ECONOMIC COMMENTARY

Inflation: Drivers and Dynamics
2019 CEBRA Annual Meeting Session Summary

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The relationship between the Phillips curve and inflation has become weaker over time, producing questions regarding how policymakers might connect inflation to the rest of the economy. Presentations given during the "Inflation: Drivers and Dynamics" session of the Central Bank Research Association's annual meeting focused on the intersection of monetary policy and inflation dynamics to examine the ways in which policy might impact inflation and related expectations and processes. This *Economic Commentary* summarizes the papers presented during this session.

Monetary policy and inflation interact in intricate ways. Both theoretical modelers and real-world policymakers usually connect inflation to the rest of the economy via the Phillips curve. In its simplest expression, the Phillips curve equation states that stronger economic activity leads to higher inflation. More sophisticated Phillips curves contain a role for inflation expectations—beliefs about what prices are likely to do in the future—in determining the rate of inflation. While monetary policy doesn't directly enter the Phillips curve, it can affect inflation in two ways: by affecting economic activity and by influencing inflation expectations directly.

Understanding how inflation expectations are formed in the first place, and how they may change over time, is therefore helpful for understanding the inflation process.

Measuring beliefs and testing their properties pose challenges for economists because the tests can depend on assumptions about how to model individuals' behaviors, what information people have access to, and how people process that information. Nevertheless, it is reasonable to think that some policy actions would have a large impact on inflation expectations and the inflation process. For example, if monetary policymakers were to change the inflation target, then individuals would likely take this information into account when making economic decisions, and the inflationary environment would be affected. This relationship between inflation and monetary policy can be particularly relevant under the threat of liquidity traps and when the monetary policy rate is at or near its effective lower bound, a situation that prevents lowering the rate further.

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Moreover, while inflation is an economy-wide phenomenon, it is ultimately driven by the prices that are set for individual goods and services. Studying businesses' price-setting behavior under different inflationary environments is thus crucial to understanding how aggregate inflation is going to react to shocks in the economy if inflation targets change.

The "Inflation: Drivers and Dynamics" session of the Central Bank Research Association (CEBRA) 2019 Annual Meeting addressed some of these issues at the nexus of monetary policy and inflation dynamics. This *Commentary* summarizes the papers presented at the session, which was organized by the Cleveland Fed's Center for Inflation Research and was held on July 19, 2019.

Summaries of Presented Papers
The Phillips curve is a central building block of many of the models used by central banks around the world. That the Phillips curve relationship has become much weaker in recent years than in prior decades is puzzling. The paper "The Role of Expectations in Changed Inflation Dynamics," by Damjan Pfajfar and John M. Roberts, considers two hypotheses to explain the so-called "flattening" of the Phillips curve. One is that prices at the microeconomic level are stickier than they used to be—in the context of the canonical Calvo model, firms are adjusting prices less often. The other is that firms' and households' expectations about future inflation are now less informed by macroeconomic conditions; because expectations are important in the setting of current-period prices, inflation is therefore less sensitive to macroeconomic conditions.

The authors first document that, from the perspective of the New Keynesian Phillips curve under model-consistent expectations, the sensitivity of inflation to economic activity has been markedly lower in the period starting in 1997 than in the preceding two decades. To distinguish between the two hypotheses, the authors bring to bear information on inflation expectations from surveys. This strategy allows them to distinguish changes in the sensitivity of inflation to economic conditions, given expectations, from changes in the sensitivity of expectations themselves to economic conditions.

The authors find that, across surveys and time periods, survey measures of inflation expectations react more sluggishly to economic conditions than a simple benchmark model would predict for expectations. The sensitivity of inflation to economic conditions is estimated to be greater when they condition on survey expectations than in the model with model-consistent expectations. Results on the expectations hypothesis are sensitive to the measure of inflation expectations. With various measures of expectations, the reduction in the sensitivity of inflation to economic activity across their two subsamples is considerably less than in the model with consistent expectations. However, it is only with the University of Michigan's survey of household inflation expectations that the paper also finds a large reduction in attentiveness. In

this case, the authors find that a reduction in attentiveness can account for somewhat more than half of the reduction in the reduced-form sensitivity of inflation to an identified aggregate demand shock. The authors cross-check their findings with available microeconomic studies and find that while this evidence predicts some reduction in the slope of the Phillips curve, it cannot fully account for the large reduction found in the conventional New Keynesian Phillips curve estimated under model-consistent expectations.

A deeper underlying question to understanding the importance of inflation expectations in the Phillips curve is to understand in the first place how individuals formulate macroeconomic expectations, in particular whether or not people form their expectations rationally. Several studies have concluded that, in fact, economic forecasters are not rational when judged on the basis of error predictability—if people make systematic mistakes, then errors can be predicted. This testable implication, however, is unique to a particular class of linear models. The paper "Time-Varying Volatility as a Source of Overreactions," by Julio Ortiz, shows that when macroeconomic variables are allowed to exhibit stochastic volatility, otherwise rational forecasters can exhibit predictable mistakes. As a result, error predictability is not prima facie evidence against rationality.

What is the technical intuition behind this conclusion? When individuals forecast a variable that exhibits time-varying volatility, the optimal Bayesian forecast can no longer be derived exactly. Instead, forecasters must approximate the optimal prediction. A key tension arises in this setting, namely, that better approximations come at a computational cost. The paper shows that in such an environment, forecast revisions can predict forecast errors. Monte Carlo experiments verify this result.

Beyond accounting for predictable mistakes in a nonlinear setting, the model can also explain why the same forecaster might appear to overreact to one variable while simultaneously underreacting to another. Existing theories are unable to naturally account for this. However, the model presented in the paper suggests that this arises because some macroeconomic variables are noisier and more difficult to forecast. More specifically, whether one over- or underreacts ultimately depends on the signal-to-noise ratio associated with a specific variable. Overreactions arise when the signal-to-noise ratio is low, while underreactions occur when the signal-to-noise ratio is high. Cross-sectional evidence from the Survey of Professional Forecasters lends support to the testable implications of the model. Taken together, survey data on expectations point to evidence against linear rational expectations.

The inflationary process can also change because the monetary policymaker explicitly decides to change the inflation target. The policymaker might decide to raise the inflation target to address a key challenge monetary policymakers face these days, which is the risk of hitting the zero lower bound (ZLB) on nominal interest rates. Indeed,

the length of the recent ZLB episodes in the United States, Europe, and Japan have in the past few years focused renewed attention on an old topic of macroeconomic policy: What can be done about the ZLB on nominal interest rates? There are at least two angles to this concern: one is growth-based, another purely monetary. The first is based on observing the sluggish recovery of developed economies following the global 2008 financial crisis, a circumstance that has triggered a heated debate regarding whether these countries could have entered a period of so-called "secular stagnation." The second is grounded in recent evidence—based on lower-than-usual inflation and policy rates (Kiley and Roberts, 2017)—suggesting that liquidity traps could be more frequent events in the future. As a result of both of these concerns, researchers have contemplated raising the inflation target as a valid strategy to create more monetary policy room to counteract large negative demand shortfalls.

Jean-Paul L'Huillier and Raphael Schoenle in "Raising the Inflation Target: How Much Extra Room Does It Really Give?" investigate the constraints on a policy aimed at achieving more monetary policy room by raising the inflation target. They provide a simple answer to their titular question: less room than intended. According to their calculations, in order to get, for example, 2 percentage points of effective extra room for monetary policy, the target needs to be raised from 2 percent to more than 4 percent. A theoretical analysis in the paper shows that the actual effective room gained when raising the target is always smaller than the intended room. The reason for this is a shift in the behavior of the private sector: When monetary policymakers change the inflation target, firms endogenously respond such that prices adjust more frequently, thereby lowering the potency of monetary policy. The authors also derive a simple formula for the effective gain expressed in terms of the potency of monetary policy. They then quantitatively investigate this channel across different models, based on a calibration using micro data, finding that, by raising the target from 2 percent to 4 percent, the monetary authority only gains from 0.51 percentage points to 1.60 percentage points of policy room (not 2 percentage points as intended). The quantitative models allow the authors to derive the Bayesian distribution of the effective room under parameter uncertainty.

The assumption of staggered prices lies at the very core of almost any modern macroeconomic model used to analyze the effects of monetary or fiscal policy. Numerous studies have tested this assumption in granular data and shown that individual prices do indeed change infrequently. The paper "Sticky Prices and the Transmission Mechanism of Monetary Policy: A Minimal Test of New Keynesian Models," by Guido Ascari and Timo Haber, takes a slightly different approach by testing two basic empirical predictions of sticky price models in aggregate data.

In particular, this paper starts from the premise that if sticky prices are of such paramount importance in the

transmission mechanism of monetary policy, then two very general predictions of state-dependent pricing models should emerge in the aggregate data. First, large absolute value monetary policy shocks should lead more firms to adjust their prices, and hence yield a proportionally larger response of the aggregate price level and inflation. Second, the frequency of price changes should be an increasing function of underlying levels of inflation; that is, prices should be more flexible in a high-trend inflation regime than otherwise.

Analyzing the response of a range of real and nominal variables in the United States between 1969 and 2007, the authors provide some statistically significant evidence in favor of the sticky price theory of the propagation mechanism of monetary policy shocks. First, large absolute value shocks have disproportionately larger effects on prices on impact, but are less persistent, matching the first theoretical prediction. Second, the impulse response functions in the high- and low-trend inflation regimes are significantly different and also in line with the second theoretical prediction of higher price flexibility in the high-trend inflation regime.

This selection of papers emphasizes the progress that has been made in understanding the drivers and dynamics of inflation. But there remain many open questions in inflation research, such as the importance of networks for the inflation process. We look forward to future installments of the "Inflation: Drivers and Dynamics" series.

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