Why Do Central Banks Monitor So Many Inflation Indicators?

By Sharon Kozicki

Monetary policy is typically undertaken with an eye to achieving a select few objectives in the long run. In the United States, the Federal Reserve conducts monetary policy to promote two long-run goals: price stability and sustainable economic growth. In many other countries, central banks have a single long-run goal defined in terms of an inflation target. Yet while central banks have narrowly defined long-run goals, most monitor a wide range of economic indicators.

Why do central banks collect and analyze so many indicators? To understand the answer, it is first important to recognize that monetary policy affects economic activity and inflation with long and variable lags. One consequence of the lagged response is that central banks cannot undertake policy actions to immediately realize their inflation or output goals. A second consequence is that the magnitudes of economic responses to policy actions cannot be estimated with precision. Thus, policymakers face the difficult task of taking forward-looking policy actions when they cannot be certain about the magnitudes of the economic implications of their actions. To cope with this uncertainty, central banks search for economic indicators that may be closely related to policy's long-term goals.

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This article presents multicountry empirical evidence to assess whether any single indicator reliably predicts inflation. If such an indicator exists, it would need to perform adequately under a wide variety of economic conditions and changing economic structures, because no country faces an unchanging economic environment. One way to test for such robust performance is to examine the value of indicators across a variety of countries experiencing different economic conditions, financial structures, policy shifts, and so forth.

The first section discusses why several widely used indicators might predict inflation. The second section explains how the predictive performance of these indicators can be compared. The third section reports empirical results for 11 developed economies, including the United States. The article concludes that while monitoring the change in GDP growth is useful on average across countries, no single economic indicator is always reliable. This evidence supports an approach to policymaking that involves monitoring a wide range of economic indicators.

I. POTENTIAL INDICATORS OF INFLATIONARY PRESSURES

Many economic indicators may help predict inflation. For instance, a recent study on forecasting U.S. inflation examined 168 variables (Stock and Watson 1999). Rather than cast such a wide net, this article limits the list of indicators to those that are more closely linked to inflation by economic theory or that have been regularly used in previous empirical studies. In addition, because the analysis is done for a collection of industrialized countries, data availability imposes further limitations on the variables that may be analyzed.[1] Consequently, the indicators discussed in this section are likely only a subset of the economic variables monitored by policymakers. Nevertheless, the chosen indicators have broad coverage.

This section reviews reasons why these indicator variables might be expected to predict inflation. The indicators fall into two basic groups. One group includes financial variables that might predict inflation because they reflect current or expected monetary policy actions. This group includes variables such as interest rates, money growth, and exchange rates. The second group includes measures of real economic activity which might predict inflation because they provide information on excess demand conditions in the economy. This group includes variables such as the unemployment rate and real GDP growth.

Interest rates

Most central banks conduct monetary policy by setting or targeting an overnight interest rate or another short-term rate. Increases in these interest rates are generally regarded as tightenings of monetary conditions and are expected to slow economic activity and decrease inflationary pressures. Decreases in these rates are easings of monetary conditions and are expected to boost real economic activity and possibly increase inflationary pressures. Indeed, historical evidence suggests that when the Federal Reserve has held down interest rates in the face of demand pressures, inflation has accelerated (Dewald).

Interest rates are not, however, a clear signal of the stance of monetary policy. Interest rates contain an expected inflation component and a real interest rate component. A specific value of a short-term interest rate may reflect relatively tight monetary policy if expected inflation is low or relatively accommodative monetary policy if expected inflation is high. For a similar reason, rising interest rates may not signal a tightening of monetary policy and falling interest rates may not signal an easing of policy. For example, if expected inflation increases by more than an increase in interest rates, then policy might be viewed as less tight.

One approach to controlling for expected inflation is to use real interest rates rather than nominal interest rates as a potential indicator of future inflation. Real interest rates, constructed as nominal interest rates less expected inflation, do not suffer from the difficulties associated with the expected inflation component of nominal interest rates. Consequently, short-term real interest rates may provide a better measure of the stance of monetary policy and, therefore, may be a better predictor of inflation than nominal interest rates. Nevertheless, real interest rates are also likely to be an imperfect indicator of future inflation. The level of real rates consistent with flat inflation (that is, the equilibrium real rate) may change over time. Thus, an increase in real interest rates may not reflect a tightening of monetary policy if the equilibrium real rate also increases.

A second approach to controlling for expected inflation is to use the spread between a long-term interest rate and a short-term interest rate as a measure of the stance of monetary policy. Because long-term interest rates move with changes in expected inflation, they are often regarded as a reasonable benchmark to control for the level of expected inflation. When monetary policy is tightened, short-term interest rates rise. Although long-term interest rates may react to policy, they rarely rise one-for-one with short-term interest rate increases. As a result, the spread usually falls when monetary policy is tightened, indicating a likely decrease in future inflation.[2]

Long-term interest rates may also help predict inflation on their own. Nominal long-term interest rates incorporate market expectations of inflation over a long horizon. An increase in the market's expectation of inflation, all else equal, will lead to an increase in long-term interest rates. Consequently, if market expectations of inflation are correct on average, changes in long-term interest rates may signal a change in future inflation in the same direction.[3]

Movements in long-term interest rates may, however, occur without changes in expected inflation. Such shifts draw into question the predictive power of long-term interest rates and interest rate spreads for future inflation. For instance, long-term interest rates contain liquidity premiums that may rise when market participants become more uncertain about the outlook for interest rates. Additionally, long-term rates may shift with changes in the relative supply and demand for long-maturity securities.[4]

Money growth

Although central banks conduct monetary policy by targeting or setting a short-term interest rate, some central banks have chosen to use an intermediate target, such as money growth, to guide monetary policy.[5] Analysts generally agree that money growth and inflation are linked. Countries with relatively rapid increases in their money stocks tend to have relatively high inflation rates, and vice versa (McCandless and Weber). Additionally, there are no examples in history of substantial inflations lasting for more than a brief period that were not accompanied by roughly corresponding rapid increases in the quantity of money

(Friedman 1992; Dewald). Furthermore, a number of historical episodes support the view that money growth is the cause and inflation the effect.[6]

Numerous studies have found empirical evidence suggesting that money growth explains inflation.[7] Recently, however, several studies have suggested that the predictive power of money growth for inflation has waned. While monetary aggregates may once have captured information important in predicting inflation, some analysts suggest they are no longer reliable predictors.[8]

Exchange rates

The exchange rate is another financial variable used by many central banks as a guide for monetary policy.[9] The exchange rate is the price of one unit of domestic currency in terms of a foreign currency, or a weighted-average of foreign currencies. A decline in the foreign exchange value of the domestic currency (that is, a depreciation of the domestic currency) could indicate that the risks of higher inflation have increased. These risks of higher inflation may be traced to domestic or foreign sources.[10] For instance, depreciation of a currency could indicate that domestic monetary policy has become more accommodative, increasing domestic demand and inflationary pressures (Hafer). Depreciation also could lead to increased foreign demand for domestically produced goods and services (through increased exports of goods and increased tourism) and higher import prices—each of which may lead to higher domestic inflation.

But the links between exchange rates and inflation are sufficiently complicated that exchange rates may not always predict inflation well.[11] Because exchange rates reflect differences in economic activity, fiscal and monetary policies, and prices between countries, exchange rates may not be good predictors of inflation. For instance, rather than predict an increase in inflation, a depreciation could also suggest that weaker foreign growth will lead to reduced foreign demand for U.S. goods and decreased inflationary pressures. Empirical evidence suggests that low pass-through of exchange rate changes to consumer price inflation may, at times, be attributed to other economic factors such as the degree of openness of a country, unutilized capacity at home and abroad, the price of oil, and the wage, fiscal and monetary policies followed by the country after a large change in the exchange rate (De Grauwe and Tullio; and Amritano, De Grauwe, and Tullio).

Unemployment rate

While recognizing that inflation is a monetary phenomenon in the long run, many analysts disregard measures of monetary policy and favor instead measures of real economic activity to signal near-term inflationary pressures. These analysts believe that the amount of economic slack, or unutilized resources, is a key determinant of inflation. The Phillips curve, which captures an apparent tradeoff between unemployment and wage or price inflation, is the most common model linking economic slack to inflation.[12]

The intuition behind the Phillips curve is that low unemployment rates usually signal tight labor market conditions. Because tight labor market conditions breed larger wage increases that might be passed on to higher prices, low unemployment rates are expected to predict increasing inflation.[13] The flip side of this story is that high unemployment rates reflect an excess supply of workers and downward pressures on wages and prices. The NAIRU (non-accelerating inflation rate of unemployment) is defined as the rate of unemployment that exerts neither downward nor upward pressures on wage inflation, given expectations of price inflation.[14] Thus, if the unemployment rate is above the NAIRU, then inflation tends to decrease, and vice versa.[15]

Analysts are divided on whether or not Phillips curves are useful for predicting inflation. The usefulness of Phillips curves for forecasting inflation has been questioned for numerous reasons. Traditional estimates of Phillips curves are based on an assumption that unemployment is dominated by aggregate demand disturbances (King and Watson). When subject to hard-to-estimate supply shocks, such as oil price shocks or changes in trend productivity, inflation predictions of simple Phillips curves are likely to be poor. Even in the absence of supply shocks, because the NAIRU is unobserved, it must be estimated for the Phillips curve to be a useful forecasting model of inflation. Unfortunately, not only are estimates of the NAIRU imprecise, but they have changed over time.[16] Some analysts hold an even stronger view that the

NAIRU has never had any sound basis in theory and has not found support in the historical data (Eisner).[17] Finally, some analysts challenge the usefulness of the Phillips curve by pointing to persistent increases in European unemployment rates for a sustained period after the high-inflation 1970s or to episodes in the United States where the Phillips curve relationship did not hold.[18]

Despite the many criticisms of the Phillips curve, many analysts continue to use versions of Phillips curves to predict inflation.[19] In response to criticisms that the relationship may be less reliable in the presence of supply shocks, models are modified to account for such shocks (Gordon 1982, 1998). In response to criticisms that the NAIRU may not be constant, due to, say, demographic changes or structural forces affecting the labor market, time-varying estimates of the NAIRU are provided (Blanchard and Katz; Weiner). In response to persistent increases in European unemployment rates, a theory to explain such persistence was born.[20]

While most analysts focus on the level of the unemployment rate as a predictor of inflation changes, Phillips also suggested that the *change* in the unemployment rate may help predict inflation changes.[21] In fact, Moore suggests that the level of the unemployment rate is less important than the direction of change of the unemployment rate for predicting inflation. Inflation tends to increase when the unemployment rate is falling, and inflation tends to decrease when the unemployment rate is rising.

Economic growth

Another measure of real economic activity that might predict inflation is economic growth. Strong real economic activity is usually associated with strong growth in aggregate demand. Some analysts argue that strong growth in aggregate demand indicates that inflation will likely increase. Because periods of strong growth tend to have falling unemployment rates and periods of weak growth tend to have rising unemployment rates, a view that real growth may predict changes in inflation is similar to the view expressed earlier that changes in the unemployment rate may predict changes in inflation.[22]

For example, frictions associated with expansion of productive capital imply that generally strong output growth may indicate a pickup in inflationary pressures. Consider a shock that induces a larger than expected increase in demand. Increasing production to meet increasing demand at minimal cost generally requires increases in both capital and labor inputs. However, adjusting some forms of new productive capital, such as building new plants or assembling and installing new equipment, typically takes time. Consequently, rapid expansion of production in the short run is accomplished by increasing labor and those forms of capital that can be adjusted quickly. As this is not the most economical way to expand production, in the short run, production costs and, consequently, prices will increase. In addition, the increase in employment will imply increased income to workers and stronger consumer demand.

Strong economic growth, however, may be an imperfect indicator of increasing inflation. Strong growth due to a positive supply shock, such as an increase in trend labor productivity growth, is unlikely to signal an increase in inflation. Likewise, sustainable demographic changes, such as increased immigration flows or other sources of faster population growth, lead to stronger sustainable rates of economic growth without increased inflationary pressures.

In theory, a number of these potential indicators might be expected to predict inflation. Whether it is helpful to use these indicators, of course, depends on how well they actually predict inflation. To evaluate their effectiveness, this article compares the accuracy of inflation forecasts based on each of the indicators. The next section discusses the methodology.

II. EVALUATING THE INDICATORS

This section provides details on how the forecasts made by the set of inflation indicators discussed in the last section will be constructed and evaluated. The discussion focuses on the horizons at which the information content of the indicators will be compared, the specification of the forecasting models, and the out-of-sample evaluation procedure.

Forecast horizons

The ability of the indicators to predict inflation is evaluated at both one-year and two-year horizons. It is important to consider two different forecast horizons because some indicators may contain information more relevant in the immediate future, whereas others may contain information more relevant at an intermediate horizon.

It is also important to extend the analysis beyond the standard one-year horizon because monetary policy actions have effects with long and variable lags. One to two years often pass before inflation actually responds to a policy adjustment (Freedman). Moreover, a two-year horizon also conforms closely to the one-to-two-year inflation-target horizons of the Bank of England and the Bank of Canada.

The forecasting models

This article uses simple forecasting models to assess the ability of an indicator to predict inflation. The models relate future inflation to current inflation and the indicator. The one-year-ahead forecasts are the sum of a constant, current inflation, and a coefficient multiplied by the current value of the candidate variable. The two-year-ahead forecasts are also the sum of a constant, current inflation, and a coefficient multiplied by the current value of the candidate variable. Separate models are estimated for one-year and two-year-ahead forecasts for each country.[23] One appealing feature of the specification is that it corresponds to a simple Phillips curve model when the candidate variable is the unemployment rate.[24]

Taking this approach, each indicator's ability to predict inflation is assessed individually. Potential indicators are evaluated one at a time because the article seeks to establish whether a simple parsimonious forecasting model based on a single indicator can reliably forecast inflation. The one-at-a-time approach is also used for a second reason—simple models often predict better than less parsimonious models.[25]

Out-of-sample evaluation

This article uses an out-of-sample procedure to evaluate how well indicators predict inflation. The key property of out-of-sample procedures is that forecasts are based on models estimated using only the data available at the time of the forecast. This property may characterize the approach followed by analysts in real time. In making forecasts, analysts tend to update their forecasting models as more recent data become available. For instance, if in the fourth quarter of 1993 a one-year or two-year forecast was made (that is, a forecast of inflation in the fourth quarter of 1994 or the fourth quarter of 1995), then the forecast model would be estimated using data extending no later than the fourth quarter of 1993.

Forecast performance over 1991 through 1998 is summarized using the root mean squared error (RMSE) of forecast errors, a measure commonly used to evaluate forecasts. The smaller the RMSE, the better the forecast, and the larger the RMSE, the worse the forecast (Box).

A benchmark for comparing the forecasts is a naïve forecast. The naïve forecast predicts that future inflation will equal current inflation, regardless of the horizon of the forecast or any other information. In out-of-sample evaluations, forecasts that use information from a second variable in addition to current inflation can perform worse than a naïve forecast. In fact, as will be seen below, this is not uncommon. Clearly, a variable that leads to a worse forecast than the naïve forecast would not be helpful in forecasting inflation.

III. RESULTS

This section shows how well the various indicators predict inflation. The empirical results help evaluate whether policymakers should monitor the signals from a broad range of indicators. The results help answer two related questions: First, do any of the indicators consistently fail to help predict inflation? If so, then dropping them from a list of variables to be monitored might be justified. Second, which, if any, of the indicators consistently helps predict inflation? If one indicator consistently provides precise inflation predictions, then focusing on it to the exclusion of the other indicators might be justified. There is also a reason to

OUT-OF-SAMPLE FORECAST EVALUATION

The process for evaluating forecasts begins by creating a series of forecasts and implied forecast errors. The three-stage process is described below for one-year-ahead forecasts. In the first stage, data from 1975 through the first quarter of 1990 are used to estimate a forecasting model for each indicator. In the second stage, each estimated model is used to create a forecast of inflation over the next four quarters, that is, over the four quarters ending in the first quarter of 1991. In the third stage, the forecast errors are recorded as the difference between actual inflation over the four quarters ending in the first quarter of 1991 and the forecasts. This process is then repeated, adding an additional quarter of data to the sample used to estimate the models and advancing the forecast period ahead one quarter. In other words, in the next repetition the models are estimated using data through the second quarter of 1990 and forecast over the four quarters ending in the second quarter of 1991. The process repeats until forecast errors are calculated for every quarter from the first quarter of 1991 through the fourth quarter of 1998. Series of two-year-ahead forecasts and forecast errors are created in a similar fashion.*

Indicators are ranked by their ability to generate forecasts of inflation close to actual inflation. The root mean squared error (RMSE) of the forecast errors provides a measure of how close the forecast is to actual inflation, with larger RMSEs indicating that inflation forecasts are further from actual inflation. RMSEs are calculated for each series of forecast errors by first squaring the forecast errors, then averaging the squared errors over the out-of-sample evaluation interval, and finally taking the square root of the average. The out-of-sample evaluation interval is the first quarter of 1991 through the fourth quarter of 1998.

* For each model estimated for two-year ahead forecasts, one year less of data is used at the end of the sample compared to when models were estimated for one-year-ahead forecasts. For example, to generate forecasts for the first quarter of 1991, data through the first quarter of 1990 is used to estimate the forecasting models used to generate one-year-ahead forecasts, but only data through the first quarter of 1989 is used to generate two-year-ahead forecasts. As was the case for one-year-ahead forecasts, forecast errors are calculated for every quarter from the first quarter of 1991 through the fourth quarter of 1998.

look for consistency in the ability of an indicator to predict inflation across countries. If such an indicator exists, it may be a more reliable predictor of inflation in different economic environments within a single country and therefore increase confidence in the indicator.

Exploring the ability of an indicator to predict inflation over a limited time period, but across multiple countries, might also be seen as a proxy for exploring the ability of an indicator to predict inflation over a long time period in a single country. While some shocks, such as oil price shocks, may hit all countries at once, the more likely occurrence is that different countries will be affected by different shocks in a given decade. Consequently, if an indicator is a good predictor of inflation across a collection of countries, then it might be more likely to be a good predictor of inflation in a single country as its economic environment changes.

The empirical results suggest that there is considerable heterogeneity across countries in the ability of indicators to predict inflation. One implication of the heterogeneity is that a considerable narrowing of the list of indicators is not justified. Almost all of the indicators performed well for at least one horizon in one country. A second implication is that even the indicator that predicts inflation with the most consistency does so with insufficient precision to justify singling it out. In other words, the empirical results justify the standard central bank policy of monitoring the information contained in a broad range of indicators.

International results

The potential inflation indicators are listed in Table 1. Variables are grouped under the headings as used in the first section of this article where the variables were motivated. (Since the precise definition of the series differs somewhat across countries, a more detailed description of the data series, including the source of the series, is provided in the appendix.) The list in Table 1 is not meant to be exhaustive, but merely sufficiently broad to be able to reasonably assess regularities in the empirical results.

General results on forecast performance are summarized by country in Table 2. For each country, and for both one-year and two-year forecast horizons, this table provides the RMSE of the best forecast, the

Table 1

CANDIDATE INDICATORS

Interest rates	Short-term interest rate Real short-term interest rate Spread Long-term interest rate Change in long-term interest rate
Money	1-year money growth 2-year money growth 1-year change in money growth 2-year change in money growth Money growth GDP growth (1-year growth rates) Money growth GDP growth (2-year growth rates)
Exchange rate	Exchange rate 1-year change in exchange rate 2-year change in exchange rate
Unemployment rate	Unemployment rate 1-year change in unemployment rate 2-year change in unemployment rate
Output growth	1-year GDP growth 2-year GDP growth Change in GDP growth

Table 2

PERFORMANCE OF THE BEST, WORST, AND NAÏVE FORECASTS (RMSE)

	One-year-ahead forecasts			Two-year-ahead forecasts		
	Best	Naïve	Worst	Best	Naïve	Worst
Australia	1.76	1.96	2.42	2.31	2.58	3.31
Canada	1.35	1.91	2.18	.88	1.79	2.61
France	.47	.61	1.22	.55	.84	2.80
Germany	1.29	1.29	2.02	1.30	1.98	2.68
Italy	.95	1.27	2.05	1.31	1.82	3.51
Japan	1.02	1.24	1.99	1.29	1.50	3.17
Netherlands	.64	.66	1.03	.41	.63	1.32
Sweden	3.01	3.08	4.44	2.07	2.40	3.31
Switzerland	.89	1.35	1.92	1.39	1.86	4.58
UK	1.10	1.46	2.00	1.37	2.10	3.51
U.S.	.32	.49	.78	.35	.71	1.27

RMSE of the naïve forecast, and the RMSE of the worst forecast. The lower the RMSE is, the closer the forecast is to actual inflation and, consequently, the better the forecast.

Comparing the best and worst forecasts to the naïve forecast reveals two immediate results. First, for some countries, the best forecast is not much better than a naïve forecast. For the Netherlands and Sweden, the best forecast of inflation at a one-year horizon is less than a tenth of a percentage point better than the naïve forecast. In the case of the Netherlands, the low RMSE of the naïve forecast suggests that this may be because inflation was relatively stable in the 1990s. However, in Sweden, the high RMSE indicates this was not the case.[26]

Second, an indicator can actually generate a worse forecast than a naïve forecast. In all countries, at least one indicator generated an inflation forecast that performed worse than the naïve forecast. In fact, for Germany, no indicator improves on the naïve one-year forecast. One explanation for this poor performance may be the length of the evaluation interval. In particular, if changes in inflation were due to different shocks in different years, then a single indicator may not forecast inflation well on average.

Rankings of inflation indicators by countries support the practice of looking at signals from a broad range of indicators. The best and worst inflation indicators as ranked by lowest RMSE are in Tables 3a and 3b. Table 3a contains a list for one-year-ahead forecasts and Table 3b contains a list for two-year-ahead forecasts. All but two of the candidate variables appear among the best three indicators for at least one horizon in one country. And, the two indicators that do not appear in best-three lists, *1-year money growth* and *money growth GDP growth (2-year growth rates)*, are variations on two indicators that do appear in best-three lists, *2-year money growth* and *money growth GDP growth (1-year growth rates)*. Thus, the results do not justify a considerable narrowing of the list of indicators and support examining of a broad range of indicators.

The table clearly reveals considerable heterogeneity. No one indicator performs best in all 11 countries. Furthermore, indicators that perform well in some countries often perform poorly in others.[27] Nevertheless, some regularities are apparent.

Table 3a

BEST AND WORST INFLATION INDICATORS BY COUNTRY (ONE-YEAR-AHEAD FORECASTS)

	Best three indicators	Worst three indicators
Australia	1. Change in GDP growth	21. 2-year change in unemployment rate
	2. 1-year change in money growth	20. 1-year GDP growth
	3. 2-year money growth	19. 2-year GDP growth
Canada	1. 1-year change in unemployment rate	21. 1-year money growth
	2. 2-year change in unemployment rate	20. Money growth GDP growth (2 years)
	3. 1-year change in exchange rate	19. Money growth GDP growth (1 year)
France	1. 1-year change in exchange rate	21. 2-year GDP growth
	2. Change in long-term interest rate	20. Short-term interest rate
	3. Exchange rate	19. Long-term interest rate
Germany	1. Naïve	21. 2-year money growth
	2. 2-year change in unemployment rate	20. Long-term interest rate
	3. 1-year change in unemployment rate	19. Short-term interest rate
Italy	1. Change in GDP growth	21. 2-year change in exchange rate
	2. 2-year GDP growth	20. Short-term interest rate
	3. Spread	19. 1-year change in unemployment rate
Japan	1. 1-year change in exchange rate	21. 1-year GDP growth
	2. Change in GDP growth	20. 2-year change in money growth
	3. Spread	19. Short-term interest rate
Netherlands	1. 2-year change in exchange rate	21. Change in long-term interest rate
	2. Change in GDP growth	20. Spread
	3. 1-year change in money growth	19. Real short-term interest rate
Sweden	1. Change in GDP growth	21. 1-year change in unemployment rate
	2. Real short-term interest rate	20. Unemployment rate
	3. Naïve	19. 2-year change in unemployment rate
Switzerland	1. Change in long-term interest rate	21. Exchange rate
	2. 1-year GDP growth	20. 2-year change in unemployment rate
	3. 2-year GDP growth	19. Real short-term interest rate
UK	1. 1-year change in money growth	21. Long-term interest rate
	2. Short-term interest rate	20. Spread
	3. 2-year change in money growth	19. Real short-term interest rate
U.S.	1. 1-year GDP growth	21. Money growth GDP growth (2 years)
	2. Change in long-term interest rate	20. Money growth GDP growth (1 years)
	3. Real short-term interest rate	19. 2-year change in money growth

In Table 3a, the *change in GDP growth* appears in the best-three lists of five countries but in none of the worst-three lists. Similarly, the *1-year change in money growth* is in the best-three lists of three countries, but in none of the worst-three lists. By contrast, the *long-term interest rate* is absent from the best-three lists of all countries but appears in the worst-three lists of several countries. Most of the remaining indicators appear in the best-three lists of some countries and in the worst-three lists of others.

In Table 3b, the *change in GDP growth*, the *change in the long-term interest rate*, the *1-year change in money growth*, and the *2-year change in money growth* appear in the best-three lists of several countries, but in none of the worst-three lists. As was the case for one-year-ahead forecasts, the *long-term interest rate* appears in the worst-three lists of several countries. In addition, the *exchange rate* is absent from the best-three lists of all countries, but does appear in some worst-three lists.

The evidence suggests some consistency across countries in terms of an indicator that may be useful for predicting inflation. The *change in GDP growth* helps predict inflation in many different countries, suggesting that it might be a good indicator in different economic environments.

Another way to rank the inflation indicators is by average performance across the 11 countries. Table 4 presents the average RMSEs over the countries and ranks indicators with lower average RMSEs higher. Indicators with higher rankings provide better predictions of inflation more consistently than indicators with lower rankings. The results in Table 4 confirm what was suggested by the rankings in Table 3. In particular, on average, at both one-year and two-year forecast horizons, the *change in GDP growth* provides the best predictions of inflation.

Although the *change in GDP growth* receives the top ranking in for both one-year and two-year-ahead forecasts, the empirical results do not justify considering its inflation predictions to the exclusion of those based on other indicators. While this is the most consistent indicator, it only improves forecasts on average by at most a tenth of a percentage point relative to naïve forecasts. Individual country results suggest that considerably more precise forecasts could be achieved using a different indicator in some economic environments.

Table 3b

BEST AND WORST INFLATION INDICATORS BY COUNTRY (TWO-YEAR-AHEAD FORECASTS)

	Best three indicators	Worst three indicators
Australia	1. Unemployment rate	21. 1-year change in unemployment rate
	2. Short-term interest rate	20. 2-year GDP growth
	3. Spread	19. 1-year GDP growth
Canada	1. 1-year change in unemployment rate	21. 1-year money growth
	2. 2-year change in unemployment rate	20. Long-term interest rate
	3. Change in GDP growth	19. Short-term interest rate
France	1. 2-year change in money growth	21. 2-year GDP growth
	2. Change in GDP growth	20. Long-term interest rate
	3. Change in long-term interest rate	19. 1-year GDP growth
Germany	1. 1-year change in unemployment rate	21. Long-term interest rate
	2. 2-year GDP growth	20. 2-year money growth
	3. 2-year change in unemployment rate	19. 1-year money growth
Italy	1. Change in long-term interest rate	21. Short-term interest rate
	2. 2-year change in money growth	20. 2-year change in exchange rate
	3. Money growth GDP growth (1 year)	19. 1-year change in exchange rate
Japan	1. Spread	21. Exchange rate
	2. Change in GDP growth	20. Short-term interest rate
	3. Naïve	19. 1-year GDP growth
Netherlands	1. 2-year change in exchange rate	21. Spread
	2. 2-year money growth	20. Real short-term interest rate
	3. 2-year change in money growth	19. 2-year change in unemployment rate
Sweden	1. 2-year GDP growth	21. 1-year change in unemployment rate
	2. 2-year money growth	20. Long-term interest rate
	3. Real short-term interest rate	19. Unemployment rate
Switzerland	1. 1-year GDP growth	21. 2-year change in unemployment rate
	2. Short-term interest rate	20. Exchange rate
	3. Long-term interest rate	19. Unemployment rate
UK	1. 1-year change in money growth	21. Long-term interest rate
	2. Exchange rate	20. 2-year GDP growth
	3. 2-year change in money growth	19. Short-term interest rate
U.S.	1. 2-year money growth	21. Money growth GDP growth (2 years)
	2. Change in GDP growth	20. Money growth GDP growth (1 year)
	3. Change in long-term interest rate	19. Long-term interest rate

Table 4

INDICATOR RANKINGS (BASED ON LOWEST AVERAGE RMSE ACROSS COUNTRIES)

Forecast horizon	Indicator Average	RMSE
One-year-ahead	Change in GDP growth	1.35
	Naïve	1.39
	1-year change in exchange rate	1.42
	1-year change in money growth	1.42
	Change in long-term interest rate	1.44
	2-year money growth	1.47
	Money growth GDP growth (1 year)	1.50
	Real short-term interest rate	1.50
	Spread	1.51
	Money growth GDP growth (2 years)	1.52
	1-year money growth	1.53
	Exchange rate	1.53
	2-year change in exchange rate	1.54
	1-year GDP growth	1.54
	2-year change in money growth	1.55
	Short-term interest rate	1.58
	Unemployment rate	1.58
	1-year change in unemployment rate	1.59
	2-year GDP growth	1.59
	2-year change in unemployment rate	1.61
	Long-term interest rate	1.66
Two-years ahead	Change in GDP growth	1.55
	1-year change in money growth	1.64
	Naïve	1.65
	Spread	1.70
	Change in long-term interest rate	1.70
	2-year change in money growth	1.76
	2-year money growth	1.80
	1-year change in exchange rate	1.81
	Money growth GDP growth (1 year)	1.81
	Money growth GDP growth (2 years)	1.81
	Real short-term interest rate	1.82
	1-year money growth	1.84
	Unemployment rate	1.86
	2-year change in exchange rate	1.91
	1-year change in unemployment rate	1.91
	Exchange rate	1.92
	1-year GDP growth	1.93
	2-year GDP growth	2.08
	2-year change in unemployment rate	2.13
	Short-term interest rate	2.27
	Long-term interest rate	2.29

Results for the United States

For the United States, several indicators provide considerably better forecasts of inflation than a naïve forecast. Although not identical, rankings of the indicators based on RMSEs for one-year forecasts are similar to those based on RMSEs for two-year forecasts. Consequently, indicators are ranked in Table 5 by the lowest average RMSE over the two forecast horizons. Inflation forecasts based on all the exchange rate indicators are better than the naïve forecast. Indicators based on nominal interest rate levels (that is, the *short-term interest rate* and the *long-term interest rate*) perform poorly, although the other interest rate indicators perform quite well. And, with the exception of the *unemployment rate*, indicators that measure real economic activity tend to predict inflation well. By contrast, the performance of inflation predictions based on money indicators varies widely, with some forecasts considerably better than the naïve forecast and others considerably worse. An important caveat to the results is that RMSE provides only limited information on forecast performance. Other information may be needed to assess forecast reliability (Box).

Why do results differ across countries?

Although the empirical evidence suggests a certain degree of consistency for a few inflation indicators, in the 1990s different indicators helped predict inflation in different countries. In fact, monitoring signals from a wide range of indicators is likely worthwhile precisely because most indicators were good predictors of inflation in at least one economic environment. Differences across countries in economic structure, economic experiences, and monetary policy procedures may help explain why in a given period an indicator might predict inflation well in some countries but be largely useless in others.

One explanation for heterogeneity across countries in the performance of some inflation indicators is differences in economic structure. Economic structure refers to characteristics of the economy that tend to change only slowly, if at all. The relationship between inflation indicators and inflation may depend on such structural characteristics. For example, differences in labor market structure across countries may

Table 5

FORECAST PERFORMANCE FOR THE UNITED STATES (RANKED BY LOWEST AVERAGE RMSE)

	One-year horizon (RMSE)	Two-year horizon (RMSE)	Average RMSE
Change in long-term interest rate	.37	.38	.38
2-year money growth	.40	.35	.38
1-year GDP growth	.32	.49	.41
Spread	.38	.45	.41
Change in GDP growth	.46	.37	.42
1-year change in exchange rate	.38	.50	.44
Real short-term interest rate	.37	.53	.45
2-year change in exchange rate	.44	.48	.46
1-year change in unemployment rate	.42	.53	.48
Exchange rate	.44	.53	.49
2-year GDP growth	.46	.56	.51
1-year money growth	.51	.54	.52
1-year change in money growth	.45	.60	.53
2-year change in unemployment rate	.48	.64	.56
Naïve	.49	.71	.60
Unemployment rate	.58	.71	.65
2-year change in money growth	.61	.88	.75
Short-term interest rate	.46	1.04	.75
Long-term interest rate	.60	1.18	.89
Money growth GDP growth (1 year)	.62	1.25	.93
Money growth GDP growth (2 years)	.77	1.27	1.02

influence the relationship—if one exists—between inflation and either the unemployment rate or the change in the rate. Countries like Japan and Germany have less flexible labor markets historically than countries with fewer traditions of lifelong employment and less regulated labor markets like the United States. A second example is the differing degrees of openness of the countries. The exchange rate might be expected to be a better predictor of inflation in countries such as Canada or Australia where trade is a large share of economic activity.

A second explanation for heterogeneity across countries is differences in economic experiences in the 1990s. Economic experiences refer to shocks to economic conditions. Some indicators may do a good job at predicting the inflationary consequences of specific types of shocks. Consequently, if the size, frequency, and type of shocks faced by countries differ, it is likely that the forecasting performance of indicators will

ARE LOW-RMSE FORECASTS RELIABLE?

Some indicators with a low RMSE might not provide reliable forecasts. Information other than RMSE can be used to assess reliability. The discussion in the first section suggested not only which variables might help predict inflation, but also how inflation is likely to be related to the variables. Inflation predictions might be regarded as unreliable if information on the estimated direction of predicted changes in inflation are inconsistent with the expected relationship, or, if estimated directions change within the evaluation sample.

Columns with information on the estimated direction of predicted changes in inflation are included in the table for U.S. data to assess the reliability of the various inflation forecasts. The columns labeled *one-year direction* and *two-year direction* provide the direction predicted by the estimated model for one-year and two-year-ahead forecasts of inflation, respectively. Entries that contain "+" signify that if the indicator rises (falls), then inflation will rise (fall) from current levels. Entries that contain "-" signify that if the indicator rises (falls), then inflation will fall (rise) from current levels. If an entry contains "+/-" then the estimated direction changed within the 1991:Q1 to 1998:Q4 evaluation interval. Since a naïve forecast predicts no change in inflation, its estimated direction is recorded as "0."

Using this approach, several of the top-ranked inflation predictors turn out to be unreliable. At the one-year horizon, the estimated direction is unstable for the change in the *long-term interest rate* and *2-year money growth* and is contrary to the expected direction for the *spread* and the *change in GDP growth*. At the two-year horizon, the estimated direction is unstable for the *change in GDP growth* and contrary to expectations for the *change in the long-term interest rate*. Nevertheless, several variables provide inflation forecasts that are better than the naïve forecast and appear to be reliable. In particular, predictions based on *GDP growth*, exchange rate variables, and the changes in the unemployment rate are in the expected direction, and with lower RMSEs than the naïve model.

ESTIMATED DIRECTION OF PREDICTED INFLATION CHANGES FOR THE U.S. (RANKED BY LOWEST AVERAGE RMSE)

	One-year direction	Two-year direction	Average RMSE
Change in long-term interest rate	+/		.38
2-year money growth	+/	+	.38
1-year GDP growth	+	+	.41
Spread		+	.41
Change in GDP growth		+/	.42
1-year change in exchange rate			.44
Real short-term interest rate			.45
2-year change in exchange rate			.46
1-year change in unemployment rate			.48
Exchange rate			.49
2-year GDP growth	+	+	.51
1-year money growth		+/	.52
1-year change in money growth			.53
2-year change in unemployment rate			.56
Naïve	0	0	.60
Unemployment rate			.65
2-year change in money growth			.75
Short-term interest rate			.75
Long-term interest rate			.89
Money growth GDP growth (1 year)			.93
Money growth GDP growth (2 years)			1.02

differ considerably across countries. Some indicators may lose their ability to predict inflation, however, if structural changes in a country alter the historical relationships between the indicators and inflation.

The economic experiences of the countries examined differed considerably in the 1990s. The Asian crisis in 1997 is an example of a large shock—one that affected economic activity in Japan more negatively than other countries. Effects of the Asian crisis on other countries differed. Whereas the Australian and Canadian dollars depreciated considerably as a sizable market for their natural resources fizzled, the U.S. dollar appreciated strongly with safe haven flows. The breakdown of the Euopean Monetary System and then the drive to European Monetary Union likely affected economic activity in Europe. Four of the eleven countries examined in this study—France, Germany, Italy, and the Netherlands—were in the first group of countries to adopt the euro. However, convergence pressures also may have affected economic conditions in other European countries, particularly Sweden and the United Kingdom, that may adopt the euro at a later date. Changes in tax policy provide examples of shocks that directly affected inflation in Canada. The introduction of the goods and services tax and large changes in taxes imposed on tobacco caused considerable year-to-year variation in Consumer Price Index inflation in Canada in the 1990s. Such variation would not have been predicted by the indicators examined in this article.

A third explanation for heterogeneity across countries is differences in monetary policy procedures. Central banks may react to different sources of economic information. Suppose, for example, that sustained increases in money growth lead to increases in inflation. Some central banks may respond to changes in money growth while others may not. A central bank may tighten policy in reaction to an increase in money growth, anticipating that if no action is taken, inflation will increase. However, the mere fact that a central bank responds to the monetary signal may make the ex post relationship between money growth and inflation disappear—every time money growth picks up, policy responds to bring it back down, and inflation is not affected. Paradoxically, money growth may provide more information on future inflation in countries where central banks do *not* react to money growth. The same paradox can arise with other indicators.

IV. CONCLUSIONS

This article examines whether any single indicator reliably predicts inflation. If one indicator consistently forecasts inflation well under a wide range of economic conditions and changing economic structures, then central banks might want to focus on the inflation signals it provides and narrow the range of indicators they monitor.

Results from a country-by-country analysis suggest that in most countries non-trivial improvements over naïve inflation forecasts can be made with the help of several indicators. However, only one indicator, the change in GDP growth, improved on naïve inflation forecasts on average across all 11 countries—but the improvement was small.

These empirical results provide support for an approach to policy-making that involves collecting, monitoring, and analyzing a wide range of economic indicators. The results suggest that focusing attention too narrowly on one or a few indicators could be risky since the ability of any given indicator to predict inflation varies across different economic environments.

APPENDIX

When raw data were reported monthly, "raw" quarterly series were constructed as the average over the quarter of the three monthly observations. Observations for other series in quarter *t* were constructed from the raw quarterly series as follows:

Inflation (t) = log(Consumer Price Index (t)) log(Consumer Price Index (t-4));

Real short-term interest rate = Short-term interest rate (t) Inflation (t);

Spread (t) = long-term interest rate (t) short-term interest rate (t).

For any variable x, changes, 1-year changes, 1-year growth rates, and 2-year growth rates were calculated as:

Change in x (t) = x (t) x (t-4)

1-year change in x (t) = x (t) x (t-4)

2-year change in x (t) = x (t) x (t-8)

1-year growth of x (t) = log(x (t)) log(x (t-4))

2-year growth of x (t) = (1/2) (log(x (t)) log(x (t-8))).

The raw data series are described below by country.

Australia

Short-term interest rate (Short Rate) — Weighted average yield on 13-week Treasury notes. Missing observation in October 1997 replaced with average of observations for September 1997 and November 1997. Source: International Financial Statistics, International Monetary Fund (IFS).

Long-term interest rate (Long Rate) — Assessed secondary market yields on nonrebate bonds with maturity of at least 10 years. Source: IFS.

Consumer Price Index (CPI) — Source: IFS.

Exchange Rate (Ex) — Australian $ / U.S.$, Source: Board of Governors (BOG).

Unemployment Rate (U) — Source: Reserve Bank of Australia.

Gross Domestic Product (GDP) — 1996-1997 prices, Australian dollars Source: IFS.

Money Supply (M) — M3, millions of Australian dollars. Source: Reserve Bank of Australia.

Canada

Short Rate — Weighted average of the yields on successful bids for 3-month bills. Source: IFS.

Long Rate — Secondary market, average bond yields on Government of Canada bonds over 10 years. Source: IFS.

CPI — Source: IFS.

Ex — Weighted average exchange rates of the Canadian dollar, weighted by G-10 countries, CPI-adjusted. Source: BOG.

U — Source: Statistics Canada.

GDP — Real, Canadian dollars. Source: Statistics Canada.

M — M2Plus, Newly defined 1/92 to include money market mutual funds, millions of Canadian dollars. Source: Bank of Canada.

France

Short Rate — 3-month Paris interbank offer rate. Break in January 1987: Previously rates practiced on money market (pensions between banks). Source: BIS.

Long Rate — Secondary market yield, public and semi-public bonds. Missing observation in April 1974 replaced with average of observations for March 1974 and May 1974. Missing observation in March 1979 replaced with average of observations for February 1979 and April 1979. Source: BIS.

CPI — Source: IFS.

Ex — Weighted average exchange rates of the French franc, weighted by G-10 countries, CPI-adjusted. Source: BOG.

U — Source: INSEE.

GDP — Billions of 1980 francs. Source: INSEE.

M — M3, new definition December 1990 billions of francs. Source: Bank of France.

Germany

Short Rate — Frankfurt 3-month interbank loan rate. Source: BOG.

Long Rate — From January 1961 through December 1982 and for June 1983 data is for 7-15 year public sector bonds. Source: BIS. From January 1983 through December 1997, excluding June 1983, data are the yield on German Government Bellwether bond. Source: BOG.

CPI — Data cover the former Federal Republic of Germany prior to 1991. Data cover the former Federal Republic of Germany and the former German Democratic Republic from 1991 onward. Source: IFS.

Ex — Weighted average exchange rates of the deutsche mark, weighted by G-10 countries, CPI-adjusted. Source: BOG.

U — Western Germany unemployment rate. Source: Deutsche Bundesbank.

GDP — Real, billions of deustche marks. Source: Deutsche Bundesbank.

M — M3 equal to M2 + savings deposits at statutory notice, end of month, billions of deustche marks. Source: Deutsche Bundesbank.

Italy

Short Rate — Average of the allotment rates at public auction of ordinary Treasury bills (compound yield) gross of tax. Source: BIS. Missing observations February 1979 through October 1979 are 3-month interbank rate. Source: IFS.

Long Rate — Yields to maturity of fixed-coupon Treasury bonds with residual maturities between 9 and 10 years. Prior to 1991, yields to maturity on bonds with original maturities of 15 to 20 years, issued on behalf of the Treasury by the Consortium of Credit for Public Works. Source: IFS.

CPI — Source: IFS.

Ex — Weighted average exchange rates of the Italian lira, weighted by G-10 countries, CPI-adjusted. Source: BOG.

U — Source: ISTAT.

GDP — 1995 prices. Source: BIS.

M — M2 monthly average, billions of lira. Source: BIS.

Japan

Short Rate — Yields of bonds trading with repurchase agreement (3-month). Rates are those offered by clients to securities companies. Source: BIS.

Long Rate — yield at issue, to subscribers on 10-year interest bearing government bonds (prior to January 1973, 7-year). Source: BIS.

CPI — Source: IFS.

Ex — Weighted average exchange rates of the Japanese yen, weighted by G-10 countries, CPI-adjusted. Source: BOG.

U — Source: Economic Planning Agency of Japan.

GDP — Billions of 1990 yen. Source: Economic Planning Agency of Japan.

M — M2 includes CDs. Monthly average measure, Note: Data prior to Jan. 1986 have been computed from percent changes; these computed data are imprecise. Billions of yen. Source: U.S. State Department.

Netherlands

Short Rate — 3-month Amsterdam interbank offer rates (monthly average) based on offer rates of seven banks. Prior to December 1985, interbank deposit rate. Source: BIS.

Long Rate — Yield on most recent 10-year government bond. Source: IFS.

CPI — Source: IFS.

Ex — Weighted average exchange rates of the guilder, weighted by G-10 countries, CPI-adjusted. Source: BOG.

U — 3-month uncentered moving average. Source: Central Bureau of Statistics.

GDP — Billions of 1995 guilders. Source: BIS.

M — M2 National Concept reported until December 1997. From Jan 1998 on, use M3 National Concept, billions of guilders. Source: BIS.

Sweden

Short Rate — Rate on 3-month Treasury discount notes. Source: IFS.

Long Rate — Starting in December 1986: data are secondary market yield on 9-year or 10-year government bonds. From January 1994, 9-year government bonds. Source: BIS. Data prior to December 1986: Until December 1979 data refer to yields on government bonds maturing in 15 years, For January 1980 through November 1986 data refer to yields on bonds maturing in 10 years. Source: IFS.

CPI — Source: IFS.

Ex — Weighted average exchange rates of the krona, weighted by G-10 countries, CPI-adjusted. Source: BOG.

U — Source: Haver.

GDP — Billions of 1995 kroner. Source: Haver.

M — M3 equal to M1 + quasi money, billions of kroner. Source: BIS.

Switzerland

Short Rate — Time deposits, 3-month, with large banks. Data prior to June 1989 applied by agreement by 4 main banks (fixed deposit convention). Source: BIS.

Long Rate — Secondary market yield on Confederation bonds. Until December 1981: all loans with remaining maturity of between 5 and 12 years. From January 1982 onwards, all loans with at least 5 years to maturity and at least 3 years to first call date. Source: BIS.

CPI — Source: IFS.

Ex — Weighted average exchange rates of the Swiss franc, weighted by G-10 countries, CPI-adjusted. Source: BOG.

U — Source: Reuters—Federal Department of Public Economics.

GDP — Billions of 1995 francs. Source: Haver.

M — Historical Money Supply: Adjusted central bank money, reported until July 1992. From August 1992 on, adjusted central bank money. Millions of Swiss francs. Source: BIS.

United Kingdom

Short Rate — Daily 3-month interbank sterling figs. Source: BOG.

Long Rate — Theoretical gross redemption bond yields. Issue at par with 20 years to maturity. Source: IFS.

CPI — Source: IFS.

Ex — Weighted average exchange rates of the pound sterling, weighted by G-10 countries, CPI-adjusted. Source: BOG.

U — Source: Department of Employment.

GDP — Real. Source: Department of Employment.

M — M0, billions of pounds sterling. Source: Bank of England.

USA

Short Rate — 3-month Treasury bill secondary market rate. Source: BOG.

Long Rate — Market yield on U.S. Treasury securities at 10-year constant maturity. Source: BOG.

CPI — Source: U.S. Department of Labor—Bureau of Labor Statistics.

Ex — Weighted average exchange rates of the U.S. dollar against the other G-10 currencies, CPI-adjusted. Source: BOG.

U — Civilian. Source: U.S. Department of Labor—Bureau of Labor Statistics.

GDP — Billions of chain-weighted 1996 U.S. dollars. Source: U.S. Department of Commerce—Bureau of Economic Analysis.

M — M2—monthly average, billions of dollars. Source: BOG.

ENDNOTES

[1] A third factor that influenced the choice of variables was a desire that the variable be observed. To reduce the potential for criticisms that results were affected by subjective decisions on how to transform a variable, unobservable variables and variables defined using unobserved variables were generally not considered. For example, deviations of trending series from estimates of their "potential" growth trend, as examined by Stock and Watson (1999 and 2001), were not considered because views on how to estimate trends are not uncontroversial. One exception to this was the decision to include a measure of the short-term real interest rate. This exception was made because the proxy used for expected inflation is very common.

[2] The predictive power of the spread for future inflation has been investigated in many articles, including Fama(1990), Mishkin (1990 and 1991), Jorion and Mishkin (1991), Robertson (1992), Abken (1993), Blough (1994), Frankel and Lown (1994), Engsted (1995), Estrella and Mishkin (1997a), Tzavalas and Wickens (1996), Alles and Bhar (1997), Davis and Fagan (1997), Day and Lange (1997), and Kozicki (1997). Generally, results suggest that for short horizons the spread predicts future inflation poorly, but for longer horizons the predictive power of the spread improves. Results, however, appear to be somewhat sensitive to the sample period analyzed (Koedijk and Kool (1995)).

[3] Goodfriend (1993) labels significant increases in long-term interest rates in the absence of aggressive policy tightenings "inflation scares." He argues that such increases in long-term interest rates reflect rising expected long-run inflation. Walsh (1998) notes that changes in long rates that follow policy actions may signal changes in the market's assessment of future inflation. For example, a decline in rates following a policy tightening may signal inflation is expected to decline.

[4] Two recent episodes provide examples. The announcement in early 2000 by the U.S. Treasury of reduced auction schedules and imminent buybacks provided a negative supply shock to the Treasury market that increased the price of longer term securities and decreased their yields. Instability of global financial markets in late 1998 after the Russian debt default provides an example of a demand shock in the Treasury market. Yields on Treasury bonds fell in response to huge safe-haven flows of funds into low-risk securities.

[5] The view that monetary policymakers could use money to attain their ultimate inflation objective is based on a presumed stable relationship between money and prices. In the United States, this view was the basis for the 1976 congressional mandate to the Federal Reserve, the Humphrey/Hawkins Act, to specify annual targets for monetary growth (Heller). In the European Monetary Union, a reference value for the growth of a specific monetary aggregate is one of two pillars used to achieve the goal of price stability (ECB). In addition, conducting monetary policy with an eye to monetary growth targets is often viewed as more transparent. Issing (1996) advocates the use of monetary targets because they increase the transparency of the policy rule and promote a clear definition of economic policy responsibility.

[6] Friedman (1992) provided an interesting example from the American Civil War. "The South financed the war largely through the printing press, in the process producing an inflation that averaged 10 percent per month from October

1861 to March 1864. In an attempt to stem the inflation, the Confederacy enacted a monetary reform" and in May 1864 the stock of money was reduced. Despite ongoing civil, economic, and political disarray, reducing the stock of money had a significant effect and the general price index dropped dramatically (Lerner).

[7] Examples include Darby, Mascaro, and Marlow (1989), Hafer (1993), Hallman, Porter, and Small (1991), Haslag and Ozment (1991), Dewald (1998), and Crowder (1998). Although Friedman (1968) exposited a relationship between inflation and the difference between money growth and output growth, investigations usually focus on the relationship between inflation and money growth, perhaps because "what happens to money tends to dwarf what happens to output" (Friedman 1992).

[8] See, for instance, Friedman and Kuttner (1992 and 1996), Estrella and Mishkin (1997b), and Sill (1999). Friedman and Kuttner (1996) argue that increasing instability of money demand is the most consistent explanation for the loss of predictive power of money growth. Instability in money demand may be a response to new technology, deregulation, new forms of deposit holdings, and globalization among other changes in economic conditions.

[9] With the demise of the Bretton Woods international monetary system in 1973, some countries, such as the United States, opted for floating exchange rates while others chose to operate under currency pegs. Eichengreen provides an international history of exchange rate policies.

[10] Movements in the exchange rate have been cited as one source of increased inflation in the U.S. in 1972 and 1973. Then-Chairman of the Federal Reserve, Arthur Burns noted in a statement before the Committee on Banking and Currency of the House of Representatives on July 30, 1974: "a worldwide boom in economic activity during 1972 and 1973 led to a bidding up of prices everywhere….The impact of worldwide inflation was especially severe in the U.S. because of the decline in the exchange value of the dollar relative to other currencies. Besides stimulating our export trade, and thereby reinforcing the pressures of domestic demand on available resources, devaluation raised the dollar prices of imported products, and these effects spread through our markets."

[11] Evidence on whether or not movements of the exchange rate predict inflation is mixed. Whitt, Koch, and Rosensweig (1986) find that between April 1973 and June 1985, U.S. exchange rate movements were followed by substantial changes in the price level. However, examining the episode of U.S. dollar depreciation between 1985 and early 1987, Kahn (1987) finds that the 40 percent depreciation would likely only have a small impact on inflation, as the effect on the level of consumer prices would be spread over several years. Furthermore, Kahn (1987) and Hafer (1989) argue that the impact on inflation should be only temporary. In particular, while a depreciation of the domestic currency or increase in the foreign currency price of imports may raise the domestic price of imports, such relative price increases will only have transitory effects on inflation unless domestic monetary policy accommodates the increase in the relative price of imports. Examining data for the G7 countries, Papell (1994) finds that exchange rate movements have relatively small effects on national price levels.

[12] Phillips (1958) is credited with finding a relationship between inflation and the level of the unemployment rate and the rate of change of unemployment. Phillips wrote that "the rate of change of money wage rates can be explained by the level of unemployment and the rate of change of unemployment. . . ."

[13] An alternative interpretation is that a low unemployment rate signals excess demand in the economy. In situations of excess demand, strong demand for scarce products bids up prices. Consequently, low unemployment may predict rising inflation.

[14] The NAIRU is often referred to as the natural rate of unemployment, the equilibrium rate of unemployment, the neutral rate of unemployment, or the full employment rate of unemployment. While some analysts may argue that these terms apply to slightly different concepts, they will be used interchangeably in this article.

[15] This relationship of the change in inflation to the gap between the unemployment rate and the NAIRU is implied by an "accelerationist," or expectations-augmented, Phillips curve with past inflation used to proxy for expected inflation. In response to critiques by Friedman (1968) and Phelps, Phillips curves were modified to so that they would not include a permanent tradeoff between inflation and unemployment. In these modified Phillips curves, sometimes referred to as accelerationist Phillips curves, inflation rises above expected inflation if the unemployment rate falls below the NAIRU and inflation falls below expected inflation if the unemployment rate rises above the NAIRU. To understand why only temporary tradeoffs are possible, consider a situation where unemployment is below the NAIRU. According to the theory, tight labor market conditions lead to higher wage increases and subsequent higher inflation. Workers, however, realize this likelihood and build higher expectations of inflation into their wage demands. Consequently, unemployment below the NAIRU will lead to accelerating inflation. To simplify exposition, the label "accelerationist" will be dropped in the text. See Okun (1975) and Espinosa-Vega and Russell (1997) for a review of the history and theory of the NAIRU.

[16] Tootell (1994) acknowledges that there are difficulties associated with estimating the NAIRU. Staiger, Stock, and Watson (1997), Chang (1997), and Solow (1998) discuss time-variation in the NAIRU and imprecision associated with estimates.

[17] In particular, Eisner argues that for the U.S., while inflation appears to decline when the unemployment is above the NAIRU, there are little or no lasting effects on inflation when unemployment is below the NAIRU. In addition, Fair (1999) suggests the dynamics implied by the Phillips curve are rejected.

[18] As noted by Solow (1998), it is not clear that the U.S. economy before 1970 behaved in a way consistent with the accerlationist (expectations-augmented) Phillips curve.

[19] Gordon (1998), Stiglitz (1997), Fuhrer (1995), King and Watson (1994), and Weiner (1993) are examples of recent research that is generally supportive of Phillips curve models of inflation.

[20] To account for persistence in the unemployment rate, Blanchard and Summers (1987) developed a "hysteresis" theory of the European unemployment problem. "Hysteresis" refers to the tendency of a shock to a variable to persist. Evidence of hysteresis in unemployment was reported by Blanchard and Summers (for

France, West Germany, and the U.K) and Brunello (for Japan). Evidence of hysteresis in unemployment was not supported by Canadian data according to Poloz and Wilkinson.

[21] The suggestion that the change in unemployment will help predict the change in inflation is often referred to as a "speed effect" or "speed limit effect." See, for example, the discussion in Fuhrer (1995).

[22] Moore (1978) concludes that not only in the U.S., but in other industrialized countries, declines in the rate of inflation have almost invariably been associated with slowdowns in real economic growth and a diminution in unemployment rates, and have not occurred at other times.

[23] The basic models estimated are: *inflation(t+k) = constant + inflation(t) + variable(t) + error(t)*, where *inflation(t+k)* is inflation over the four quarters ending in quarter *t+k* quarters, *inflation(t)* is inflation over the four quarters ending in quarter t, *variable(t)* is the measure of the candidate variable in quarter t, *error(t)* is the error in the forecast, and *constant* and are estimated parameters. For one-year-ahead forecasts $k=4$ and for two-year-ahead forecasts $k=8$. Estimates of *constant* and differ for different *k* and for different countries. The specification of the models is similar to that used by Stock and Watson (1999 and 2001).

[24] Slightly less restrictive models were also considered. The difference between these models and the models described above is that in the less restrictive models, current inflation is also multiplied by a coefficient to be estimated. However, as these models generally performed slightly worse that the models described above, the results have not been included in this article. Although more simplistic, the specification of the less restrictive models resembles that used by Cecchetti, Chu and Steindel (2000).

[25] More general models including multiple indicators and more parameters to be estimated often suffer from in-sample over-fitting problems. In other words, while the models tend to explain historical data well within the sample used to estimate the model, forecast performance out-of-sample is frequently worse than would be obtained with a much simpler model.

[26] Over 1991:Q1 through 1998:Q4, the Netherlands had the lowest variance of inflation (0.31) and Sweden had the highest variance of inflation (8.02).

[27] Stock and Watson (2001) obtained similar results in a study of the predictive performance for inflation of up to 38 indicators for seven OECD countries and two subsamples. In particular, they found that some variables forecast relatively well in some countries in one or the other of the subsamples.

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