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Fixing the New Keynesian Phillips Curve

Price rigidity is a key mechanism through which monetary policy is thought to affect the economy. When some prices are hard to change, firms may respond to a monetary impetus by changing instead their production and employment levels. Economists often link price rigidity, inflation, and movements in the real economy using some form of Phillips curve, often the New Keynesian Phillips curve (NKPC), a model that relates inflation to factors like capacity utilization or production costs. Unfortunately, an array of papers have shown that the NKPC is unable to match the time series properties of aggregate inflation, failing to capture inflation's persistence, overstating the role of expectations in price-setting, and implying what many believe to be excessive price rigidity.

These inconsistencies between the model and the data are important, not least because much of our intuition for what constitutes good monetary policy has been built up using models in which the NKPC is central. A model that cannot satisfactorily explain why inflation is persistent is of doubtful value for forecasting. Moreover, a model that overstates the magnitude of price rigidity will also tend to overstate monetary policy's importance for determining real outcomes, potentially providing a distorted view of the role that monetary policy plays in macro-stabilization.

This *Economic Letter* looks at the problems with the NKPC and discusses some alternatives that are increasingly being used to think about inflation and the monetary policy transmission mechanism.

The New Keynesian Phillips curve

The NKPC describes a simple relationship between inflation, the expectation that firms hold about future inflation, and real marginal costs, that is, the real (adjusted for inflation) resources that firms must spend to produce an extra (marginal) unit of their good or service. According to the NKPC, inflation will tend to rise when real marginal costs rise, as firms pass on higher costs in the form of higher prices, and when expectations of future inflation rise, as firms raise their price today anticipating higher prices tomorrow. Although the NKPC can be obtained several different ways, it is most commonly derived using an approach pioneered by Calvo (1983).

An early critic of the NKPC was Ball (1991), who showed that it implied that a central bank making a credible commitment to a lower inflation target could generate an economic boom—that is, a rise in output relative to potential—together with a rapid disinflation. But this behavior flies in the face of practical experience, which suggests that disinflations occur gradually and are often associated with rises in the unemployment rate, sluggish growth, and even sustained recessions; the U.S. economic slowdown in the early 1980s is a good example. More generally, Estrella and Fuhrer (2002) showed that the NKPC implies correlations between inflation, future inflation, and real marginal costs that are not reflected in actual data. One manifestation of this problem is that the NKPC cannot replicate, even qualitatively, the hump-shaped response that U.S. inflation is widely accepted to display following shocks.

Setting the behavior of the NKPC aside, Rudd and Whelan (2006) estimate the NKPC and obtain coefficients on expected future inflation and on real marginal costs that are numerically small; they also find that lagged—that is, past—inflation is an important predictor of future inflation. They argue that, contrary to what the NKPC suggests, lagged inflation plays a more important role in shaping inflation outcomes than expected inflation and that inflation is largely unresponsive to movements in real marginal costs. As if this were not enough, Bils and Klenow (2004) analyzed a large portion of the data used by the Bureau of Labor Statistics to construct the CPI price index and showed that the average duration between price changes is just over six months, whereas estimates of the NKPC typically place the average duration between price changes at about 20 months.

Extending the NKPC

By and large, these criticisms of the NKPC have not gone unanswered. In fact, in parallel with the NKPC, hybrid specifications, in which inflation

outcomes are shaped by forward dynamics (expected future inflation) and backward dynamics (lags of inflation), were used to explain inflation outcomes. The problem with hybrid Phillips curves was not that they could not explain inflation outcomes, and not that they could not generate hump-shaped responses for inflation following shocks, but rather that they lacked a theory of how firms behave to motivate their structure. As such, they were largely viewed as being ad hoc.

The standard hybrid Phillips curve was given greater structure by Christiano et al. (2005). Building on the Calvo model, in which a fixed share of randomly chosen firms could set their prices optimally each period, they assumed that, rather than keeping their prices unchanged, the remaining firms would change their prices in relation to lagged aggregate inflation. Although it is natural for the remaining firms to look at lagged inflation when changing their prices, because lagged inflation is readily observable, it also had the effect of making current inflation depend on past inflation. The result was an expression for inflation that looked much like a hybrid Phillips curve, but with a lead-lag structure motivated by firm behavior. A key feature of this hybrid Phillips curve was that it implied that the coefficients on lagged and future inflation should each equal about one-half.

The tight coefficient structure implied by the Christiano et al. framework was relaxed by Smets and Wouters (2005). Instead of having some firms change their price one-for-one with lagged inflation, they introduced a proportionality, or indexation, parameter, whose main effect was to regulate the persistence of inflation. Estimates of the indexation parameter generally place its value less than one, so partial indexation seems to be useful, at least statistically. Relative to the Calvo model, indexation generally gives rise to a tighter distribution in prices across firms, and, because this price distribution reflects inefficient production, the welfare cost of inflation is generally smaller with indexation than without. Although their specification generalized the full-indexation model, Smets and Wouters estimated that about 10%–15% of firms changed their price optimally each quarter, reminiscent of the Calvo model.

While these extensions to the Calvo model overcome some of the problems associated with the NKPC, questions remain about their ability to explain the change in inflation (Rudd and Whelan, 2006), and they, too, fail when confronted with micro-data because they assert that all firms change their price every quarter (although not necessarily optimally). Moreover, with indexation driving inflation, and relatively few firms setting their prices optimally, these models suggest that, while the central bank can easily engineer a change in the real interest rate, large movements in the real interest rate may be required to stabilize inflation. As a consequence, these models can generate large interest-rate swings over the business cycle.

Information costs

Mankiw and Reis (2002) advance an alternative pricing framework in which it is costly for firms to gather information and, therefore, firms ration the information they acquire to form expectations. They assume that while all firms get to change their price each period they must forecast inflation to do so. Drawing on Calvo, before forecasting inflation, a fixed share of firms can update its information to include the latest data, but the remaining share cannot. With the firms that are able to update their information determined randomly, firms forecast inflation endowed with quite different information. As a consequence, shocks pass through to aggregate prices gradually because it takes time for some firms to recognize that a shock has actually occurred. According to Mankiw and Reis, "information rigidity" rather than "price rigidity" explains price inertia.

Drawing on Mankiw and Reis and Calvo (1983), Dennis (2006) develops a model that seeks to address the criticisms leveled at the NKPC. In Dennis's model, each period a share of firms can change price while the remaining firms keep price unchanged. However, among the firms that can change price, a share of randomly chosen firms can set price optimally, with the remaining firms indexing price to the lagged inflation rate. In this respect, the model is similar to Galí and Gertler (1999). The share of firms that can change price is associated with "menu costs," a term for the costs firms face when changing price: when menu costs are high, a larger share of firms will choose not to change price. Similarly, the share of firms that index price is associated with the costs of gathering and processing the information firms need to set price optimally: when these information gathering/processing costs are high, a larger share of firms will resort to the indexation-based pricing rule.

Dupor et al. (2006) also develop a model combining elements of price rigidity and information

rigidity. Unlike Dennis however, Dupor et al. assume that there are two distinct types of firms, those behaving like the firms in the (price-rigidity) Calvo model and the remaining firms behaving like the firms in the (information rigidity) Mankiw and Reis model.

Using U.S. data for the period 1982:Q1 to 2002:Q4, Dennis estimates that about 60% of firms change their price each quarter, suggesting that menu costs are quite small. However, he also finds that the majority of price-changing firms use indexation, which implies that the costs of gathering and processing information are high. Dupor et al. use U.S. data spanning 1960:Q1 to 2005:Q2 and estimate that only about 15% of firms change their price each quarter and that about 60% of the firms that do change their price do so using information that is outdated.

Conclusion

The NKPC has a number of problems that raise questions about its use for practical policymaking. Importantly, although it is useful for pedagogic purposes, the curve struggles to explain why inflation is persistent and why inflation responds gradually to shocks. Further, some believe that the curve provides a misleading description of the relationship between inflation and real marginal costs. Economists have developed a range of alternatives to the NKPC, such as indexation models, with better explanatory power and better descriptions of how inflation responds to shocks. However, these alternatives also generally fall short when exposed to micro-data on price changes, and are still often viewed as being ad hoc. Models that combine both sticky prices and sticky information hold promise but remain in their infancy.

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References

Ball, L. 1991. "The Genesis of Inflation and the Costs of Disinflation." *Journal of Money, Credit, and Banking* 23(3, part 2) pp. 439–452.

Bils, M., and P. Klenow. 2004. "Some Evidence on the Importance of Sticky Prices." *Journal of Political Economy* 112(5) pp. 947–985.

Calvo, G. 1983. "Staggered Prices in a Utility-Maximizing Framework." *Journal of Monetary Economics* 12, pp. 383–398.

Christiano, L., M. Eichenbuam, and C. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy* 113(1) pp. 1–45.

Dennis, R. 2006. "The Frequency of Price Adjustment and New Keynesian Business Cycle Dynamics." FRBSF Working Paper 2006-22. http://www.frbsf.org/publications/economics/papers/2006/wp06-22bk.pdf

Dupor, B., T. Kitamura, and T. Tsuruga. 2006. "Do Sticky Prices Need to Be Replaced with Sticky Information?" Bank of Japan Working Paper 06-E-23.

Estrella, A., and J. Fuhrer. 2002. "Dynamic Inconsistencies: Counterfactual Implications of a Class of Rational Expectations Models." *American Economic Review* 92(4) pp. 1,013–1,028.

Galí, J., and M. Gertler. 1999. "Inflation Dynamics: A Structural Econometric Analysis." *Journal of Monetary Economics* 44, pp. 195–222.

Mankiw, N., and R. Reis. 2002. "Sticky Information Versus Sticky Prices: A Proposal to Replace the New Keynesian Phillips Curve." *The Quarterly Journal of Economics* (November) pp. 1,295–1,328.

Rudd, J., and C. Whelan. 2006. "Can Rational Expectations Sticky-Price Models Explain Inflation Dynamics?" *American Economic Review* 96(1) pp. 303–320.

Smets, F., and R. Wouters. 2005. "Comparing Shocks and Frictions in U.S. and Euro Area Business Cycle Models: A Bayesian DSGE Approach." *Journal of Applied Econometrics* 20, pp. 161–183.

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