

ECONOMIC COMMENTARY

Inflation: Drivers and Dynamics 2019 Conference Summary

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To provide insights into the processes that drive inflationary dynamics, the Federal Reserve Bank of Cleveland holds an annual conference on the topic of inflation: “Inflation: Drivers and Dynamics.” This *Commentary* summarizes the papers presented at the 2019 conference.

Inflation is a complex process. While the simplest incarnations of the Phillips curve posit that a relatively strong economy tends to push up the rate of inflation, research suggests that this is only one of the key drivers of inflation dynamics. Commodity price shocks—especially fluctuations in the prices of oil and gasoline—have frequently had an impact on consumer price inflation, in no small part because these shocks have historically been quite large. International factors can also affect inflation, as some consumer goods are imported from abroad. A number of theoretical models find that, if businesses are forward-looking when they set their prices, then expectations of where inflation is likely to be in the future can have an effect on inflation rates in the present. This latter point highlights that, while inflation is an economy-wide phenomenon, it

is ultimately driven by the prices that are actually set for individual goods and services. As a result, closely studying businesses’ price-setting behavior may yield insights into an aggregate phenomenon.

To provide insights into the processes that drive inflationary dynamics, the Federal Reserve Bank of Cleveland holds an annual conference on the topic of inflation: “Inflation: Drivers and Dynamics.” This *Commentary* summarizes the papers presented at the latest conference, which was organized by the Cleveland Fed’s Center for Inflation Research and was held on May 16-17, 2019. The papers of this conference broadly fell into three categories: (1) international influences on inflation; (2) expectations formation; and (3) price-setting behavior and inflation.

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International Influences on Inflation

The Phillips curve is a central building block of models used by central banks around the world to analyze and forecast inflation. Historically, periods of lower unemployment have been associated with higher levels of inflation. In recent years, however, this association has weakened, which has called into question the ongoing usefulness of the Phillips curve and prompted a search for possible causes of the weakening. One hypothesis for the weaker association between inflation and economic activity is the increased openness of national economies. Domestic consumers increasingly rely on imports, which loosens the relationship between domestic demand, domestic production, and domestic prices. Simon Gilchrist and Egon Zakrajšek test this hypothesis in their paper “Trade Exposure and the Evolution of Inflation Dynamics.”

Using a rich set of industry-level price data, the authors find that the relationship between inflation and economic activity has indeed weakened over time, and this weaker relationship coincides with the increase in international trade observed since the early 1990s. While this phenomenon exists across industries, the industries that are more exposed to global trade exhibit a weaker relationship between inflation and output, consistent with the idea that international trade has played a central role in changing inflation’s dynamics. In a final set of empirical results, the paper focuses on changes in output resulting from shocks to the financial sector to identify shifts in economic activity that are driven by changes in demand. These results support the view that inflation in more-globalized industries responds less to demand-driven fluctuations in economic activity than it does in less-globalized industries. Taken as a whole, the paper provides considerable evidence that the rise in globalization could be a significant factor that explains the weakening relationship between inflation and economic output.

While the impact of globalization on inflation occurs over the longer term, there are also important shorter-term international influences on inflation. Changes in the exchange rate—or the relative value of the domestic currency when compared with foreign currencies—serve as one source of shorter-term fluctuations in inflation. A standard assumption in the research literature is that import prices respond symmetrically to exchange rate appreciations and depreciations. In the paper “Asymmetries and Nonlinearities in Exchange Rate Pass-through,” Mina Kim, Logan T. Lewis, and Robert J. Vigfusson provide empirical evidence that import prices instead respond asymmetrically to exchange rate changes. Specifically, they use microdata from the Bureau of Labor Statistics on US import prices at the dock and find that foreign currency appreciations pass through more quickly than foreign currency depreciations. Moreover, this asymmetry is more pronounced among differentiated consumer goods rather than differentiated intermediate and capital goods. Because the asymmetry varies by the type of good, the nature of competition and

price-setting may be playing important roles in generating this asymmetry.

Kim et al. explore two possible sources of the observed asymmetry and find no support for either. While the asymmetry could be driven by the selective exit of products from the market induced by exchange rate changes, Kim et al. find that exchange rate changes do not alter the probability of product exit. Alternatively, the asymmetry could result from differences in price stickiness if price changes are more likely to occur when there are foreign currency appreciations. But the paper documents that the asymmetry exists even after controlling for the occurrence of a price change and that foreign appreciations do not result in a greater probability of a price change. Thus, price stickiness does not appear to be driving the observed asymmetry. Determining the ultimate source or sources that are driving the asymmetric response of prices to exchange rate fluctuations will require additional research.

Expectations Formation

Most macro models assume that agents form their expectations “rationally” in the sense that they use all available information when forecasting the future and they believe that all other agents are behaving similarly. However, empirical work documents that the expectations formation of firms and households is hard to reconcile with the strong assumptions implicit in rational expectations. Motivated by this discrepancy, Betsy Bersson, Patrick Hürtgen, and Matthias Paustian study macroeconomic dynamics in a model of boundedly rational belief formation, called level-k thinking, as discussed in Garcia-Schmitt and Woodford (2019) and Farhi and Werning (2017). Under level-k thinking, agents revise their expectations about future variables in response to a policy intervention via a small number of iterative steps, called levels of thinking. In the first level, agents compute their optimal choices for every period given the new stance of policy but without changing their expectations about the future. This gives rise to a sequence of temporary equilibria. In the next level, expectations about the future are updated based on this sequence of temporary equilibria, and the process continues a finite number of (“k”) times. Under some conditions, this process converges to rational expectations as the number of levels of thinking gets very large.

Bersson et al. focus on the implications of level-k thinking in sticky price models when the economy is at the zero lower bound (ZLB) in “Expectations Formation, Sticky Prices, and the Zero Lower Bound.” While certain findings derived under rational expectations carry over to the level-k framework, there can be some important quantitative differences. For example, the paper considers optimal monetary policy under commitment in an environment in which an adverse demand shock drives the economy to the ZLB. A policymaker who knows that the private sector forms expectations according to level-k thinking will optimally choose to deploy forward guidance and to stay at the ZLB for longer than would be the case under a baseline,

Taylor-type policy rule. In fact, the length of time at the ZLB is longer than with an optimal commitment policy under rational expectations. Similarly, the paper shows that fiscal multipliers at the ZLB are bigger than unity as would be the case under rational expectations—although typically only slightly larger than unity.

Importantly, a number of puzzling features in rational expectations models at the ZLB do not arise with level- k thinking. For example, in sticky price models with rational expectations, extending the time that monetary policy stays at the ZLB over and above what is indicated by a Taylor-type rule may stimulate GDP and inflation under a small extension, but it can weigh on GDP and inflation if the extension is too long. This so-called “reversal puzzle” does not occur under level- k thinking. These types of results show the importance of understanding and considering alternative models of the expectations formation process, or at the very least demonstrating some of the results that may be fragile in typical models that use rational expectations.

To further explore alternative approaches to forming expectations, Mirko Wiederholt considers a New Keynesian model in which monetary policy can be constrained by the ZLB that matches basic features of survey data on expectations in “Empirical Properties of Inflation Expectations and the Zero Lower Bound.” In any model with full-information rational expectations, there is no heterogeneity in inflation expectations because everyone believes the same things, everyone is fully informed at all times, and inflation expectations respond instantly to shocks. Perhaps unsurprisingly, survey data indicate that households report heterogeneous inflation expectations, and the average inflation expectation responds sluggishly to shocks. To match these features of the survey data, Wiederholt introduces dispersed information among households about the state of the world. In addition, firms also need to gradually learn about the length of time that the economy will remain at the ZLB. This feature helps to match the fact that, at the beginning of the ZLB period in the United States, surveys of market participants showed that they expected the policy rate to move up within about a year and only eventually learned that it would take longer for the policy rate to move up.

Wiederholt’s paper has two main findings. First, the low perceived persistence of the ZLB among firms at the beginning of the ZLB period resolves the “missing deflation” puzzle, in which inflation failed to decline as much as might have been expected given the severity of the recession. Second, the presence of information frictions among households helps to prevent consumption from declining significantly in bad states of the world.

While considerable work has focused on how individuals form their own expectations, it is important to recognize that there is a wider scope to the expectations formation process. For example, economic models describing the actions of firms in a competitive environment require

firms to form higher-order expectations – that is, beliefs about the beliefs of others. A difficulty faced in this line of research has been a lack of empirical evidence about these expectations. Using a novel survey of firms in New Zealand, Olivier Coibion, Yuriy Gorodnichenko, Saten Kumar, and Jane Ryngaert study the higher-order macroeconomic expectations of firm managers in the paper “Do You Know That I Know That You Know: Higher-Order Expectations in Survey Data.” These firms were asked to report not just what they expect inflation to be over the next 12 months (their “first-order” expectations), but also what they believe other firms expect future inflation to be (their “higher-order” expectations). The average higher-order forecast of inflation across firms is close to the average first-order forecast of inflation: 3.5 percent versus 3.4 percent, respectively (both of which were considerably higher than the true rate of inflation in New Zealand at the time of the survey, which was 1.7 percent). However, there is more disagreement across firms in first-order expectations than in higher-order expectations. In addition, the average uncertainty around firms’ higher-order beliefs of inflation is significantly lower than the uncertainty around their own forecasts. The paper also finds that disagreement is much larger than uncertainty, and there is a strong positive correlation between first-order and higher-order beliefs.

The survey provided an opportunity to characterize the way managers update both their first- and higher-order beliefs when they receive new information. This was done by providing random subsets of managers with different types of information. The experiment included several different information treatments, as well as a control group that received no information. Some managers received a lagged realization of the inflation rate itself, others were told the average inflation expectation of managers in the survey, and some received information about the average higher-order expectation of managers in the survey. Managers’ beliefs react strongly to information about realized inflation and the average higher-order expectation of other managers, but they change little in response to information about the average first-order expectation of other managers.

Based on a follow-up wave of the survey, the paper describes how information treatments that exogenously affect firms’ inflation expectations subsequently affected firms’ economic decisions. Firms that revised their inflation forecasts upward also increased their employment and investment relative to the control group, but not their prices or wages, regardless of which information treatment induced the change in inflation expectations. Thus, changes in inflation expectations appear to have a causal effect on firms’ decisions. However, the changes affect employment and investment rather than prices, even though models of firm behavior typically posit a central role for inflation expectations to affect price-setting.

Turning to households, many macroeconomic models posit that expectations of the future also play a role in driving consumer spending. In particular, the consumption

Euler equation relates consumption, nominal interest rates, and inflation expectations and is at the center of modern dynamic models in macroeconomics and finance. Conventional monetary policy aims to stabilize the economy by changing interest rates, and hence households' consumption expenditures, through intertemporal substitution – that is, by changing the pattern of consumption across time periods. Intertemporal substitution is also central to the effectiveness of unconventional monetary policies as well as fiscal policies. As noted above, obtaining reliable estimates of the effectiveness of policy interventions requires knowledge of how expectations will likely respond. The paper “IQ, Expectations, and Choice,” by Francesco D’Acunto, Daniel Hoang, Maritta Paloviita, and Michael Weber, provides further evidence on some of the factors influencing the expectations formation process of consumers.

The paper suggests that limited cognitive abilities may serve as impediments to the effectiveness of policies that operate through household expectations. In a representative sample of Finnish men that contains administrative data on cognitive abilities through IQ tests, the paper finds substantial variation in economic expectations across individuals and over time, with expectations often deviating from the full-information rational-expectations benchmark. Cognitive abilities appear to play a central role in generating forecast errors of inflation, uncertainty in forecasts, and forecasts of implausible values. Cognitive abilities are also systematically related to individuals' plans for current and future consumption, their understanding of intertemporal substitution, and their forward-looking behavior, such as the choice of saving for retirement or the choice of borrowing to finance education-related expenses and not just current consumption. Only men with high cognitive abilities adjust their consumption propensities in response to changes in inflation expectations, as predicted by the consumption Euler equation. Men with relatively high IQs are twice as sensitive to changes in interest rates when making borrowing decisions compared with men who have relatively low IQs, at times of both increases and decreases in monetary policy rates. Differences in income, education, borrowing constraints, or other expectations such as household income expectations cannot explain the heterogeneity in consumption and borrowing responses by IQ.

Price-Setting Behavior and Inflation

The extent to which prices react to monetary policy shocks is a fundamental question in economics. According to theoretical and empirical models in economics, if prices respond a great deal to a monetary policy shock, then relatively little of the shock will have an effect on real economic activity. A key determinant of the response of prices is the presence of price selection—the prices that are farthest from their desired, profit-maximizing level will be those most likely to change (that is, they will be “selected”) in response to a monetary policy shock, and those prices also change by a relatively large amount due to the existing

gap between actual and desired prices. At an aggregate level, a large amount of price selection can therefore amplify the inflation response and dampen the response of real activity to a monetary policy shock. However, little direct evidence has been provided on the empirical importance of price selection. In the paper “Price Selection,” Carlos Carvalho and Oleksiy Kryvtsov provide such evidence and explain its implications for sticky price models.

The paper proposes a simple, non-model-based approach to measure price selection and its impact on inflation. Using detailed micro-level consumer price data for the United Kingdom, the United States, and Canada, the paper reports evidence of strong price selection across goods and services in all three countries. In particular, price selection accounts for around 36 percent of the observed variance of inflation in the United Kingdom and the United States and 28 percent of the observed variance of inflation in Canada at a disaggregated level of analysis. Price selection is stronger for goods with less frequent price changes or with larger average price changes. Aggregation largely dissipates the effects of price selection for regular price changes but not for changes associated with price discounts.

The paper also shows that standard multisector models can account for approximately 60 percent of the effects of price selection across sectors while explaining only a modest portion of the aggregation effect. The analysis suggests that models that exploit additional dimensions of heterogeneity across goods and retailers should strengthen our ability to account for the empirical evidence concerning price selection effects. Adding information frictions or an interaction of large sector-specific shocks and nonlinearities in these models are examples of extensions along these lines.

Product turnover is another important issue for the analysis of price behavior in monetary policy models. A defining feature of modern economies is the high rate of product turnover in the market place, but much work in macroeconomics, especially work on the design of monetary policy, abstracts from this feature of the data. Klaus Adam and Henning Weber investigate this assumption and show that product turnover and the product life cycle are important for determining the optimal inflation rate that a welfare-maximizing central bank should target.

In their paper “Price Trends over the Product Life Cycle and the Optimal U.K. Inflation Target,” Adam and Weber use the micro price data that underlie the construction of the consumer price index in the United Kingdom and document a new set of facts describing how product prices evolve over the product lifetime. In particular, for most expenditure categories, the prices of individual products decline over the product lifetime, relative to the average price of the products in the specific expenditure category. Put differently, new products tend to be initially expensive and become cheaper over their lifetime in relative terms. But there is considerable heterogeneity across expenditure categories in the average rate at which relative prices

decline. For instance, fashion and entertainment products, which arguably feature some “news value,” display very high rates of relative price decline.

These empirical facts turn out to have important normative implications for the optimal inflation target. In sticky price models, the documented relative price declines over products’ lifetimes reflect fundamental forces, such as the evolution of product quality or productivity over time. This suggests that relative price declines are efficient. Monetary policy can hasten these relative price declines through a positive value for the inflation target. The optimal target value is roughly equal to the average strength of the observed relative price decline across expenditure categories. For the UK economy, this calculation implies that the optimal inflation target is between 2.6 percent and 3.2 percent. The optimal target has increased over the past two decades by around 1.2 percentage points because declining relative price trends have picked up over this period.

Policymakers and forecasters often look for signs of an impending rise in the general price level by concentrating on price movements in particular sectors. The underlying rationale is the maintained view of a cascade effect. The cascade effect occurs as price developments in a single sector affect other sectors’ prices through input-output interactions, thereby moving the aggregate price level and thus inflation. Recent policy work and the popular press have labeled this cascade effect metaphorically as “pipeline pressures.” The purpose of the paper “Pipeline Pressures and Sectoral Inflation Dynamics,” by Frank Smets, Joris Tielens, and Jan Van Hove, is twofold. First, it develops a multisector New Keynesian model that accommodates both producer and consumer prices to derive a structural definition of pipeline pressures for inflation. The model is estimated using quarterly US data to infer the presence of these pipeline pressures, and comparisons among model variants highlight the statistical relevance of the underlying economic transmission mechanisms.

In a second step, the paper assesses the role of pipeline pressures in shaping inflation persistence and inflation volatility at both the economy-wide and sectoral levels. Pipeline pressures explain 21.5 percent of the volatility of headline inflation measured by the producer price index, and 28.2 percent of the volatility of inflation measured by the personal consumption expenditures price index. In the case of disaggregated inflation, pipeline pressures’ contribution reaches as high as 43.3 percent. Broadly, producer prices of sectors higher up in the value chain (such as agriculture, primary metals) are less subject to pipeline pressures than downstream producer prices and consumer prices (such as healthcare, clothing and footwear). Price stickiness along the production chain implies that shocks only slowly feed into other sectors’ marginal costs and output prices. Due to the heterogeneous price stickiness of sectors, some pipeline pressures manifest themselves quickly, whereas others take time to build up. This heterogeneity in price setting is shown to explain a large share of the heterogeneity observed in the persistence of disaggregated

inflation data. Furthermore, accurately identifying pipeline pressures is instrumental in correctly differentiating between aggregate and sectoral sources of inflation volatility and inflation persistence.

Finally, the aggregate implications of heterogeneity in price rigidities across sectors are examined for the effect of monetary policy by Christopher Clayton, Xavier Jaravel, and Andreas Schaab in “Heterogeneous Price Rigidities and Monetary Policy.” The paper establishes three new empirical facts: (1) prices are more rigid in sectors selling to college-educated households, (2) prices are more rigid in sectors employing college-educated households, and (3) sectors that employ college-educated households also sell more to these households.

The paper develops a sticky price model with partial insurance, two sectors, and two types of households: college-educated households and non-college-educated households. The model matches the distribution of consumption and the income share across the two different worker types. In this setting, the aggregate effect of monetary policy is 5 percent stronger than in an economy with homogeneous price rigidity across sectors, and consumption of college-educated households is 22 percent more sensitive to monetary policy shocks.

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