Welfare Loss and Policy Trade-Offs: Calvo vs. Rotemberg*

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Abstract

This paper shows that the Calvo and Rotemberg pricing models lead to different outcomes regarding welfare losses and inflation-output dynamics, based on the type of subsidies used to achieve an efficient steady state. When revenue subsidies are applied in the Rotemberg model, the inflation-output dynamics and welfare loss functions are identical to those of the Calvo model. However, with employment subsidies, the two models differ. Aligning the inflation-output dynamics causes differences in the welfare loss function. These findings underscore the importance of model selection in the design of monetary policy, influencing the trade-off between inflation and output gap stabilisation.

Keywords: Welfare loss, New Keynesian Phillips curve, Optimal monetary policy

JEL Classification: E12, E44, E52

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1 Introduction

Monetary policy models often rely on either the Calvo (1983) or Rotemberg (1982) pricing mechanisms to introduce nominal price rigidity. These models have been studied extensively for their implications on inflation and output dynamics, as well as welfare losses. Previous literature, notably Nisticó (2007) and Lombardo and Vestin (2008), demonstrated that under efficient steady-state conditions with revenue subsidies to firms, the two models produce identical inflation-output dynamics and identical welfare loss functions.

However, this paper argues that the type of subsidy plays a crucial role in determining the outcomes, particularly in the Rotemberg model. Employment subsidies are commonly used in the literature, such as in Galí and Monacelli (2005) and Galí (2015), to correct distortions stemming from monopolistic competition. When subsidies are provided to employment rather than revenue, it becomes impossible to make both inflation-output dynamics and welfare loss functions identical across the Calvo and Rotemberg models.

The Calvo model assigns a larger weight to inflation in its welfare loss function compared to the Rotemberg model when subsidies are provided to employment. Consequently, the Calvo model leads to policies that prioritise inflation stabilisation more aggressively, at the expense of higher output gap volatility. This distinction has significant implications for optimal policy design, particularly when managing the trade-offs between inflation stabilisation and output gap stabilisation, as the choice of subsidy type directly affects these trade-offs. Furthermore, understanding these differences is crucial for researchers working on nonlinear sticky-price models, such as those incorporating heterogeneous agents (e.g., Acharya et al., 2023 and Bilbiie, 2024) or the zero lower bound (e.g., Eggertsson and Woodford, 2003, Nakata, 2017, and Bonciani and Oh, 2025), where the interaction between pricing mechanisms and subsidy policies can shape policy outcomes and welfare implications.

2 The Calvo and Rotemberg Models

I consider two sticky-price models with alternative price-setting mechanisms. The first one is the Calvo model, in which a fraction of firms can adjust prices each period, leading to price dispersion. The second one is the Rotemberg model, which assumes that firms face quadratic adjustment costs when changing prices.

2.1 New Keynesian Phillips Curves

The New Keynesian Phillips curve (NKPC) plays a central role in both models, linking inflation and the output gap. For the Calvo model, the NKPC is derived as:

$$\hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta} (\sigma + \varphi) \hat{x}_t + \hat{u}_t, \tag{1}$$

where $\hat{\pi}_t$ is inflation, $\hat{x}_t$ is the output gap, and $\hat{u}_t$ is a cost-push shock which follows the exogenous AR(1) process. β is the discount factor, θ is the Calvo price rigidity parameter, σ is the inverse elasticity of intertemporal substitution, and φ is the inverse labor supply elasticity. In the Calvo model, the NKPC remains identical irrespective of where the subsidy is applied (employment or revenue). That is not the case in the Rotemberg model. When subsidies are provided to employment, the NKPC in the Rotemberg model takes the form:[1]

$$\hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\varepsilon - 1}{\phi_1} (\sigma + \varphi) \hat{x}_t + \hat{u}_t. \tag{2}$$

On the other hand, when subsidies are provided to revenue, it takes the form:

$$\hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\varepsilon}{\phi_2} (\sigma + \varphi) \hat{x}_t + \hat{u}_t, \tag{3}$$

where ε is the elasticity of the intermediate good's demand and ϕ_1 and ϕ_2 are the corresponding Rotemberg price rigidity parameters. The NKPCs become identical if we set the Rotemberg price

[1] The NKPC is identical to that under an inefficient steady state in the Rotemberg model.

rigidity parameters as:

$$\phi_1 = \frac{(\varepsilon - 1)\,\theta}{(1-\theta)\,(1-\theta\beta)}, \quad \phi_2 = \frac{\varepsilon\theta}{(1-\theta)\,(1-\theta\beta)}. \tag{4}$$

This adjustment ensures that all models have the same inflation-output gap relationship, despite their different price-setting mechanisms.

2.2 Welfare Loss Functions

I derive a second-order approximation to the welfare loss functions as in Woodford (2003) and Galí (2015). For the Calvo model, the average welfare loss per period can be derived as:

$$\mathbb{L}^C = \frac{1}{2}\left(\frac{\varepsilon\theta}{(1-\theta)\,(1-\theta\beta)} var\left(\hat{\pi}_t\right) + (\sigma+\varphi)\, var\left(\hat{x}_t\right)\right), \tag{5}$$

For the Rotemberg model, the average welfare losses per period are derived similarly:

$$\mathbb{L}^{Ri} = \frac{1}{2}\left(\phi_i var\left(\hat{\pi}_t\right) + (\sigma+\varphi)\, var\left(\hat{x}_t\right)\right), \quad i \in \{1, 2\}. \tag{6}$$

In the Rotemberg model, the results depend on the type of subsidy. When subsidies are applied to revenue, the welfare loss function is identical to that in the Calvo model, as shown in Nisticó (2007) and Lombardo and Vestin (2008):

$$\frac{\varepsilon\theta}{(1-\theta)\,(1-\theta\beta)} = \phi_2 > \phi_1 = \frac{(\varepsilon-1)\,\theta}{(1-\theta)\,(1-\theta\beta)}. \tag{7}$$

However, when subsidies are applied to employment, the inflation-output dynamics can be matched with the Calvo model, but this leads to a divergence in the welfare loss functions. This inequality suggests that welfare losses due to inflation are smaller in the Rotemberg model with employment subsidies than in the Calvo framework.

3 Optimal Monetary Policy

In this section, I analyse how the type of subsidy affects the design of optimal monetary policy under discretion and commitment.

Table 1: Quarterly Calibration

Parameter	Description	Value
β	Discount factor	0.99
θ	Calvo price rigidity	0.75
σ	Inverse elasticity of intertemporal substitution	1
φ	Inverse labor supply elasticity	1
ε	Elasticity of the intermediate good's demand	6
ρ_u	Cost-push shock persistence	0.9
σ_u	Cost-push shock volatility	0.01

Table 2: Welfare Loss Evaluation

	Calvo = Rotemberg 2			Rotemberg 1		
	$\mathbb{L}^C = \mathbb{L}^{R2}$	$var\left(\hat{\pi}_t\right)$	$var\left(\hat{x}_t\right)$	$\mathbb{L}^{R1}$	$var\left(\hat{\pi}_t\right)$	$var\left(\hat{x}_t\right)$
Discretion	2.88%	0.04%	1.46%	3.04%	0.06%	1.41%
Commitment	1.59%	0.004%	1.46%	1.56%	0.005%	1.42%

Note: Rotemberg 1 refers to the Rotemberg model with employment subsidies, while Rotemberg 2 refers to the Rotemberg model with revenue subsidies.

3.1 Calibration and Solution Method

The models are calibrated to a quarterly frequency. I parameterise the model using standard values in the literature, as listed in Table 1. Then, I solve the models using a first-order approximation around the deterministic steady state by using the Dynare software package developed by Adjemian et al. (2024).

3.2 Numerical Results

Table 2 reports the average welfare loss per period and the variances of inflation and the output gap for all models. Figure 1 plots the impulse response functions of inflation and the output gap to a positive cost-push shock in the Calvo and Rotemberg models under optimal discretion and commitment policies.

This distinction is crucial when designing monetary policy. As seen in Table 2 and Figure 1, under both discretion and commitment, the Calvo model and the Rotemberg 2 model (with revenue subsidies) result in identical welfare losses, leading to smaller inflation variance but at the cost

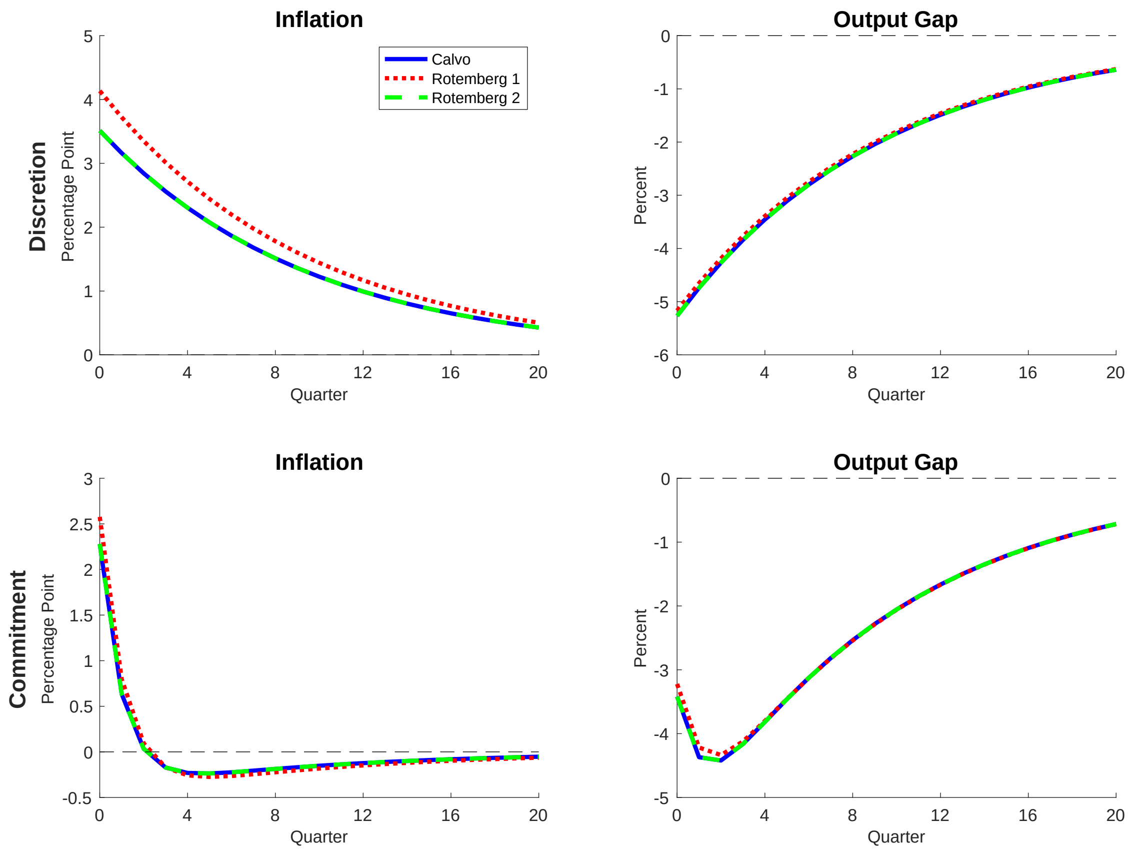

Figure 1: Impulse Responses to a Positive Cost-Push Shock

Note: The figure displays the impulse responses to a positive cost-push shock under the optimal monetary policy under discretion and commitment. Rotemberg 1 refers to the Rotemberg model with employment subsidies, while Rotemberg 2 refers to the Rotemberg model with revenue subsidies. Inflation is expressed as an annualised percentage-point deviation from the steady state. The output gap is expressed as percentage deviations from the steady state.

of higher output gap variance compared to the Rotemberg 1 model (with employment subsidies). This indicates that the Calvo model prioritises inflation stabilisation more aggressively, while the Rotemberg 1 model places greater emphasis on stabilising the output gap. As a result, the Calvo model favours policies that reduce inflation volatility at the expense of greater output gap volatility compared to the Rotemberg 1 model.

4 Conclusion

This paper has examined how different types of subsidies used to achieve an efficient steady state affect the welfare loss function and inflation-output dynamics in the Calvo and Rotemberg models.

When revenue subsidies are applied in the Rotemberg model, the inflation-output dynamics and welfare loss functions are identical to those of the Calvo model, resulting in no distinction between the two in terms of policy implications. However, when employment subsidies are applied in the Rotemberg model, the results diverge.

In particular, we show that in this case it is not possible to match both the inflation-output dynamics and the welfare losses across the two models. These findings show that the type of subsidy plays a critical role in shaping the policy trade-offs within the Rotemberg model, a factor that is not a concern in the Calvo model. This highlights the importance of model selection in the design of monetary policy, as different models imply different policy trade-offs and welfare outcomes.

Appendices

A New Keynesian Phillips Curve

In this section, I derive the New Keynesian Phillips curve (NKPC) for both the Calvo and Rotemberg models, respectively.

A.1 Calvo Model

According to the stochastic time-dependent rule proposed by Calvo (1983), in each period, an intermediate goods firm i keeps its previous price with probability θ and resets its price with probability $1-\theta$. The firm that gets the chance to set its price chooses its price $P_t^\star(i)$ to maximise:

$$\max_{P_t^\star(i)} \mathbb{E}_t \sum_{j=0}^{\infty} \theta^j \Lambda_{t,t+j} \left(\left((1+\tau_p) \frac{P_t^\star(i)}{P_{t+j}} - (1-\tau_n) \frac{MC_{t+j}}{P_{t+j}} \right) Y_{t+j}(i) - T_{t+j} \right), \tag{A.1}$$

subject to its demand:

$$Y_t(i) = \left(\frac{P_t^\star(i)}{P_t} \right)^{-\varepsilon} Y_t, \tag{A.2}$$

where $\Lambda_{t,t+j}$ is the stochastic discount factor for real payoffs of the households, MC_t is the nominal marginal cost, and T_t is a lump-sum tax. τ_p is a revenue subsidy and τ_n is an employment subsidy. The optimal reset price, $P_t^\star(i) = P_t^\star$, is the same for all firms resetting their prices in period t because they face the identical problem above. This implies that the optimal reset price $p_t^\star = \frac{P_t^\star}{P_t}$ is:

$$p_t^\star = \frac{\varepsilon}{\varepsilon - 1} \frac{p_t^n}{p_t^d}, \tag{A.3}$$

$$p_t^n = (1-\tau_n)\, mc_t Y_t + \theta \mathbb{E}_t \Lambda_{t,t+1} {\pi_{t+1}}^{\varepsilon} p_{t+1}^n, \tag{A.4}$$

$$p_t^d = (1+\tau_p)\, Y_t + \theta \mathbb{E}_t \Lambda_{t,t+1} {\pi_{t+1}}^{\varepsilon-1} p_{t+1}^d, \tag{A.5}$$

$$p_t^\star = \left(\frac{1 - \theta {\pi_t}^{\varepsilon-1}}{1-\theta} \right)^{\frac{1}{1-\varepsilon}}. \tag{A.6}$$

There are two cases to eliminate distortions stemming from monopolistic competition: (i) employment subsidy ($\tau_p = 0$ and $\tau_n = \frac{1}{\varepsilon}$) and (ii) revenue subsidy ($\tau_p = \frac{1}{\varepsilon - 1}$ and $\tau_n = 0$). However, the linearised NKPC remains identical regardless of where the subsidy is applied:

$$\hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta} \hat{mc}_t. \tag{A.7}$$

A.2 Rotemberg Model

Rotemberg (1982) assumes that each intermediate goods firm i faces costs of adjusting price, which are assumed to be quadratic and zero at the steady state. Therefore, firm i sets its price $P_t(i)$ to maximise profits given by:

$$\max_{P_t(i)} \mathbb{E}_t \sum_{j=0}^{\infty} \Lambda_{t,t+j} \left(\left((1+\tau_p) \frac{P_{t+j}(i)}{P_{t+j}} - (1-\tau_n) \frac{MC_{t+j}}{P_{t+j}} \right) Y_{t+j}(i) + \frac{\phi}{2} \left(\frac{P_{t+j}(i)}{P_{t+j-1}(i)} - 1 \right)^2 Y_{t+j} - T_{t+j} \right), \tag{A.8}$$

subject to its demand:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\varepsilon} Y_t. \tag{A.9}$$

Since all intermediate goods firms face an identical profit maximisation problem, they choose the same price $P_t(i) = P_t$ and produce the same quantity $Y_t(i) = Y_t$. In a symmetric equilibrium, the optimal pricing rule implies:

$$\phi(\pi_t - 1)\pi_t = \phi \mathbb{E}_t \Lambda_{t,t+1} (\pi_{t+1} - 1) \pi_{t+1} \frac{Y_{t+1}}{Y_t} + (1+\tau_p)(1-\varepsilon) + (1-\tau_n) \varepsilon mc_t. \tag{A.10}$$

Contrast to the Calvo model, the linearised NKPCs for each case are as follows:

(i) Employment subsidy ($\tau_p = 0$ and $\tau_n = \frac{1}{\varepsilon}$):

$$\hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\varepsilon - 1}{\phi} \hat{mc}_t, \tag{A.11}$$

(ii) Revenue subsidy ($\tau_p = \frac{1}{\varepsilon - 1}$ and $\tau_n = 0$):

$$\hat{\pi}_t = \beta \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\varepsilon}{\phi} \hat{mc}_t. \tag{A.12}$$

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