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State-dependent fiscal multipliers: Calvo vs. Rotemberg[☆]

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HIGHLIGHTS

- We study the fiscal multiplier in the Calvo and Rotemberg variants of the NK model.
- The multiplier is significantly more variable across states in the Rotemberg model.
- Multipliers are more variable when the nominal interest rate is pegged.
- The difference between models is magnified when the nominal interest rate is pegged.
- An interaction between inflation and the cost of inflation drives the difference.

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ABSTRACT

This paper studies the properties of the fiscal multiplier in both the Calvo (1983) and Rotemberg (1982) variants of the New Keynesian model. Though identical to first order, the two variants of the model are not the same globally or to higher order. We solve both versions of the model using a third order approximation, and compute the distributions of fiscal multipliers by drawing from the ergodic distributions of states. The multiplier is significantly more variable across states in the Rotemberg model. These differences are magnified when the nominal interest rate is pegged instead of governed by an active Taylor rule.

1. Introduction

There has recently been renewed interest in the use of fiscal policy as a macroeconomic stabilization tool, particularly in models with nominal rigidities and passive monetary policy. The textbook New Keynesian (NK) model incorporates nominal rigidity either via the Calvo (1983) assumption of staggered price-setting or the Rotemberg (1982) assumption that firms face a quadratic cost of price-adjustment. To a first order approximation about a zero inflation steady state, the two variants of the model are identical; this is not true globally or to a higher order approximation. Because the Rotemberg model features one fewer state variable, authors employing global solution methodologies to study the fiscal multiplier (e.g. Boneva et al. 2016) often favor its use to the Calvo model.

The objective of this paper is to examine the properties of the fiscal multiplier in both the Calvo and Rotemberg variants of the NK model. We parameterize the two variants of the model to be identical to first order, but solve the models via a third order approximation. In a higher order approximation, the effects of any shock depend on the initial state vector. We generate the ergodic distribution of states from both variants of the model and compute fiscal multipliers at each realization of the state vectors. The multiplier in the Rotemberg model is substantially more volatile than in the Calvo model, with a standard deviation across states

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that is roughly four times larger. We also compute multipliers across states when monetary policy is characterized by a transient interest rate peg instead of a Taylor rule. For both versions of the model, the mean and volatility of the multiplier across states is larger the longer is the duration of the interest rate peg, though the differences between the properties of the multiplier in the Rotemberg model relative to the Calvo model are accentuated. When the interest rate is pegged for eight periods, for example, the min–max range for the multiplier in the Rotemberg model is 1.4–2.9, compared to 1.7–2.0 for the Calvo model.

Our paper is related to previous work comparing the Calvo and Rotemberg models of price stickiness. Ascari and Rossi (2012) study the differences between the two variants of the NK model when steady state inflation differs from zero. Richter and Throckmorton (2016) estimate non-linear versions of the Calvo and Rotemberg models taking a ZLB constraint into account, and argue that the data favor the Rotemberg model. They argue that the Rotemberg model endogenously generates more volatility at the ZLB. Our results are similar in that we find the fiscal multiplier is more volatile across states in the Rotemberg model, though they do not study the fiscal multiplier. Miao and Ngo (2015) compare the fiscal multiplier in the Calvo and Rotemberg models in a fully non-linear solution. Our results are complementary to theirs in that we document substantial differences between the two variants of the model. Our paper differs from theirs in studying the two models under a Taylor rule in addition to periods where monetary policy is passive. We also focus on distributions of fiscal multipliers across all states, whereas they only focus on comparing multipliers in the two model variants when the interest rate is constrained by zero due to a preference shock.

2. Model

We briefly lay out the elements of a basic NK model under both the Calvo and Rotemberg models of price stickiness. The household, monetary, and fiscal sides of both versions of the model are identical. There is a representative household who saves through one period bonds and supplies labor. A monetary authority sets the nominal interest rate according to a Taylor rule. A fiscal authority chooses government consumption exogenously and finances this spending with lump sum taxes on the household.

The optimality conditions for the household are:

$$\omega N_t^{\frac{1}{\eta}} = \frac{1}{C_t} w_t \tag{1}$$

$$\frac{1}{C_t} = \beta(1+i_t)\mathbb{E}_t \frac{\nu_{t+1}}{\nu_t}\frac{1}{C_{t+1}}(1+\pi_{t+1})^{-1} \tag{2}$$

C_t is consumption, N_t is labor supply, and w_t is the real wage. ω is a scaling parameter and η is the Frisch labor supply elasticity. π_t is the inflation rate. (1) is an intratemporal labor supply condition and (2) is an intertemporal Euler equation. The nominal interest rate is i_t. ν_t is an exogenous preference shock which follows an AR(1) with non-stochastic mean of unity:

$$\ln \nu_t = \rho_\nu \ln \nu_{t-1} + s_\nu \varepsilon_{\nu,t}, \quad 0 \le \rho_\nu < 1, \quad \varepsilon_{\nu,t} \sim N(0,1) \tag{3}$$

The Taylor rule and process for government spending are:

$$\begin{aligned} i_t &= (1-\rho_i)i^* + \rho_i i_{t-1} \\ &+ (1-\rho_i)\Big[\phi_\pi(\pi_t - \pi^*) + \phi_y\left(\ln Y_t - \ln Y_t^f\right)\Big] \\ &+ s_i\varepsilon_{i,t}, \quad 0 \le \rho_i < 1, \quad \phi_\pi > 1, \quad \phi_y \ge 0 \end{aligned} \tag{4}$$

$$\begin{aligned} \ln G_t &= (1-\rho_G)\ln G^* + \rho_G \ln G_{t-1} + s_G\varepsilon_{G,t}, \\ &0 \le \rho_G < 1, \quad \varepsilon_{G,t} \sim N(0,1) \end{aligned} \tag{5}$$

The non-stochastic steady state value of government spending is G^*. The non-stochastic mean of the interest rate is i^*, and π^* is an exogenous inflation target. Y_t^f is the hypothetical flexible price level of output and is the same across both variants of the model. A continuum of firms, indexed by $j \in (0, 1)$, produce differentiated goods according to the production technology:

$$Y_t(j) = A_t N_t(j) \tag{6}$$

A_t is an exogenous productivity shock and follows an AR(1) with non-stochastic mean of unity:

$$\ln A_t = \rho_A \ln A_{t-1} + s_A\varepsilon_{A,t}, \quad 0 \le \rho_A < 1, \quad \varepsilon_{A,t} \sim N(0,1) \tag{7}$$

Intermediates are bundled into a final output good via a CES technology with elasticity of substitution $\epsilon > 1$. Cost-minimization implies that all firms have the same real marginal cost:

$$mc_t = \frac{w_t}{A_t} \tag{8}$$

The flexible price level of output is implicitly defined by:

$$\omega\left(\frac{Y_t^f}{A_t}\right)^{\frac{1}{\eta}} = \frac{1}{Y_t^f - G_t}\frac{\epsilon-1}{\epsilon}A_t \tag{9}$$

2.1. Calvo model

In the Calvo model a randomly selected fraction of firms, $1-\theta$, with $\theta \in [0, 1)$, can adjust their price in a given period. All updating firms adjust to the same price, $P_t^{\#}$. The optimal reset price, $1+\pi_t^{\#} = \frac{P_t^{\#}}{P_{t-1}}$, satisfies:

$$\frac{1+\pi_t^{\#}}{1+\pi_t} = \frac{\epsilon}{\epsilon-1}\frac{x_{1,t}}{x_{2,t}} \tag{10}$$

$$x_{1,t} = \frac{1}{C_t} mc_t Y_t + \theta\beta\mathbb{E}_t(1+\pi_{t+1})^{\epsilon}x_{1,t+1} \tag{11}$$

$$x_{2,t} = \frac{1}{C_t} Y_t + \theta\beta\mathbb{E}_t(1+\pi_{t+1})^{\epsilon-1}x_{2,t+1} \tag{12}$$

Inflation evolves according to:

$$(1+\pi_t)^{1-\epsilon} = (1-\theta)(1+\pi_t^{\#})^{1-\epsilon} + \theta \tag{13}$$

The aggregate production function is:

$$Y_t = \frac{A_t N_t}{v_t^p} \tag{14}$$

v_t^p is a measure of price dispersion:

$$v_t^p = (1+\pi_t)^{\epsilon}\left[(1-\theta)(1+\pi_t^{\#})^{-\epsilon} + \theta v_{t-1}^p\right] \tag{15}$$

The aggregate resource constraint is:

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

2.2. Rotemberg model

In the Rotemberg model, firms face a quadratic cost of adjusting their price governed by the parameter $\psi \ge 0$. This resource cost is proportional to nominal GDP. In equilibrium all firms behave identically and charge the same prices. The inflation rate satisfies:

$$\begin{aligned} \epsilon - 1 &= \epsilon mc_t - \psi(1+\pi_t)\pi_t \\ &+ \beta\mathbb{E}_t\frac{C_t}{C_{t+1}}\psi(1+\pi_{t+1})\pi_{t+1}\frac{Y_{t+1}}{Y_t} \end{aligned} \tag{17}$$