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Introduction to the New Keynesian Phillips Curve

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In most industrialized economies inflation tends to be pro-cyclical; that is, inflation is high during times of high economic activity. When economic activity is measured by the unemployment rate this statistical relationship is known as the Phillips curve. The Phillips curve is sometimes viewed as a menu for monetary policymakers, that is, they can choose between high inflation and low unemployment or low inflation and high unemployment. But this interpretation of the Phillips curve assumes that the relationship between unemployment and inflation is structural and will not break down once a policymaker attempts to exploit the perceived tradeoff. After the high inflation episodes experienced by many economies in the 1970s, this structural interpretation of the Phillips curve was discredited. Yet, after a period of low inflation in the 1980s and early 1990s, economists have again worked on a structural interpretation of the Phillips curve. This New Keynesian Phillips curve (NKPC) assumes the presence of nominal price rigidities. In this special issue of the *Economic Quarterly*, we publish four surveys on the history of the Phillips curve, the structural estimation of the New Keynesian Phillips curve, and the policy implications of the nominal rigidities underlying the New Keynesian Phillips curve.

The Phillips Curve and U.S. Economic Policy

Robert King surveys the evolution of the Phillips curve itself and its usage in U.S. economic policymaking from the 1960s to the mid-1990s. He first describes how, in the 1960s, the Phillips curve became an integral part of U.S. macroeconomic policy in its pursuit of low unemployment rates. A stylized version of the Phillips curve that emerges from this period relates current

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inflation, π, to the current unemployment rate, u, and lagged inflation,

$$\pi_t = \sum_{i \geq 1} \gamma_i \pi_{t-i} - \beta u_t.$$

Similar to other elements of the then-standard Keynesian IS-LM macromodel, economists would tell stories that motivated the Phillips curve but the Phillips curve was not derived from an explicit theory. Furthermore, the estimated parameters were taken as structural, in particular as invariant to policy interventions. In the late 1960s, Phelps (1968) and Friedman (1968) interpreted the Phillips curve as arising from search and information frictions in labor markets, and they argued that the relation between a real variable such as unemployment and nominal inflation was based on misperceptions about inflation on the part of the public. Phelps proposed an expectations-augmented Phillips curve,

$$\pi_t - \rho \pi_t^e = -\beta u_t,$$

where π^e denotes expected inflation. If, as Phelps and Friedman argued, $\rho = 1$, then a tradeoff between inflation and unemployment exists only to the extent that actual inflation deviates from expected inflation. At the time, inflation expectations were modeled as adaptive, that is, a geometric distributed lag of past actual inflation. In this case, for a constant actual inflation rate the expected inflation rate would eventually converge to the actual inflation rate and the unemployment rate would settle down at its natural rate. Thus, there is no long-run tradeoff between inflation and unemployment. Although Phelps and Friedman's argument originally represented a minority view in the profession, the argument became more widely accepted in the 1970s after periods of high inflation and unemployment.

Accounting for the instability of the Phillips curve in the 1970s had lasting effects on the way macroeconomic analysis was done and continues to be done today. First, since expectations play a crucial role in the expectations-augmented Phillips curve, it seemed necessary not to resort to some arbitrary assumption on the expectations mechanism. For this purpose, macroeconomists started to assume that expectations are rational. By this we mean that expectations are such that they do not lead to systematic mistakes given the available information. Sargent and Wallace (1975) used the idea of rational expectations in an otherwise standard IS-LM macromodel with an expectations-augmented Phillips curve to argue that systematic monetary policy actions do not systematically affect unemployment or output. Second, macroeconomists not only started to work with model-consistent expectations in otherwise ad hoc models, but they started to study the optimal choices of economic agents in explicitly specified environments agents; that is, they started to study macroeconomic questions using the tools of general equilibrium analysis. The seminal work was Lucas' (1972) formal analysis of the

Phelps-Friedman Phillips curve in an environment where agents had difficulty sorting out their own relative price shocks from aggregate price level shocks.

King describes how, at the end of the 1970s after years of persistently high inflation and high unemployment, monetary policymakers moved to lower the inflation rate. At that time, the debate centered on the perceived cost (in terms of elevated unemployment) associated with a reduction of the inflation rate. On the one hand, proponents of the more standard Phillips curve argued that these costs would be substantial. On the other hand, proponents of a rational expectations-augmented Phillips curve argued that the costs could be quite low, especially if the low inflation policy was credible to the public. In the end, the Federal Reserve under Paul Volcker reduced inflation over a relatively short time period at some cost, but not as high a cost as predicted by standard Phillips curves. For the remainder of the 1980s and the early 1990s, the Federal Reserve under Alan Greenspan further lowered average inflation and, in the process, strengthened its credibility for continued low inflation policies. King ends his survey in the mid-1990s when the Federal Reserve Board's monetary policy model incorporated an expectations-augmented Phillips curve with elements of rational expectations, and the Federal Open Market Committee debated the desirability of a target for low long-run inflation and what that target should be.

The New Keynesian Phillips Curve

At the time that U.S. inflation started to decline in the 1980s there was a resurgence of interest in business cycle analysis. Continuing the general equilibrium program in macroeconomics started with Lucas (1972), real business cycle analysis developed quantitative models of the aggregate economy based on the stochastic neoclassical growth model, e.g., Kydland and Prescott (1982) or Long and Plosser (1983). Using simulation studies, one could show that these models were able to mimic the U.S. business cycle in terms of the statistical properties of the time series of a limited number of aggregate variables (output, consumption, investment, and employment). As the name indicates, real business cycle theory addressed the behavior of quantities and relative prices over the business cycle, implicitly assuming that money is neutral. Working on the assumption that money is not neutral, economists in the mid-1990s then started to introduce nominal price rigidities into these models, now also known as Dynamic Stochastic General Equilibrium (DSGE) models. From this research program emerged the New Keynesian Phillips curve that relates actual and expected inflation not to the unemployment rate but to a measure of aggregate marginal cost. The second and third paper in this issue discuss the estimation of the structural parameters of the NKPC.

Once one assumes that nominal prices do not continuously adjust to clear markets, one has to decide how these prices are set in the first place.

Almost all of the work on nominal price rigidities has answered this question using the framework of monopolistic competition, which assumes that the product whose price has to be determined is produced by a profit-maximizing monopoly. There may be imperfect substitutes for the monopolist's product; that is, the demand for the product depends not only on its own price but also on the prices of the substitutes. When the monopolist decides on his own price he will, however, take these other prices as given, hence the term monopolistic competition. A monopolist that can continuously adjust his nominal price will set the price to equate contemporaneous marginal revenue and marginal cost and the price will be a markup over marginal cost. Compare this with flexible prices in perfectly competitive markets where the price and marginal cost are equated. If nominal prices cannot be continuously readjusted, then the monopolist will choose the current nominal price such that he equates the expected present value of marginal revenue and marginal cost over the time that the price remains fixed.

The model of an individual monopolistically competitive producer is then typically embedded into a general equilibrium model with a large number of these producers, e.g., Blanchard and Kiyotaki (1987). These producers are identical except for the time when they can adjust their nominal price. Various mechanisms for price adjustment have been proposed; most assume that the opportunity for price adjustment is exogenously given. One popular modeling technique is a Calvo-type price adjustment where, each period, a firm gets to adjust its price with some probability that is fixed over time. Using Calvo-type price adjustment, Woodford (2003) shows that the aggregation of the linearized optimal price adjustment rules for the individual firms yields an expression in current and expected future inflation and a measure of aggregate marginal cost, mc,

$$\pi_t = \gamma_f E_t \pi_{t+1} + \lambda mc_t + \xi_t.$$

This is the structural NKPC where γ_f and λ are functions of structural parameters, including the probability of price adjustment, α, and ξ_t is a random variable. The random disturbance is often interpreted as an exogenous shock to the firms' markup. Solving this difference equation forward, one can see that current and expected future marginal cost are driving today's inflation.

For most measures of inflation and what could be considered reasonable measures of marginal cost, inflation tends to be more persistent than marginal cost. Since marginal cost "drives" inflation in the basic NKPC, this makes it hard for the model to match the data. Economists have, therefore, modified the basic NKPC by introducing "rule of thumb" price adjusters or firms that simply index their price to the aggregate inflation rate, e.g., Galí and Gertler (1999). These assumptions lead to the inclusion of lagged inflation,

$$\pi_t = \gamma_b \pi_{t-1} + \gamma_f E_t \pi_{t+1} + \lambda mc_t + \xi_t,$$

and, therefore, make the NKPC a hybrid of the basic NKPC and more standard Phillips curves. The coefficients γ_b, γ_f, and λ are again functions of structural parameters. The ability of monetary policy to control inflation with a NKPC depends on the relative magnitudes of these coefficients. Loosely speaking, monetary policy affects inflation through its effects on marginal cost. Thus, the smaller the coefficient on marginal cost, the less impact monetary policy will have on inflation. In the extreme case when $\lambda = 0$, inflation evolves independently of monetary policy and whatever else happens in the rest of economy. How "costly" it is to reduce inflation depends on the relative magnitude of the coefficients on past and future inflation, γ_b and γ_f. If the coefficient on lagged inflation is large, then inflation is mostly driven by its own past and policy actions might affect inflation only with a long time lag. In order to evaluate the effectiveness of monetary policy actions we, therefore, need estimates of these parameters.

Single-Equation Estimation of the NKPC

In the second paper of this issue, James Nason and Gregor Smith survey the estimation of the parameters of the NKPC using only the NKPC itself. Single-equation estimation of the NKPC parameters is appealing because it does not require any assumption on how the rest of the economy should be specified. Yet standard ordinary least squares estimation of the NKPC is not applicable since expected inflation in the NKPC is an endogenous variable that is correlated with the error term of the estimation equation. Consistent parameter estimates can still be obtained through the use of the General Method of Moments (GMM) technique, which in turn requires instrumental variables that are correlated with expected inflation but uncorrelated with the other variables in the NKPC.

Nason and Smith report that, in general, estimated parameters for the hybrid NKPC are consistent with prior restrictions. For example, estimated price adjustment probabilities are between zero and one. They also find that the coefficient on expected future inflation tends to be larger than the coefficient on lagged inflation. This suggests that monetary policy can affect inflation in the short term. Nason and Smith also discuss the finding that the estimated coefficient on marginal cost tends to be small and barely significant. This is bad news for the NKPC as a model of inflation and for monetary policy.

The ambiguous evidence on the marginal cost coefficient may be related to weak identification through weak instrumental variables in the GMM estimation. Instrumental variables are essentially used to forecast expected inflation independent of the other variables in the NKPC. For an instrumental variable to serve its purpose it has to be correlated with expected future inflation and it should not be correlated with marginal cost and current and lagged inflation. But as Nason and Smith point out, past empirical work on inflation has shown that lagged inflation tends to be a good forecast of future inflation and it is difficult to improve on that forecast. This suggests that the instrumental variables in the GMM procedure are quite weak. Nason and Smith then show that after one takes into account that we have weak instruments, the evidence in favor of the NKPC is weakened or the NKPC is rejected outright.

System Estimation of the NKPC

In the third paper of this issue, Frank Schorfheide surveys system methods to estimate the parameters of the NKPC. For this approach one specifies a more or less complete model of the aggregate economy, a DSGE model, and then identifies the structural parameters from the restrictions that the equilibrium process imposes on the moments of a set of observable variables.

Using a simple example, Schorfheide interprets the various identification schemes used in the literature. He explains why it may not be possible to obtain consistent parameter estimates using single-equation methods. System methods on the other hand can obtain consistent parameter estimates through the imposition of prior constraints on elements of the DSGE model other than the NKPC. Essentially these prior restrictions allow one to identify exogenous shocks that may serve as instruments for the NKPC. As an example, Schorfheide points to the procedure of identifying monetary policy shocks from the restriction that the public cannot respond to contemporaneous monetary policy shocks. Schorfheide also suggests that it may not be possible to identify the coefficient on lagged inflation in the NKPC if one allows for serially correlated markup shocks. Indeed, single-equation estimates of the NKPC identify γ_b through the implicit prior restriction that the markup shock is i.i.d. This lack of identification affects the evaluation of policy effectiveness if it also implies that the coefficient on future inflation is not identified.

Schorfheide then surveys papers that estimate the NKPC as part of a more complete DSGE model. Most of this empirical work uses data on output, inflation, and a nominal interest rate. Marginal cost in the NKPC is then treated as a latent variable that is constructed from the observable variables and the equilibrium relationships implied by the DSGE model. But some empirical work also includes measures of marginal cost in the set of observable variables. Schorfheide observes that the range for the estimated coefficients on marginal cost in the NKPC is much larger when marginal cost is a latent variable. The range of estimated NKPC coefficients on marginal cost becomes much closer to that obtained from single-equation estimations once observations on marginal cost are included. Thus, with marginal cost as a latent variable, features of the DSGE model that are different from the NKPC can become much more important for the determination of the NKPC marginal cost coefficient. As is apparent from the work of Krause, López-Salido, and Lubik (2008), the implied process for the latent marginal cost variable is then very different from the process of various measures of marginal cost used in the literature.

In general, the literature review suggests that there is no consensus on the magnitude and role of nominal rigidities in the estimated price-setting process. Furthermore, introducing additional nominal rigidities in the wage-setting process affects the estimates for nominal rigidities in the price-setting process, that is, the NKPC. It also appears as if the relative role of nominal price and wage rigidities is not identified from the data.

Policy Implications of Nominal Price Rigidities

In the final paper of this issue, Stephanie Schmitt-Grohé and Martín Uribe discuss the implications of nominal price rigidities for optimal monetary policy. They first ask how the presence of nominal price rigidities affects the design of optimal policy when fiscal and monetary policy are jointly determined. They then go on to study if simple policy rules such as the Taylor rule can get the economy close to the optimal policy outcome. They find that with small amounts of nominal price rigidities, optimal policy involves price stability, i.e., it tightly stabilizes inflation at zero, and that simple rules that exclusively focus on deviations from price stability get the economy very close to the optimum.

These results provide a nice contrast between optimal monetary policy in environments with and without nominal rigidities. When nominal prices are flexible and there is a well-defined demand for real balances, a zero nominal interest and, hence, deflation minimize the welfare costs from holding money. Furthermore, if in a stochastic environment fiscal policy has to use distortionary taxes to finance given expenditures, mean zero unanticipated changes in the inflation rate represent lump-sum taxes and are an efficient way to raise revenues. Thus, optimal policy leads to low and volatile inflation. In contrast with nominal rigidities, deviations from price stability introduce relative price distortions among the monopolistically competitive producers and make production inefficient. Schmitt-Grohé and Uribe argue that in environments that contain both a well-defined demand for real money and nominal rigidities, even small amounts of nominal rigidities imply that price stability is optimal. This is a useful result since the surveys of Nason and Smith and Schorfheide provide some evidence for the presence of nominal rigidities, but also show that there is no agreement on how substantial nominal rigidities are.

Optimal policies that determine fiscal and monetary policies jointly can be quite complicated, yet Schmitt-Grohé and Uribe show that simple policy rules involve only minor welfare losses relative to the optimal policy. These simple rules are modeled on the Taylor rule that has the nominal interest responding to deviations of inflation and output from their targets with some dependence on past interest rates. It turns out that a simple rule that aggressively targets price stability involves only minimal welfare losses relative to the optimal policy, and that a response to deviations of output from trend significantly decreases welfare. An open question remains why most monetary policymakers prefer to target some positive inflation rate rather than price stability with a zero inflation rate.

Conclusion

The surveys in this special issue show that discussions of the Phillips curve have been at the core of monetary policymaking since the 1960s. Our understanding of what underlies the correlation between unemployment and the inflation rate and what that means for monetary policymaking has changed over the years. At first, many economists and policymakers took the statistical relationship as a fixed menu of choices between inflation and unemployment and targeted relatively low unemployment outcomes. From the period of high inflation and high unemployment in the 1970s, economists emerged believing that there is no inflation-unemployment tradeoff that remains invariant to policy interventions, and policymakers agreed that the objective of monetary policy should be low and stable inflation. Finally, in the 1990s, economists again started to study the inflation-output tradeoff using the new techniques developed in macroeconomics in the 1970s and 1980s, rational expectations and explicit quantitative general equilibrium models of the aggregate economy. This research program gave rise to the NKPC, which is based on the maintained assumption of nominal price rigidities. As is apparent from the surveys in this issue, there is some support for the NKPC in aggregate data, but there is no agreement on the extent of nominal price rigidities in the aggregate economy. Furthermore, one should be aware that not all macroeconomists agree that nominal rigidities are relevant for an understanding of the aggregate economy, e.g., see Williamson (2008) or Chari, Kehoe, and McGrattan (2009) for a skeptical view on this research program. To be sure, research on the relationship between unemployment and inflation will remain an active area in macroeconomics for anyone with an interest in applied monetary economics.

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