Asset Prices, Nominal Rigidities, and Monetary Policy: Case of Housing Price

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Abstract

Carlstrom and Fuerst (2007) ["Asset Prices, Nominal Rigidities, and Monetary Policy," *Review of Economic Dynamics* 10, 256–275] find that monetary policy response to share prices is a source of equilibrium indeterminacy in a sticky-price economy. We find that if housing price is a target of a central bank, monetary policy response to asset price is helpful for equilibrium determinacy.

Keywords: Housing price; asset prices; monetary policy; equilibrium determinacy;

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1 Introduction

Should monetary policy respond to asset prices? This classic policy question has been investigated by many researchers, and with varying results. A recent paper by Carlstrom and Fuerst (2007) show that equilibrium indeterminacy arises if monetary policy responds to share prices in a standard sticky-price economy. An increase in inflation reduces firm's profits, and the share prices decline, since they reflect the firm's profits. Then, monetary policy response to share prices implicitly weakens overall reactions to inflation. This is a source of equilibrium indeterminacy. If a monetary policy causes equilibrium indeterminacy, it should not be taken by the central bank, because we cannot predict what happens if a shock hits the economy and economic fluctuations might be caused by non-fundamental expectation shocks.

The main objective of this paper is to study whether the equilibrium indeterminacy results found by Carlstrom and Fuerst (2007) are applicable to housing price. Housing price has been the focus of attention after recent U.S. financial crisis, and it is worth to be analyzed as asset price. To end this, we construct a standard sticky price model with housing. In our model, housing is a fixed supplied asset, and it yields utility of households. We find that monetary policy response to housing price is helpful for equilibrium determinacy. This result is robust to a model where both nominal prices and wages are sticky. A permanent increase in inflation causes an increase in housing price in our model, while share price decreases in the model of Carlstrom and Fuerst (2007), and then monetary policy response to housing price strengthens the overall reaction to inflation. A permanent increase in inflation causes an increase in the real marginal cost, that is the wage in our model, because of sticky prices, and then, households increase their consumption and housing demand by wealth effect. This increase in housing demand causes an increase in housing price.

There are some papers that monetary policy response to asset prices from the viewpoint of equilibrium determinacy. Bullard and Schaling (2002), Carlstrom and Fuerst (2007), and Nutahara (2014, 2015) employ this approach. Bullard and Schaling (2002),

using one-period claims to random nominal quantities as asset, Lucas tree, monetary policy response to the price of Lucas tree is a source of equilibrium indeterminacy. Carlstrom and Fuerst (2007) introduces share of firm into a standard sticky-price model, and they find that monetary policy response to share prices is a source equilibrium indeterminacy. On the contrary to this, Nutahara (2014) find that in the case of monetary policy responding to capital price fluctuations, the result is overturned. The result of this paper is close to that of Nutahara (2014). The difference is that the capital investigated by Nutahara (2014) is a productive and tangible asset while the housing in our model is non-productive but it yields utility directly. Nutahara (2015) investigates the implication of credit market imperfection for monetary policy response to asset price fluctuations. On the other hand, there are papers from the viewpoint of welfare or variance of inflation and output. Bernanke and Gertler (2001), Gilchrist and Leahy (2002), Iacoviello (2005), and Faia and Monacelli (2007) are included in this group.

The rest of this paper is organized as follows. Section 2 introduces our model. Section 3 presents the main results and their interpretation. Section 4 checks the robustness of the main result in a model with sticky price-wage economy. Finally, Section 5 presents our concluding remarks.

2   The model

We employ a standard sticky-price model with housing. In our model, housing is fixed supplied asset and it yields utility. [1]

The representative household begins period t with B_t one-period nominal bonds that pay R_{t-1} gross risk-free interest rate and H_t housing that sell at price Q_t. The utility

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[1]It is another way of modeling housing so that housing is used for the production of goods. However, we focus on the asset that yields utility directly in this paper because it is already shown that monetary policy response to the price of productive assets, e.g., capital, is helpful for equilibrium determinacy by Nutahara (2014).

function is

$$U = \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \phi \frac{L_t^{1+\gamma}}{1+\gamma} + \eta \frac{H_t^{1-\nu}}{1-\nu} \right] \tag{1}$$

Where C_t denotes consumption, L_t denotes labor supply, The budget constraint of household is

$$P_t C_t + B_{t+1} + P_t Q_t H_{t+1}$$

$$\leq P_t W_t L_t + R_{t-1} B_t + P_t Q_t H_t + X_t, \tag{2}$$

where P_t denotes aggregate price level, W_t denotes real wage rate, and X_t denotes monetary injection. The first order conditions of households are

$$\phi C_t^{\sigma} L_t^{\gamma} = W_t, \tag{3}$$

$$C_t^{-\sigma} = \beta C_{t+1}^{-\sigma} \cdot \frac{R_t}{\Pi_{t+1}}, \tag{4}$$

$$C_t^{-\sigma} Q_t = \beta C_{t+1}^{-\sigma} Q_{t+1} + \eta H_{t+1}^{-\nu}, \tag{5}$$

where $\Pi_{t+1} \equiv P_{t+1}/P_t$ denotes gross inflation. Equation (3) is the intratemporal optimization condition, equation (4) is the Euler equation for consumption, and equation (5) is the Euler equation for housing.

There are monopolistically competitive intermediate-goods firms and competitive final-goods firms. The production technology of final-goods firms is

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\theta-1}{\theta}} di \right)^{\frac{\theta}{\theta-1}}, \tag{6}$$

where θ denotes the elasticity of substitution and $Y_t(i)$ denotes outputs of intermediate-goods indexed by i. The profit maximization of final-good firms implies the demand curve for $Y_t(i)$ as

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\theta} Y_t, \tag{7}$$

where $P_t(i)$ denotes the price level of intermediate-good indexed by i. Combining equations (6) and (7) yields the following price index for intermediate goods:

$$P_t = \left(\int_0^1 P_t(i)^{1-\theta} di \right)^{\frac{1}{1-\theta}}. \tag{8}$$

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The intermediate-good firms are monopolistically competitive, and they produce intermediate-good $Y_t(i)$ employing labor $H_t(i)$ from households. The production function of intermediate-good firm is

$$Y_t(i) = H_t(i). \tag{9}$$

The cost minimization problem implies

$$W_t = Z_t, \tag{10}$$

where Z_t denotes the Lagrange multiplier of the cost minimization problem, and it can be interpreted as the real marginal cost. Intermediate goods firms set their prices subject to Calvo-type price staggeredness. The price can be re-optimized at period t only with probability $1 - \kappa$. Under this setting, we obtain the New Keynesian Phillips curve,

$$\pi_t = \lambda z_t + \beta \pi_{t+1}, \tag{11}$$

where

$$\lambda \equiv \frac{(1 - \kappa)(1 - \kappa\beta)}{\kappa}, \text{ and}$$

π_t and z_t denote the log deviations from a steady state of inflation and the real marginal cost, respectively.

The central bank follows a Taylor rule:

$$r_t = \tau_\pi \pi_t + \tau_q q_t, \tag{12}$$

where r_t and q_t denote the log-deviations from steady state values of R_t and Q_t, respectively. We focus on the case with $\tau_\pi > 0$ and $\tau_q \geq 0$. If $\tau_q > 0$, a central bank responds to asset price fluctuations.

The market clearing conditions are

$$L_t = \int_0^1 L_t(i)di, \tag{13}$$

$$H_t = 1, \tag{14}$$

$$B_t = 0. \tag{15}$$

The resource constraint is

$$C_t = Y_t \tag{16}$$

and the aggregate production function is

$$Y_t = \frac{1}{\Delta_t} L_t, \tag{17}$$

where Δ_t is a measure of resource cost of price dispersion:

$$\Delta_t \equiv \int_0^1 \left(\frac{P_t(i)}{P_t} \right)^{-\theta} di. \tag{18}$$

Since we focus on the log-linearized dynamics around zero inflation steady state, we can ignore effects from the price dispersion.

3 Main result

The linearized equilibrium system is given as follows:

$$(\sigma + \gamma)c_t = z_t, \tag{19}$$

$$\sigma(c_{t+1} - c_t) = r_t - \pi_{t+1}, \tag{20}$$

$$q_t = \beta q_{t+1} + (1 - \beta)\sigma c_t + \beta(\pi_{t+1} - r_t), \tag{21}$$

$$w_t = z_t, \tag{22}$$

$$\pi_t = \beta \pi_{t+1} + \lambda z_t, \tag{23}$$

$$r_t = \tau_\pi \pi_t + \tau_q q_t, \tag{24}$$

where c_t denotes consumption; w_t, the real wage rate; r_t, the nominal interest rate; and q_t, housing prices. σ denotes the relative risk aversion; $1/\gamma$, the Frisch elasticity; z, the steady-state real marginal cost; τ_π, the sensitivity of monetary policy to inflation; and τ_q, the sensitivity of monetary policy to housing prices.

This system is reduced to the following matrix form:

$$
\begin{bmatrix} 1 & \chi & 0 \\ \beta & 0 & \beta \\ \beta & 0 & 0 \end{bmatrix}
\begin{bmatrix} \pi_{t+1} \\ z_{t+1} \\ q_{t+1} \end{bmatrix}
=
\begin{bmatrix} \tau_\pi & \chi & \tau_q \\ 1 & -\lambda & 0 \\ \beta\tau_\pi & \Phi & 1 + \beta\tau_q \end{bmatrix}
\begin{bmatrix} \pi_t \\ z_t \\ q_t \end{bmatrix},
$$

where

$$\chi \equiv \frac{\sigma}{\sigma + \gamma} > 0,$$

$$\Phi = \frac{\sigma(1 - \beta)}{\sigma + \gamma} > 0.$$

The first equation is the consumption Euler equation, equation (20), the second equation is the Euler equation for housing, equation (21), the third equation is the New Keynesian Phillips curve, equation (23).

The main result of this paper is as follow.

Proposition 1. *A necessary and sufficient condition for equilibrium determinacy is*

$$(\tau_\pi - 1)\lambda + \tau_q \Phi > 0.$$

Proof. For equilibrium determinacy, all roots must be outside the unit circle. It is easily shown that one of the roots are $1/\beta > 1$. The two remaining roots are solutions of a characteristic equation:

$$F(x) = x^2 + F_1 x + F_2,$$

where

$$F_1 \equiv -\frac{\beta + \chi + \beta\chi(1 + \tau_q)}{\beta\chi} < 0,$$

$$F_2 \equiv \frac{\chi + \lambda\tau_\pi + \tau_q(\Phi + \beta\chi)}{\beta\chi} > 0.$$

It is shown that $F(0) = F_2 > 0$ and $F'(0) = F_1 < 0$. At $x = 1$, $F(x)$ is decreasing because

$$F'(1) = 2 + F_1$$
$$= \frac{-\chi(1 - \beta) - \beta(1 + \chi\tau_q)}{\beta\chi} < 0.$$

Then, a necessary and sufficient condition for equilibrium determinacy is

$$F(1) = \frac{(\tau_\pi - 1)\lambda + \tau_q \Phi}{\beta\chi} > 0.$$

$\square$

In the case where $\tau_q = 0$, a necessary and sufficient condition for equilibrium determinacy is $\tau_\pi > 1$. This is well-known necessary and sufficient condition for equilibrium determinacy in standard sticky-price models. Our result implies that even if $\tau_\pi < 1$, equilibrium is determinate if

$$\tau_q > \frac{(1 - \tau_\pi)\lambda}{\Phi}. \tag{25}$$

In this sense, Proposition 1 implies that monetary policy responses to housing prices ($\tau_q > 0$) is helpful for equilibrium determinacy.

This condition is highlighted by the Taylor principle: a permanent increase in the inflation rate leads to a more-than-proportionate increase in the inflation rate. By the New Keynesian Phillips curve, equation (23), it is implied that a one-percent permanent increase in inflation (one-percent increase of both q_t and q_{t+1}) causes $(1 - \beta)/\lambda$ percent increase in real marginal cost, z_t. Because the equation (21) can be rewritten as

$$q_t = \beta q_{t+1} + \Phi z_t + \beta(\pi_{t+1} - r_t), \tag{26}$$

the housing prices, q_t and q_{t+1}, increase by $\lambda\Phi$ percent. As a result, the overall reaction to inflation via our Taylor rule is

$$\tau_\pi + \lambda\Phi\tau_q. \tag{27}$$

The Taylor principle requires that the equation (27) is greater than one, and it is consistent with the necessary and sufficient condition for equilibrium determinacy in Proposition 1.

In the model of Carlstrom and Fuerst (2007), a permanent increase in inflation reduces their asset prices, share prices, because an increase in inflation increases the real marginal cost of firms, and it is a downward pressure of firm's profits and share prices. Then, monetary policy response to share prices weakens the overall reaction to inflation. In our model, a permanent increase in inflation generates an increase in housing price, and monetary policy response to the housing price strengthens the overall reaction to inflation.

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Why does housing price increase if a permanent increase in inflation occurs? As it is said in the previous paragraph, a permanent increase in inflation causes an increase in the real marginal cost. Since the real marginal cost is the wage in this model, households increase their consumption and housing demand by wealth effect. This increase in housing demand causes an increase in housing price.

4 Robustness: Sticky price-wage economy

It has been assumed that nominal wages are flexible in Section 2. However, Carlstrom and Fuerst (2007) find that a permanent increase in inflation might have a different effects on asset prices in a sticky-wage economy. In this subsection, we consider an economy in which nominal wages are also sticky.

The nominal wage rigidity à la Erceg, Henderson, and Levin (2000) is introduced to the model presented in the previous section. The linearized intratemproral optimization condition (19) becomes

$$(\sigma + \gamma)c_t = zh_t + w_t, \tag{28}$$

where zh_t is the monopoly distortion, that measures the difference between the household's marginal rate of substitution and the real wage. The following two equations are also introduced to the log-linearized equilibrium system:
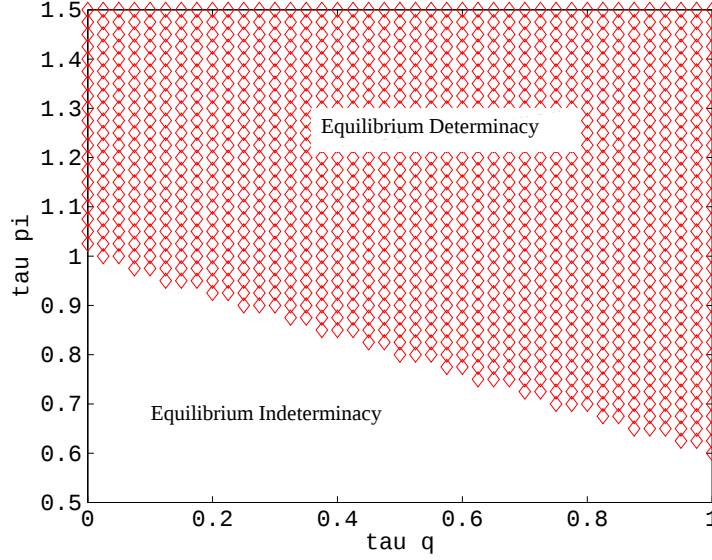
$$\pi_t^w = \beta \pi_t^w + \lambda_w z h_t, \tag{29}$$

$$w_t - w_{t-1} = \pi_t^w - \pi_t, \tag{30}$$

where π_w is nominal wage inflation.

In this case, the equilibrium system is reduced to the one with four jump variables (inflation, real marginal cost, housing price, and wage inflation) and one state variable (real wage). Since it is difficult to derive an analytical condition for equilibrium determinacy, we calculate the determinacy region by numerical simulations. Following Carlstrom and Fuerst (2007), the parameter values are set as follows: $\sigma = \gamma = 2$, $z = 0.85$, $\beta = 0.99$, $\lambda = 0.019$, and $\lambda_w = 0.035$.

Figure 1: Determinacy region: Sticky price-wage economy

Notes: The vertical axis is the central bank's stance on inflation τ_π. The horizontal axis is the central bank's stance on the housing price τ_q.

Figure 1 shows the determinacy region of equilibria. It is found that monetary policy response to housing price is helpful for equilibrium determinacy since an increase in τ_q enlarges the determinacy region of τ_π. A permanent increase in inflation causes not only increase in wage as in the model of previous section, but also an increase in zh_t through equations (29) and (30), and they has positive effects on consumption, housing demand, and housing price by wealth effects. As a result, an increase in housing price occurs in this sticky price-wage model as in the sticky price model. Thus, our result is robust in the case where both nominal prices and wages are sticky.

5   Concluding remarks

This paper has studied that monetary policy response to housing price. In our model, housing is a fixed supplied asset, and it yields utility of households.

It has been found that monetary policy response to housing price is helpful for equi-

librium determinacy, that is different from the finding by Carlstrom and Fuerst (2007), monetary policy response to share price is a source of equilibrium indeterminacy. This is because a permanent increase in inflation generates an increase in housing price in the model. Our result is robust to a model where both nominal prices and wages are sticky.

Housing price has been the focus of attention after recent U.S. financial crisis. The result of this paper would imply the importance of housing price for monetary policy.

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