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## Understanding the Recent Behavior of U.S. Inflation

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*One of the most surprising features of the long current expansion has been the decline in price inflation through the late 1990s. Some observers interpret the decline as evidence of a permanent change in the relationship between inflation and economic growth. But an analysis based on a standard forecasting model suggests that conventional economic factors—most notably, a decrease in import prices—can account for the low inflation rates in recent years.*

Economists customarily expect inflation to rise during the expansionary phase of the business cycle. During the current economic boom, however, inflation has taken a very different course. Following the 1990-91 recession, inflation in the core CPI—the consumer price index excluding its volatile food and energy components—began a marked decline that continued through the end of the decade (Chart 1).<sup>1</sup> Adding to the puzzle is the fact that for some time unemployment rates have been at levels typically associated with rising inflation.

Two major explanations have been offered for the unusual behavior of U.S. inflation in the 1990s. The first attributes the low rates to conventional economic forces—and, in particular, to a series of “positive supply shocks.” These shocks include periodic declines in commodity and energy prices and intervals of dollar appreciation and dramatically slower growth in medical costs. Such shocks are transitory in nature and so can be reversed at any time. The second explanation for the behavior of inflation during the last decade holds that heightened competition among producers and the productivity advances made possible by the new information technology have fundamentally altered the relationship between economic growth and inflation. According to this explanation, the low inflation rates reflect a permanent change in the dynamics of the inflation process.

In this edition of *Current Issues*, we consider the merits of these conflicting interpretations as we explore the inflation performance of the U.S. economy. To determine which explanation best fits the facts, we make use of a Phillips curve model—a standard tool for forecasting inflation. We specify the model to include a measure of supply shocks and other factors that have helped determine inflation movements in the past. If the model can account for the behavior of inflation in the 1990s, then the recent low rates most likely stem from conventional economic forces—not from a fundamental and lasting change in the U.S. inflation process.

Our tests of the Phillips curve model suggest that it can, in fact, account for the low inflation rates of the 1990s. In addition, we find that one supply shock in particular—a large and protracted decline in import prices—has proved especially important in curbing inflation over the past several years.<sup>2</sup>

### The Triangle Model

To understand the behavior of inflation during the current expansion, we use a formulation of the Phillips curve known as the triangle model of inflation. Developed principally by Robert Gordon of Northwestern University, the triangle model takes its name from the specified dependence of the inflation rate on a set of three determinants: inertia, demand, and supply.<sup>3</sup>

*How the Determinants Affect Inflation*

Inertia describes the tendency of inflation to deviate only gradually from its own past values. When the economy is buffeted by a shock, inflation responds slowly, with changes occurring over a number of quarters or years. Various explanations for the persistence of inflation have been proposed. Some economists argue that the sluggish adjustment of inflation expectations keeps the rate of increase in the general price level on a steady course; others contend that the presence of wage and price contracts in the economy acts as a significant restraint on rapid changes in inflation. But whatever its sources, this slow adjustment means that past inflation will help to determine the current level of inflation.

Understanding how demand affects inflation is a bit more complicated. The relationship requires some familiarity with the notion of output trends. The amount of output produced in the economy tends to grow over time because of increases in labor and capital and advances in technology. Although the utilization of these resources varies over the business cycle, their long-run movements can be thought of as generating a smooth underlying trend for output. When demand is above the trend level of output, there is excess demand in the economy and inflation will begin to rise. When demand is below the trend level of output, there is slack in the economy and inflation will begin to fall. Economists assume that there are unique levels of unemployment and capacity utilization that correspond to this trend growth in output. To gauge excess demand pressures in the economy, economists construct proxies measuring the current deviation of a demand variable—such as unemployment or capacity utilization—

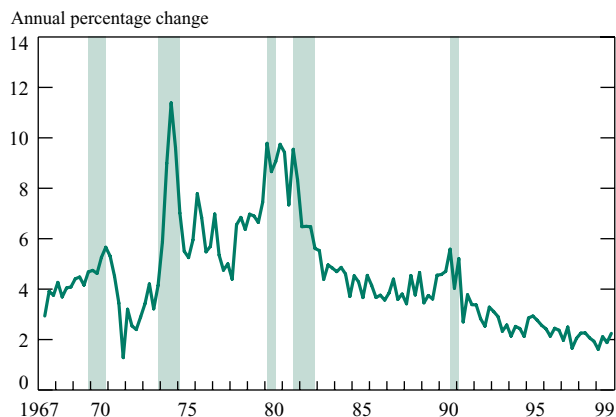
from the level at which there would be no tendency for inflation to accelerate or decelerate.<sup>4</sup>

Supply factors, the third determinant in our triangle model, influence inflation through sharp changes in business costs. In the 1970s, large increases in the price of imported inputs raised producers’ costs dramatically and contributed to an acceleration in inflation. Such supply shocks may take on greater relevance as the increased openness of the U.S. economy exposes domestic producers and consumers more fully to shifts in the prices of imported inputs and final goods. Variables intended to capture supply shocks include the price of imports as well as food and energy prices. All three of these items can affect inflation directly because they are components of the domestic price index. In addition, import prices may have an indirect effect on inflation because changes in import prices can induce domestic firms to alter the prices of competing goods.

*Specifying the Model*

To make the triangle model of inflation operational, we select variables to represent the inertia, demand, and supply components. To capture the inertia component—the influence of recent inflation trends on current values—we use past inflation rates. To measure excess demand pressures in the economy, we include the unemployment rate for prime-age males (Chart 2).<sup>5</sup> Finally, to capture the effect of supply shocks, we use the change in the price of imports (including raw materials, intermediate goods, and commodities) relative to the change in domestic prices. More specifically, we measure the difference between the percentage change in import prices and the percentage change in the core CPI (Chart 3).<sup>6</sup>

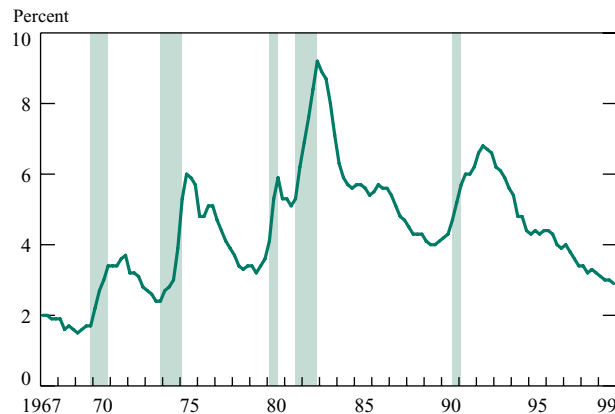
**Chart 1**  
**Core CPI Inflation**



Sources: U.S. Department of Labor, Bureau of Labor Statistics; authors’ calculations.

Note: The shaded areas denote periods designated recessions by the National Bureau of Economic Research.

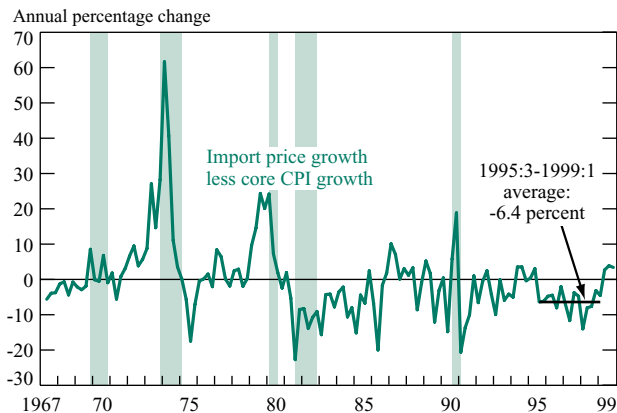
**Chart 2**  
**Unemployment Rate of Prime-Age Males**



Source: U.S. Department of Labor, Bureau of Labor Statistics.

Notes: Prime-age males are twenty-five to fifty-four years old. The shaded areas denote periods designated recessions by the National Bureau of Economic Research.

**Chart 3**  
**U.S. Relative Import Prices**



Sources: U.S. Department of Labor, Bureau of Labor Statistics; U.S. Department of Commerce, Bureau of Economic Analysis; authors' calculations.

Note: The shaded areas denote periods designated recessions by the National Bureau of Economic Research.

A quick look at the movements of these demand and supply variables suggests that a relationship with inflation is quite plausible (compare Charts 2 and 3 with Chart 1). With the exception of episodes in the 1970s and the most recent past, decreases in unemployment have been associated with rising inflation, while increases have been associated with declining inflation. In addition, the path of inflation has closely tracked the rise and fall of relative import prices at several points in the past. For example, increases in relative import prices in the early and late 1970s accompanied sharp surges in inflation. More recently, a large and persistent drop in relative import prices from the third quarter of 1995 to the first quarter of 1999 (the period highlighted in Chart 3) has coincided with a decline in inflation. During this period, relative import prices—influenced by a mix of events that included a reduction in oil prices, a dollar appreciation, and the Asian financial crisis—fell at an average annual rate of 6.4 percent.<sup>7</sup>

### What the Triangle Model Excludes

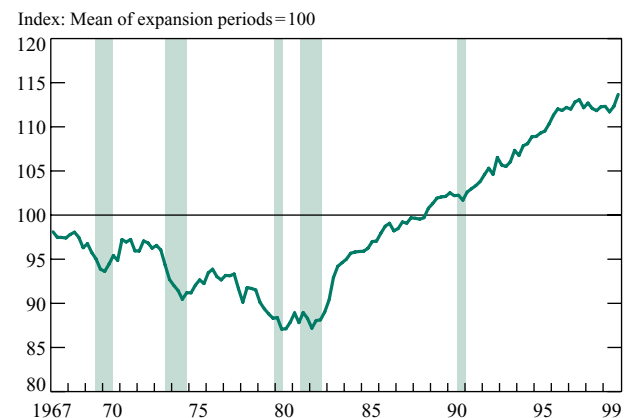
Absent from the triangle model are two factors commonly viewed as exerting an important influence on inflation—wage changes and exchange rate movements. Wage changes are thought to affect inflation through their impact on production costs. Because wages account for the bulk of production costs, firms that raise employee wages may seek to offset the increase in their expenditures by raising the price of their goods. Exchange rate movements affect inflation through their influence on import prices. For example, those who see exchange rates as a key factor in inflation stress that a depreciation of the dollar may cause U.S. consumers and companies to pay significantly more for foreign goods.

Although these arguments seem persuasive, there is reason to question the importance of both wage changes and exchange rate movements as determinants of inflation in the short run—by which we mean quarterly changes in inflation. In the case of wage changes, we note first that increased worker productivity can offset the inflationary pressures that arise from higher wages. For this reason, studies investigating the link between wages and inflation behavior should use a productivity-adjusted measure of compensation—unit labor costs, or the cost of labor per unit of output.

When we plot the spread between prices and productivity-adjusted wages during the past few decades, it becomes clear that the two variables have not moved in tandem (Chart 4).<sup>8</sup> Far from reflecting a constant markup, prices have varied considerably from unit labor costs over time. In the 1990s, the period of immediate interest for our analysis, the spread increased steadily, reaching a historically unprecedented level at the end of the decade. Thus, the evidence does not support the existence of a close link between wage changes and quarter-to-quarter movements in inflation. Indeed, the growing spread between these variables in the 1990s suggests that firms have an alternative to increasing their prices when wages rise. If prices are rising markedly faster than unit labor costs, then firms are realizing higher profit margins. In that case, firms have considerable latitude to absorb increases in wages by reducing profits rather than by charging more for their goods.

The impact of exchange rates on inflation may also be overstated. The size of this effect depends critically

**Chart 4**  
**Spread between Price and Unit Labor Cost**



Sources: U.S. Department of Labor, Bureau of Labor Statistics; authors' calculations.

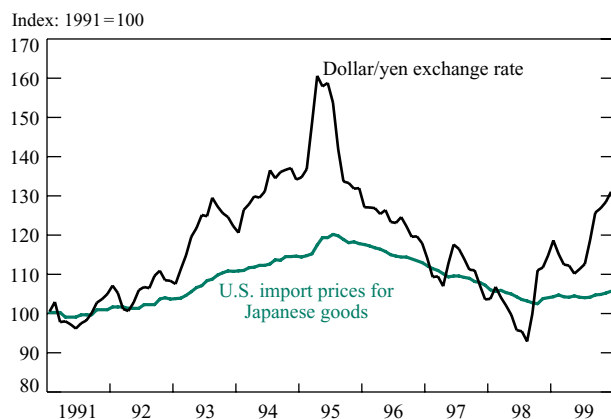
Notes: The shaded areas denote periods designated recessions by the National Bureau of Economic Research. The spread is defined as the ratio of the core CPI to unit labor cost.

on the degree to which foreign exporters adjust their prices in response to dollar movements. Consider the following example. If the dollar falls in value relative to the pound, U.S. businesses and consumers will expect to pay a higher price for British goods.<sup>9</sup> British exporters may, however, choose to moderate the increase in the dollar price of their goods rather than to pass through the full effect of the exchange rate change to their customers. By doing so, they stand a better chance of maintaining a more stable *volume* of exports to the United States, even though the profit margins on their U.S. sales will narrow.

It appears that many export firms have in fact adopted this strategy. Several studies have documented the incomplete pass-through of exchange rates to import prices as well as variation in pass-through over time.<sup>10</sup> In an analysis of the effects of exchange rate changes on pricing practices, Klitgaard (1999) finds that in the 1990s, Japanese export firms tended to shield their foreign customers from price swings by adjusting the profit margins on their exports. Chart 5, based on data from the Klitgaard study, shows that the dollar price of U.S. imports from Japan did not fluctuate as much as the dollar-yen exchange rate during this period—a strong indication that Japanese exporters were altering prices to strike a balance between the goals of stable profit margins and stable export volumes.<sup>11</sup>

Like wage changes, then, exchange rate movements show no clear and consistent short-run relationship to changes in inflation. In both cases, the flexibility to vary profit margins over time weakens the link with inflation. Consequently, we exclude wage changes and exchange rate movements from our model.<sup>12</sup>

**Chart 5**  
**Index of Dollar/Yen Exchange Rate and U.S. Import Prices for Japanese Goods**



Sources: U.S. Department of Labor, Bureau of Labor Statistics; Board of Governors of the Federal Reserve System.

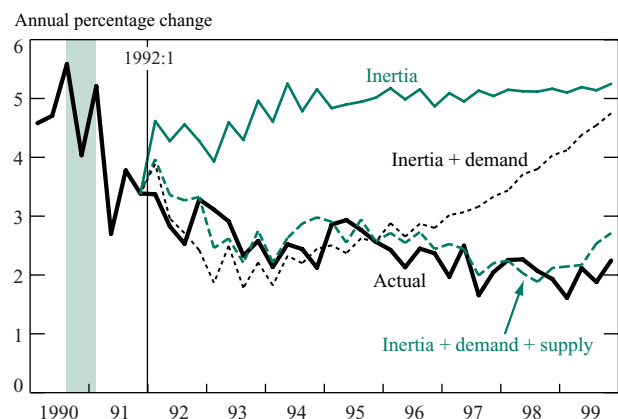
### Testing the Triangle Model

The triangle model we have constructed relates inflation to its own past values as well as to the unemployment rate and changes in relative import prices. One important objective of our analysis is to determine whether a model specified in this way can explain the behavior of inflation in the 1990s. If the model performs well, then we can rule out the view that the recent low rates of inflation reflect a permanent change in the dynamics of inflation.

To evaluate the performance of the model, we undertake an “out-of-sample” forecasting exercise. First, we estimate the model over the sample period extending from the second quarter of 1971 through the fourth quarter of 1991. We then use the estimated model to generate one-quarter-ahead inflation forecasts for the out-of-sample (or projection) period beginning in the first quarter of 1992 and ending in the fourth quarter of 1999 (Chart 6).<sup>13</sup> By comparing the forecasts with the actual values of inflation during the 1992-99 period, we can gauge the model’s reliability. If the two series correspond closely, then the model is correctly specified—that is, the variables we have included in the model can indeed account for the behavior of inflation in the 1990s. But if the inflation forecasts deviate markedly from the actual path of inflation, then we have evidence of model instability. Such instability would support the claim that a fundamental change has occurred in the way that inflation reacts to its underlying determinants.

A second objective of our analysis is to determine the extent of each variable’s role in the recent behavior of inflation. To this end, we conduct our forecasting exercise in a sequential manner. Initially, only past

**Chart 6**  
**Inflation in the 1990s: A Comparison of the Model Predictions and Actual Values**



Note: The shaded area denotes a period designated a recession by the National Bureau of Economic Research.

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inflation rates are included in the model. Next we incorporate the unemployment rate, and finally we add the change in relative import prices.<sup>14</sup> In this way, we see how the addition of each variable affects the capacity of the model to account for the movements of inflation.

As Chart 6 indicates, a model based solely on past values of inflation shows a clear and immediate breakdown. It systematically overpredicts inflation, with the forecast error eventually reaching 3 percentage points by the end of 1999. Incorporating the demand component—the unemployment rate—improves the performance of the model over the first half of the projection period, but after 1995, the predicted values of inflation diverge sharply from the actual values. Thus, we conclude that inflation trends and movements in the unemployment rate cannot by themselves account for the impressive U.S. inflation performance in the 1990s.

The picture changes dramatically when we add relative import prices, our supply component, to the model. The model predictions plotted in Chart 6 now conform very closely to actual inflation throughout the projection period. Moreover, if we look back at Chart 3, we see that the decline in relative import prices starting in the middle of 1995 has the requisite timing and magnitude to explain the steady behavior of core inflation in the second half of the projection period. Thus, the combined evidence in Charts 3 and 6 indicates that import prices are a key influence on the recent behavior of inflation.<sup>15</sup>

Overall, the variant of the Phillips curve model used in our analysis appears to explain the movements of inflation in the 1990s quite well. Our results confirm that supply shocks and other conventional economic factors, rather than a change in the inflation process itself, underlie the low rates through the end of 1999.

These results have one further implication. The claim is often made that Phillips curve models cannot account for the simultaneous decline in inflation and unemployment rates in the 1990s without allowing for a decline in the nonaccelerating inflation rate of unemployment (NAIRU). In other words, these models will work only if they assume that the rate of unemployment at which inflation will remain constant has fallen. Our forecasting exercise effectively dispels this claim. The Phillips curve model we develop implicitly assumes an unchanged, or constant, NAIRU and yet is still able to reconcile the inflation and unemployment trends of the last decade.<sup>16</sup>

## Conclusion

Many analysts have attributed the low inflation rates of the 1990s to a fundamental change in the relationship between inflation and economic growth. By contrast, we find that conventional economic forces, comparable

to those that have shaped inflation behavior in the past, can account for the restraint that has characterized U.S. inflation over the last decade. Of these forces, a large and persistent decline in relative import prices has proved especially influential in recent years.

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## Notes

1. The data on the seasonally adjusted core CPI are quarterly and cover the period from first-quarter 1967 to fourth-quarter 1999. Because the Bureau of Labor Statistics makes periodic improvements to the CPI, we have tried to construct a methodologically consistent time series. The 1999 data (CPI-U) reflect current methods of measuring the CPI. The 1978-98 data (CPI-U-RS) provide an estimate of the CPI-U that incorporates most of the recent improvements, including the introduction of geometric means, quality adjustments, and rental equivalence computations. The 1967-77 data (CPI-U-X1) principally reflect earlier improvements in the treatment of shelter. See Gillingham and Lane (1982) and Stewart and Reed (1999) for further discussion.
2. This article continues the earlier work of Lown and Rich (1997). Although both articles find the behavior of U.S. inflation in the 1990s to be consistent with past experience, the sample period in the 1997 article ends in the middle of 1996 and so precludes the investigation of the important role of import prices over the past four years.
3. A discussion of the triangle model of inflation and its refinements over the years is provided by Gordon (1997, 1998).
4. Various terms are used to describe the level of demand variables that is consistent with a constant rate of inflation. These include “potential” or “natural” output, the nonaccelerating inflation rate of unemployment (NAIRU), and the nonaccelerating inflation rate of capacity utilization (NAIRCU). Although the level of a demand variable associated with a constant rate of inflation is not directly observable, it can be estimated after imposing certain parameter restrictions on the inflation model. King, Stock, and Watson (1995), Staiger, Stock, and Watson (1997), and Gordon (1997, 1998) discuss these restrictions.
5. This choice allows us to control for demographic shifts in the economy-wide unemployment rate.
6. The model also includes variables accounting for the imposition and relaxation of price controls during the Nixon administration in the 1970s. The dating and definition of the variables for the price controls are from Gordon (1982).
7. The import price index is a weighted average of the prices of imported oil and non-oil goods. The approximate weights on the oil price index and the non-oil goods price index are 10 percent and 90 percent, respectively. Almost 70 percent of the decline in import prices over the period from third-quarter 1995 to first-quarter 1999 can be traced to the prices of non-oil goods.
8. Note, however, that some caution should be used in this comparison because unit labor costs are more directly linked to the prices of goods and services in the nonfarm business sector than to the core CPI. For an alternative view of the role of markups in the recent U.S. inflation performance, see Brayton, Roberts, and Williams (1999).
9. The degree to which exchange rate movements induce import price adjustments is referred to as “exchange rate pass-through.”

10. Goldberg and Knetter (1997) provide a review of research on exchange rates and goods prices.

11. A depreciation of the dollar represents a decline in the value of the dollar relative to another nation's currency and is depicted in Chart 5 as an increase in the number of dollars per yen. The opposite holds true in the case of an appreciation of the dollar against the yen. The two series plotted in the chart are indexed in a similar manner to allow for a more direct comparison of their movements.

12. The arguments and evidence presented in this section offer good reasons for discounting the influence of wage changes and exchange rate movements on inflation. Moreover, we found that the addition of these variables to our model did not improve the model's performance. This finding is consistent with the results obtained in Huh and Trehan (1995), Emery and Chang (1996), and Gordon (1998).

13. Note that we treat the inertia component somewhat differently from the demand and supply components in our forecasting exercise. Because the evolution of inflation is assumed to depend on its past history, the model-based forecasts provide the lagged values of inflation that are used to generate the subsequent forecasts. By contrast, the exercise always uses the actual values of the unemployment rate and the change in relative import prices for forecasting purposes.

14. As indicated earlier, we include dummy variables throughout the analysis to control for the imposition and relaxation of price controls in the 1970s.

15. The evidence linking import prices to the recent behavior of core inflation is particularly persuasive because our forecasts rely on model estimates based on data only through the fourth quarter of 1991, a period that corresponds to the beginning of the current expansion.

16. One could argue that our evidence in favor of a constant NAIRU is consistent with the imprecision of the estimates of the level and change in the NAIRU documented in Staiger, Stock, and Watson (1997). However, the declining and very low levels of unemployment observed over the latter part of this decade suggest that the claim of a constant NAIRU is more tenable after one controls for the influence of supply shocks on inflation.

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