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Comment

Mark Gertler, NYU and NBER

Introduction

This paper compares the performance of a sticky-information (SI) versus a sticky-price (SP) Phillips curve. It does so by estimating a DSGE model for each type and then examining the fit of the respective models to the data. It then also examines the performance of each model under alternative monetary policy rules. The specific sticky-information model is based on Mankiw and Reis (2002), while the sticky-price model comes from Calvo (1983).

There are two sets of conclusions: First the authors argue that the SI Phillips curve has an edge in empirical performance over the SP formulation. For the sample prior to the Great Recession, the SI and SP Phillips curve models fit the data equally well in rough terms. However, during the Great Recession/zero lower bound (ZLB) period, the sticky-price model exhibits some anomolous behavior. This is less true for the sticky-information model.

Second, despite the differences, the broad qualitative conclusions for monetary policy are similar for both models. In particular, the ranking of how alternative monetary policy rules perform in stabilizing output and inflation is similar across models. In addition, nominal gross domestic product (GDP) targeting or price-level targeting are found to be “robust” policy rules within either model. Not only do these models deliver good performance in normal times when the ZLB is not binding, but they also work well when this constraint does bind.

Some History of Thought

To understand the paper, it is useful to begin with some history of thought. The sticky-information Phillips curve developed by Mankiw and Reis (2002) belongs in the class of imperfect information-based (II) Phillips curves. The idea of using informational frictions to generate a short-run positive comovement between inflation and output traces at least back to Irving Fisher. In the *Purchasing Power of Money*, written in 1913, Fisher speculates how the inability of suppliers to distinguish between relative and nominal movements in their respective prices can lead to short-run, Phillips curve-type behavior following a monetary expansion, even though prices are perfectly flexible. In the late 1960s Ned Phelps and Milton Friedman introduced this type of information-based Phillips curve within an explicit macroeconomic model. In 1972 Robert Lucas wrote his monumental paper, "Expectations and the Non-Neutrality of Money," which provided a fully rigorous foundation for this approach. The information-based Phillips curve he derived came explicitly from optimizing agents with rational expectations.

The modern sticky-price literature can be traced to Taylor's (1980) model of overlapping wage contracts and Calvo's (1983) variation that facilitates aggregation. While the idea of incorporating nominal rigidities dates back to Keynes, the contribution of this literature was to incorporate nominal stickiness in environment with rational expectations. Subsequent contributions have incorporated microfoundations in price setting (subject to various frictions in the adjustment process).

The SI approach has gained traction in DSGE modeling, but it is fair to say that the same is not true for the II or for the SI variant. There are two primary reasons for this: First, the basic informational restrictions in the typical II framework appear quite strong. Typically, individuals are restricted from seeing contemporaneous data on readily available aggregates such as the price level or output. While the recent literature on rational inattention pushes back on this criticism, it remains that model predictions are highly sensitive to what individuals can and cannot see (and process).

Second, and perhaps more compelling, the microdata provides evidence for sticky prices. Studies by Klenow and Krystov (2008) and Nakamura and Steinsson (2008), for example, show that the median duration that prices are fixed ranges from seven to eleven months. A cottage industry of papers has shown that models of Ss pricing can explain most of the microfacts. Under reasonable circumstances, for

low-inflation environments the time-dependent Calvo model provides a reasonable approximation of the Ss model. It is perhaps for these sets of considerations that the Calvo approach has gained widespread acceptance in DSGE modeling.

At the same time, while there has been a considerable effort to show how Ss models can account for the microfacts, it has yet to be demonstrated that these frameworks can adequately capture the aggregate data. In particular, while the models can explain the microevidence (e.g., frequency, size of price adjustment, etc.) they may be wildly off in accounting for aggregate inflation dynamics. The problem is that aggregate inflation dynamics will in general depend on a variety of factors, including how expectations are formed, information sets, wage setting, and so on. In this spirit, the authors take the opposite approach by ignoring the microdata and instead considering how alternative models explain the aggregate data.

Model Comparison: SP versus SI

Before comparing each type of Phillips curve, it is useful to review the basic features of the US inflation data that need to be explained. Figure 1 reports annual core Consumer Price Index (CPI) inflation at the quarterly frequency from the period 1965 through 2013. The shaded areas are NBER recessions. There are three aspects of the data to note: (1) there is no correlation between the medium-frequency behavior of inflation and economic activity. Inflation was high on average from the late 1960s through early 1980s, but then moderates considerably as the 1990s begin; (2) in the short run there is a procyclical relation between inflation and economic activity. Inflation is increasing leading up to every business-cycle peak and declining following the trough; and (3) following the Great Recession, there is a “missing deflation.” While inflation drops around the trough in 2009, the absolute drop is on par with the decline during the modest recession of 2000–2001, and does not seem commensurate with the steep output decline.

The authors’ paper basically asks how well each type of Phillips curve can account for each of the three features of the inflation data I described above. The broad answer is that each model can roughly account for features (1) and (2). Neither model accounts well for feature (3) (the missing deflation), though the SP model is much further off the target than is the SI model.

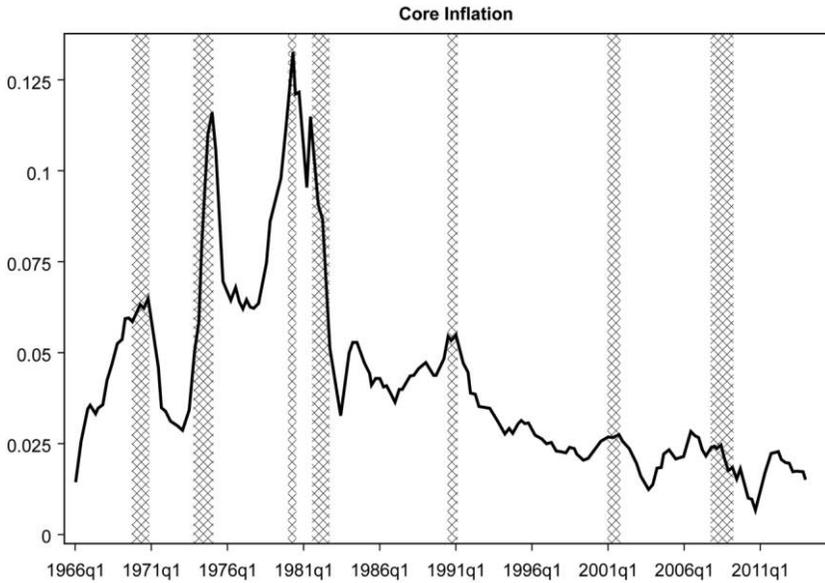


Fig. 1. Core inflation

Sticky-Price Phillips Curve (Calvo)

We can illustrate how the authors arrived at their results by analyzing stripped-down versions of each type of Phillips curve. We begin with the SP model, based on Calvo (1983). Under the Calvo formulation, a firm is able to adjust its price each period with probability $1 - \theta$, which is independent across time and across firms. Accordingly, let $p_t \equiv$ the log price index; $p_t^o \equiv$ the log of the optimal reset price; $\hat{y}_t \equiv$ the log deviation of output from the natural (flexible price equilibrium level); and $\pi_p \equiv$ the inflation rate (log difference of the price levels between t and $t - 1$). Then the Calvo Phillips curve is based on two relations: (1) a log-linear approximation of the price index and (2) a log-linear approximation of the relation for the optimal reset price, as follows:

Price index:

$$p_t = (1 - \theta)p_t^o + \theta p_{t-1}$$

Reset price:

$$p_t^o = (1 - \beta\theta)E_t \sum_{i=0}^{\infty} (\beta\theta)^i (\kappa \hat{y}_{t+i} + p_{t+i})$$

where β is the subject discount factor and κ is the output elasticity of marginal cost.

The price index is a linear combination of the reset price and the lagged price index. Given the probability of firm adjust price is *i.i.d.*, the average of the prices of the fraction θ of firms that do not adjust price is just the lagged price index p_{t-1} , while the average for the fraction $1 - \theta$ who adjust is the reset price p_t^o . The latter in turn depends on a discounted weighted average current on expected future nominal marginal cost. Intuitively, because it knows that its price may be fixed on average for $1/(1 - \theta)$ periods, a monopolistically competitive firm sets price based not only on current nominal marginal cost, but also a weighted average of future nominal marginal costs, where the weights depend on the likelihood prices will remain fixed. Combining these two equations leads to the familiar New Keynesian Phillips curve, based on Calvo.

New Keynesian Phillips curve:

$$\begin{aligned}\pi_t &= E_t \sum_{i=0}^{\infty} \beta^i \lambda \hat{y}_{t+i} \\ &= \lambda \hat{y}_t + \beta E_t \pi_{t+1}\end{aligned}$$

with $\lambda \equiv \alpha(\theta)\kappa$; $\alpha' < 0$. Note that as with a conventional Phillips curve, inflation depends positively on the output gap, which implies that the framework can capture the short-run procyclical relation between inflation and output (fact 2). In addition, there is an additive term that depends on inflation expectations, implying that the model can potentially also capture the lack of a medium-term relation between inflation and real activity (fact 1).

Sticky-Information Phillips Curve (Mankiw/Reis)

We next turn to the sticky-information Phillips curve. Following Mankiw/Reis, firms set prices each period, but they do so based on different vintages of information. Let $1 - \Delta$ be the *i.i.d.*, probability a firm updates its information (i.e., gathers all available aggregate date) and let $p_{t,i}^o \equiv$ the optimal reset price at t based on an information set vintage that is i periods old. Then, as with Calvo, the sticky-information Phillips curve can be built up with a relation for the price index and for the reset price, as follows:

Price index:

$$p_t = (1 - \delta) \sum_{i=0}^{\infty} \delta^i p_{t,i}^o$$

Reset price:

$$p_{t,i}^o = E_{t-i}(\kappa \hat{y}_t + p_t)$$

In this case the price index is a weighted average of the reset prices that vary according to information set vintages. In turn, the optimal reset price based on an information set vintage that is i periods old is simply the forecast at $t - i$ of nominal marginal cost at t . Combining these two relations yields the sticky-information Phillips curve:

→ SI-Phillips curve

$$\pi_t = \eta \hat{y}_t + (1 - \delta) \sum_{i=0}^{\infty} \delta^i E_{t-1-i}(\kappa \Delta \hat{y}_t + \pi_t)$$

$\eta = [(1 - \Delta)/\Delta]\kappa$. As with the SP-Phillips curve, inflation depends both the current output gap and an additive term, similarly implying that the model can potentially capture facts (1) and (2) above. The additive terms differ, however. For the SP model, the additive term is the expectation of inflation, which is based on the expectation of the future path of nominal marginal cost. For the SI model, it is the weighted average of different information vintage forecasts of current nominal marginal cost. As we discuss shortly, it is the difference in these additive terms that accounts for the differences in model dynamics.

SI versus SP Models

In particular, the models the authors consider have same aggregate-demand structure but differ only according to price and wage setting. In our simplified setup, the aggregate-demand side comes from the canonical New Keynesian framework that relates the current output gap inversely to the interest gap and the expected future output gap. Let i_t be the nominal interest rate and r_t^* be the natural (flexible price equilibrium real rate of interest). Then we can compactly write the SP versus SI models as:

AD:

$$\hat{y}_{tt} = -\sigma(i_t - E_t \pi_{t+1} - r_t^*) + E_t \hat{y}_{t+1}$$

AS: SP:

$$\pi_t = \lambda \hat{y}_t + \beta E_t \pi_{t+1}$$

AS: SI:

$$\pi_t = \eta \hat{y}_t + (1 - \delta) \sum_{i=0}^{\infty} \delta^i E_{t-1-i} (\kappa \Delta \hat{y}_t + \pi_t)$$

Given that both models share the same aggregate demand curve and given that the respective aggregate supply curves differ only in the details of the additive terms, the qualitative behavior of the output gap \hat{y}_t and inflation π_t is similar across the two frameworks. The presence of \hat{y}_t in each AS curve implies that each generates a positive short-run comovement between π_t and \hat{y}_t . Also, as we noted earlier, the presence in each case of additive terms based on expectations implies that both models can capture the disconnection between real economic activity and inflation over medium-term horizons. Further, the transmission of monetary policy is qualitatively similar across models. In each case, for example, an increase in the nominal rate i_t reduces \hat{y}_t and, in turn, π_t . It is accordingly not entirely surprising that the two models have similar implications for what kinds of policy rules work well.

While there are qualitative similarities in behavior across the two models, the short-run dynamics can differ between the two models due to differences in the way expectations affect inflation. In particular, because price setting is forward looking in the SP model, there is an immediate response of inflation to news about the future. By contrast, in the SI model, there is a delayed “pipeline” response of inflation to news as different vintages of price setters slowly update their information sets.

As the authors note, due to the qualitative similarities, the fit of the two models to the aggregate data is in the same ballpark for the pre-ZLB period. However, differences emerge during the ZLB period, where beliefs about the future course of policy take on added importance. We illustrate this point next.

Two Criticisms of the SP Model at the ZLB

As the authors argue, the baseline SP has two unsettling features at ZLB. These unsettling features, further, are interrelated phenomena. First, the model predicts a much larger drop in inflation than occurred in practice, which is inconsistent with the missing deflation. Second, the

model predicts counterfactually large effects on the economy of central bank forward guidance about the path of future short rates (i.e., the “forward guidance” puzzle.) Both these anomalies are of the forward-looking nature of inflation.

We can illustrate how these anomalies arise by examining the SP model at the ZLB. Let $r_t^* < 0$ for T periods and > 0 afterward. Suppose that whenever the economy is in a liquidity trap ($r_t^* < 0$), the central bank pushes i_t to zero. Then we can express the SP model as

AD (given $i_t = 0$ when $r_t^* < 0$)

$$\hat{y}_t = E_t \sum_{i=0}^{T-1} \sigma(\pi_{t+1+i} + r_{t+i}^*) + E_t \sum_{i=T}^{\infty} -\sigma(i_{t+i} - \pi_{t+1+i} - r_{t+i}^*)$$

AS

$$\pi_t = E_t \sum_{i=0}^{\infty} \beta^i \lambda \hat{y}_{t+i}$$

Suppose further that once the economy is out of the liquidity trap, the central bank adjusts the nominal rate to stabilize inflation and output, which means setting $i_{t+i} = r_{t+i}^*$. The net effect is that a large deflation can emerge at time t . The size of the deflation is magnified by the interaction between the AD and AS curves. The positive interest rate gap in ZLB leads to a decline in output throughout the period of the ZLB, which in turn leads to a drop in inflation, which depends on the current and expected future path of \hat{y}_t . This raises real interest rates, thus lowering output further. The problem is that the central bank cannot reduce the nominal interest rate to stop this downward spiral.

Similarly, the interaction between the AD and AS curves induce a large forward-guidance multiplier. As is well known, one way to stimulate the economy when it is in a liquidity trap is to promise to keep the interest rate at the ZLB for a period after it has escaped this trap. That is, promise $i_{t+1} < r_{t+1}^e$ for a period once $r_{t+1}^e > 0$. The reduction in the expected future short rates will stimulate current output, as the AD curve makes clear. There will be a multiplier effect, however: inflation will increase, reducing real rates and further stimulating output. As the authors show, with standard parameter estimates the SP model produces an implausibly large response of output and inflation to this kind of forward guidance.

The SI model fares better with forward-guidance policy experiments, but this may be in part due to brute force assumptions. In the SI model, when the central bank announces a path for future short rates, only a fraction of individuals pays attention. While one could well imagine

that not many people pay attention to the central bank in normal times, one might wonder whether this is a plausible assumption during unusual times like the Great Recession. The broader point is that a more explicit modeling of the degree of attention paid to the central bank would be desirable for the SI approach.

Possible Solutions to the Missing Deflation and Forward-Guidance Puzzles within the SP Framework

The authors consider a conventional formulation of the SP model to assess the anomalies that arise at the ZLB. However, there may be modifications that address these issues. Here, I discuss several.

Del Negro, Giannoni, and Schorfheide (2014) argue that by more carefully modeling the aggregate-demand side of the standard SP DSGE model, one obtains estimates of a much flatter Phillips curve than is typical. In the context of our simple model, the estimate value of λ is low, which reduces the sensitivity of inflation to the output gap. The authors show that this lower estimate eliminates both the deflation and forward-guidance puzzles, as the behavior of inflation is much stickier than in the conventional model. The only issue is that the implied estimates of price stickiness imply much greater price rigidity than the microevidence suggest.

Another possibility is to account for the drop in trend productivity growth that occurred prior to the Great Recession, following Christiano, Eichenbaum, and Trabandt (2014). Doing so raises the expected path of \hat{y}_t , which can help explain part of the missing deflation. One does, however, need learning about trend breaks to avoid a jump in inflation.

Another possibility is to consider the inflation of financial market frictions on price behavior, to the extent that a nontrivial component of firms' marginal costs depend on borrowing, as both Christiano et al. (2014) and Gilchrist et al. (2014) suggest. This approach may be promising, given financial distress during the Great Recession may have raised marginal costs, but more direct evidence is needed.

Evidence for Imperfect Information (II)?

As I noted earlier, a strong selling point for the SP approach is the evidence for price stickiness in the microdata. By contrast, there is little direct evidence for SI. However, there is evidence for II (imperfect information) more generally. An example is Coibin and Gorodnichenko

(2012), who present evidence from survey data of strong serial correlation in forecast errors.

Figure 2 illustrates by present forecasts of inflation and output from the Survey of Professional Forecasters (SPF) over the period of the Great Recession. The top panel gives the SPF forecast of inflation versus the data and the bottom panel does the same for output.

Overall, during the Great Recession, SPF forecasts of inflation and

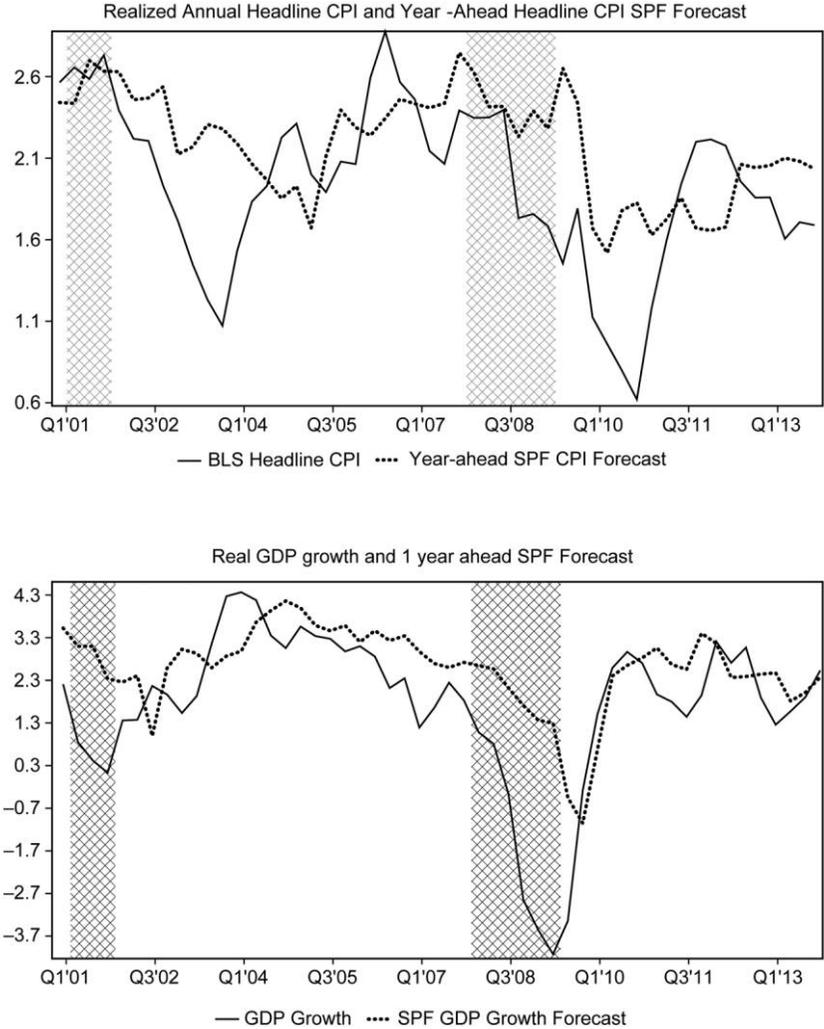


Fig. 2. Realized headline CPI and year-ahead headline CPI-SPF forecast

output exhibit persistent over-optimism, as well as relatively anchored behavior. The anchored behavior of inflation expectations no doubt contributed to the stable behavior of inflation during the Great Recession, as would be an implication of both the SI and SP models. It is very difficult to account for these facts without appealing to some form of imperfect information.

Conclusions

This is an interesting paper. It makes a case for paying more attention to imperfect information in DSGE modeling, though more work is needed on modeling forward guidance in SI or II frameworks.

Here is my hunch about how to move forward: given the microprice data and survey expectations data, the “true” model contains both sticky prices and imperfection information. Examples of this hybrid approach already exist (e.g., Lorenzoni 2009; Dupor, Kitamura, and Tsuruga 2010; Angeletos and La’O 2009). Perhaps we need to see more.

Endnote

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