Economics Bulletin

Volume 29, Issue 2

Supply-side effects of monetary policy and the central bank's objective function

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Abstract

This paper considers a new Keynesian model with the cost channel and evaluates the supply-side effects of monetary policy on macroeconomic volatility and welfare, taking into account the endogenous nature of the objective function of monetary authorities. When the cost channel matters, supply-side effects of monetary policy depend on the degree of interest rate pass-through and the degree of price rigidity. Numerical results show that the welfare consequences of an increase in the degree of interest rate pass-through are independent of how the central bank specifies its loss function. By contrast, the welfare consequences of an increase in price rigidity depend critically on the nature of the loss function considered. Macroeconomic volatility as a function of the pass-through is almost independent of the central bank's loss function. In contrast, this volatility as a function of the degree of price rigidity depends more on the nature of the loss function.

Citation: Eurilton Araujo, (2009) "Supply-side effects of monetary policy and the central bank's objective function", *Economics Bulletin*, Vol. 29 no.2 pp. 680-692.
Submitted: Apr 04 2008. **Published:** April 27, 2009.

1. Introduction

Monetary policy analysis emphasizes the effects of interest rate changes on aggregate demand. Nevertheless, firms' costs of external finance are also sensitive to monetary policy outcomes. The model presented in Ravenna & Walsh (2006) changes the basic new Keynesian framework by introducing supply-side effects of monetary policy through the lending costs of firms. In this model, a trade-off between stabilizing inflation and the output gap emerges endogenously.

In Ravenna & Walsh (2006), firms borrow at the policy rate controlled by the central bank. Therefore, the interest rate pass-through is always equal to one. Following Chowdhury et al. (2006), I consider the effects of financial market imperfections on firms' lending costs, which imply varying degrees of pass-through from the policy risk-free interest rate to the bank lending rate. Thus, the effects of changes in the policy rate can be amplified or dampened.

When the cost channel matters, supply-side effects of monetary policy depend on the degree of interest rate pass-through and the degree of price rigidity.

In this paper, I derive the optimal monetary policy under discretion and evaluate quantitatively the macroeconomic effects of different degrees of interest rate pass-through and price rigidity. I consider both exogenous and endogenous loss functions. Following Walsh (2005), I take into account that the relative weights attached to competing objectives in the policy maker's loss function depend on structural parameters, and therefore are not exogenous.

Numerical simulations show that the welfare consequences of an increase in the degree of interest rate pass-through are independent of how the central bank specifies its loss function. By contrast, the welfare consequences of an increase in price rigidity depend critically on the nature of the loss function considered. Macroeconomic volatility as a function of the pass-through is almost independent of the central bank's loss function. On the other hand, the volatilities of macroeconomic variables as a function of the degree of price rigidity seem to be more sensitive to the way the loss function is specified.

The rest of the paper is organized as follows. In section 2, I describe briefly the model. In section 3, I derive the optimal monetary policy under discretion. Results are presented in section 4. I offer my conclusions in section 5.

2. The Model

2.1 Households

Households with a time-separable utility and a discount factor β, where $0 < \beta < 1$, maximize their expected lifetime utility given a sequence of budget constraints. The period utility is given by:

$$U(C_t, N_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{N_t^{1+\eta}}{1+\eta}$$

where C_t and N_t are consumption and employment, respectively.

The parameter σ denotes the inverse of the intertemporal elasticity of substitution and η is the inverse of the elasticity of substitution between work and leisure.

At each date, the budget constraint is:

$$M_{t+1} - M_t = W_t N_t - D_t + I_t D_t + \Pi_t - P_t C_t - P_t T_t$$

where D_t is the household's deposit at financial intermediaries, M_t is nominal money balances, W_t is the nominal wage, I_t is the gross nominal interest rate, Π_t is nominal profits received from firms, and T_t is a real lump-sum tax. The government satisfies its intertemporal budget constraint, not explicitly considered, by adjusting T_t.

Aggregate demand is derived from the representative household's Euler equation. After imposing market clearing conditions, the log-linear form of the Euler equation is:

$$x_t = E_t(x_{t+1}) - \frac{1}{\sigma}[i_t - E_t(\pi_{t+1})] + g_t \tag{1}$$

The variables x_t, i_t and π_t are the output gap, the nominal risk-free interest rate and inflation, respectively. Inflation and the nominal interest rate are expressed in log-deviations from their steady states.

A shock g_t is added to the aggregate demand equation. This disturbance follows an autoregressive process:

$$g_t = \rho_g g_{t-1} + \varepsilon_t^g \tag{2}$$

where $0 < \rho_g < 1$ is the autoregressive coefficient and ε_t^g is white noise, with variance σ_g^2.

2.2. Financial Intermediaries

The financial intermediaries receive deposits from households and supply loans to firms at the gross nominal interest rate I_t^l. At the end of each period, deposits and interests are repaid to households. Following Chowdhury et al.(2006), I consider financial market imperfections, which are captured by means of a function $\Psi(I_t)$ that depends on the risk-free interest rate. The function $\Psi(I_t)$ is defined in the interval $(0, 1)$ and can be interpreted as a measure of the likelihood of defaults on loans.

The profits are: $I_t^l[1 - \Psi(I_t)]Z_t - I_t D_t - vZ_t$, where Z_t is the supply of loans and v, a positive parameter, measures managing costs per unit of loans.

The financial intermediaries maximize profits subject to the balance sheet constraint $Z_t = D_t$. The first order condition in log-linear form implies:

$$i_t^l = (1 + \psi)i_t$$

where i_t^l is the bank lending rate and i_t is the policy risk-free interest rate.

The effects of changes in i_t on i_t^l, captured by ψ, can be amplified or dampened according to the relative importance of financial market imperfections and managing costs. Thus, the model generates varying degrees of pass-through from the policy risk-free interest rate to the bank lending rate.

2.3. Firms

Firms in a monopolistic competitive environment produce differentiated goods with a linear technology using only labor. The Calvo mechanism describes price decisions, where ω is the fraction of firms not adjusting their price in a given period. This parameter measures the degree of price rigidity.

Following Ravenna & Walsh (2006) and Chowdhury et al.(2006), firms have do pay for their wage bills before the goods market opens. Therefore, they have to borrow from financial intermediaries at the gross nominal interest rate I_t^l. In log-linear form, real marginal costs are $mc_t = i_t^l + s_t$, where i_t^l and s_t are the bank lending rate and real unit labor costs in log-deviations from their steady states.

In the neighborhood of a zero-inflation steady state, the new Keynesian Phillips curve characterizes inflation dynamics according to the following expression:

$$\pi_t = \beta E_t(\pi_{t+1}) + k(\sigma + \eta)x_t + k(1 + \psi)i_t + u_t \tag{3}$$

where $k = \frac{(1-\beta\omega)(1-\omega)}{\omega}$.

A cost-push shock u_t is added to the new Keynesian Phillips curve. This shock follows an autoregressive structure:

$$u_t = \rho_u u_{t-1} + \varepsilon_t^u \tag{4}$$

$0 < \rho_u < 1$ is the autoregressive coefficient and ε_t^u is white noise, with variance σ_u^2.

3. Optimal Monetary Policy under Discretion

The policy problem is to choose time paths for π_t, x_t and i_t that minimize the central bank's loss function, which translates the behavior of macroeconomic aggregates into a welfare measure to evaluate different policy choices. Clarida et al. (1999) and Giannoni & Woodford (2003a, 2003b) discuss more extensively the design of optimal monetary policies in new Keynesian models.

The policymaker seeks to minimize the objective function

$$L = \frac{1}{2} U_c Y E \left[\sum_{t=0}^{\infty} \beta^t (\lambda_\pi \pi_t^2 + \lambda_x x_t^2) \right] \tag{5}$$

subject to the constraints imposed by the structural equations (1) to (4).

The positive weights placed on the stabilization of inflation and the output gap are λ_π and λ_x. The variables U_c and Y are steady state values for the marginal utility of consumption and output. The product $U_c Y$ is a scale parameter which is normalized to one.

Woodford (2003) and Ravenna & Walsh (2006) show that expression (5) can be interpreted as a second-order approximation to the lifetime utility function of a representative household. In this case, the endogenous weights λ_π and λ_x are given by the following expressions:

$$\lambda_\pi = \frac{\theta}{k} \tag{6}$$

$$\lambda_x = (\sigma + \eta) \tag{7}$$

The parameter θ is the demand elasticity faced by individual firms.

I assume that monetary policy is set under discretion. In practice, monetary authorities do not make any kind of binding commitments concerning the course of future policy actions. In this context, the central bank cannot manipulate private expectations, which are taken as given. The optimal policy is obtained by solving the following sequence of static optimization problems:

$$\underset{\pi_t,x_t,i_t}{Min}\frac{1}{2}[\lambda_\pi \pi_t^2 + \lambda_x x_t^2] + F_t$$

subject to

$$x_t = -\frac{1}{\sigma}i_t + f_t \tag{8}$$

and

$$\pi_t = k(\sigma+\eta)x_t + k(1+\psi)i_t + h_t \tag{9}$$

where $f_t = E_t(x_{t+1}) + \frac{1}{\sigma}E_t(\pi_{t+1}) + g_t$ and $h_t = \beta E_t(\pi_{t+1}) + u_t$

The solution of the optimization problem implies:

$$x_t = -\frac{k(\eta - \sigma\psi)}{\lambda}\pi_t \tag{10}$$

where $\lambda = \frac{\lambda_x}{\lambda_\pi}$. If the central bank's objective function is endogenous, then $\lambda = \frac{k(\sigma+\eta)}{\theta}$.

The following first order stochastic difference equation, obtained from equations (1),(3), and (10), describes inflation dynamics.

$$\pi_t = \frac{\gamma_2}{1-\gamma_1}E_t(\pi_{t+1}) + \frac{k\sigma(1+\psi)}{1-\gamma_1}g_t + u_t$$

where $\gamma_1 = -\frac{k^2(\eta-\sigma\psi)^2}{\lambda}$ and $\gamma_2 = \beta + (1+\psi)k(1 - \frac{k\sigma(\eta-\sigma\psi)}{\lambda})$.

To find an analytical solution, according to the method of undetermined coefficients, I posit the following decision rule for inflation:

$$\pi_t = a_1 \; g_t + a_2 u_t \tag{11}$$

I solve for the unknown coefficients $a_1$and a_2 as a function of the structural parameters. The results are:

$$a_1 = \frac{k\sigma(1+\psi)}{1-\gamma_1-\rho_g\gamma_2}$$

$$a_2 = \frac{1}{1-\gamma_1-\rho_u\gamma_2}$$

I find the paths for x_t and i_t from equations (10) and (1).

4. Results

The parameters are calibrated following Ravenna & Walsh (2006). I set $\beta = 0.99$, $\sigma = 1.5$, $\omega = 0.75$, $\eta = 1$, $\theta = 1.2$, and $\psi = 0.3$. The exogenous loss function is defined by $\lambda_\pi = 1$ and $\lambda_x = 0.25$. When the central bank's objective is to maximize the utility function of the representative household, λ_π and λ_x are set according to (6) and (7). The shocks are calibrated according to Giannoni & Woodford (2002b). The autoregressive coefficients are $\rho_u = \rho_g = 0.35$. Finally, the variances are $\sigma_g^2 = 0.35$ and $\sigma_u^2 = 0.17$.

The parameter ψ is allowed to vary in the interval $[-1, 1]$. The lower bound corresponds to the situation in which the cost channel is absent. The degree of price rigidity ω is allowed to vary in the interval $[0.55, 0.85]$.

Figures 1 and 2 show the effects of different degrees of interest rate pass-through with exogenous and endogenous loss functions. There is a clear pattern in the behavior of volatilities as a function of the degree of interest rate pass-through. The volatility of inflation and the central bank's loss increase with the degree of pass-through. The volatilities of the output gap and the interest rate as a function of ψ do not follow any monotonic pattern, but their behavior seem to be independent of the way the positive weights placed on the stabilization of inflation and the output gap are specified. Though the volatilities of macroeconomic variables have different magnitudes according to the loss function in which the optimal policy is based on, these differences are small. In addition, the welfare effects of an increasing degree of pass-through do not depend on the specification of the central bank's loss function. The welfare performance, based on both loss functions, deteriorates as a function of ψ.

Figures 3 and 4 show the effects of different degrees of price rigidity with exogenous and endogenous loss functions. The output gap is less volatile if the optimal policy is based on the endogenous loss function. The behavior of the volatility of inflation as a function of ω is very different when the policy is based on different specifications for the loss function. If the central bank designs its policy based on the endogenous loss function, inflation decreases as ω increases. On the other hand, we do not observe this monotonic behavior in the equilibrium associated with the exogenous loss function. The output gap and the interest rate as a function of ω behave in the same way under both loss functions. The welfare performance, based on both loss functions, are very different. If the central bank's loss function is exogenous, the welfare measure increases with the degree of price rigidity. In contrast, the welfare performance, measured by the endogenous loss function, deteriorates as ω increases. In sum, when the cost channel matters, the welfare consequences of an increase in price rigidity depend critically on the nature of the loss function.

The discrepancy between the welfare performances as a function of ω can be explained by the fact that this parameter affects the evaluation of the loss function in two ways. First, the degree of price rigidity has an impact on the volatilities of inflation and the output gap because $\lambda = \frac{k(\sigma+\eta)}{\theta}$. Second, the weight λ_π is an increasing function of ω. In fact, the relative weight λ, which is constant if the loss function is exogenous, decreases as a function of ω if the loss function is endogenous. Therefore, more weight is attached to inflation relatively to the output gap as ω increases.

5. Conclusion

This paper considers a new Keynesian model with the cost channel and evaluates the supply-side effects of monetary policy on macroeconomic volatility and welfare, taking into account the endogenous nature of the objective function of monetary authorities. Numerical results suggest that the impact of endogenous objectives on the evaluation of monetary policies is quantitatively important, and can change the conclusions about how a structural change in the economy affects macroeconomic volatility and welfare measures.

This paper draws two main conclusions. First, macroeconomic volatility as a function of the pass-through is almost independent of the central bank's loss function. In contrast, this volatility as a function of the degree of price rigidity depends more on the nature of the loss function. Second, though the welfare consequences of an increase in the degree of interest rate pass-through are independent of how the central bank specifies its loss function, the welfare implications of an increase in price rigidity depend critically on the nature of the loss function.

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Figure 1: Pass-Through Effects with Exogenous Loss

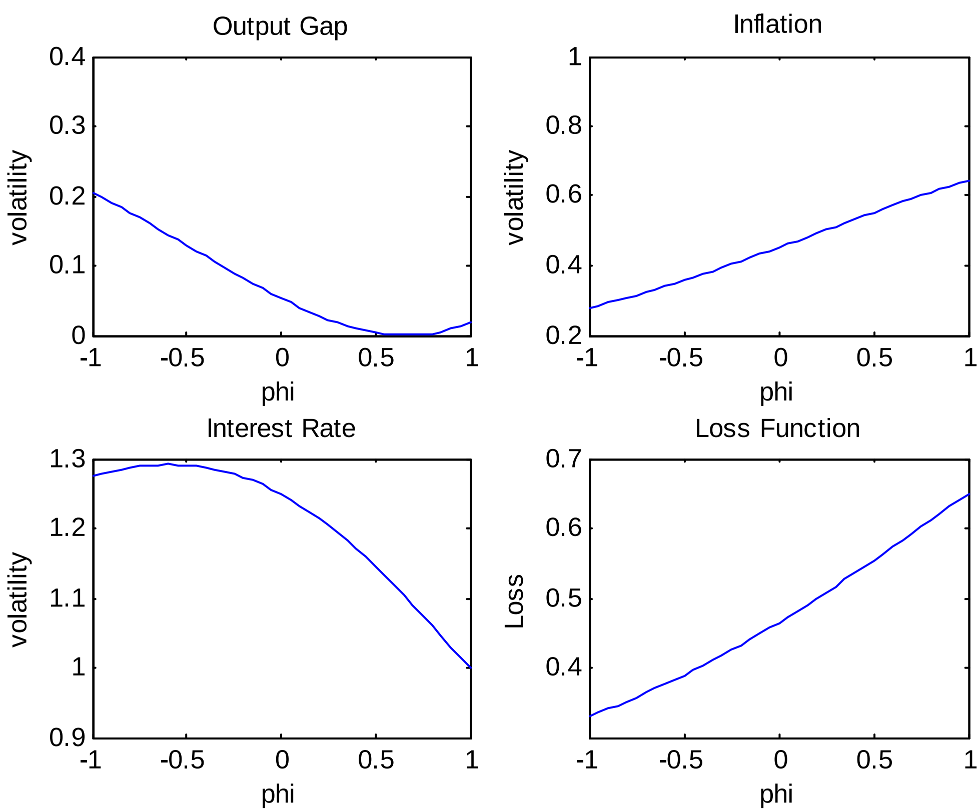

Figure 2: Pass-Through Effects with Endogenous Loss

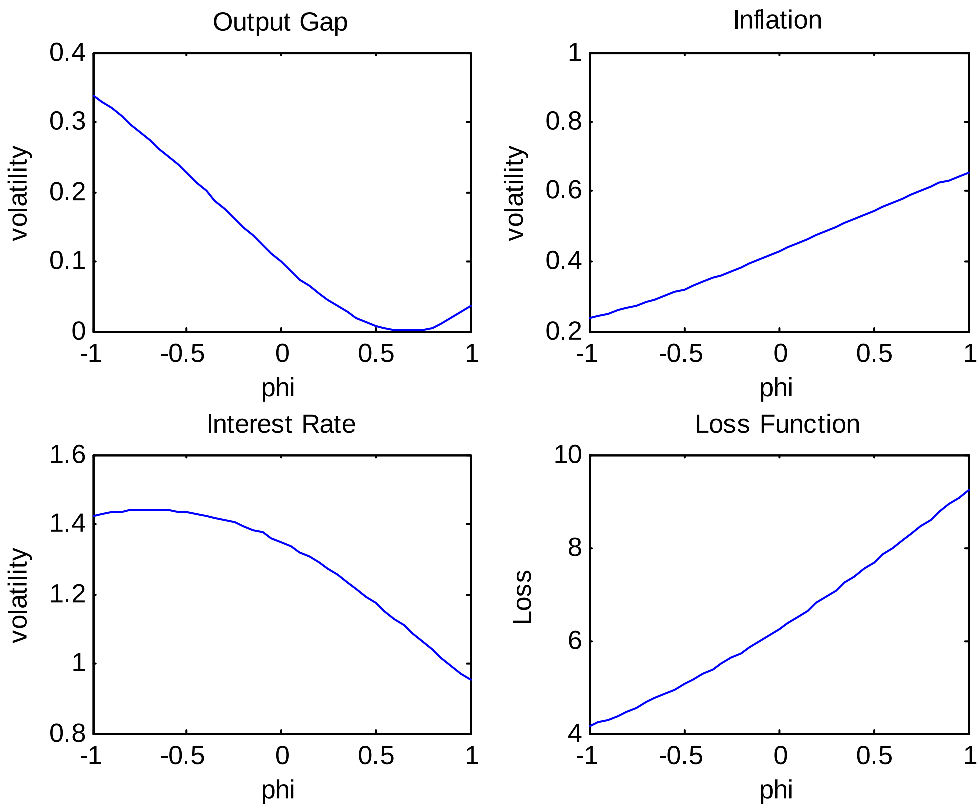

Figure 3: Price Rigidity Effects with Exogenous Loss

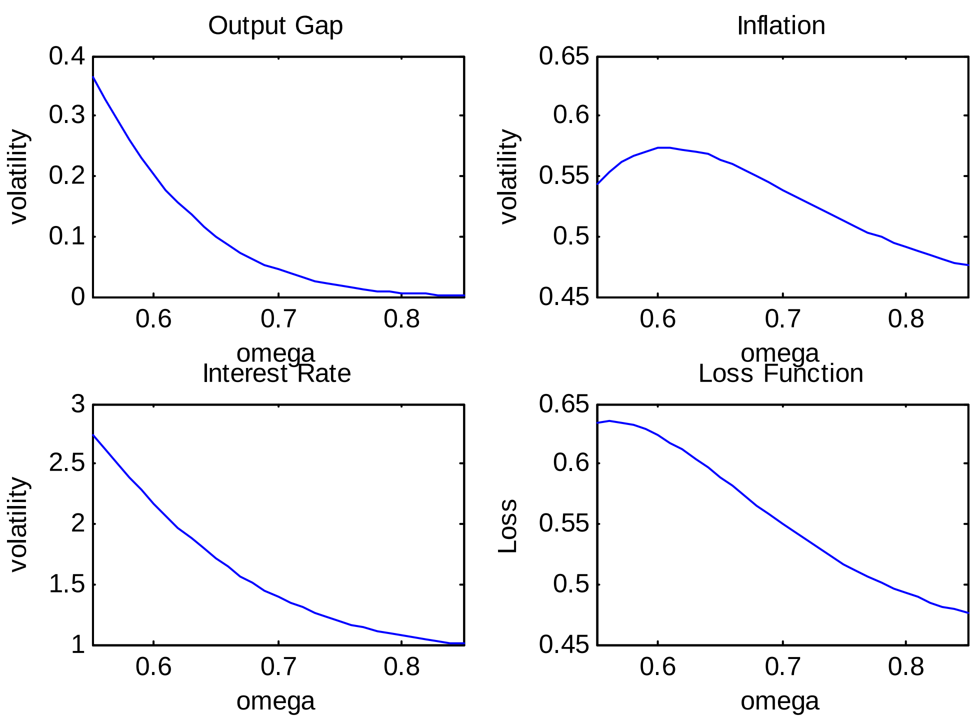

Figure 4: Price Rigidity Effects with Endogenous Loss