.85
$\gamma_3$	0.2	$\rho_\phi$	0.85
$\rho_r$	0.7	$\rho_\mu$	0.85
$\rho_c$	1.5	$\mu^H$	0.75
$\rho_d$	1.5		

## 4 Simulation Results

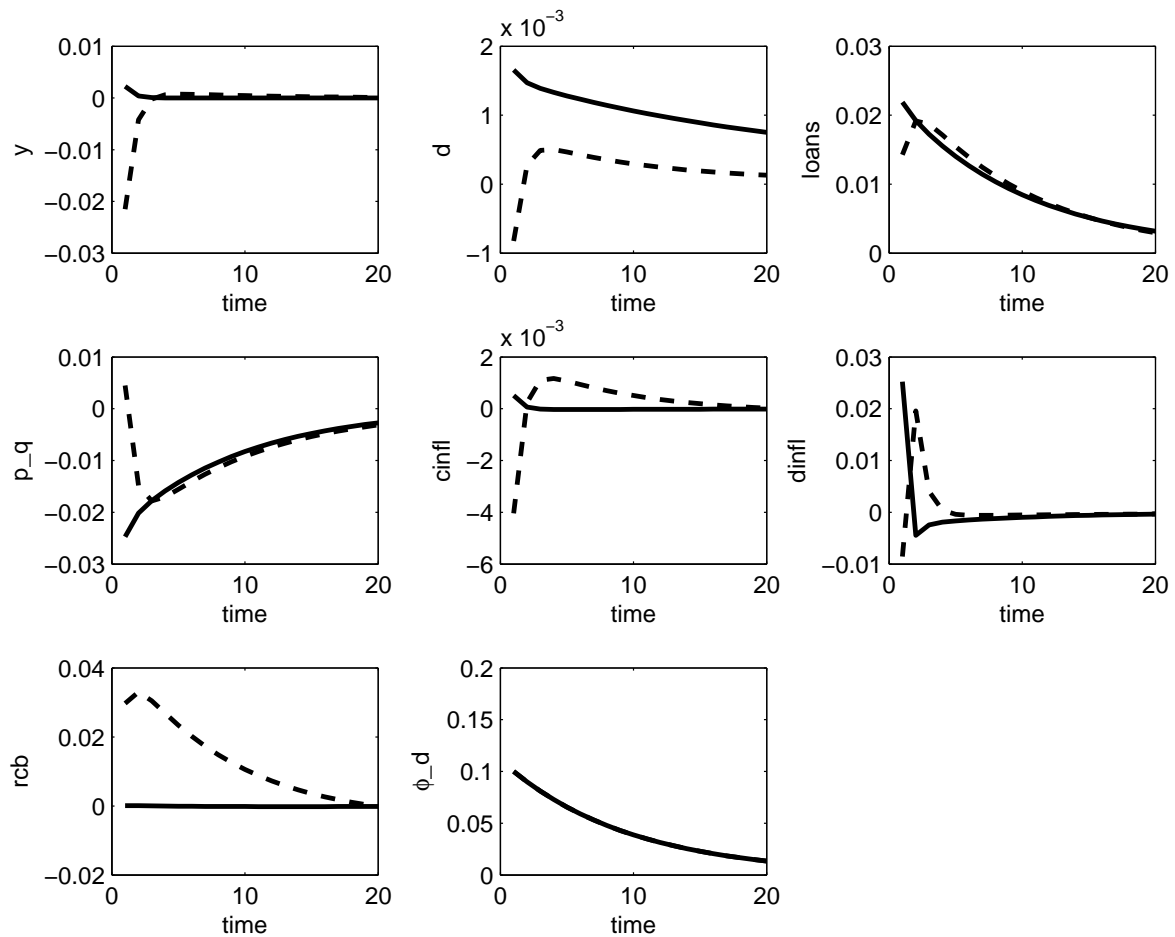
This section presents impulse response functions for two types of shocks: a preference shock to housing and a shock to the household borrowing constraint. For each variable, we report impulse responses for the case, in which the central bank is of type 1 and only reacts to consumer goods prices (solid lines) and for the case, in which the central bank is of type 2 and also reacts to house prices (dashed lines). Impulse responses for the following variables are depicted: the output (which equals consumption) of consumer goods (**y**), the evolution of the housing stock (**d**), the relative price of consumer goods (**p-q**), inflation of consumer goods (**cinfl**), inflation of housing (**dinfl**), the evolution of the amount of loans (**loans**), the interest rate on the interbank market (**rcb**), and the evolution of the respective shock variable.

### 4.1 The Effects of a Preference Shock to Housing

In this section, we study the effects of an increase in household preferences for housing, which is reflected in the parameter  $\phi_t^d$ . We assume that  $\hat{\phi}_t^d$  follows the exogenous process  $\hat{\phi}_t^d = \rho_\phi \hat{\phi}_{t-1}^d + \epsilon_t^1$  and consider a shock that increases the preference for housing by 10%. One can observe from Figure 1 that a central bank reacting to house prices causes a contraction in both sectors. There is a persistent decrease in consumer goods prices relative to housing prices. In both cases, the central bank succeeds in preventing a strong and immediate increase in house prices but the greater preference for housing nevertheless leads to a persistent increase in house prices. While the central bank's target interest

rate remains nearly constant under a type 1 rule, it is considerably increased under a type 2 rule.

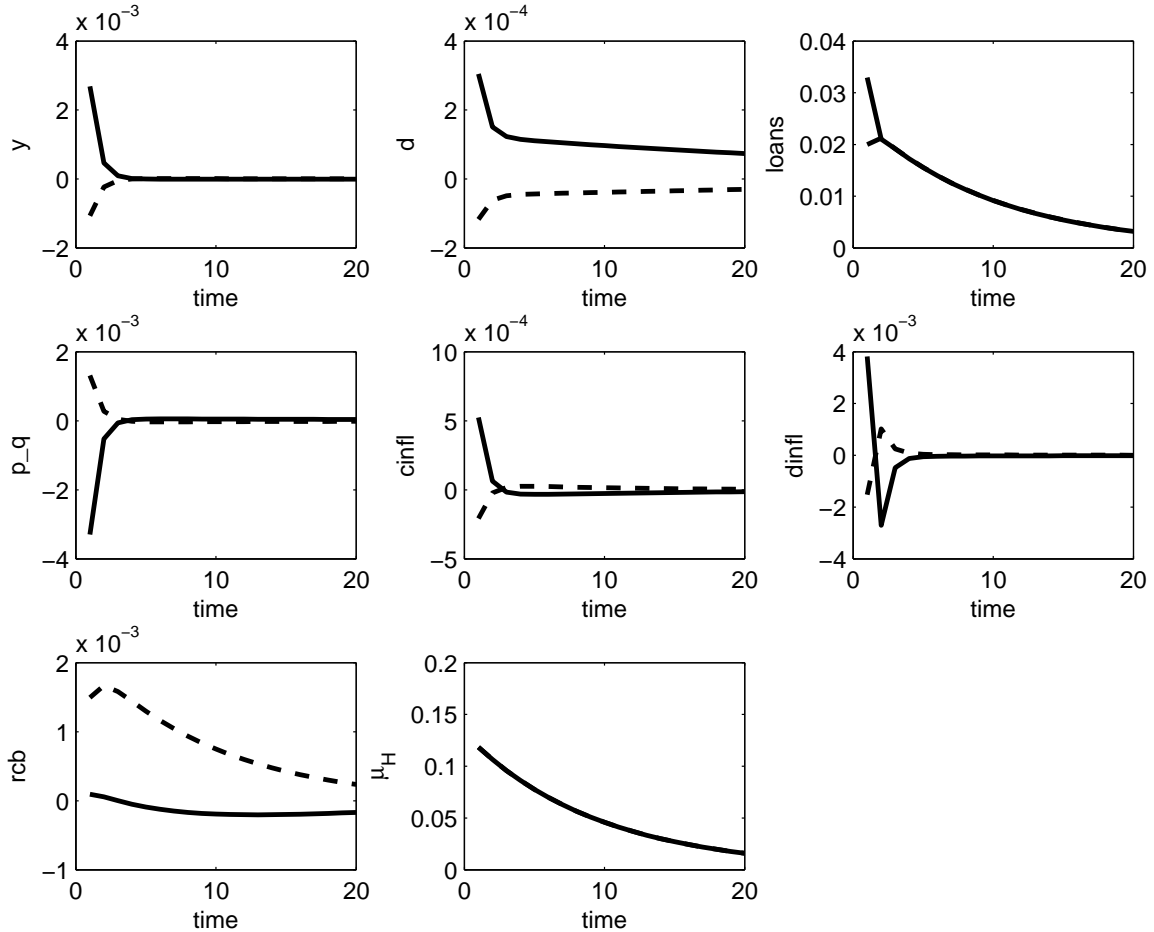
Figure 1: Preference Shock for Housing (type 1: solid lines; type 2: dashed lines)



## 4.2 The Effects of a Shock to the Borrowing Constraint

In this section, we analyze the effects of a shock to the borrowing constraint. Thus, we assume that  $\mu_t^H$  is time-varying and follows the exogenous process  $\hat{\mu}_t^H = \rho_\mu \hat{\mu}_{t-1}^H + \epsilon_t^2$ . We consider a shock that increases  $\mu_t^H$  by 10%. As can be seen in Figure 2, a positive shock to the borrowing constraint  $\mu_t^H$  only leads to an expansion of the housing sector under a type 1 rule. Under a type 1 rule, this expansion spills over to the consumer goods sector. If the central bank behaves according to the type 2 rule, there is a contraction in both sectors. One can also see that the central bank succeeds in limiting the increase in both inflation rates if it behaves according to the type 2 rule. The direction of the reaction of the relative price of consumer goods also depends on the type of central bank considered. If the central bank reacts to house prices, housing becomes relatively less expensive.

Figure 2: Shock to Borrowing Constraint (type 1: solid lines; type 2: dashed lines)



### 4.3 Welfare Analysis

This section focuses on the welfare impact of the two types of central banks.<sup>1</sup> In our welfare analysis, we consider a measure of accumulated welfare over the long-term horizon of the representative agent. Formally, welfare  $W$  is defined as the present value of utility changes  $dU_t$  over the subsequent five years, or twenty quarters:

$$W = \sum_{t=0}^{t=20} \beta^t dU_t \quad (27)$$

Table 2 depicts welfare under the two types of shocks we consider and the two types of central banks. One can see that a central bank reacting to house price inflation (type 2) will not only cause lower economic growth rates but will also reduce the welfare of the representative individual. We also conduct a sensitivity analysis for different degrees of persistence of the shock processes, whereby a high degree of persistence corresponds to a parameter value of 0.95 for  $\rho_\phi$  and  $\rho_\mu$ , in contrast to the previously used value of 0.85 for the baseline case.

Table 2: Welfare Analysis

Scenario	Welfare type 1	Welfare type 2
Preference Shock (baseline persistence)	0.0093	−0.0170
Preference Shock (high persistence)	0.0241	−0.0197
Borrowing Constraint (baseline persistence)	0.0128	−0.0139
Borrowing Constraint (high persistence)	0.0202	−0.0301

---

<sup>1</sup>There are different approaches to computing welfare. Below, we follow the approach selected by, for instance, Ganelli and Tervala (2010).

## 5 Conclusion

In this paper, we have analyzed the economic impacts of a central bank reacting to house price inflation. Two different potential sources of inflation in house prices are considered. The analysis is performed using a New Keynesian model with two production sectors and a banking sector. The findings illustrate that these two factors - namely a shock to the preference for housing and a shock to the borrowing constraint - may lead to a persistent increase in housing demand and house prices. Our analysis also reveals that the central bank can, to some extent, prevent this by taking the evolution of house prices into account when determining its monetary policy. However, this is associated with lower economic growth rates over the business cycle and a decline in welfare. Further research should consider a more in-depth model of the banking sector, which could potentially shed further light on how the banking sector transmits the considered shocks within the economy. A complete welfare analysis in a model including bubble and bust scenarios would also be an interesting direction for future research.



## References

- Aslam, A. and Santoro, E. (2008), ‘Bank Lending, Housing and Spreads’, *University of Copenhagen. Department of Economics Discussion Paper No. 08-27*.
- Bils, M. and Klenow, P. J. (2004), ‘Some Evidence on the Importance of Sticky Prices’, *Journal of Political Economy* **112**(5), 947–985.
- Calvo, G. A. (1983), ‘Staggered prices in a Utility-maximizing Framework’, *Journal of Monetary Economics* **12**(3), 383–398.
- Carlstrom, C. T. and Fuerst, T. S. (2006), ‘Co-movement in Sticky Price Models with Durable Goods’, *Working Paper No.0614*.
- Finocchiaro, D. and Heideken, V. Q. (2013), ‘Do Central Banks React to House Prices?’, *Journal of Money, Credit and Banking* **45**(8), 1659–1683.
- Freixas, X. and Rochet, J.-C. (1997), *Microeconomics of Banking*, The MIT Press.
- Gali, J. (2008), *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework*, Princeton University Press.
- Ganelli, G. and Tervala, J. (2010), ‘Public infrastructures, Public consumption, and Welfare in a New-Open-Economy-Macro Model’, *Journal of Macroeconomics* **32**(3), 827–837.
- Gerali, A., Neri, S., Sessa, L. and Signoretti, F. M. (2010), ‘Credit and Banking in a DSGE Model of the Euro Area’, *Journal of Money, Credit and Banking* **42**(s1), 107–141.
- Guerrieri, L. and Iacoviello, M. (2013), ‘Collateral Constraints and Macroeconomic Asymmetries’, *Board of Governors of the Federal Reserve System (U.S.)* (1082).
- Iacoviello, M. (2005), ‘House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle’, *American Economic Review* **95**(3), 739–764.
- Iacoviello, M. and Neri, S. (2010), ‘Housing Market Spillovers: Evidence from an Estimated DSGE Model’, *American Economic Journal: Macroeconomics* **2**(2), 125–64.
- Jensen, H., Ravn, S. H. and Santoro, E. (2013), Changing Credit Limits, Changing Business Cycles, mimeo, University of Copenhagen.
- Monacelli, T. (2009), ‘New Keynesian Models, Durable goods, and Collateral Constraints’, *Journal of Monetary Economics* **56**(2), 242–254.

Ravenna, F. and Walsh, C. E. (2006), ‘Optimal Monetary Policy with the Cost Channel’,  
*Journal of Monetary Economics* **53**(2), 199–216.