

# Inflation Signals and Inflation Noise

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**T**he employment report for March, released last Friday and showing a jobs gain of 308,000 over February, was certainly good news. Everyone hopes that monthly reports over the rest of this year and for years to come will also bring good news on the employment front.

Assuming that employment gains continue, market focus will naturally shift from employment to concerns over inflation risks. Indeed, some market commentary already has shifted in that direction. My purpose today is to provide my perspective on the problem policymakers face in determining when inflation risks are rising.

Before proceeding, I want to emphasize that the views I express here are mine and do not necessarily reflect official positions of the Federal Reserve System. I thank my colleagues at the Federal Reserve Bank of St. Louis for their comments; Robert H. Rasche, senior vice president and director of Research, provided special assistance. However, I retain full responsibility for errors.

## BACKGROUND

In the four decades since the beginning of the Great Inflation of the 1960s and 70s, economists and central bankers have acquired a much better understanding of the source and consequences of inflation. When the Great Inflation began, it was common to cite one or another idiosyncratic events as the driving force behind the observed change in prices: OPEC, steel prices, anchovies and forth. Anchovies? Few today will understand

this reference, so I'll have to explain that some analysts argued that the disappearance of anchovies from the coast of Peru in 1972 had something to do with rising inflation in 1973. Today, however, economists universally accept the proposition that sustained inflation or deflation is, in the words of Milton Friedman, "everywhere and always a monetary phenomenon."

The experience of the Great Inflation brought home to the public and policymakers alike the burden that inflation imposes on an economy. In the absence of institutions adapted to an inflationary environment, the efficiency of market prices to signal the relative scarcity of goods and services is impaired. Incomes and wealth are redistributed capriciously, even when the inflation is partially foreseen, in a tax system that is not fully indexed. Regulations on nominal interest rates, such as deposit ceilings and usury laws, interact with the inflation rate to distort demand in certain sectors such as housing. Some financial institutions, such as the thrifts that specialized in housing finance, were driven towards extinction. It is possible, though the evidence is not conclusive, that even modest sustained inflation negatively impacts the rate of growth of labor productivity.

Central bankers world-wide have taken these lessons to heart. Since the initial inflation targeting experiment by the Reserve Bank of New Zealand in 1990, thought at the time to be radical, inflation targeting has become the stated objective of at least 11 central banks, including those of developed and developing countries. These central banks publish either a numeric value, or a range of values, to which they commit as an infla-

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tion policy objective over some time horizon. For most of these central banks, achieving the inflation target is, under normal market conditions, the single policy objective. For these policymakers, the idea, embodied in the original Phillips curve analyses, that it is possible to permanently trade-off a lower unemployment rate or a higher level of real output for a higher rate of inflation has been relegated to the textbooks on the history of economic thought.

Other central banks, including the Federal Reserve, have declined to quantify their inflation objective. Nevertheless, most, if not all of these institutions acknowledge their primary responsibility to produce a low and stable inflation environment. In the case of the Federal Reserve, the FOMC has stated as its policy objective to achieve price stability in order to achieve maximum sustainable economic growth, thereby fulfilling its dual legislated mandate under the Humphrey-Hawkins Act.

The FOMC has never defined “price stability” numerically, but its commitment to price stability is not in doubt. I have indicated on several occasions that my own inflation target is zero, properly measured. Because all our measures of inflation have some upward bias, my definition of price stability is consistent with a small positive measured rate of inflation. Our recent inflation experience is, I believe, a good approximation of price stability.

The policy problem faced by the FOMC, and many other central bankers, today is significantly different from that 25 years ago. By the late 1970s, the inflation rate in the United States had become unacceptably high—both for the FOMC and for the public in general. There was disagreement in the economics profession as to whether the costs of disinflationary monetary policy were worth bearing, but the FOMC concluded that a more disciplined monetary policy was necessary. The decisive date was October 6, 1979, when the FOMC decided to adopt the “New Operating Procedures.” Subsequently, the FOMC permitted the federal funds rate to exceed 20 percent. With the tighter monetary policy and changing inflation

expectations in the market, the economy experienced a severe recession in 1981-82.

Measuring inflation by 12-month changes in the consumer price index (CPI), inflation fell from a peak of 13.3 percent in 1979 to 3.8 percent in 1982, and remained in the neighborhood of 4 percent into the mid 1980s. Inflation rose a bit in the late 1980s, and reached 6.1 percent in 1990, in the face of the oil shock that accompanied Iraq’s invasion of Kuwait.

In the early 1990s, the consensus was that the economy had not returned to price stability. Any substantial risk that inflation might rise was clearly undesirable and necessitated a policy response. But over the course of the 1990s, inflation was flat to gradually falling, and with further declines in the early part of this decade most observers concluded that the battle for price stability had been won.

Policy discussions today must consider two-sided outcomes—the risks to price stability are symmetric. A significant breakout of inflation above our current situation is certainly not desirable—no one wants to throw away the hard-earned accomplishments of the past 25 years. However, a significant decline in inflation from current rates may not be desirable either—no one wants to replicate the deflationary experiences of the 1930s or Japan’s experience in the 1990s. The consensus of the FOMC, as reflected in the most recent press release, is that the upside and downside risks to inflation are almost balanced.

When the primary battle against inflation started in 1979, there was a strong case for paying great attention to the rate of money growth as a measure of the thrust of monetary policy. Money growth is not irrelevant to assessing inflation risks today, but the emphasis has changed. For a variety of reasons, and especially because expectations of low inflation are so entrenched in the markets, short-run money growth is an inadequate indicator for monetary policy purposes. What we need to do instead is to extract as best we can evidence of possible inflationary pressures from a variety of other sources of information.

## TRANSITORY AND PERMANENT CHANGES IN PRICES

How can we best read the “news” in the price data that become available every month? The problem is to uncover information that might indicate that a higher rate of sustained inflation could be at hand. The FOMC should respond to the signal and not to the noise in the data. Separating inflation signals from inflation noise is a serious challenge.

Throughout most of the post-World War II history in the United States, inflation has been a highly persistent process. Nevertheless there is a lot of random month-to-month variation in the measured price indexes. It is this non-systematic variation that we call “noise.” Somehow, policymakers have to look through the “noise” to discern the signal about the underlying trend in inflation in order to formulate appropriate policy actions.

This signal extraction problem is the rationale for the development of a number of supplementary measures of inflation, beyond the broad-based price indexes collected by the government statistical agencies. In particular, in addition to the CPI and personal consumption price index, “core” measures of inflation that exclude food and energy prices are often highlighted.

In monetary policy reports to Congress, congressional testimony, and public speeches, Chairman Greenspan and other members of the FOMC have focused on the core measure of the personal consumption price index. The rationale for the construction of the core measures of inflation is not that food and energy are unimportant items of household consumption. The core measures came to prominence in the 1970s when food and energy prices were extremely volatile. Under those conditions the core inflation measures likely provided helpful filters through which to discern a signal of the inflation trend. Removing these components removes a source of short-run noise that can obscure underlying price developments.

Another approach to identifying the signal is the median CPI index. The Federal Reserve Bank

of Cleveland publishes such an index.<sup>1</sup> The median CPI, by construction, will exclude any CPI component price index that is highly volatile in the short run, as this component inflation rate will typically appear in one of the tails of the cross-section dispersion of the inflation rates of the CPI components.

I must confess that I am uncomfortable with arbitrarily defined filters. Filtering of transitory shocks where the shocks are understood and can be identified is clearly appropriate. An example is the increase in tobacco prices following the legal settlement with the major tobacco companies several years ago. It was well understood that this was a one-time increase in tobacco prices that would finance the funds established as part of the settlement. It was possible to estimate the impact of those price changes on the overall CPI and most economists filtered this impact out in order to assess the inflation signal at the time.

Absent specific information on which to base estimates of “inflation noise,” care must be taken to assure that the techniques used to filter transitory inflation are robust. The late Karl Brunner used to criticize the “upper tail theory of inflation”—that inflation is caused by the increases in the prices of those items that happened to be rising the fastest at any point in time. If these “upper tail” rates of inflation are filtered out of the inflation measure, then there can be no inflation! Clearly arbitrary filtering can be used to define away substantive problems. I believe that additional research into defining and extracting inflation trends has the potential to provide valuable insights to monetary policymakers.

Though the evidence suggests that U.S. inflation in the second half of the twentieth century was a highly persistent process, it is possible that the observed persistence may result from the way that monetary policy was implemented. Unlike organized asset markets, where economic theories suggest that price changes should approximate a random walk, there is no strong theoretical

<sup>1</sup> Each month’s release can be found at <http://www.clevelandfed.org/research/data/mcpipr.htm>.

basis for highly persistent inflation rates. Recent research suggests that the persistence of inflation in the U.S. has diminished since the mid 1980s.<sup>2</sup> Economic historians who study the gold standard period conclude that inflation in various countries was much less persistent during that period than in the twentieth century. The lesson for those trying to separate inflation signals from inflation noise is that the filters may not be robust to changes in monetary policy regimes.

## FORECASTING INFLATION

A critical question for all central bankers, and the FOMC in particular at the present time, is how inflation will evolve in the near future. Are near-term inflationary (or deflationary) pressures really quiescent? The answer to this question requires a forecasting model, or alternatively a set of leading indicators of inflation.

### *Supply Chain Theories of Inflation*

One view that currently is receiving considerable attention is what I will label the “supply chain theory of inflation.” Proponents of this view characterize inflation shocks as originating in raw materials markets and subsequently transmitted through intermediate products to finished products and finally to consumer prices. From this perspective, inflation of commodity prices is a leading indicator of PPI inflation which in turn is a leading indicator of consumer price inflation.

To proponents of the supply chain view, rapid inflation in scrap steel prices and other basic commodity prices in the past six months is a cause of significant concern. Last month, a *Wall Street Journal* article reported that some firms are passing along materials price increases. “Indeed a handful of companies—among them makers of mattresses and gym equipment—already has or are preparing to ask shoppers to pay more to cover

their rising steel costs. But most other manufacturers are trying to push steel-price jumps of up to 30 percent to 50 percent to other companies along the supply chain, creating tension between steel producers, their biggest customers and numerous smaller suppliers between them.”<sup>3</sup> Similar concerns are often expressed about the depreciation of the dollar against the currencies of our major trading partners as a source of CPI inflation directly through the price of imported goods or indirectly through induced price changes on domestically produced goods that compete with imports.

Without question, individual firms often do pass along increases in prices of their inputs. The issue is whether this phenomenon is general enough to explain overall inflation. Undoubtedly there are times during which inflation shocks are transmitted through such mechanisms. However such forces are not universal. Automobile manufacturers, faced with weak demand in recent years have effectively cut retail prices through incentive programs, discounts, rebates and zero interest financing. In this environment, they have demanded and obtained substantial price concessions from their suppliers. In this case, downward price pressures have been transmitted backward through the supply chain starting from retail markets rather than forward from commodity markets.

Backward and forward price pressures can exist at the same time. The forward pressures have been visible recently in some industries, but backward pressures have been evident for several years and seem less newsworthy at present. Competitive forces can frustrate efforts to push increased input costs up the supply chain. The *Wall Street Journal*, also in an article last month, reported that airlines, facing substantial increases in jet fuel prices “have made at least 12 attempts to boost airfares in the past 2½ months alone. But most of the efforts have failed to stick, and increasingly the spoiler has been one or more

<sup>2</sup> See T. Cogley and T. Sargent, “Evolving Post-World War II U.S. Inflation Dynamics,” *NBER Macroeconomics Annual*, 2001, pp. 331-72; and A. Levin and J. Piger, “Is Inflation Persistence Intrinsic in Industrial Countries?” Federal Reserve Bank of St. Louis Working Paper 2002-023.

<sup>3</sup> “Companies Fight Rising Steel Prices,” *Wall Street Journal*, March 8, 2003, p. A3

budget-price airlines, which see a chance in the current squeeze to extend their market shares.”<sup>4</sup> In this case competition in consumer markets is limiting the transmission of price pressures through the supply chain.

Nor are exchange rate depreciations necessarily leading indicators of price changes at the retail level. First, the U.S. remains a relatively closed economy with a large fraction of the goods and services consumed here produced domestically. Second, research indicates that the “pass-through” of exchange rate fluctuations is not instantaneous, complete or constant.<sup>5</sup>

There are several ways to test the idea that inflation at an earlier stage of processing feeds into inflation at a latter stage. Consider a statistical equation in which we try to explain monthly CPI inflation from the producer price index. The consumer price index is an index of retail prices. The PPI, which used to be called the “wholesale price index,” is an index of prices at an earlier stage of production. The equation employs two groups of explanatory variables. The first group consists of the previous 12 months of CPI inflation. We include the CPI history because we want to determine the contribution of the PPI over and above the contribution of the CPI history itself. The second group consists of the contemporaneous and previous 12 months inflation of the PPI price index for finished goods.

Most of the predictive value is in the contemporaneous PPI term and the lagged CPI inflation terms. The fact that the contemporaneous CPI and PPI inflation rates move together is a consequence of inflation shocks that affect prices at all stages of processing at the same time.<sup>6</sup> The twelve lagged PPI variables account for only 11 percent of the variance in the CPI inflation not attributable to the contemporaneous PPI inflation and the

history of CPI inflation itself. Thus, we simply do not observe PPI inflation being passed along over time into the CPI to any significant degree.

Another approach to testing the supply-chain theory of inflation is to examine the relationship between various stages of processing in the PPI. It turns out that the lead/lag relationship for the PPI stage of processing is even weaker than that for the PPI and CPI. Consider the statistical equation explaining PPI inflation for finished goods using the history of finished goods inflation and the current and previous 12 months inflation of the PPI index for intermediate products. The intermediate products inflation adds less than 1 percent to the predictive value of the equation. Using the same approach to explain the inflation rate for the PPI for intermediate products, we find that inflation in the PPI index for crude materials adds only 4 percent to the predictive value of the equation.

To summarize this discussion, although it may seem logical that increases in crude materials prices, such as petroleum, would feed forward into semi finished goods and then forward again to finished goods, in fact the inflation process does not work this way. Depending on conditions in individual markets, sometimes inflation does feed forward, but sometimes it feeds back. We just cannot reliably conclude that today’s materials prices inflation will be tomorrow’s finished goods inflation.

### “Gap” Theories of Inflation

Another popular framework in which to analyze the transmission of inflation is the “gap” model. Various implementations of this model are rooted in the expectations-augmented Phillips curve. A typical empirical representation of this

<sup>4</sup> “Growing Heft Puts Budget Airlines in the Pilot’s Seat,” *Wall Street Journal*, March 29, 2004, p. A1.

<sup>5</sup> See P.K. Goldberg and M.M. Knetter, “Goods Prices and Exchange Rates: What Have We Learned?” *Journal of Economic Literature*, 1997, 35(3), pp. 1243-72; and P.S. Pollard and C.C. Coughlin, “Size Matters: Asymmetric Exchange Rate Pass-Through at the Industry Level,” Federal Reserve Bank of St. Louis Working Paper 2003-029C.

<sup>6</sup> The simple correlation between monthly percentage changes of the PPI crude materials price index and the PPI intermediate products price index is 0.48; between percentage changes in the PPI intermediate products price index and the PPI finished products price index is 0.74 and between percentage changes in the PPI finished products price index and the CPI is 0.64 over the period March 1948 through December 2003.

framework postulates that the inflation rate is determined by inflation expectations, current and lagged values of a “gap measure,” current and lagged “supply shocks” and undetermined residual factors. In these equations, a common specification of supply shocks includes changes in the relative prices of food and energy, changes in relative import prices, and “productivity shocks.” “Gaps” typically are measured as the difference between real GDP and a measure of “potential GDP” such as that constructed by the Congressional Budget Office, or by the deviation of the unemployment rate from an estimated equilibrium unemployment rate.<sup>7</sup>

There are several tricky parts of such analyses; one is uncertainty over the level of potential GDP or of the equilibrium unemployment rate. Another is obtaining a reliable measure, or proxy, for the expected rate of inflation. To measure expected inflation, one of two approaches is frequently applied. The first is to represent expected inflation as a weighted average of past observed rates of inflation. The alternative approach is to embed the gap equation within a model of the entire economy and to equate expectations of future inflation with the model based forecasts of inflation.<sup>8</sup>

Recent research at the Federal Reserve Bank of St. Louis shows that with several different models of expected inflation, including the lagged inflation proxy, neither the “gap” term nor the “supply shock” terms account for the major movements in the rate of inflation. The expected inflation term trumps the other factors as the major moving force in the U.S. inflation history.

## FORECASTING INFLATION— EMPIRICAL EVIDENCE

In 1999, James Stock and Mark Watson published an exhaustive study of models for forecast-

ing inflation.<sup>9</sup> The focus of their analysis was forecasts of inflation on a twelve-month horizon. They started their analysis with “conventional specifications of the Phillips curve” that related the change in the inflation rate to past values of an unemployment gap measure, past changes of inflation and current and past values of various measures of “supply shocks”—the type of specification discussed above.

Stock and Watson reached several conclusions:

1. In out-of-sample forecasts the various supply shock measures did not improve the forecasting performance of their models;
2. while the estimated relationship between changes in the inflation rate and current and past changes in inflation and unemployment fail statistical tests for stability, in economic terms the relationship is robust;
3. alternative measures of real economic activity generate more accurate forecasts than do equations with the unemployment rate;
4. the addition of interest rates and interest rate spreads fails to improve the forecasting performance of the estimated model;
5. commodity prices do not improve inflation forecasts; and
6. forecasts using the unemployment rate outperform simple models using only lagged changes in inflation, but the gain in forecasting accuracy is relatively small. Their analysis is wide ranging covering a total of 168 economic indicators. An overall assessment of their results is that our ability to deliver significantly more accurate forecasts of inflation beyond those that can be generated from the history of inflation itself is quite limited.

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<sup>7</sup> Robert J. Gordon has authored numerous studies applying this framework.

<sup>8</sup> R. Clarida, J.; Gali and M. Gertler, “The Science of Monetary Policy: A New Keynesian Perspective,” *Journal of Economic Literature*, December 1999, 37(4), pp. 1661-704.

<sup>9</sup> J.H. Stock and M.W. Watson, “Forecasting Inflation,” *Journal of Monetary Economics*, 1999, 44, pp. 293-335.

## ANCHORING INFLATION EXPECTATIONS

How is a monetary policymaker to interpret the above conclusions? One possible reaction would be despair—it is close to impossible to discern that near future inflation will differ systematically from recent past inflation and society will just have to live, at least for a while, with recent history.

I have an optimistic alternative interpretation of the available data and research results. My conclusion is that the unfolding inflationary experience is most strongly anchored by how the public and financial market participants expect inflation to evolve. Well designed and articulated policy under such conditions can produce great outcomes. However, badly designed policies under the same conditions can produce disasters!

If my characterization of the importance of inflationary expectations as a determinant of inflation is correct, then there are important lessons for monetary policymakers. In an economy that works this way, it is essential that the central bank clearly articulate its inflation objectives, and have this message regarded as highly credible. If a central bank is committed to a low-inflation environment, and that commitment is credible, then the general public will believe future inflation will be low. Under these circumstances the economy has a strong external nominal anchor. That nominal anchor generates behavior by buyers and sellers that produces low and stable realized inflation. In recent vernacular, at any given time few firms in the economy have any “pricing power.”

In this type of economy, if the central bank fails to articulate an inflation objective, or if it lacks credibility with the public that the stated objective will be pursued, then the downside risk to the economy is enormous. Environments in which expectations are not anchored externally are inherently unstable. We observe this behavior

in asset markets when, for reasons that are not well understood, “bubbles” develop. Reality chases expectations, which in turn chase reality. Events are determined by “inflationary psychologies.” Prices follow explosive paths, either upward or downward, for a time.

Within a few weeks of the dramatic change in policy direction in 1979, Chairman Volcker testified before Congress on the FOMC’s new operating procedures. Market expectations played a prominent role in his thinking. “The clear and present danger was that failure to deal with inflation and inflationary expectations would in time produce more—not less—economic instability, ultimately with higher prices and greater unemployment. In that setting, the priority for policy was decisive action to deal with inflationary pressures and to defuse the dangerous expectational forces that were jeopardizing the orderly function of financial and commodity markets.”<sup>10</sup>

## CONCLUDING COMMENT

The FOMC is unavoidably in a situation of having to apply its best judgment to a variety of economic indicators of possible inflationary pressure. I’ve not discussed today a range of information on inflation pressures, which include the rate of productivity growth, the rate of increase in unit labor costs, measures of wage inflation anecdotal reports from business firms on the inflation environment they see. Instead, I hope I’ve convinced you that there is no regular and reliable relationship between inflation in materials prices or goods at an early stage of processing and retail price inflation.

Of critical importance to maintaining low and stable inflation is the FOMC’s commitment to act aggressively when inflation risks change, either up or down. That commitment anchors market expectations of long-run inflation, and makes the economy more robust to short-run inflation shocks. Short-run disturbances do not

<sup>10</sup> Statement by Paul A. Volcker before the Subcommittees on Domestic Monetary Policy and on International Trade, Investment and Monetary Policy of the Committee on Banking, Finance and Urban Affairs, U.S. House of Representatives, Nov. 13, 1979, *Federal Reserve Bulletin*, December, 1979, p. 959.

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automatically get built into inflation, which helps to dampen the impacts on the economy of inflation shocks.

This stable environment also helps the FOMC to avoid mistakes. Above all, we do not want to respond to inflation noise, which would add further instability to the economy. Extracting the inflation signal, and responding to it, is what we try to do.