



# Endogenous nominal rigidities and monetary policy

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## ABSTRACT

Recent empirical research finds that the degree of nominal rigidities varies over monetary policy regimes. This implies that monetary policy analysis with exogenously given nominal rigidities is subject to the Lucas critique. We allow firms to choose the probability of price adjustment in a Calvo-style sticky price model, and analyze how this probability changes according to an inflation coefficient of the Taylor rule. The model shows that a more aggressive monetary policy response to inflation makes firms less likely to reset prices and gives the resulting New Keynesian Phillips curve a flatter slope and a smaller disturbance, as observed during the Volcker-Greenspan era. Also, such a policy response can stabilize both inflation and the output gap by exploiting the feedback effects of this policy response on firms' price-setting. These results offer theoretical support for the good policy hypothesis about the Great Moderation.

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## 1. Introduction

Recent studies of monetary policy typically assume exogenously given nominal rigidities. The most conspicuous example is the now very popular Calvo (1983)-style sticky price models. Most studies consider the probability of price adjustment given in these models as a structural parameter in evaluating alternative policy choices. Obviously, such policy evaluation is inappropriate if the probability depends on the policy choices. Empirical research by Fernández-Villaverde and Rubio-Ramírez (2008) addresses the question of “How structural are structural parameters?” and finds that the probability of price adjustment varied over the years in the United States. It particularly changed sometime after Paul Volcker assumed the chairmanship of the Federal Reserve. This empirical finding indeed suggests that monetary policy analysis with exogenously given nominal rigidities is subject to the Lucas (1976) critique.

In this paper, we endogenize the degree of nominal rigidities in a Calvo-style sticky price model. Specifically, firms choose the probability of price adjustment so as to maximize expected profit in the face of the cost involved to set a new price, as in previous studies such as Ball et al. (1988), Romer (1990), Kiley (2000), Devereux and Yetman (2002), and Levin and Yun (2007). Our analysis, however, differs from these previous studies in the following important way. The previous studies stress that firms' probability of price adjustment changes with a central bank's inflation target. In this setting, even when monetary policy responses to key macroeconomic variables change significantly, the nominal rigidities remain constant unless there are changes in the inflation target. By contrast, this paper focuses on how the probability of price adjustment varies in response to changes in an inflation coefficient of the Taylor (1993) rule with a fixed inflation target. As emphasized in the recent literature, such as Taylor (1999) and Clarida et al. (2000), this inflation coefficient is one of the most important aspects determining the monetary policy regime.

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Two sets of results are obtained. The first set is that a more aggressive monetary policy response to inflation makes firms less likely to reset prices and gives the resulting New Keynesian (NK) Phillips curve a flatter slope and a smaller disturbance. When a central bank responds more aggressively to inflation, each firm's relative price becomes more stable and thus firms are less likely to reset prices due to the cost involved. This makes the aggregate price level and hence inflation less responsive to the output gap, resulting in a flatter slope of the NK Phillips curve (i.e. a lower elasticity of inflation with respect to the output gap). It also makes inflation less responsive to price shocks (e.g., price markup shocks). This is because the disturbance to the NK Phillips curve is represented as the price shock multiplied by its coefficient and because a central bank's more aggressive policy response to inflation reduces this coefficient. As a consequence, the size of the disturbance to the NK Phillips curve becomes smaller, even when the magnitude of the price shock is unchanged.

These results are consistent with the findings of the recent empirical literature on the U.S. economy. Taylor (1999), Clarida et al. (2000), and others show that Taylor-style policy rules contained a much more aggressive policy response to inflation in the Volcker-Greenspan period than in the pre-Volcker period. Lubik and Schorfheide (2004) indicate that the slope and the variance of disturbances of the NK Phillips curve became smaller in the Volcker-Greenspan period, and Smets and Wouters (2007) and Fernández-Villaverde and Rubio-Ramírez (2008) find that the probability of price adjustment became lower in the same period.

The second set of results is that an aggressive monetary policy response to inflation can stabilize both inflation and the output gap by exploiting the feedback effects of this policy response on firms' price-setting. As noted above, a more aggressive policy response to inflation lessens the magnitude of disturbances to the NK Phillips curve. Since these disturbances induce a trade-off in monetary policymaking between the stabilization of inflation and the output gap, the smaller disturbances reduce this trade-off and therefore a central bank can stabilize both inflation and the output gap by responding aggressively to inflation. This suggests that central banks ought to take into account the feedback effects of their policy stance on firms' price-setting.

These results offer theoretical support for the good policy hypothesis about the Great Moderation suggested by Bernanke (2004). He argued that the aggressive policy stance toward price stability taken by Paul Volcker and Alan Greenspan affected firms' price-setting behavior and reduced a policymaking trade-off between the stabilization of inflation and real economic activities, thereby stabilizing the U.S. macroeconomic fluctuations successfully. These views of the Great Moderation can be explained consistently by our model with endogenous nominal rigidities.

The remainder of the paper proceeds as follows. Section 2 endogenizes the degree of nominal rigidities in a Calvo-style sticky price model. Section 3 analyzes how this degree varies with monetary policy responses and then examines its implications for the resulting NK Phillips curve, impulse responses to shocks, and macroeconomic volatility. Section 4 shows that our model with endogenous nominal rigidities gives a satisfactory explanation of the U.S. economy in the Volcker-Greenspan era. Finally, Section 5 concludes.

## 2. An optimizing model with endogenous nominal rigidities

In this section, we endogenize the degree of nominal rigidities in a Calvo (1983)-style sticky price model, which has been a canonical model of monetary policy in the recent literature (Walsh, 2003; Woodford, 2003). The approach of this paper is similar to those of previous studies, such as Ball et al. (1988), Romer (1990), Kiley (2000), Devereux and Yetman (2002), and Levin and Yun (2007). That is, firms choose the probability of price adjustment so as to maximize expected profit in the face of the cost involved to set a new price.<sup>1</sup> Yet our analysis differs from these previous studies in that we focus on how the probability of price adjustment changes with an inflation coefficient of the Taylor (1993) rule rather than an inflation target. In order to examine the relationship between policy rule coefficients and the degree of nominal rigidities, the model is approximated around a steady state with zero inflation.<sup>2</sup> Before describing a firm's price-setting problem, the next subsection briefly discusses how households and the central bank are modeled.

### 2.1. Households and the central bank

There is an infinitely lived representative household. Its behavior is described as the Euler equation for optimal spending decisions in terms of the output gap  $x_t$ :

$$x_t = E_t x_{t+1} - \sigma^{-1} (\dot{i}_t - E_t \pi_{t+1} - r_t^*), \quad (1)$$

<sup>1</sup> As in the previous studies, this paper assumes that firms optimally make a one-time choice of the probability of price adjustment and hold it fixed as long as there are no structural changes in the economic environment surrounding firms, i.e. no changes in model parameters. Hence the model of this paper differs from state-dependent price-setting models, where price adjustment is a period-by-period choice (e.g. Dotsey et al., 1999; Golosov and Lucas, 2007; Gertler and Leahy, 2008).

<sup>2</sup> By taking an approximation around a steady state with an arbitrary level of inflation, the analysis of this paper could be extended to study how the price adjustment probability varies with the inflation target as well as policy rule coefficients. Ascari and Ropele (2009) show that a higher inflation target is more likely to induce indeterminacy of equilibrium in a Calvo-style sticky price model with the Taylor rule. Using a framework of endogenous price stickiness similar to that of the present paper, Kurozumi (2009) finds that the indeterminacy result caused by the higher inflation target is overturned.

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