Sticky Information versus Sticky Prices

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Abstract

Mankiw and Reis (2002) have proposed to replace price stickiness by information stickiness in order to correctly reproduce empirical regularities concerning inflation-output dynamics. Using a DSGE framework, we compare this model to other sticky price based models. We show that sticky information model does not generate more consistent inflation-output dynamics.

1 Introduction

The Calvo (1983) model of staggered price setting has been abundantly used on the analysis of monetary policy during the last decade. Nevertheless, several empirical studies demonstrated that this sticky price model predictions on inflation-output dynamics are not plausible. As Mankiw and Reis (2002) point out, the model does not generate the delayed and gradual response of inflation to a monetary shock (Mankiw (2001),Christiano, Eichenbaum, and Evans (2001)). It cannot explain the observed persistence in inflation and output (Fuhrer and Moore (1995)). Mankiw and Reis (2002) show that the inflation-output dynamics generated by the model are not compatible with the so-called acceleration phenomenon, the fact that the change in inflation is positively correlated with economic activity.

Most of these critics point out the completely forward looking structure of the Calvo model of price setting. Even in a scheme where firms face constraints on their price adjustment and individual price adjustments are sticky, inflation adjustment occurs immediately.

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The early response to these critics has been to introduce backward looking behaviors for price setters to allow inflation inertia in the model. For example, in a slightly different manner, both Gali and Gertler (1999) and Christiano, Eichenbaum, and Evans (2001) assume that a fraction of firms index their prices to the last observed inflation rate. This kind of model with indexation exhibits more persistent in inflation and reproduce the gradual and delayed response of inflation to a monetary shock.

Alternatively, Mankiw and Reis (2002) have proposed to quit the sticky price framework. In particular, they propose to replace the sticky price hypothesis by a sticky information hypothesis. The idea of sticky information is that information disseminates slowly throughout the population. Using a partial equilibrium framework with a simple demand side, they perform some monetary policy experiments and they show that the sticky information model matches better than sticky price model the empirical facts concerning the effects of monetary policy.

The aim of this paper is to compare inflation dynamics predicted by all three model using a general equilibrium framework with monopolistic competition and nominal rigidities. Our result show that when the overall economy is specified with optimizing agents, the sticky information model does not reproduce the empirical regularities much better than basic Calvo model and the only model to deliver delayed and gradual response of inflation is the sticky price with indexation model.

The rest of the paper is organized as follows. Section 2 describes our model specification and the three price setting framework. Section 3 presents the parameterization and the simulation results. Section 4 concludes.

2 The model

In this section, we develop a general equilibrium model with monopolistic competition, nominal rigidities and capital adjustment cost. The model economy is composed of a large number of infinitely lived utility maximizing households, intermediate and final good producer firms, and a government sector.

2.1 Households

The objective of the representative household is to maximize following intertemporal utility function:

$$E_t\left[\sum_{i=0}^{\infty}\beta^i\left(\frac{C_{t+i}^{1-\gamma}}{1-\gamma}+\frac{a_m}{1-\gamma_m}\left(\frac{M_{t+i}}{P_{t+i}}\right)^{1-\gamma_m}-\frac{a_n}{1+\gamma_n}N_{t+i}^{1+\gamma_n}\right)\right] \tag{1}$$

subject to the budget constraint:

$$P_t(C_t+I_t+T_t)+M_t-M_{t-1}+B_t-R_{t-1}B_{t-1}=W_tN_t+P_tZ_tK_{t-1}+d_t \tag{2}$$

where $0<\beta<1$ is a discount factor, C_t is the level of final good consumption, $\frac{M_t}{P_t}$ is real money balances and N_t is household's labor supply. The risk aversion, γ the elasticity of real money balances, γ_m and the marginal disutility of labor supply, γ_n are positive parameters.

The budget constraint of the household is described as follows: Each period, the representative household receives from firms a payment for labor $\frac{W_t}{P_t}N_t$ and capital services Z_tK_{t-1} where W_t is the nominal wage, Z_t the real rental rate of capital services and K_{t-1} the level of capital owned by the household. The firms pay also a dividend d_t to households. The representative household receives lump sum net transfers τ_t from government. Household use those resources for the total expenditure on consumption, C_t, and investment,I_t and the change in money holdings, M_t-M_{t-1} and bonds $B_t-R_{t-1}B_{t-1}$.

The household also accumulate capital according to the following law of motion:

$$K_t=(1-\delta)K_{t-1}+I_t-\frac{\psi}{2}\left(\frac{I_t-\delta K_{t-1}}{K_{t-1}}\right)^2K_{t-1} \tag{3}$$

where the last term captures the adjustment cost with ψ the adjustment cost parameter and δ the depreciation rate.

The household determines consumption, money holdings, bonds level, labor supply, capital level and investment by maximizing utility function subject to budget and capital accumulation constraints.

2.2 Firms

The economy is composed of two types of firms: final good producers and intermediate good producers.

2.2.1 Final good producers

Final good firms are operating in a perfectly competitive market. They produce a homogenous final output by combining different inputs purchased from intermediate good producer. They transform intermediate goods to final output according to following constant returns to scale CES production function:

$$Y_t = \left(\int_0^1 Y_t(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{4}$$

where $\varepsilon > 1$ is the price elasticity of final good firm's demand. Cost minimization yields the well known demand function where the demand for each input $Y_t(z), z \in (0,1)$ depend on its relative price:

$$Y_t(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\varepsilon} Y_t \tag{5}$$

where P_t is a price index given by:

$$P_t = \left(\int_0^1 P_t(z)^{1-\varepsilon} dz \right)^{\frac{1}{1-\varepsilon}} \tag{6}$$

2.2.2 Intermediate good producer

Intermediate firms, indexed by $z \in]0,1[$, are monopolistically competitive producers of differentiated goods. Each producer faces the demand curve described above and produces output using labor, $N_t(z)$, and capital, $K_{t-1}(z)$, according to a Cobb-Douglas production function:

$$Y_t(z) = A_t K_{t-1}(z)^{\alpha} N_t(z)^{(1-\alpha)} \tag{7}$$

where A_t is an exogenous technology shock. Each period, every firms pays wage, W, for labor, and rent capital from households at a market price, Z_t. Assuming that input markets are perfectly competitive, cost minimization subject to production function yields following factor demands:

$$Z_t = MC_t \alpha \frac{Y_t}{K_{t-1}} \tag{8}$$

and

$$\frac{W_t}{P_t} = MC_t (1-\alpha) \frac{Y_t}{N_t} \tag{9}$$

where $MC_t = \frac{1}{A_t} \left(\frac{W_t}{\alpha} \right)^{\alpha} \left(\frac{Z_t}{1-\alpha} \right)^{1-\alpha}$is the real marginal cost of the firm and the Lagrangian multiplier for the constraint.

As firms on intermediate goods sector are monopolistic competitors, they set prices for their outputs. Note that if prices are flexible and firms have full information about the current state of the economy, the desired price of a firm is simply a markup over his marginal cost as in standard monopoly theory, where the markup is determined by the price elasticity of demand.

We now introduce different price setting behavior. We begin with sticky price model. We assume that every period only a random fraction $(1-\theta)$ of firms has the opportunity of adjusting their price while the remaining fraction of firms keeps their price unchanged. The probability for an individual firm to make part of this fraction is independent of the time elapsed since the last adjustment and of other firms. Note that under this specification, the average time during which a firm price remains fixed is $\frac{1}{1-\theta}$.Formally firms adjusting their price choose their new prices $P_t(z)$ to maximize:

$$E_t \sum_{i=0}^{\infty} (\theta\beta)^i \Lambda_{t,t+i} \left(\left(\frac{P_t(z)}{P_{t+i}} - MC_t \right) Y_{t+i}(z) \right) \tag{10}$$

where $\Lambda_{t,t+i} = \left(\frac{C_{t,t+i}}{C_t}\right)^{-\gamma}$ is the relevant discount factor. The intuition is that a firm maximizes its intertemporal profit by taking into account the fact that its price may remain fixed during several periods. The term θ^i captures this fact. Since all firms face the same optimization problem, each firm chooses the same optimal price $P_t^*(z) = P_t^*$. The solution to the maximization problem yields the following expression for the firm's optimal price:

$$P_t^* = \frac{\varepsilon}{\varepsilon - 1} \sum_{i=0}^{\infty} \zeta_{t+i} MC_{t+i}^n \tag{11}$$

where $\zeta_{t+i} = \frac{(\theta\beta)^i E_t(\Lambda_{t,t+i} Y_{t+i} P_{t+i}^{\varepsilon-1})}{\sum_{i=0}^{\infty} (\theta\beta)^i E_t(\Lambda_{t,t+i} Y_{t+i} P_{t+i}^{\varepsilon-1})}$ and $MC_t^n = P_t MC_t$ is firm's nominal marginal cost. This equation indicates that a firm's optimal price is a weighted sum of expected future marginal cost. Notice that given the definition of ζ, firm's optimal price depends also on expected futur aggregate variables, i.e. expected future economic conditions.

Given that the remaining fraction of firms keeps their price fixed in $t-1$, the price index can be written:

$$P_t = \left(\theta P_{t-1}^{1-\varepsilon} + (1-\theta) P_t^{*1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}} \tag{12}$$

implying a difference equation for the price level.

The second model we use is a variant of the Calvo model with indexation. Different authors have introduced indexation and rule of thumb behavior in various ways. Here we take an indexation behavior as presented in Woodford (2003), Christiano, Eichenbaum, and Evans (2001). The difference with the basic Calvo price setting is that the fraction of firms that did not have the possibility to change their price use a simple rule by indexing their price to the last observed inflation rate. The price index becomes:

$$P_t = \left(\theta \left(P_{t-1} \left(\frac{P_{t-1}}{P_{t-2}} \right)^{w} \right)^{1-\varepsilon} + (1-\theta) P_t^{*1-\varepsilon} \right)^{\frac{1}{1-\varepsilon}} \tag{13}$$

where w is the indexation parameter and $\frac{P_{t-1}}{P_{t-2}} = \pi_{t-1}$ represents the gross inflation rate in $(t-1)$.

The sticky information framework price setting is slightly different. Mankiw and Reis (2002) assume that information diffuses slowly throughout price setters. That means that when a firm sets its price, it has not full information about the state of the economy. The arrival of information update opportunity is similar to Calvo model, every period only a random fraction $(1-\lambda)$ of firms receive new information about the state of the economy. Nevertheless prices are flexible in the sense that firms can change their price every period, but they do not have necessarily the information about the actual state of the economy. The fraction of firms that did not receive new information set prices acoording to their older information set. Therefore prices fixed based on different information sets coexist in the economy. Formally, a firm that updated its information set, k periods ago, chooses its price for period t, $P_t(z)$ to maximize:

$$E_{t-k} \left(\left(\frac{P_t(z)}{P_t} - MC_t \right) Y_t(z) \right) \tag{14}$$

This yields to following expression for optimal price:

$$P_{k,t}^* = \frac{\varepsilon}{\varepsilon - 1} E_{t-k} MC_t^n \tag{15}$$

The overall price level is a weighted average of all prices in the economy, set based on information at all past dates:

$$P_t = \left((1-\lambda) \sum_{k=-0}^{\infty} \lambda^k P_t^{*(1-\varepsilon)} \right)^{\frac{1}{1-\varepsilon}} \tag{16}$$

2.3 Government

The government budget constraint is given by:

$$M_t - M_{t-1} = G_t - T_t$$

where G_t is government expenditures and follows an exogenous AR(1) process. We assume that monetary policy is conducting according to the following money supply rule:

$$M_t = (1 + mg_t) M_{t-1} \tag{17}$$
$$mg_t = \rho_m mg_{t-1} + \varepsilon_{m,t} \tag{18}$$

where mg_t is nominal money growth rate.

3 Parametrization and results

Table 1 reports parameter values for our benchmark calibration. We adopt conventional values of parameters. In both sticky information and sticky price models, we set $\theta = \lambda = 0.75$, which means that firms adjust their price or update their information set once a year in average. For the exogenous shocks, as in Mankiw and Reis (2002), we set money growth persistence equal to 0.5 and standard deviation of money growth shock equal to 0.008. Concerning technology and government spending shocks, we use parameter values estimated by Canzoneri, Cumby, and Diba (2005).

Using Dynare (Juillard (2003)), we calculate a first order approximation to the models and simulate the responses of inflation and output to a one standard deviation monetary shock. The results are reported in figures 1 and 2. We focus on the response of inflation. Specifically, we verify if inflation response is hump-shaped.

Under Calvo scheme, we find the standard response of inflation where the largest impact of a monetary shock occurs immediately. In the sticky price model with indexation, inflation is inertial, it reproduces a hump-shaped response of inflation where inflation peaks four quarter later. The response of inflation under the sticky information assumption is not as gradual and delayed as Mankiw and Reis forcefully argued. Inflation peaks one period after the shock and doesn't generate a gradual and delayed response of inflation.

We now turn to acceleration phenomenon. Table 2 documents the correlation between output deviations from steady state and change in inflation. On this issue, the sticky information model does not generate the correct value of correlation between output and change in inflation.

Our findings are in line with Keen (2004) who finds that the sticky information model needs substantial real rigidities to reproduce hump shaped response of inflation. In contrast, assuming firm specific labor market, Trabandt (2003) shows that sticky information generate hump shaped response.

4 Conclusion

Using a general equilibrium model with monopolistic competition, nominal rigidities and capital adjustment cost, this paper has compared three price setting specifications: sticky price, sticky price with indexation and sticky information. Our results show that sticky information model doesn't improve the empirical performance of the inflation-output trade-off models. The response of inflation to a monetary shock is hum shaped but inflation peaks just one period after the shock.

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Table 1: Calibration

	Parameter	Value
Discount factor	β	0.99
Risk aversion coefficient	γ	2
Elasticity of real money balances	γ_m	2
Elasticity of labor supply disutility	γ_n	0.5
Capital share	α	0.35
Markup	$\varepsilon/\varepsilon - 1$	1.2
Depreciation rate	δ	0.0125
Adjustment cost parameter	ϕ	2
Price (Information) Stickiness	θ, λ	0.75
Persistence of technology shock	ρ_a	0.95
Standard deviation of technology shock	ε_a	0.007
Persistence of money growth	ρ_m	0.5
Standard deviation of money growth shock	ε_m	0.008
Persistence of gov. spending shock	ρ_g	0.95
Standard deviation of gov. spending shock	εg	0.01

Table 2: Acceleration Phenomenon

	$corr(y_t, \pi_{t+2} - \pi_{t-2})$	$corr(y_t, \pi_{t+2} - \pi_{t-2})$
Data	0.43	0.53
Sticky Price	-0.002	0.02
Sticky Price with Indexation	0.41	0.32
Sticky Information	0.04	0.03

Figure 1: Inflation response to a money growth shock

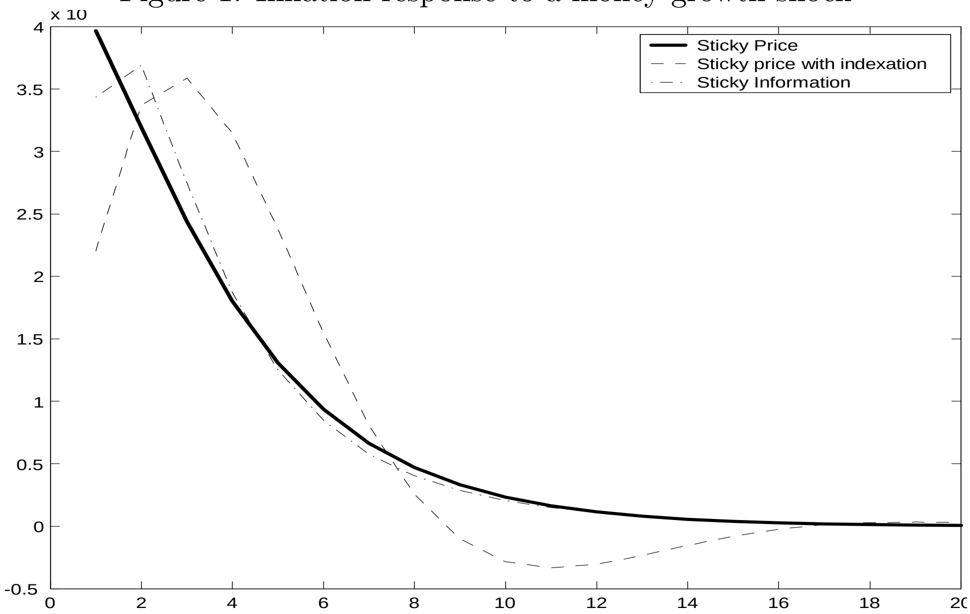

Figure 2: Output Response to a money growth shock