

# Monetary Policy and the Financial Sector

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## Abstract

In this paper we study whether central banks should react to financial sector variables in their policy rules. We find that responding to asset prices does not affect the determinacy conditions. However, responding to entrepreneurial net worth increases the likelihood of determinacy.

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# 1 Introduction

The financial sector, through the intermediation of borrowing and lending, is essential to the efficient allocation of resources in an economy. The recent experience of the 2008 financial crisis emphasizes the importance of considering whether central banks should respond directly to financial sector developments in their monetary policy rules. The literature has mostly focused on whether central banks should respond to asset prices. But as pointed out by Gilchrist and Leahy (2002), asset prices are endogenous variables that reflect underlying state variables, such as the capital stock or the net worth of entrepreneurs. Consequently, it is also worth investigating whether policy should respond to these variables directly. We use the framework of Bernanke, Gertler and Gilchrist (1999) (henceforth BGG) to study the interaction between financial sector variables and monetary policy.

The BGG model is a standard New Keynesian model (henceforth NKM) with credit market frictions. The economy consists of four types of agents: households, entrepreneurs, retailers and government. Households work, consume and save. Firms are owned by entrepreneurs who use capital and labor to produce wholesale goods. They acquire capital by using internal funds and by borrowing from households. Credit market frictions arise because of asymmetric information between borrowers and lenders. If credit markets were perfect, in equilibrium at the optimal level of investment, the expected return on assets would equal the risk-free rate. However, due to costly state verification, the cost of external funds is higher than the cost of internal funds. In particular, in equation (10), the external finance premium depends on entrepreneurs' net worth relative to the gross value of capital  $[n_{t+1} - (q_t + k_{t+1})]$ , where  $v$  is the elasticity of the external finance premium to leverage. In this model, the gross asset (capital) return, equation (9), depends not only on the marginal product of capital adjusted by real marginal cost  $[(1 - \epsilon)(y_{t+1} - k_{t+1} - x_{t+1})]$  but also on changes in asset prices  $[\epsilon q_{t+1} - q_t]$ . The net return on assets influences entrepreneurial

net worth, equation (16), which is an additional state variable in BGG. Retailers buy the wholesale goods from entrepreneurs, differentiate them and sell them in a monopolistically competitive retail market characterized by Calvo-type staggered nominal price setting. The government sector conducts monetary policy. We consider two types of monetary policy rules: a current data policy rule and a forward-looking policy rule, discussed in detail in the following section.

Using this framework, we study how responding to financial sector variables—net worth and asset prices—in the policy rule affects equilibrium determinacy.

## 2 Results

We compute the determinacy region numerically following Sims (2002). All of the linearized equations and calibrated parameters used in the numerical analysis are in the Appendix.

### 2.1 Current data policy rule

The determinacy regions for the current data policy rule are plotted in Figure 1. If the rational expectations equilibrium (henceforth REE) is indeterminate, the region is not shaded. The dark shaded area corresponds to combinations of policy coefficients that induce determinacy, while regions where the REE does not exist are gray.

INSERT FIGURE 1

The monetary policy rules in the top left and right panels of Figure 1 are

$$r_t^n = \phi_\pi \pi_t + \phi_y y_t \tag{1}$$

$$r_t^n = \phi_\pi \pi_t + \phi_q q_t \tag{2}$$

where the nominal interest rate,  $r_t^n$ , responds to current inflation ( $\pi_t$ ) and the current output gap ( $y_t$ ) or deviations of asset prices from their steady

state level ( $q_t$ ) with policy response coefficients  $\phi_\pi$  and  $\phi_y$  or  $\phi_q$  respectively. In this case, responding to asset prices does not affect the determinacy region.<sup>1</sup> One explanation is that the channel through which asset prices affect inflation and output is not strong enough; models incorporating the financial accelerator have been unable to generate asset price volatility of the magnitude seen in the data.<sup>2</sup> Nonetheless, responding to asset prices does not *increase* the likelihood of indeterminacy, which is in contrast to the findings of Carlstrom and Fuerst (2007) and Bullard and Schaling (2002). In these papers, asset prices are incorporated in ways that result in quite specific sources of indeterminacy: through the profit mechanism in Carlstrom and Fuerst (2007), and via an inverse relationship between equity prices and the gross nominal interest rate on a one-period bond in Bullard and Schaling (2002).<sup>3</sup>

Responding to deviations of net worth from its steady state, following equation (3)

$$r_t^n = \phi_\pi \pi_t + \phi_{nw} nw_t + \phi_y y_t \quad (3)$$

increases the likelihood of determinacy (bottom left panel in Figure 1 where  $\phi_y = 0$ ). This is because a positive shock to net worth lowers the external finance premium on loans, equation (10), encourages borrowing and increases investment. If the policymaker responds to a positive shock to net worth by raising the policy rate, this discourages investment and prevents a rise in current and future inflation. Although the response to net worth affects determinacy via the demand channel, the gains from responding to net worth are not subsumed by responding to the output gap (bottom right panel in Figure 1 where  $\phi_y = 2$ ).<sup>4</sup> Incorporating interest rate smoothing in

<sup>1</sup>Our results are robust even if the central bank responds to growth in asset prices.

<sup>2</sup>See Airaudo, Cardani and Lansing (2013) for a discussion of this issue.

<sup>3</sup>Using the Rotemberg and Woodford (1999) framework, consistent with Bullard and Schaling (2002) and augmented with the stock price equation of Carlstrom and Fuerst (2007), Pfajfar and Santoro (2011) find that while a strong response to the level of asset prices could generate indeterminacy, responding to asset price growth could induce determinacy in some cases.

<sup>4</sup>The transmission of monetary policy through the demand channel in BGG is standard. For example, a rise in the real interest rate lowers consumption and investment demand,

the current policy rule does not alter our finding, however it ensures that REE exists for the combinations of policy coefficients considered here.

## 2.2 Forward-looking policy rule

As noted previously in the literature, such as Carlstrom and Fuerst (2005), Sveen and Weinke (2005), Kurozumi and Van Zandweghe (2008) and Duffy and Xiao (2011), indeterminacy is more likely to occur in a NKM with capital and a forward-looking policy rule. Using the monetary policy rule given in equation (4), Figure 2 plots the results for the BGG model which are consistent with findings in the literature.

$$r_t^n = \phi_\pi E_t \pi_{t+1} + \phi_y E_t y_{t+1} \quad (4)$$

INSERT FIGURE 2

Kurozumi and Van Zandweghe (2008) argue that in models with capital, the no-arbitrage condition between capital and bonds and the cost channel of monetary policy interact to produce indeterminacy via self-fulfilling inflationary expectations. This also holds in the BGG framework. For example, suppose that agents expect future inflation to increase due to a sunspot shock. An active policy response would increase the *real* interest rate and, via equation (10), also increase the expected rate of return on capital, increasing future marginal cost via equations (12) and (13). Consequently, expected inflation rises.<sup>5</sup> Therefore in the BGG model, like most New Keynesian models with capital, the policymaker should counteract 

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marginal cost declines and inflation falls.

<sup>5</sup>The timing of the cost channel in BGG is the same as in Kurozumi and Van Zandweghe (2008) among others. In these models, a change in the real interest rate impacts future expected marginal cost. If changes in the nominal interest rate impact current real marginal cost instead, the Taylor Principle does not hold even for the current data policy rule. See, for example, Figures 2b and 2c in Pfajfar and Santoro (2014). In the BGG model employed in our analysis, this is not true (top left panel in Figure 1). If the policy maker follows the forward-looking policy rule, indeterminacy becomes more likely in BGG, while in Pfajfar and Santoro (2014) it is exacerbated.

the cost channel (which puts an upper bound on  $\phi_\pi$  and  $\phi_y$ , as seen in Figure 2) to induce equilibrium determinacy.

Previous literature has established that while a response to the current output gap (instead of the future output gap) can increase the upper bound on  $\phi_y$  consistent with determinacy, it cannot restore the Taylor principle. To restore the Taylor principle, the policymaker should respond to current and past inflation via interest rate smoothing, or the capital adjustment cost has to be high enough to subdue the effects of the cost channel.

Do these mechanisms operate in models with credit market frictions? Essentially yes. As noted earlier, in the BGG model the cost of external funds depends on net worth through the arbitrage condition. Our conjecture, based on the findings in section 2.1, is that responding to *current* net worth would be as effective in partially restoring equilibrium determinacy as responding to the *current* output gap by operating through the demand channel. This is confirmed in the top panel of Figure 3 where the policy maker responds to expected future inflation and the current output gap or current net worth. However, the Taylor principle still does not hold. As in the current data rule, responding to current asset prices does not affect equilibrium determinacy suggesting once again that asset prices are not critical in driving the dynamics in this model.

INSERT FIGURE 3

We also find that in the BGG model, higher capital adjustment costs affect the determinacy conditions by suppressing the cost channel. The presence of capital adjustment costs means that the price of capital depends on investment. In our calibration we set the capital adjustment cost elasticity,  $\psi$ , to 0.25 following BGG. Raising this elasticity to 2, following King and Wolman (1996), restores the Taylor principle when the policy rule is given by equation (4).<sup>6</sup> But there is still an upper bound on  $\phi_y$  consistent with de-

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<sup>6</sup>By substituting equation (11) in equation (9) in the Appendix, it is clear that a fall in asset prices (associated with a fall in investment when the policy rate increases) will subdue the cost channel to a greater extent when the capital adjustment cost is higher.

terminacy, operating via the demand channel (bottom left panel in Figure 3).<sup>7</sup> With interest rate inertia, equation (5), however, both the demand channel and the cost channel help to ensure determinacy (bottom right panel in Figure 3 where  $\psi = 0.25$  and  $\phi_r = 0.8$ ) and the Taylor Principle holds. Note that the determinacy region in the bottom right panel in Figure 3 is similar to the top left panel in Figure 1. And if the policy maker responds to future expected net worth instead, the determinacy region is similar to the bottom left panel in Figure 1.

$$r_t^n = \phi_r r_t^n + (1 - \phi_r)[\phi_\pi E_t \pi_{t+1} + \phi_y E_t y_{t+1}] \quad (5)$$

Overall, the conclusions from the current data policy rule carry through to the forward-looking policy rule. In particular, with interest rate smoothing, responding to future expected net worth would increase the likelihood of determinacy while responding to asset prices has no impact on equilibrium determinacy in the forward-looking policy rule.

### 3 Conclusion

Our main finding is that a central bank will not induce additional volatility, due to indeterminacy, by responding to financial sector variables. While responding to deviations in net worth makes indeterminacy less likely, responding to asset prices does not affect the determinacy conditions.

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<sup>7</sup>A higher capital adjustment cost along with a response to the current output gap (current net worth), also restores determinacy and the determinacy region is similar to the top left (bottom left) panel in Figure 1.

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## 4 Appendix

### Variables

$y$	output	$h$	labor
$c$	consumption	$r^k$	return on capital
$c^e$	entrepreneurial consumption	$-x$	marginal cost
$g$	government spending	$r$	real interest rate
$i$	investment	$a$	technology
$k$	capital		

### 4.1 Linearized equations from BGG (1999)

The capital letters without the time subscript denote the steady state value of the variable while the small letters with the time subscripts are the log deviations from the steady state.

$$y_t = \frac{C}{Y}c_t + \frac{I}{Y}i_t + \frac{C^e}{Y}c_t^e + \left(1 - \frac{C}{Y} - \frac{I}{Y} - \frac{C^e}{Y}\right)g_t + \dots + \phi_t^y \quad (6)$$

$$c_t = -r_{t+1} + E_t c_{t+1} \quad (7)$$

$$c_t^e = n_{t+1} + \dots + \phi_t^{c^e} \quad (8)$$

$$r_{t+1}^k = (1 - \epsilon)(y_{t+1} - k_{t+1} - x_{t+1}) + \epsilon q_{t+1} - q_t \quad (9)$$

$$E_t r_{t+1}^k - r_{t+1} = -v(n_{t+1} - (q_t + k_{t+1})) \quad (10)$$

$$q_t = \psi(i_t - k_t) \quad (11)$$

$$y_t = a_t + \alpha k_t + (1 - \alpha)\Omega h_t \quad (12)$$

$$y_t - h_t - x_t - c_t = \eta^{-1}h_t \quad (13)$$

$$\pi_t = -\kappa x_t + \beta E_t \pi_{t+1} \quad (14)$$

$$k_{t+1} = \delta i_t + (1 - \delta)k_t \quad (15)$$

$$n_{t+1} = \frac{\gamma RK}{N}(r_t^k - r_t) + r_t + n_t + \dots \phi_t^n \quad (16)$$

$$\phi_t^n = \frac{(R^k/R - 1)K}{N}(r_t^k + q_{t-1} + k_t) + \frac{(1 - \alpha)(1 - \Omega)(Y/X)}{N}y_t - x_t$$

$$g_t = \rho_g g_{t-1} + \varepsilon_t^g \quad (17)$$

$$a_t = \rho_a a_{t-1} + \varepsilon_t^a \quad (18)$$

Terms  $\phi_t^y$  and  $\phi_t^c$  are ignored following the literature. The New Keynesian Phillips curve, equation (14), is different from BGG but the same as Gilchrist and Leahy (2002) and Carlstrom and Fuerst (2005).

### Calibrated parameter values

$\alpha$	0.35
$\beta$	0.99
$\delta$	0.025
$(1 - \alpha)\Omega$	0.64
$\psi$	0.25; 2.0
$\nu$	0.05
$\theta$	0.75
$\gamma$	0.9728
$\kappa$	$\frac{(1-\theta)}{\theta}(1 - \theta\beta)$
$\eta$	3
$\epsilon$	$\frac{(1-\delta)}{(\alpha * Y / (XK) + 1 - \delta)}$
$N/K$	0.5
$C^e/Y$	0.04
$R^k - R$	0.005
$G/Y$	0.2
$X$	1.11

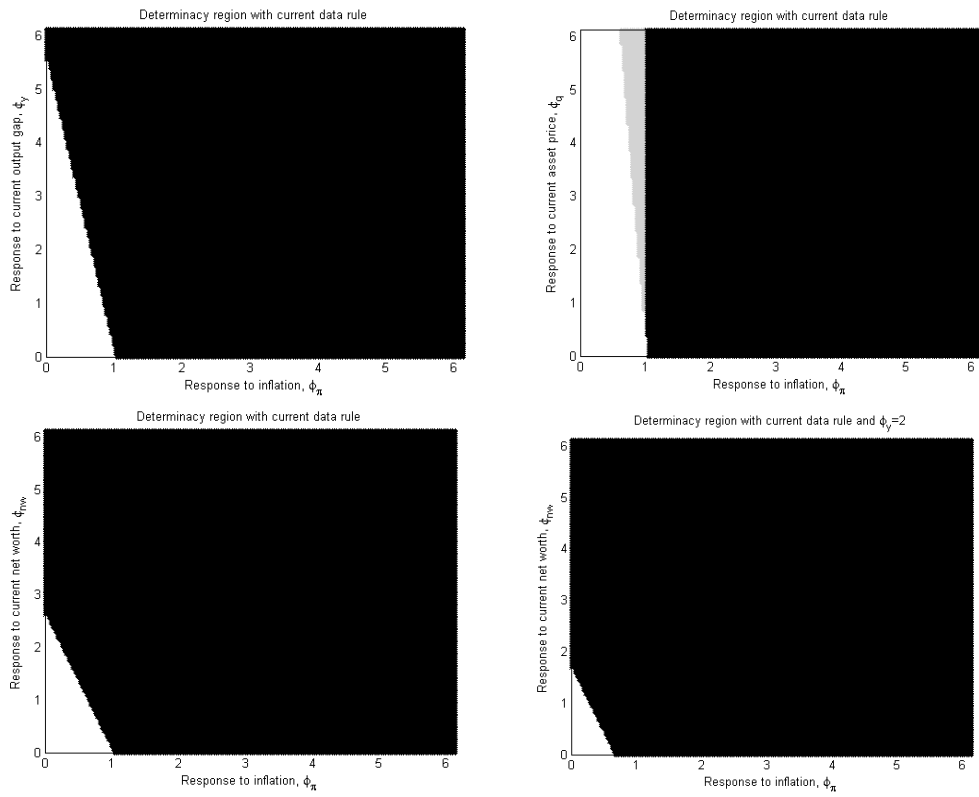


Figure 1: Current data rule with and without a response to financial sector variables.

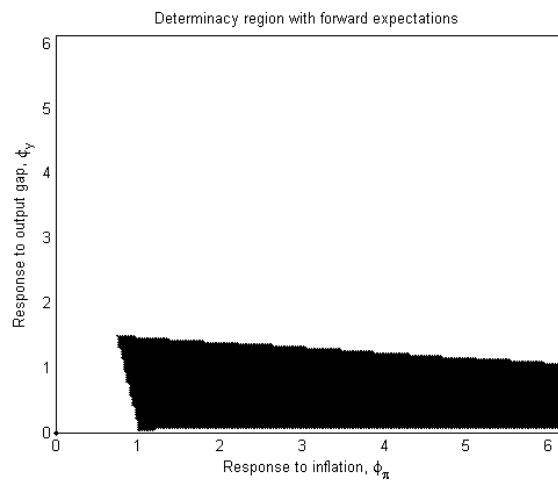


Figure 2: Forward-looking rule without a response to financial sector variables.

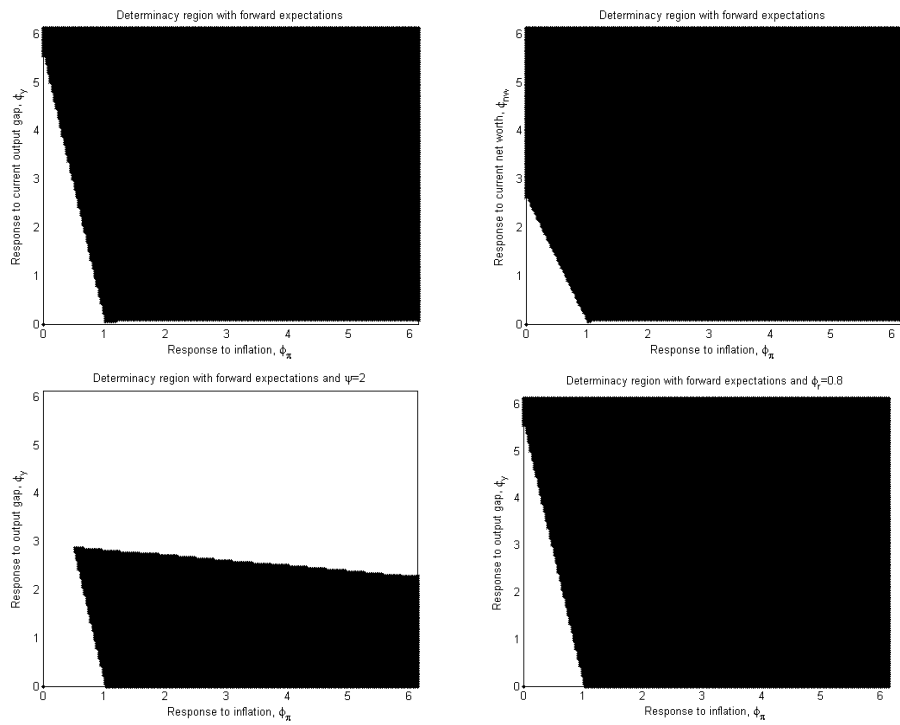


Figure 3: Restoring REE determinacy in forward-looking policy rules.