Does Inflation Uncertainty Increase with Inflation?

By John E. Golob

One of the most important costs of inflation is the uncertainty it creates about future inflation. This uncertainty clouds the decisionmaking of consumers and businesses and reduces economic well-being. Without this uncertainty, consumers and businesses could better plan for the future.

According to many analysts, uncertainty about future inflation rises as inflation rises. As a result, these analysts argue that the Federal Reserve could reduce inflation uncertainty by reducing inflation. Other analysts argue that high inflation creates no more uncertainty than low inflation, as long as inflation remains stable. As a result, these analysts argue that high inflation does not necessarily interfere with decisionmaking or reduce economic well-being.

While most previous studies have found a positive relationship between inflation and inflation uncertainty, a few key studies have not. Previous studies may be flawed, however, because they ignore a general downtrend in inflation uncertainty that has occurred over time. Reasons for the downtrend —which is independent of the level of inflation— are not well understood. Nevertheless, accounting for the downtrend is important in determining the true relationship between inflation and inflation uncertainty.

This article accounts for the downtrend in inflation uncertainty and finds unambiguous evidence that inflation uncertainty rises with inflation. The first section identifies the consequences of uncertainty about inflation and discusses some likely causes of the positive relationship between inflation and inflation uncertainty. The second section reviews the results and inconsistencies in previous research. The third section presents empirical evidence resolving these inconsistencies and pointing to a robust positive relationship between inflation and inflation uncertainty.

HOW DOES INFLATION UNCERTAINTY INTERACT WITH THE ECONOMY?

Whenever expected inflation is a factor in an economic decision, uncertainty about inflation is also likely to be a factor. For example, uncertainty about future inflation can affect both business investment decisions and consumer saving decisions. This uncertainty has adverse economic consequences that potentially rise with inflation.[1]

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Consequences of inflation uncertainty

Uncertainty about inflation has two types of economic effects. First, inflation uncertainty causes businesses and consumers to make economic decisions that differ from the ones they would make otherwise. Analysts refer to these effects as *ex ante*, because the decisions anticipate future inflation. The second category of effects takes place after the decisions have been made, or *ex post*. These effects occur when inflation differs from what had been expected.

Ex ante effects. Uncertainty about inflation can affect the economy ex ante through three channels. First, inflation uncertainty affects financial markets by raising long-term interest rates. Second, inflation uncertainty leads to uncertainty about other variables that are important in economic decisions. Finally, inflation uncertainty encourages businesses to spend resources avoiding the associated risks.

The first channel through which inflation uncertainty affects the economy is by increasing long-term interest rates. An important determinant of long-term rates is the return required by investors. If inflation is uncertain, the return on nominal long-term debt will be riskier. As a result, investors will require higher expected returns, which imply higher long-term interest rates. Higher rates, in turn, imply that businesses will invest less in plant and equipment, and consumers will invest less in housing and other durable goods.

Some economists believe inflation uncertainty has been an important factor in explaining high long-term interest rates in the 1980s and 1990s. Before the high inflation of the 1970s, the spread between short-term and long-term rates was usually much lower than in recent years. Concern about another episode of high inflation is one possible reason the term premium remains high today.

The second channel through which inflation uncertainty affects the economy is by causing uncertainty about interest rates and other economic variables. When the payments in a contract are not indexed to inflation, inflation uncertainty causes the real value of future payments to be uncertain. For example, inflation uncertainty can cause employers and employees to be uncertain about future wages, and landlords and tenants to be uncertain about future rents. To the extent that taxes are not indexed to inflation, inflation uncertainty also implies uncertain tax rates. For example, capital gains taxes are not indexed, so inflation uncertainty implies that entrepreneurs will be uncertain about the tax rates on their capital gains. Also, the value of depreciation deductions will be uncertain, affecting the way profits are calculated and taxed. This spread of uncertainty to other economic variables interferes with the ability of consumers and businesses to make informed decisions.

Uncertainty about interest rates and other economic variables can reduce economic activity. When businesses are uncertain about interest rates, wages, tax rates, and profits, they may choose to delay hiring, production, and investment decisions until some of the uncertainty is resolved. Investment is most vulnerable because investment is so costly to reverse.

Uncertainty about interest rates also encourages businesses and consumers to finance investment with long-term fixed-rate debt to avoid the risk of increases in short-term interest rates. But since fixed long-term rates are typically higher than short-term rates, using long-term debt increases financing costs and thereby reduces investment. The purchase of a home mortgage provides an example of this effect. A consumer who is uncertain about future inflation will be uncertain about future interest rates as well. To eliminate the risk of future increases in interest rates, the consumer may choose a fixed-rate over a variable-rate mortgage. But this choice could lead the consumer to take out a smaller mortgage than otherwise because interest rates are typically higher in the first years of fixed-rate mortgages. So inflation uncertainty could limit the size of the mortgage and therefore the size of the home that the consumer purchases.

In the third channel through which inflation uncertainty affects the economy, businesses spend resources avoiding the risks of future inflation. For

example, when inflation uncertainty is high businesses may spend more resources improving their forecast of inflation. In addition, some businesses may try to hedge against unexpected inflation using specialized financial instruments, known as derivatives. But both forecasting and hedging activities imply that resources are diverted from other more productive business purposes. And while these strategies reduce the risk of unexpected inflation, they do not eliminate risk.[2] Furthermore, forecasting and hedging are not practical for most small businesses and consumers.

Ex post effects. The other effects of inflation uncertainty—the ex post effects—occur when inflation differs from what had been expected. Unexpected inflation leads to a transfer of wealth whenever the payments in a contract are specified in nominal dollars. When inflation is higher than forecast, the real value of nominal payments is lower than expected. A fixed-rate mortgage provides one example where unexpected inflation implies a transfer of wealth from the lender to the borrower. If inflation is unexpectedly high, the real value of the mortgage payments to the lender is less than had been expected. Similar effects occur in wage and rent contracts. When wages and rents are fixed in nominal dollars, employees and landlords are hurt by an unexpected increase in inflation.

Because a wealth transfer implies that someone wins while someone else loses, it is difficult to measure aggregate ex post effects. But if the unexpected inflation is large enough, the effect can be felt throughout the economy. The crisis in the savings and loan industry provides a striking example of an inflation-induced wealth transfer. In this industry, S&Ls used short-term deposits to make long-term loans. When inflation rose unexpectedly in the late 1970s, the real value of the payments on fixed-rate mortgages declined. Meanwhile, as short-term nominal interest rates rose with inflation, S&Ls were forced to pay higher rates to their depositors. By paying higher rates on deposits than they were receiving on loans, many S&Ls went bankrupt. Thus, the unexpected inflation of the 1970s led to a massive transfer of wealth out of the S&L industry. If the inflation of the 1970s had been less of a surprise, the taxpayer bailout of the industry might have been avoided.

Why inflation uncertainty might increase with inflation

While the costs of inflation uncertainty are relatively easy to identify, explaining why inflation uncertainty increases with inflation is more difficult. The most appealing explanation involves the response of monetary policy to inflation.[3] When inflation is low, monetary policymakers try to keep it low. To the extent they are successful, inflation remains low and stable. When inflation is high, however, monetary policymakers are more likely to adopt disinflationary policies. These policies, by lowering the inflation rate, increase inflation variability. Moreover, the policies create inflation uncertainty because the timing and short-run impact of policy on inflation are uncertain.

The timing of disinflationary policy actions is uncertain, in part, because of short-run tradeoffs among the goals of monetary policy. Although the long-run goal of monetary policy is to make progress toward eliminating inflation, the Federal Reserve also tries in the short run to moderate the depth of economic downturns. When inflation is high at the same time the economy is in a slump, it is not obvious which goal should take immediate priority. Thus, uncertainty arises about the timing of policy actions to reduce inflation.

The impact of monetary policy on inflation is also uncertain (Holland 1993b). In particular, the effects of policy take time to work their way through the banking system, to the real economy, and eventually to inflation. Moreover, the speed with which monetary policy actions are transmitted to inflation varies widely over time. Thus, the complexity of predicting how much and how quickly prices will respond to monetary policy creates inflation uncertainty, even if the stance of monetary policy were known with certainty.[4]

PREVIOUS RESEARCH

Research on inflation uncertainty goes back over 20 years. In the first study on the issue, Okun found that countries with high inflation also had more variable inflation. He interpreted the greater variability as an indication of greater uncertainty. Since Okun's initial work, over 20 empirical papers have been published on inflation uncertainty. The greatest flurry of activity occurred in the early 1980s, after a decade of unusually high inflation in the industrialized countries.

The vast majority of the research—17 of the 21 papers since Okun's study—has concluded that high inflation leads to more inflation uncertainty. However, four papers have been unable to find this relationship. In addition to these four papers, some research on exchange rate regimes is relevant. When inflation uncertainty is examined across exchange rate regimes, the evidence suggests uncertainty does not rise with inflation. Thus, although substantial evidence suggests that inflation leads to more inflation uncertainty, the evidence is not unanimous.

In recent research, two different strategies have been used to estimate inflation uncertainty.[5] The first strategy uses surveys and the second uses forecasting models. Since different estimates of uncertainty can lead to different empirical results, this section discusses both research strategies. Researchers using survey estimates of uncertainty consistently find a positive relationship between inflation and inflation uncertainty. Researchers using forecasting models do not find this relationship as consistently because different models yield different results.

The survey strategy

The first strategy for estimating uncertainty about inflation uses surveys of economists and consumers. Analysts estimate inflation uncertainty from the surveys using two different approaches. One approach estimates uncertainty by asking respondents to provide a range of values over which inflation might fall.[6] For example, one respondent might expect inflation of 3 to 4 percent, while another one might expect inflation of 2 to 5 percent. Because the second respondent identified a wider range of possible outcomes, this respondent is presumed to be more uncertain about future inflation.

The second approach to estimating inflation uncertainty from surveys is based on the variability, or dispersion, of inflation expectations across survey participants. Unlike the first approach where uncertainty can be estimated for an individual, the variability estimate of uncertainty requires several survey participants. When survey participants have similar expectations of future inflation, uncertainty is presumed to be low. But if they disagree about the inflation outlook, uncertainty is presumed to be high. For example, if 90 percent of participants' median inflation forecasts are between 3 and 4 percent, uncertainty is lower than if only 60 percent of the forecasts are in this range.

When inflation uncertainty is estimated from surveys, researchers consistently find that uncertainty is high during periods of high inflation. Eight papers reach this conclusion using data from four surveys.[7]

The forecasting model strategy

The second strategy for estimating inflation uncertainty uses economic forecasting models. In this approach researchers use an econometric model of inflation to forecast future inflation. Large forecast errors from the model imply high uncertainty, while small forecast errors imply low uncertainty.

Results from the forecasting model strategy are less consistent than those from the survey strategy. While most researchers find large forecast errors during periods of high inflation, some do not. One reason for this inconsistency is a lack of consensus about the best way to forecast inflation. Forecasts are typically based on previous values of a variety of economic variables, such as wage inflation, money growth, unemployment, import price

changes, and overall inflation. But there are many ways of building a model of inflation from these variables, and the relative performance of different models depends on the time period being considered. For example, growth in the M1 money supply has often been used in inflation forecasting models. But changes in the behavior of M1 in the early 1980s caused the performance of these models to deteriorate. Since economists have different opinions about how to forecast inflation, they have different interpretations of the forecasting model evidence on inflation uncertainty.

Two branches of research using forecasting models fail to find the positive relationship between inflation and inflation uncertainty. In the first branch, researchers use a highly restrictive model structure to investigate the link between inflation and uncertainty. In the second branch, inflation uncertainty is examined across exchange rate regimes.

Restricted-uncertainty models. Of the four papers in the literature that do not find more uncertainty when inflation is high, three use "restricted-uncertainty" models.[8] These models were originally developed to analyze financial data, where volatility often changes over time. Since inflation volatility also appears to change over time, researchers have adapted these models for analyzing inflation. The restricted-uncertainty models typically constrain uncertainty to change slowly over time.

Although researchers have found restricted-uncertainty models useful for financial data, the assumptions may be inappropriate for inflation uncertainty. Specifically, any rapid change in inflation uncertainty would be inconsistent with the constraints typically imposed in these models. For example, after Iraq's invasion of Kuwait in 1990, oil prices increased rapidly and uncertainty about their impact on overall inflation was high. However, the quick resolution of the resulting war in the Gulf led to a rapid decline in both oil prices and uncertainty about inflation. Such a rapid decline in uncertainty would be inconsistent with the assumptions in a typical restricted-uncertainty model. To the extent that the assumptions in these models are inappropriate, the results from the models are also suspect.

Inflation uncertainty across exchange rate regimes. If the only evidence against a relationship between inflation and inflation uncertainty came from restricted-uncertainty models, analysts might discount this limited contrary evidence. But research on exchange rate regimes also suggests that inflation uncertainty does not increase with inflation. The United States has been in two distinct regimes since the end of World War II. Exchange rates were fixed during the Bretton Woods period, which ended in 1973. Since the collapse of the Bretton Woods system, U.S. exchange rates have been allowed to float.

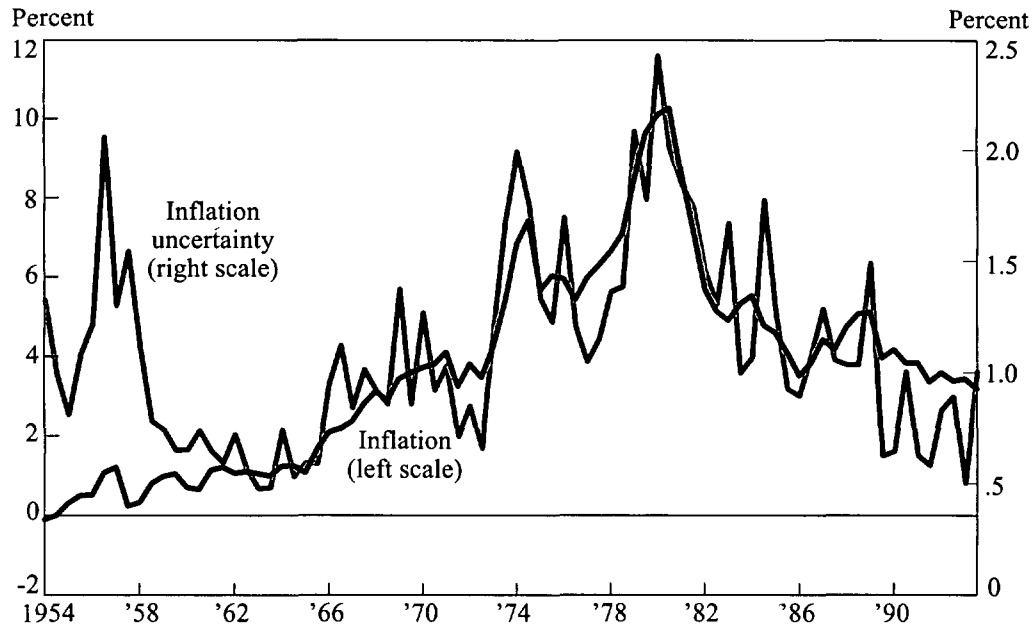
By examining inflation uncertainty across exchange rate regimes, researchers have indirectly provided evidence on the link between inflation and inflation uncertainty. This indirect evidence exists because the average level of inflation is higher in the floating-rate regime. If inflation uncertainty increases with inflation, uncertainty should also be higher in the floating-rate regime.

Inflation uncertainty has been examined across exchange rate regimes by Meltzer (1985, 1986, 1988) and Meltzer and Robinson.[9] The forecasting models use quarterly data for the GDP deflator and annual data for the producer price index. In all of these papers, inflation uncertainty was about the same or slightly higher during the fixed-rate regime as during the post-1973 floating-rate regime. Yet inflation was only about half as high during the fixed-rate regime as during the floating-rate regime. This finding suggests that inflation uncertainty may not increase with inflation.

In summary, researchers who estimate inflation uncertainty from survey data consistently find that inflation uncertainty rises with inflation. But results from forecasting models are not as conclusive. Results from restricted-uncertainty models are mixed, and results from exchange rate research suggest no relationship at all. To reconcile the disagreement, the next section takes another look at the evidence.

Chart 1

Inflation and Inflation Uncertainty



Note: Inflation is the average of the Livingston Survey 12-month inflation forecasts. Inflation uncertainty is the dispersion of the Livingston Survey 12-month inflation forecasts.
Source: Livingston Survey, Federal Reserve Bank of Philadelphia.

EMPIRICAL EVIDENCE

This section presents empirical evidence of an unambiguously positive relationship between inflation uncertainty and inflation. The analysis also reveals that, independent of the level of inflation, inflation uncertainty has been trending down over time. This downtrend explains the apparent inconsistencies in both the restricted-uncertainty models and the research on exchange rate regimes.

The empirical analysis in this paper is based on the 1954-93 period. The 1954 starting date is typical of research on inflation uncertainty.[10] Although earlier data are available, it is desirable to avoid the influences of World War II, the Korean War, a price control period in the early 1950s, and occasional episodes of deflation that could complicate the analysis. To ensure robustness and overcome the criticisms of the individual measurement techniques, the analysis uses evidence from a survey and from forecasting models.

Survey evidence

Uncertainty in CPI inflation is estimated using the Livingston survey, the only survey conducted continuously since 1954.[11] In the Livingston survey, approximately 50 economists are surveyed twice a year, in June and December.[12] Inflation uncertainty is estimated as the standard deviation of the participants' inflation expectations. The standard devia-

Table 1

Regression Results Using the Livingston Survey, 1954-93

Dependent variable	Constant	Time trend	Lagged uncertainty	Expected inflation
Inflation uncertainty (6-month horizon)	.443** (.096)	-.011** (.003)	.432** (.098)	.137** (.025)
Inflation uncertainty (12-month horizon)	.479** (.133)	-.011** (.004)	.395** (.146)	.110** (.027)

Note: Inflation uncertainty is estimated as the standard deviation of inflation forecasts from the Livingston Survey. Standard errors are in parentheses.

** Indicates significance at 0.01.

tion is a measure of the variability, or dispersion, of their inflation expectations.

A chart of the 12-month Livingston forecasts reveals a positive relationship between inflation and inflation uncertainty (Chart 1).[13] Both of these variables were highest in 1980, when inflation was over 10 percent and the standard deviation of inflation expectations was over 2 percent.[14]

In addition to the positive relationship between inflation and inflation uncertainty, Chart 1 also reveals a modest downtrend in uncertainty. In particular, the estimates of inflation uncertainty are generally above estimates of inflation in the early years and generally below inflation in the later years.[15]

A formal statistical analysis of the relationship between the level of CPI inflation and the dispersion measure of CPI uncertainty confirms the results suggested by Chart 1. Table 1 shows the results when uncertainty is regressed on expected inflation, time, and last period's uncertainty. For both six-month and 12-month Livingston forecasts, the coefficient on inflation is positive. This result implies that higher inflation is associated with more inflation uncertainty. The negative coefficient on the time trend implies that uncertainty has been declining over time.[16] This decline in inflation uncertainty over time is independent of the relationship between inflation uncertainty and the level of inflation.[17]

The main result in Table 1 confirms what other researchers have found in survey data—that inflation uncertainty increases with inflation. The downtrend, however, is a feature of the data that was not observed in previous research. Given the results in the literature, finding a positive relationship between inflation and uncertainty is not surprising. A more interesting question is whether the downtrend in uncertainty can resolve any of the inconsistent evidence from forecasting models.

Forecasting model evidence

Inflation uncertainty is estimated in forecasting models for two versions of the CPI and for the GDP deflator. The two versions of the CPI are the total CPI and the core CPI. The total CPI reflects the prices paid by a typical urban consumer, whereas

Table 2

Regression Results from Forecasting Models for Consumer Price Indexes

(Models based on 1957-93 quarterly data)

Dependent variable	Constant	Time trend	Lagged inflation
Uncertainty in core CPI inflation	.092 (.053)	-.0012* (.0006)	.28** (.035)
Uncertainty in total CPI inflation	.266** (.057)	-.0002 (.0006)	.127** (.033)

Note: Uncertainty is estimated from forecast errors. Standard errors are in parentheses.

* Indicates significance at 0.05.

** Indicates significance at 0.01.

the core CPI excludes food and energy prices. This latter index may give a more accurate representation of inflation because the total CPI is distorted by short-term volatility in its food and energy components. The analysis uses both of these indexes to see if the downtrend in uncertainty can be attributed to a decline in the volatility of food and energy prices.[18]

Uncertainty in the CPI. The forecasting model used to estimate uncertainty in total CPI and core CPI inflation is similar to a model evaluated by Stockton and Glassman. The model uses quarterly data on inflation and assumes that next quarter's inflation depends on inflation in each of the past four quarters.[19] Stockton and Glassman have shown that the performance of this simple model is comparable to the performance of more complicated models.

For uncertainty in core CPI inflation, results from the forecasting model approach are similar to results from the survey approach (Table 2). Uncertainty increases as inflation rises, but uncertainty declines over time.[20] More precisely, for a 1 percent increase in inflation, the regression indicates that uncertainty (as measured by the forecast error) increases by 0.28 percentage points.

The forecasting model results for the total CPI differ slightly from those for core CPI (Table 2). While uncertainty still rises as total CPI inflation rises, the coefficient on the time trend is no longer significant. The insignificant coefficient implies that unlike core CPI, uncertainty is not trending down in total CPI. This result likely occurs because the volatility of food and energy prices is the dominant component of uncertainty in total CPI. Food and energy volatility has not declined over time, and this high volatility obscures the declining uncertainty in the core component of total CPI.[21]

Uncertainty in the GDP Deflator. Two different forecasting models are used to estimate uncertainty in the GDP deflator. Ball and Cecchetti devised the first model, which forecasts inflation using past values of inflation and past forecast errors. Bollerslev devised the second model, which estimates uncertainty for the GDP deflator using a restricted-uncertainty model.[22] Inflation still depends on past inflation, but the model restricts how

Table 3

Regression Results from Forecasting Models for the GDP Deflator

(Models based on 1954-93 quarterly data)

Dependent variable	Constant	Time trend	Lagged inflation
Ball and Cecchetti Model			
Inflation uncertainty	.325*	-.0062*	.094*
	(.044)	(.0014)	(.039)
Bollerslev Restricted-Uncertainty Model			
Inflation uncertainty	.219**	-.0008*	.920*
	(.038)	(.0003)	(.415)
Inflation uncertainty	.135**		.75
	(.026)		(.42)

Note: For both the Ball-Cecchetti and Bollerslev models inflation uncertainty is estimated from forecast errors, but the Bollerslev model imposes restrictions on how uncertainty varies over time. Standard errors are in parentheses.

* Indicates significance at 0.05.
**Indicates significance at 0.01.

fast uncertainty can change over time.

Results from both GDP forecasting models are similar to results from the analysis of core CPI uncertainty. In the first model in Table 3, estimated uncertainty is larger when inflation is higher, but uncertainty declines over time. Similar results are obtained with the restricted-uncertainty model.[23] Table 3 also shows the results of a second regression with the restricted-uncertainty model. When time is removed from the regression, the coefficient on past inflation is no longer significant. This result illustrates how excluding time from the analysis can change the interpretation of the results.[24]

Reconciling the evidence

The downtrend in uncertainty may explain why a positive relationship between inflation and inflation uncertainty is not found in some previous research. The failure of previous researchers to recognize the downtrend may have biased their results. While higher inflation in the second half of the sample tends to raise uncertainty, the downtrend works in the other direction. Thus, the failure of previous studies to detect a relationship between inflation and uncertainty arises because the two effects on uncertainty tend to counteract each other.

The downtrend also explains the results from research on exchange rate regimes. Recall that although inflation was almost twice as high in the floating-rate as in the fixed-rate regime, there was no corresponding increase in inflation uncertainty. In this case, the combined effects of inflation and time neutralized each other, so there was little change in uncertainty across the two regimes.

Recognizing that inflation uncertainty has trended down over time substantially increases the weight of evidence that uncertainty increases with inflation. While some studies from the literature seem to be inconsistent with this result, the vast majority of these studies were based on either restricted-uncertainty models or exchange rate regime research. When these analyses are reexamined in the light of this article's evidence of a downtrend in inflation uncertainty, the conclusion that high inflation is associated with high uncertainty is even more compelling.

SUMMARY

Most research on inflation uncertainty finds high uncertainty during periods of high inflation. But this conclusion is not universal, and contrary evidence is found both in restricted-uncertainty models and in exchange rate research. This article reaffirms the positive relationship between inflation and inflation uncertainty, and offers an explanation for the inconsistent results in previous research.

The article provides evidence of a downtrend in inflation uncertainty, and shows how this downtrend can conceal the positive relationship between inflation and inflation uncertainty. Both survey and forecasting model estimates of uncertainty confirm the downtrend. When inflation uncertainty research is reexamined in the light of this downtrend, the conclusion that uncertainty increases with inflation is unambiguous.

The results in this article have a clear implication for monetary policy. To minimize the disruptions to economic decisionmaking caused by inflation uncertainty, the Federal Reserve should continue to work toward price stability.

ENDNOTES

[1] Several researchers find that inflation uncertainty has negative effects on economic activity. Holland (1993a) and Golob give summary discussions of this research.

[2] A few companies have encountered problems using complicated hedging strategies with derivatives. In an ironic twist, the strategies have inadvertently led to greater rather than less risk. The strategies are vulnerable to two problems. First, the strategies are so complicated that even alleged experts find it difficult to anticipate all possible contingencies. Second, strategies can require frequent trading when markets are moving, which requires that markets exist for each financial instrument used in a strategy. Unfortunately, when long-term interest rates moved rapidly in early 1994, even dealers were unable to establish prices of some exotic derivatives, so these markets essentially shut down. This led to a failure of the hedging strategies that depended on the closed markets.

[3] This explanation is similar to a formal economic model developed by Ball. In Ball's model policymakers have different attitudes toward inflation, some will disinflate while others will not. Since the public is uncertain about who will control policy in the future, the public is uncertain about whether high inflation will be reduced.

[4] Uncertainty about the impact of monetary policy is likely to contribute more to inflation uncertainty, at least in the short run, than uncertainty about monetary policy itself. Most evidence suggests monetary policy takes six months to a year to have an impact on inflation. Consequently, a change in monetary policy today will have only a limited impact on forecasts for inflation over the next six months to a year. The near-term outlook for inflation will, however, continue to be clouded by uncertainty about the impact of past monetary policy actions.

[5] Early researchers assumed that inflation variability was a good measure of uncertainty, but limitations of this approach were quickly recognized (Foster). A basic weakness is that some variations in inflation can be predicted, so variability does not always represent uncertainty. Because of this weakness, the variability approach has not been used much over the last decade.

[6] Only the Survey of Professional Forecasters measures the uncertainty of individual respondents. Respondents are asked to assign specific probabilities to different ranges for inflation. For example, a respondent could assign a probability of one-half to the range from 2 to 3 percent and a probability of one-half to the range from 3 to 4 percent.

This survey was first conducted by the American Statistical Association and the National Bureau of Economic Research, and is sometimes referred to as the ASA-NBER survey. It is currently conducted by the Federal Reserve Bank of Philadelphia.

[7] Most of this research is based on U.S. data, but Australian researchers find a similar result using the Morgan Poll.

[8] The technical description of these models is "conditional heteroskedasticity," which is often designated by the acronyms ARCH (autoregressive conditional heteroskedasticity) and GARCH (generalized ARCH).

[9] Inflation uncertainty in the United States since World War II is only one aspect of the research on uncertainty across exchange rate regimes. The research also considers uncertainty in other economic variables, other countries, and time periods back to the 1800s. The general conclusion from this research is that economic uncertainty in the United States was much higher at the turn of the century when the United States was on the gold standard. Uncertainty was higher in inflation, nominal GDP, real GDP, and money. Results for other countries are similar, although not as consistent across different economic variables as in the United States.

[10] Several researchers have noted that inflation was significantly more volatile before 1954 (Cosimano and Jansen). Most of the results in this article are robust to changing the starting and ending dates of the analysis.

[11] The survey is named after the late Joseph Livingston, who started the survey in 1946 when he was a columnist with the *Philadelphia Enquirer*. The survey is currently conducted and published by the Federal Reserve Bank of Philadelphia.

The Survey of Professional Forecasters includes estimates of both the GDP deflator and the CPI, but this survey did not begin until 1968. The University of Michigan Survey did not begin asking for estimates of CPI inflation until 1966. Previously, participants had only been asked whether prices were going up or down.

[12] When the surveys are collected in June and December, official data are only available through April and October, respectively. This has led Carlson to conclude that the forecasts actually cover the subsequent 8-month and 14-month periods. Many analyses of the Livingston data recognize the Carlson adjustment.

[13] Inflation is the average of inflation expectations across survey participants. The results of the analysis are the same when the ex post measured inflation rate is substituted for the expected rate from the survey. Using the survey estimate of inflation avoids the controversy about the time horizon of the Livingston survey that is discussed in note 12.

[14] Chart 1 also reveals that inflation uncertainty is more variable than expected inflation. For example, although expected inflation was approximately 6 percent in 1976 and 1977, uncertainty declined from 1.7 to 1.1 percent over these two years.

[15] Uncertainty was particularly high in the early part of the sample. But an econometric analysis reveals that the downtrend exists even when the 1954-60 period is excluded.

[16] The regressions were corrected for serial correlation in the residuals using a maximum likelihood approach (Hall, TSP User's Guide). Other specifications for the regression were also explored. But coefficients were not significant for lagged expected inflation or for higher order lags on uncertainty. To allow for a possible unit root in inflation, a regression was also conducted on differenced data. In this regression, inflation uncertainty increased with inflation and a negative constant suggested a downtrend over time. But the constant coefficient was not statistically significant.

[17] While there is evidence of a downtrend in inflation uncertainty, the reasons for this decline are not immediately apparent. Lower uncertainty could reflect structural changes in the economy or more knowledgeable forecasters. An example of structural change in the economy would be a change in how consumers spend their income. For example, compared with 40 years ago, more of the typical budget is spent on health services and less is spent on durable goods. If the price of health services is less variable than the price of durable goods, the increased weight of health services might make overall inflation less variable and more predictable. Better forecasting is another reason that uncertainty may have declined. That is, forecasters may be using advances in computer and communication technology to develop better models of the economy. However, with the limited evidence shown above, it is not yet possible to diagnose definitively the true cause of the downtrend in inflation uncertainty.

[18] Since data on the core CPI are available only from 1957, this analysis starts three years later than the other work in this article.

[19] In the Stockton and Glassman model, inflation depends on four lagged values. Standard model selection criteria (see Wei) indicate that this is a good model. For the core CPI, a model with three lagged values is better.

[20] Past inflation is taken as the average over the last six months to smooth out the short-term fluctuations in quarterly

data. This approach will be used in regressions of uncertainty on past inflation for all of the forecasting models.

[21] The regressions in Table 2 provide evidence that uncertainty is higher in total CPI than core CPI. The constant term is almost three times higher for total CPI than for core CPI.

[22] In Bollerslev's model, inflation depends on inflation over the previous four quarters. The conditional heteroskedasticity (uncertainty) is assumed to follow a GARCH(1,1) process.

[23] The dependent variable in Table 3 is the conditional variance from the restricted-uncertainty model. Since this number is very small in a model that forecasts quarterly percentage changes in the GDP deflator, all the coefficients in Table 3 are shown as 10,000 times the actual values. The regressions were corrected for serial correlation in the errors using a maximum likelihood technique. This regression is not as robust as the other results in this article. Results from other models were robust to changing the starting and ending dates, and to eliminating the 1973-81 period when oil price shocks were important. In contrast, results with the restricted-uncertainty model are more sensitive to such adjustments.

[24] Researchers have proposed alternative explanations for the inconsistent results in inflation uncertainty research. Brunner and Hess suggest that asymmetry is an important issue in the failure of GARCH models to find a relationship between inflation and inflation uncertainty. Ball and Cecchetti suggest that inflation uncertainty should be separated into short-term and long-term components and that the level of inflation is more closely related to long-term uncertainty than to short-term uncertainty.

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