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Sylvain Leduc
Keith Sill
Tom Stark
Federal Reserve Bank of Philadelphia

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FEDERAL RESERVE BANK OF PHILADELPHIA
Ten Independence Mall, Philadelphia, PA 19106-1574• (215) 574-6428• www.phil.frb.org

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Self-Fulfilling Expectations and the Inflation of the 1970s: Evidence from the Livingston Survey[1]

Sylvain Leduc, Keith Sill, and Tom Stark[2]

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[2] Federal Reserve Bank of Philadelphia

Abstract

Using survey data on expectations, we examine whether the post-war data are consistent with theories of a self-fulfilling inflation episode during the 1970s. Among commonly cited factors, oil and fiscal shocks do not appear to have triggered an increase in expected inflation that was subsequently validated by monetary policy. However, the evidence suggests that, prior to 1979, the Fed accommodated temporary shocks to expected inflation, which then led to permanent increases in actual inflation. We do not find this behavior in the post-1979 data.

Key words: Monetary policy, inflation, time-series model

JEL Classification: E52; E31; C32

1. Introduction

The post-war inflation experience of the U.S. economy is dominated by the dramatic acceleration of inflation during the decades of the 1960s and 1970s and the sharp disinflation of the 1980s. The sustained peacetime inflation of the 1970s had no parallel in the previous 100 years of U.S. history.[1]

Why was inflation so high in the 1970s and low in the 1980s and 1990s? Recent, and perhaps controversial, theories of high and low inflation episodes center on the idea that inflation can rise because increases in expected inflation become self-fulfilling due to accomodative monetary policymaking and institutions. One avenue by which self-fulfilling inflations can come about is that the monetary authority may find itself in a bind when confronted with an upward revision to inflation expectations: It can either choose to accommodate the higher expectations, resulting in higher actual inflation, or it can choose not to accommodate and suffer the consequence of a drop in output and employment. In this light, the experience of the 1970s is interpreted as demonstrating that monetary policymakers were unwilling to pay the costs of disinflation in an environment of rising expected inflation. On the other hand, during the 1980s, monetary policymakers were willing to pay the costs of disinflation, and inflation came down rapidly, though at the cost of a severe recession.

[1] See DeLong (1997)

We examine whether the post-war data are consistent with theories of a self-fulfilling inflation episode during the 1970s that was reined in by more aggressive monetary policy in the 1980s and 1990s. The unique aspect of our empirical methodology is the use of a long time series on inflation expectations from the Philadelphia Fed's Livingston Survey. Since 1946, this survey has been recording forecasters' expectations of CPI inflation and many other macroeconomic variables. The benefit of using the survey data is that we have independent information on inflation expectations and so do not have to impose modeling assumptions to generate those expectations.[2]

The Livingston Survey data are used in several small VAR models to study whether monetary policy in the 1970s accommodated sudden movements in expected inflation resulting in highly persistent actual inflation. Our evidence suggests that it did. Results from a VAR estimated using pre-1979 data show that temporary shocks that increased expected inflation led to permanent increases in actual inflation. However, over the 1980s and 1990s sample period, we do not find this permanent inflation response to temporary shocks.

The theories that underlie self-fulfilling inflations suggest there may be a permanent rise in inflation in response to temporary shocks to fundamentals or to exogenous movements in expectations via sunspot equilibria. We investigate the response of inflation expectations to

[2] Although the Michigan Survey of Households and the Survey of Professional Forecasters also maintain a database on expected inflation, their series start in the 1960s.

oil-price shocks, monetary policy shocks, and fiscal shocks. For the most part, we find that oil, fiscal, and monetary shocks are not associated with long-lasting, statistically significant increases in expected or actual inflation. We do, however, find a strong and significant inflation response to exogenous shocks to expected inflation: A one-time exogenous increase in expected inflation leads to significantly higher inflation 10 years after impact. The design of the Livingston Survey is such that it gives a natural restriction that helps identify these exogenous movements in expected inflation. Consistent with theories that associate sunspots and self-fulfilling inflations with monetary policy that did not react aggressively to inflation, we find that the 1970s represent an episode in which exogenous increases in expected inflation were accompanied by a falling real interest rate. We also show that expectations shocks are much more important for the variability of inflation and the unemployment rate than monetary policy shocks. Expectations shocks account for approximately 30 percent of the variability of inflation and 30 percent of the variability of unemployment in the pre-1979 data. In comparison, the contribution of monetary policy shocks for both inflation and unemployment variability is about 5 percent during the same period.

The rest of the paper is organized as follows. The next section briefly describes the theoretical findings of models of self-fulfilling inflation and the channels through which they operate. We then describe the behavior of actual and expected inflation since the mid-1950s and discuss our identification procedures for the different shocks we wish to analyze. Section 5 introduces the benchmark model and describes our main findings, and Sections 6 and 7 conduct some sensitivity analysis. The last section concludes.

2. Theories of Self-Fulfilling Inflation

The expectations trap hypothesis, as developed in Chari, Christiano and Eichenbaum (1998), and Albanesi, Chari, and Christiano (2002), provides a mechanism by which expected inflation can become self-fulfilling in a dynamic, general equilibrium environment with rational agents. These models build on the time-inconsistency literature of Kydland and Prescott (1977) and Barro and Gordon (1983) in modeling policymakers at the level of objectives and constraints, but extend those models by explicitly modeling the actions of a rational private sector.

In general, an expectations trap is a situation in which a benevolent monetary authority may be pushed into accommodating the inflation expectations of the private sector because the cost of not doing so is an undesirable loss of output and employment. Dynamic inconsistency and lack of a commitment technology lead to the possibility of multiple equilibria and self-fulfilling inflations. In Chari et al. the absence of commitment brings about two types of expectations traps. In the first, agents expect monetary policymakers will react to shocks that don't affect preferences or technology. Thus, nonfundamental shocks may become a source of volatility for the economy. In the second type of expectations trap, the monetary authority may overreact to fundamental shocks, amplifying volatility. In this situation, temporary shocks to fundamentals may lead to long-lasting effects on variables like inflation. In the expectations trap models, the principal driving force for multiplicity of equilibria is that defensive actions taken by households and firms to protect themselves from high inflation reduce the costs of inflation for policymakers. In Chari et al. and Albanesi et al. unexpected inflation raises output because some prices are sticky. Monopoly power causes output to be inefficiently low. When firms expect high inflation, they set high prices. If the monetary authority does not accommodate, output will be low hence, the monetary authority has an incentive to validate high expected inflation. On the household side, agents take defensive actions against inflation by shifting consumption away from goods that require cash for their purchase. This lowers the cost of unanticipated inflation and gives the monetary authority incentive to inflate.

A second, closely related line of research that investigates self-fulfilling inflation outcomes is the work of Clarida, Gali, and Gertler (2000) and Christiano and Gust (1999, 2000). These models differ from Chari et al. and Albanesi et al. in that policymakers are modeled at the level of decision rules rather than at the level of objectives and constraints. Clarida et al. estimate a forward-looking Taylor rule for the 1970s and use it in a small sticky-price, dynamic ISLM model to show that the Fed's 1970s policy gave rise to local indeterminacy.[3] The key mechanism by which these models can deliver self-fulfilling inflation outcomes is that the coefficient on expected inflation in the Taylor rule is less than one. Thus, a rise in expected inflation leads to a fall in the real interest rate. In Clarida et al., this stimulates spending by standard sticky-price mechanisms, leading to a rise in output that eventually gives way to a rise in inflation.

Christiano and Gust use Taylor rules similar to those estimated by Clarida et al. for the 1970s in a limited participation model to examine whether that model better explains the 1970s data. In particular, their model accounts for the simultaneous rise in inflation and drop in output during the 1970s. In Christiano and Gust's limited participation framework, when the real interest rate falls, households reduce deposits with financial intermediaries, which puts upward pressure on nominal interest rates (firms borrow to finance their wage bill). The monetary authority pursues a policy of not letting the nominal interest rate rise too much, so it injects liquidity that eventually leads to higher inflation. Since the monetary authority does permit some rise in the nominal interest rate, output and employment fall following a rise in expected inflation.

[3] To obtain a (locally) unique equilibrium, the number of eigenvalues outside the unit circle in the model's reduced form must equal the number of non-predetermined variables. When the number of eigenvalues outside the unit circle is less than the number of non-predetermined variables, the dynamic responses of the endogenous variables to shocks to fundamentals are indeterminate. See Blanchard and Kahn (1980).

3. Actual and Expected Inflation in the 1970s

The dynamics of inflation, expected inflation, and the real interest rate are plotted in Figure 1. Actual inflation begins a marked acceleration beginning in the mid to late 1960s and peaked in 1979. Expected inflation rose through the late 1960s and 1970s as well, but largely underpredicted actual inflation during the period when actual inflation was accelerating and overpredicted inflation during the disinflation of the early 1980s. The expected inflation series shows much less volatility than the actual inflation series.

Figure 1 shows that monetary policy was very accommodative in the 1970s, with the real interest rate turning negative between 1974 and 1977. The stance of monetary policy became much more restrictive by the end of the decade. Indeed, at the end of 1979, the real interest rate was approximately 3.5 percent, more than 150 basis points above its historical average. But for a temporary drop in the early 1980s, the real interest rate continued to rise, reaching close to 7 percent in 1981. With tight monetary policy in place, inflation and expected inflation fell rapidly and stabilized around 2 to 2.5 percent in the mid-1990s.

Is the fact that expected inflation tended to lag actual inflation evidence against the view that self-fulfilling expectations or an expectations trap might have contributed to the inflation of the 1970s?[4] A

[4] See Delong (1997) and Andolfatto (1999) for an exposition of this view.

time series plot of these two variables, in and of itself, does not allow one to infer how important self-fulfilling expectations might have been for U.S. inflation performance. First, the movements in actual and expected inflation are the results of many different shocks hitting the economy, and the time series on actual and expected inflation do not allow us to disentangle how these variables reacted to specific shocks. We use a statistical model and impose identifying restrictions to show that self-fulfilling expectations remain an important component of the 1970s inflation, even though expected inflation lagged actual inflation. Second, statements by Federal Reserve officials suggest that the Fed was surprised at how strong and resilient inflation expectations seemed to be, even during recessions. The record also suggests the Fed believed that bringing down expectations would require a recession whose economic and political consequences were deemed to be unacceptably high.[5] The Fed saw itself on the horns of a dilemma: recession or inflation. We will show that identifying what could be a sudden, unanticipated rise in expected inflation, or the response of expected inflation to different shocks hitting the economy, is required before the self-fulfilling inflation hypothesis can be rejected.

[5]See Christiano and Gust (2000) and Chari, Christiano, and Eichenbaum (1998) for some of the relevant excerpts from Federal Reserve officials' statements to the public and Congress.

4. Fundamentals or Sunspots?

Several factors have been cited as contributing to the inflation acceleration of the 1970s. Supply shocks, such as the OPEC production cutbacks and oil embargoes were contributing factors to upward pressure on inflation. Government spending accelerated sharply from 1964 to 1967 with the Great Society programs and Vietnam war buildup. Under the self-fulfilling inflations hypothesis, any increase in expected inflation, exogenous or endogenous, could lead to permanently higher inflation under an accommodative monetary policy.

4.1. Oil and Government Spending Shocks

The self-fulfilling inflation hypothesis requires that an increase in expected inflation, by whatever means, leads to an increase in actual inflation. Here, we discuss two fundamental shocks that may have led to increases in expected inflation.

The sudden and unprecedented rise in oil prices in 1973-74 and again in 1979 is a widely cited factor in explanations of the 1970s inflation (see Blinder [1979,1982]). Prices for crude oil rose from about $3 per barrel in mid-1973 to more than $10 per barrel in 1974. At the end of 1978, oil prices averaged about $14 per barrel, and then rose to more than $30 per barrel in 1979. Hamilton (1983) convincingly demonstrates that exogenous oil price increases Granger-caused most economic downturns in the post-World War II period.[6]

[6]The extent to which oil price increases *per se* cause recessions has also been subject to

However, evidence on the inflation effects of the oil shocks is less clear (see Barsky and Killian [2001]). Blinder (1982) argues that special factors, such as oil price increases, contributed to a large extent to the rise in *overall* inflation. However, if oil price shocks are a key element of the inflation story, one needs to explain how one-time increases in oil prices led to permanent, or at least very long-lasting, increases in overall inflation. If oil-price shocks led to an increase in expected inflation that was accommodated by monetary policy, a long-lasting effect on inflation could result.

Although the two OPEC oil embargoes contributed to the rise in inflation in the 1970s, Figure 1 suggests that the beginning of the acceleration of inflation dates to the mid-late 1960s, well before the oil-price shocks hit the economy. DeLong (1997) and others have argued that a more likely inflationary trigger was the increase in government spending associated with the Great Society programs and the Vietnam war. Again, though, the fiscal shocks appear to be temporary in nature and so would be unlikely to drive a lasting inflation, absent an accommodative monetary policy. Inflation continued to accelerate well after these fiscal shocks hit the economy.

Our empirical exercises examine whether exogenous, one-time increases in oil prices and government spending led to increases in expected inflation and permanent increases in inflation during the 1970s.

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debate (see Bernanke, Gertler, and Watson [1997], Hamilton and Herrara [2000], and Leduc and Sill [2001]).

To identify exogenous, unanticipated increases in oil prices, we use the quantitative dummy variable developed by Hamilton (2000). This variable captures the disruptions in the oil market due to political events in the Middle East that are arguably exogenous to developments in the U.S. economy.[7] The dummy variable takes a value equal to the drop in oil production for these historical episodes and is otherwise set to zero. To identify fiscal shocks, we use the narrative account of Ramey and Shapiro (1998). Their reading of the post-war U.S. data leads them to identify three exogenous and unanticipated fiscal shocks: 1950:Q3, which is associated with the Korean War; 1965:Q1, capturing the Vietnam War effort; and 1980:Q1, the Carter-Reagan military buildup.[8]

4.2. Expected Inflation Shocks

In the Chari et al. model that delivers self-fulfilling inflation equilibria, expectations can react to fundamental shocks or to pure sunspots. Even more so than in the case of oil and fiscal shocks, identifying an exogenous movement in expected inflation is difficult. However, we exploit the design of the Livingston Survey to aid in identifying expected inflation shocks. An understanding of our identification scheme

[7]Hamilton identifies the following dates as being associated with exogenous declines (in parentheses) in world petroleum supply: November 1956 (10.1%), November 1973 (7.8%), December 1978 (8.9%), October 1980 (7.2%), and August 1990 (8.8%).

[8]See Eichenbaum (1998) and Edelberg, Eichenbaum, and Fisher (1999) for an application of these exogenous fiscal shocks in a VAR.

requires some detail on how the Livingston Survey is conducted.

The survey, which was initiated in 1946, reports eight-month-ahead forecasts by a pool of professional forecasters, on several economic variables. The forecasters are from nonfinancial businesses, investment banking firms, commercial banks, academic institutions, and from labor, government, and insurance companies.[9] The survey is conducted twice a year. Survey questionnaires go out in May and November, after the release of the CPI data for April and October, and are returned before the release of the CPI data for May and November (see Croushore [1997]).[10] A timeline of the survey is shown in Figure 2. A forecaster receiving the survey in May 2002 (when the CPI for April is known) is asked to predict the level of the CPI in December 2002, which requires an eight-month forecast. The forecaster will then receive another survey questionnaire in November 2002 and be asked to predict the level of the CPI in June 2003. The timing of the survey is critical for our identification of expected inflation shocks. The survey's timing suggests putting expected inflation first in a recursive identification scheme, since when making forecasts at time t, agents do not know the time t realization of inflation (and the other variables in our VAR), by construction. We adopt this identification strategy in our benchmark model.

It may be the case that forecasters, when forming expectations for

[9]The average number of responses for the survey is about 50. The Livingston Survey data can be accessed at http://www.phil.frb.org/econ/liv/index.html

[10]Note that the CPI data are released with a one-month delay.

the survey, may have access to within-period information unobserved by the econometrician that give information about actual inflation. In effect, this means that expected inflation would be responding to contemporaneous data. It takes time to mail out and receive the survey, and agents are continuously updating their forecasts over this time. Since we cannot fully include agents' conditioning sets in our VAR, it is sensible to think of allowing expected inflation shocks to be contemporaneously conditioned on other variables in the model. We conduct sensitivity analysis on our benchmark model by assessing the importance of alternative Cholesky orderings for the results.

5. Empirical Model

We set up a benchmark VAR with six variables: expected CPI inflation (EPDOT), CPI inflation (PDOT), a commodity price index in logs (PCOM), the unemployment rate (U), and the three-month T-bill rate (R), plus a dummy variable capturing either oil shocks (O) or shocks to government spending (G).[11] Because of the timing of the Livingston Survey, our data are at a six-month frequency: from April

[11] We use the unemployment rate to avoid real-time data issues associated with revisions in real GDP. Since they are generally limited to changes in seasonal factors, revisions in the unemployment rate are historically less important than those for real GDP. The other variables in our VAR have, at most, minor revisions. See Orphanides (2001) for the role that mismeasurement issues might have played in the economic performance of the 1970s. The inclusion of a commodity price index is standard in the literature in order that expansionary shocks to monetary policy do not lead to a drop in prices, ie. the price puzzle.

to October, and October to April. Actual inflation for the period between April and October is constructed as the log of the ratio of the October CPI level to the April CPI level (similarly for the period between October and April). The commodity price index, the unemployment rate, and the T-bill rate are six-month averages of the monthly data (May to October and November to April). Because the inflation forecasts are really eight-month-ahead forecasts, the constructed measure of expected inflation is slightly different from the constructed measure of actual inflation. In particular, suppose we are in May 2002 (see Figure 2) right after the April CPI data have been released. Expected inflation is measured as the expected CPI in December 2002 divided by the observed CPI in April 2002 (an eight-month period).

Though we describe the data as bi-annual, the observations on EPDOT in the Livingston survey overlap: expected inflation has a horizon of eight months, while the other variables in our system are measured at a six-month frequency.[12] This data construction is used so that forecasters are not given more information in the VAR at time t than they really have. To see this, imagine we are in May 2002 (see Figure 2) and working on the June survey. Forecasters' information set for the June survey includes the April 2002 CPI data, but not the May CPI (which is released in June). An eight-month measure of actual inflation would include June data (i.e., the data would cover

[12]Our measures of the T-bill, inflation, and expected inflation rates are annualized.

the period October 2001 to June 2002).[13]

Finally, note that since the frequency of our data differs from that of Hamilton's (2000) quarterly analysis, the timing of our dummy variable is slightly different from his. We constructed our dummy variable by setting the drop in production equal to that in Hamilton (1999), whenever one of the historical episodes he described falls within one of our six-month periods. The same is true of our dating of the Ramey-Shapiro (1998) fiscal shocks.

Our benchmark model is a VAR on expected inflation, inflation, commodity prices, the unemployment rate, and the federal funds rate:

$$Y_t = A(L)Y_{t-1} + B(L)D_t + u_t, \tag{5.1}$$

where Y_t is a 5x1 vector of data and D_t represents a dummy variable for oil (O). When we analyse the effect of government spending shocks, we replace the oil dummy variable with the Ramey-Shapiro fiscal dummy (G).[14] $A(L)$ and $B(L)$ are finite-ordered matrix-polynomials in non-negative powers of L, the lag operator. SIC tests indicate that two lags are sufficient to capture the system dynamics.

[13]The potential problem with aligning the data as we do is that serial correlation may be introduced because of the overlapping data intervals. However, this does not appear to be a severe problem, since the unit of time in our VAR (six months) is longer than the period over which the data overlap (two months). Formal tests suggest that serial correlation is not a problem in our VAR.

[14]Because there are relatively few data points per estimated VAR coefficient, the effects of oil and government spending shocks are analyzed separately.

The benchmark specification uses a recursive identification scheme for generating impulse response functions with the ordering [EPDOT, PDOT, PCOM, U, R]. Expected inflation is ordered first since, by construction, it is predetermined for our data. Because the frequency of our dataset is bi-annual, we assume that the Fed can freely adjust the interest rate in response to contemporaneous movements in all the other variables in the system. Hence, we order the federal funds rate last. The sensitivity of the system to alternative orderings of the variables is examined below.

We investigate impulse responses to see if the predictions of theories of self-fulfilling expectations are confirmed in the 1970s data. As in Clarida et al., we estimate our VARs over two sample periods: 1952:1 to 1979:1 and 1979:2 to 2001:1.[15] For the pre-1979 era, we look to see if temporary shocks to expectations and fundamentals lead to permanent effects on inflation via an accommodative monetary policy. We examine whether the response to shocks then changed in post-1979 era.

Temporary shocks to fundamentals can have permanent effects on the inflation rate only if the latter is a unit root process. The augmented Dickey-Fuller (ADF) test is used to test the data for unit roots. Table 1 reports results for the major variables of interest under the pre- and the post-1979 periods. The tests indicate that the

[15]Note that because we have two lags, our effective sample is 1953:1 to 1979:1 for the pre-1979 period and 1980:2 to 2001:1 for the post-1979 era.

unit root null hypothesis cannot be rejected for inflation, expected inflation, nominal interest rate, and unemployment rate in the pre-1979 era. On the other hand, we can reject the hypothesis that actual and expected inflation follow unit processes in the post-1979 period, though we cannot reject the null for the nominal interest rate and the unemployment rate. These results suggest that temporary shocks to either fundamentals or to expectations could, *a priori,* lead to permanent effects on inflation in the 1970s, but that this will not occur in the post-1979 era. To verify this conjecture, we now look at the response of the economy to oil, fiscal, expectations, and monetary policy shocks.

5.1. Oil Shock

Figure 3 presents system impulse responses to a one-time unit change in Hamilton's quantitative oil variable ($[I - A(L)L]^{-1} B(L)$, see eq(5.1)). The first column of the figure presents the responses for the pre-1979 estimated model and the second column the responses for the post-1979 estimated model. In this figure, and those that follow, the solid line represents the point estimate, while the shaded areas represent 68 percent and 90 percent confidence intervals.[16] The figure shows that, pre-1979, a temporary oil shock initially leads to a significant rise in

[16]We use the bootstrap Monte Carlo method described in Eichenbaum (1998). The results were similar when we computed the error bands using Kilian (1998) bootstrap-after-bootstrap method.

both expected and actual inflation, but the response of these variables is not significantly different from zero two years after the shock. Positive oil shocks lead to a rise in the unemployment rate (of about 21 basis points), two years following the shock. In the post-1979 period, inflation rises more on impact and the unemployment rate rises by less than in the pre-1979 period.

The pre-1979 estimates show that the real interest rate falls in response to a positive oil shock, reaching its maximum drop about two years after the shock.[17] Thus, the monetary policy response to inflation appears to less aggressive than in the post-1979 period in which the real interest rate rises following the oil-price shock. However, since the temporary oil shock does not lead to a long-lasting effect on actual inflation, we conclude that it is unlikely that this shock is the trigger that set up the inflation take-off in the 1970s.

5.2. Fiscal Policy

We use Ramey and Shapiro's (1998) fiscal dummy variable to investigate whether a positive, transitory fiscal shock in the mid-1960s led to long-lasting inflation. This could have occurred if it led the public to revise their inflation expectations upward, and the Fed then validated these expectations. Figure 4 shows the impact of a transitory

[17] The real interest rate response is constructed as the difference between the nominal interest rate response and the expected inflation response.

fiscal shock in our model. The figure presents impulse response functions only for the pre-1979 period, since we do not have a shock to government spending that falls in the post-1979 era.[18]

In general, the impulse response point estimates are consistent with the findings of Ramey and Shapiro (1998) and Edelberg, Eichenbaum, and Fisher (1999) on the effects of government spending shocks. However, in contrast to these models, our specification includes an equation that captures the interest rate response of the Fed to an unanticipated change in fiscal policy. An increase in government spending leads to a delayed increase in economic activity, represented by the drop in the unemployment rate. Inflation rises, peaking at about the same time as the unemployment rate troughs. The Fed responds to this change in government spending by raising the nominal interest rates enough, initially, to raise the real interest rate. However, the increase in the nominal interest rate is not strong enough to keep the real interest rate from falling three years after the shock. This policy brings about a permanent fall in actual and expected inflation. Note, though, that none of our point estimates are significantly different from zero in the long run at either the 68 or 90 percent confidence levels. As in the case of an oil shock, an unanticipated increase in government spending does not bring about a statistically significant, long-lasting increase in

[18]It is true that Ramey and Shapiro isolated 1980:1 as an exogenous event that led to a large military buildup and that this date falls in the post-1979 period. However, because of our lag structure (two lags), our effective sample starts in 1980:2. Similarly, our pre-1979 sample, which effectively covers the period from 1953:1 to 1979:1, includes only the military buildup of 1965:1.

the inflation rate.

5.3. Monetary Policy

Can monetary policy shocks account for the high inflation of the 1970s? Figure 5 presents the response functions of the variables to a one-percentage-point increase in the nominal interest rate.[19] In the pre-1979 period, the increase in the nominal interest rate initially raises the real rate because expected inflation is predetermined in our benchmark specification. Actual and expected inflation rise, suggesting a strong Fisher effect. Actual and expected inflation fall in the long run (although the confidence intervals include zero). In the post-1979 period, contractionary monetary policy leads to a sharp drop in expected and actual inflation about one year after the shock. The rise in the unemployment rate 18 months after the shock is significant at the 68 percent level in both the pre- and post-1979 periods.

As is the case for oil shocks and fiscal shocks, unexpected changes in the nominal interest rate do not lead to significant, permanent changes in expected or actual inflation. Our results suggest a factor other than unanticipated monetary policy shocks was responsible for the persistent rise in inflation in the pre-1979 period.[20]

[19] Our impulse responses to expectations and monetary policy shocks are normalized such that the contemporanous own responses are unity.

[20] We also ran our VAR with the monetary base in place of the short-term nominal interest rate as a monetary policy variable. Qualitatively, our results are the same under these two VAR specifications.

5.4. Expected Inflation Shocks

Consider now the effect of an unanticipated, one-time shock to expected inflation. Figure 6 presents the impulse responses, with the first and second columns describing, respectively, the response of the economy before and after 1979. Looking at the pre-1979 results, a positive, one-time shock to expected inflation leads to a large and permanent increase in both actual and expected inflation. These responses are significantly different from zero for more than 10 years after the shock at the 68 percent confidence level, in sharp contrast to the effects of oil and fiscal shocks. Actual inflation rises about 1 percent one year after a 1 percent exogenous increase in expected inflation, and then stabilizes around 0.8 percent higher than it was prior to the shock. The Fed responds to the jump in expected inflation by raising the nominal interest rate, but the rise is not enough to increase the real interest rate, which initially falls 50 basis points. Note that the drop in the real interest rate is statistically significant both initially and in the longer run at the 68 percent confidence level. The monetary policy response is strong enough to stimulate the economy in the first year, with the unemployment rate falling 0.5 percent. But in the long run, both unemployment and inflation are higher. The impulse responses for the post-1979 period are in striking contrast to those of the pre-1979 period. An unanticipated increase in expected inflation brings about an initial rise in actual inflation, but this increase is quickly reversed and is not significantly different from zero

18 months after the shock. Just as in the pre-1979 era, the nominal interest rate increases following the shock, but by more than the rise in expected inflation, so the real interest rate also rises.[21] Monetary policy appears to be much more aggressive: The real interest rate rises sharply in response to higher expected inflation. As a consequence, the rise in expected inflation is rapidly reversed so that expected inflation returns to zero about two years after the shock. The activist policy eventually leads to an economic slowdown. Initially, as in the pre-1979 period, the unemployment rate falls by about 70 basis points, but then rises to about 50 basis points relative to its pre-shock level three years after the shock. Note that there is no significant impact on the unemployment rate in the long run.

Our results do suggest that monetary policy response to inflation has been more aggressive in the post-1979 era, since temporary shocks to expectations do not lead to permanent responses in inflation. Orphanides (2001) suggests that the reason for the 1970s high inflation was that the Fed placed a lot of weight on stabilizing output and mismeasured the expected output gap because it was slow to recognize the productivity slowdown that began in the early 1970s. As a con-

[21] In general, the fact that the real interest rate rises in response to an expectations shock suggests there would be no indeterminacy in a standard equilibrium monetary model. In this case, expectations are a deterministic function of the economy's state variables. If we were to interpret our results in light of such a model, we could construe an expectations shock as measurment error to which the Fed might then respond. More generally, these expectation shocks could also capture the concept of inflation scare as in Goodfriend (1993).

sequence, it ran an easy monetary policy that resulted in higher inflation. Orphanides' estimates suggest that the Fed was about equally aggressive in responding to expected inflation in the pre- and post-1979 eras. Our evidence, on the other hand, suggests that the Fed did not respond as strongly to expected inflation shocks in the 1970s as it did in the post-1979 era.

On balance, our impulse response functions seem to provide evidence for a self-fulfilling inflation/expectations trap story for the 1970s inflation. Our evidence is in line with the predictions of a model like that in Christiano and Gust (2000) where higher expected inflation in the face of monetary policy that does not respond aggressively to high inflation, can lead to lower real interest rates, higher nominal interest rates, lower employment and, eventually, higher inflation.

How important are expectations shocks in accounting for the variability of inflation and unemployment? We saw that temporary expectations shocks led to persistent inflation responses in the pre-1979 era, but are expectations shocks an important component of the overall variation in inflation? Table 2 shows the variance decompositions of inflation and unemployment for our benchmark specification in the pre- and post-1979 episodes. We computed the variance of the six- and twelve-step-ahead forecast error (which corresponds to three and six years) that is attributable to each variable: expected inflation, inflation, commodity prices, unemployment, and nominal interest rate shocks. In the pre-1979 period, we find that about 30 percent of the variance of inflation can be attributed to expectations shocks, a number more than 5 times as large as the contribution of interest rate shocks. The contribution of expectations shocks for the variability of inflation post-1979 is smaller at 20 percent, which is about three times the contribution of interest-rate shocks.

Expectations shocks also account for a substantial fraction of the unemployment rate forecast variance in both the pre- and post-1979 periods. In the pre-1979 period, about 30 percent of unemployment variability is due to expectations shocks, and monetary policy shocks contribute only about 5 percent.[22] A larger share of unemployment rate variability is accounted for by expectations shocks in the post-1979 period. Thus, the more aggressive post-1979 monetary policy led to a larger contribution of expectations shocks to the variability of the unemployment rate.

6. Sensitivity Analysis

To gauge the sensitivity of our results, we modify the benchmark specification to take into account two possibilities: (*i*) agents' inflation forecasts are conditioned on contemporaneous data, unobserved by the econometrician, so that expected inflation is not predetermined;(*ii*) the behavior of the economy after 1979 is contaminated by the inclusion

[22] Our results are different than those of Lubik and Schorfheide (2002), who, based on a maximum likelihood estimation of a monetary model with sunspot equilibria, found that the contribution of sunspot shocks to aggregate fluctuations was small.

in the post-1979 sample of the monetarist experiment between 1979 and 1982, which represents a structural change in monetary policy.

6.0.1. Re-Ordering Expected Inflation

To analyze whether predetermined expected inflation is important for our results, we re-order the vector Y_t in equation (5.1) as: PDOT, PCOM,U, EPDOT, R. Hence, expected inflation can react to contemporanous information on inflation, commodity prices, and the unemployment rate in our recursive identification scheme. We order expected inflation before the nominal interest rate, since we are interested in understanding how the Fed responds to changes in expected inflation via the real interest rate channel.

Figure 7 shows the impulse response functions for an expectations shock under our alternative ordering. Overall, the response of the economy is very similar to that under the benchmark specification shown in Figure 6. However, the real interest rate response under the alternative ordering, in the post-1979 period, is not as strong or significant as under the baseline ordering. On impact, the real interest rate in facts drops 0.5 percent compared to a 0.5 percent rise under the baseline ordering. Subsequently, the real interest rate rise by about 0.6 percent less than under our baseline. Nonetheless, the rise in the real interest rate is sufficient to bring actual and expected inflation down quickly.

The general message from the alternative ordering is that our main result is robust: a shock to expected inflation leads to a long-lasting increase in actual inflation, consistent with the view that the Fed validates the rise in expected inflation by letting the real interest rate fall.

6.0.2. The Monetarist Experiment

Is monetary policy responsible for the better inflation performance of the U.S. economy since 1979, or was it luck? Ireland (1999) argues that a sequence of bad supply shocks pushed the natural rate of unemployment up in the 1970s. This then brought about a rise in the inflation rate because of the time-inconsistency problem faced by the central bank. The Fed was able to bring the inflation rate down in the post-1979 era only because it did not face a similar series of bad shocks. In a related paper, Sims and Zha (2002) argue that the only period since 1950 with a noticeably different monetary policy is the monetarist experiment between 1979 and 1982, in which the Fed targeted monetary aggregates. Otherwise, monetary policy in the 1970s and the post-1982 period appears to be very similar. Sims and Zha do find that the period since 1982 is characterized by a decrease in the volatility of shocks hitting the economy.

To investigate this possibility, we removed the 1979-1982 period from the post-1979 era. We then assessed whether there is a change in the economy's response to expectations shocks. Figure 8 describes the results. This set of impulse response functions clearly shows that expectations shocks did not lead to a long-lasting increase in the inflation rate during the post-1982 era. While we cannot rule out the possibility that the structure of the economy (other than monetary policy) changed between the pre-1979 and post-1982 periods, note that the real interest-rate response to an expectations shock is stronger in the post-1982 period. For example, in the post-1982 sample, the real interest rate rises 0.6 percent about one year after a 1 percent shock to expected inflation compared to a 0.25 percent rise in the pre-1979 period.

7. Omitted Fundamentals?

Of course, any expectations shocks that we claim are exogenous could only be so to the extent that our statistical model includes all the fundamentals that drive movements in expected inflation. Since it is unlikely that any model could take into account all the variables agents use in making inflation forecasts, we think of our identified expectations shocks as being due to sunspots and/or to omitted fundamentals. To the extent that our model includes the fundamentals that drive expected inflation, the probability that our identified expectations shock is exogenous is higher. Note, though, that for the self-fulfilling inflations hypothesis this distinction is not so important. Both transitory fundamental and expectations shocks can have long-lasting effects on inflation through the interaction of expectations and monetary policy.

To gauge the exogeneity of our expected inflation measure, we follow a strategy similar to that in Francis and Ramey (2001). We back out the structural shocks to expected inflation implied by our VAR and test them for exogeneity with respect to macro variables that might plausibly affect expected inflation. Thus, we regress expected inflation shocks on a constant and, alternatively, two lags of the growth rates of the US/Canada exchange rate, the US/UK exchange rate, PPI price index, the S&P500 stock index, and the monetary base.[23] The results of this exercise are reported in Table 3 for both the pre- and post-1979 periods. The highest P-value is for the stock price index in the post-1979 period. However, the table shows that none of the variables predict expectations shocks at the 5 percent significance level and explain very little of the variation in expectations shocks. This gives support to the hypothesis that our measure of expectations shocks can reasonably be thought of as exogenous.

8. Conclusion

We examined whether the post-war data are consistent with theories of a self-fulfilling inflation episode in the 1970s. Using a survey mea-

[23]We use the monetary base since it is the only monetary aggregate with a long enough time series. This enables us to conduct tests for the pre-1979 era. In the pre-1979 period, we use a second difference of the monetary base, since the growth rate has a clear upward trend. For the post-1979, we use a first-difference of the monetary base, which does not display any clear trend in that sample.

sure of expected inflation, our evidence suggests that it is. During the pre-1979 era, temporary shocks to expected inflation led to a permanent increase in actual inflation, which did not occur post-1979. The mechanism by which this occurred was a monetary policy in which the real interest rate fell in response to a positive expectations shock. Our results for the 1979-2001 sample suggest that monetary policy became more aggressive, with the Fed responding forcefully to an increase in expected inflation. Self-fulfilling inflations can arise because of shocks to expectations and shocks to fundamentals. We found that exogenous oil, fiscal, and monetary shocks did not contribute significantly to the persistent rise in inflation during the 1970s. The contribution of monetary policy shocks for the variability of inflation is dwarfed by that of expectations, which accounted for about 30 percent of that variance in the pre-1979 period.

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Table 1. Augmented Dickey-Fuller Test for Unit Roots

	Pre-1979		Post-1979	
	ρ	*ADF*	*ρ*	*ADF*
EPDOT	1.06	---	0.87	-2.96**
PDOT	0.95	-0.57	0.54	-5.07**
U	0.82	-2.53	0.91	-2.25
R	0.97	-0.41	0.85	-2.14

ρ is the coefficient estimate on the lagged variable. The variables are as described in the text. ** denotes significance at the 5-percent level, using MacKinnon's (1991) critical values. *EPDOT* = expected inflation, *PDOT* = inflation, *U* = unemployment rate, and *R* = nominal interest rate.

Table 2. Variance Decomposition of Inflation and Unemployment (Benchmark Specification)

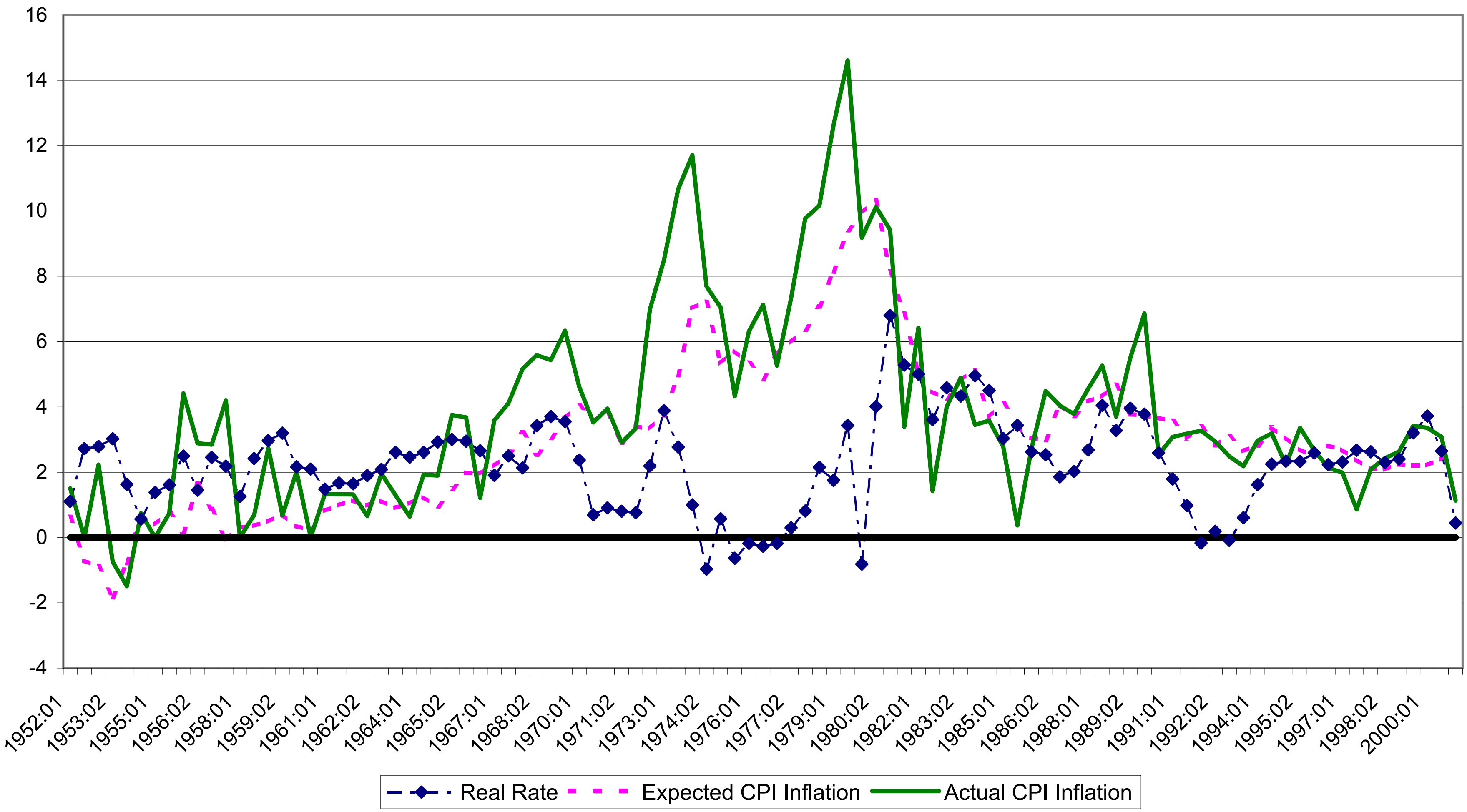
	EPDOT	*PDOT*	*PCOM*	*U*	*R*
Inflation					
Pre-1979					
3 years	25.9	29.7	38.3	2.0	4.2
6 years	30.3	21.2	42.5	2.6	3.3
Post-1979					
3 years	22.5	60.2	9.2	0.8	7.2
6 years	21.8	55.0	11.8	4.7	6.7
Unemployment					
Pre-1979					
3 years	34.0	6.2	8.5	47.5	3.9
6 years	27.0	5.3	23.4	39.1	5.3
Post-1979					
3 years	40.8	3.4	2.6	43.0	10.3
6 years	43.2	3.9	7.3	34.7	11.0

All entries are in percentage term. The variables are as described in the text. 3 and 6 years refer to the step ahead forecast for which the variance decomposition is done.

Table 3. Exogeniety Tests For Structural Shocks to Expected Inflation

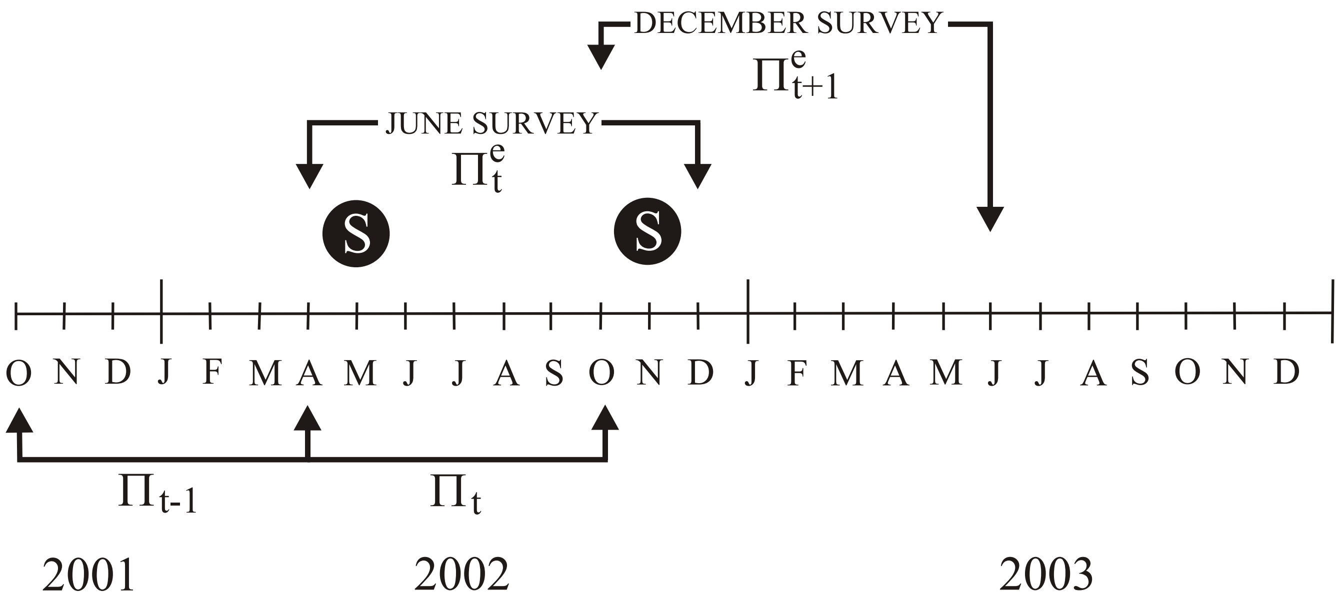
	\$US/CAN	\$US/UK	PPI	S&P500	Monetary Base
Pre-1979					
P-value of F-test	0.45	0.34	0.52	0.89	0.50
R-squared	0.03	0.04	0.03	0.01	0.03
Post-1979					
P-value of F-test	0.19	0.67	0.76	0.06	0.89
R-squared	0.08	0.02	0.01	0.13	0.01

Figure 1. Real Interest Rates and Inflation (annualized percentage points)



Actual inflation is measured by the actual change in the CPI over six months. The 8-month forecast of the CPI level from the Livingston survey is used to construct the series for expected inflation. The real interest rate is measured as the 3-month TBill less expected CPI inflation.

Figure 2
Dating of the Livingston Survey

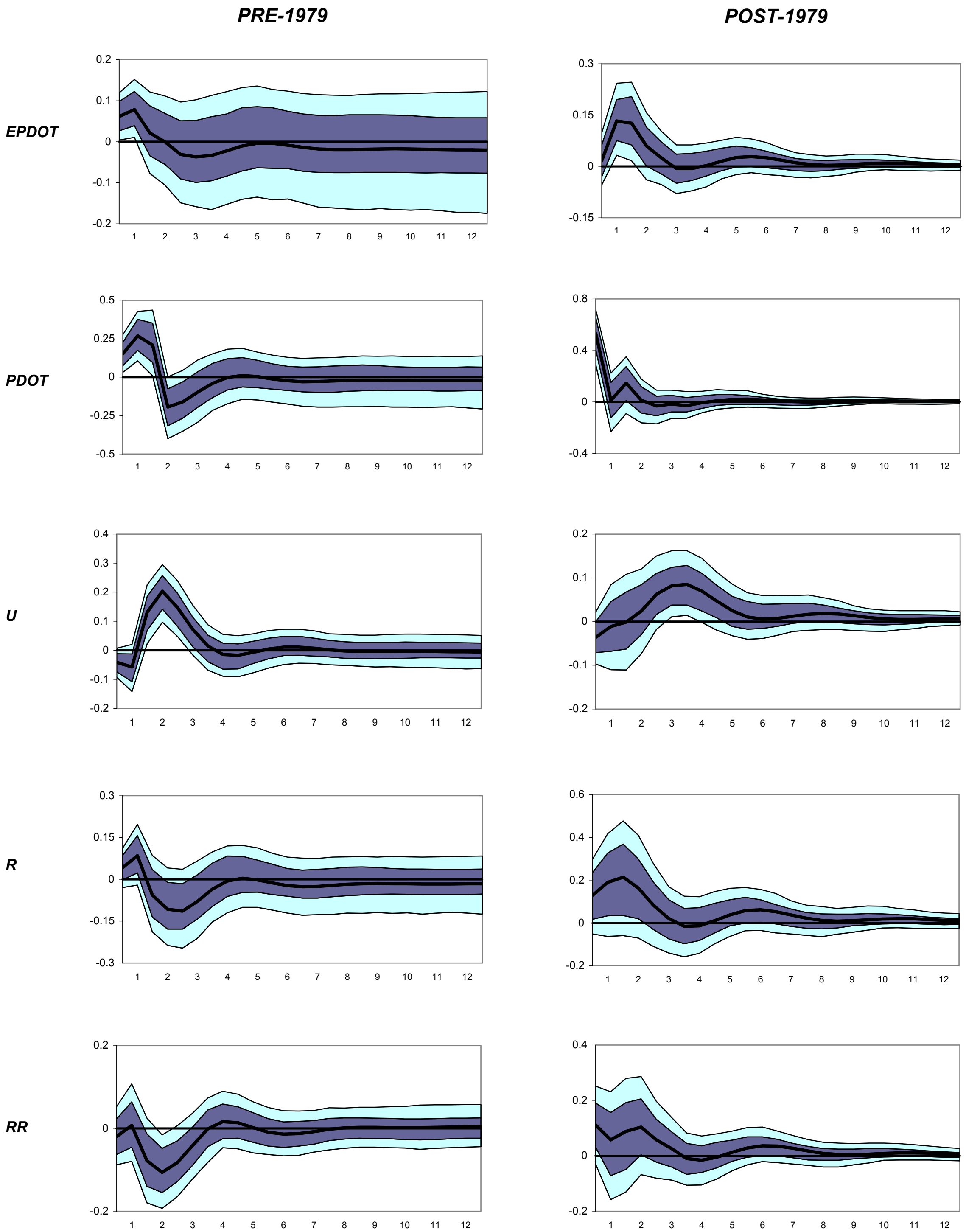


S = dates of the survey, mailed in May and November

Π_t = actual CPI inflation in period t $\left(\text{eg. log } \frac{\text{CPI (October)}}{\text{CPI (April)}}\right)$

Π^e_t = expected CPI inflation in period t $\left(\text{eg. log } \frac{\text{CPI}^e\text{ (December)}}{\text{CPI (April)}}\right)$

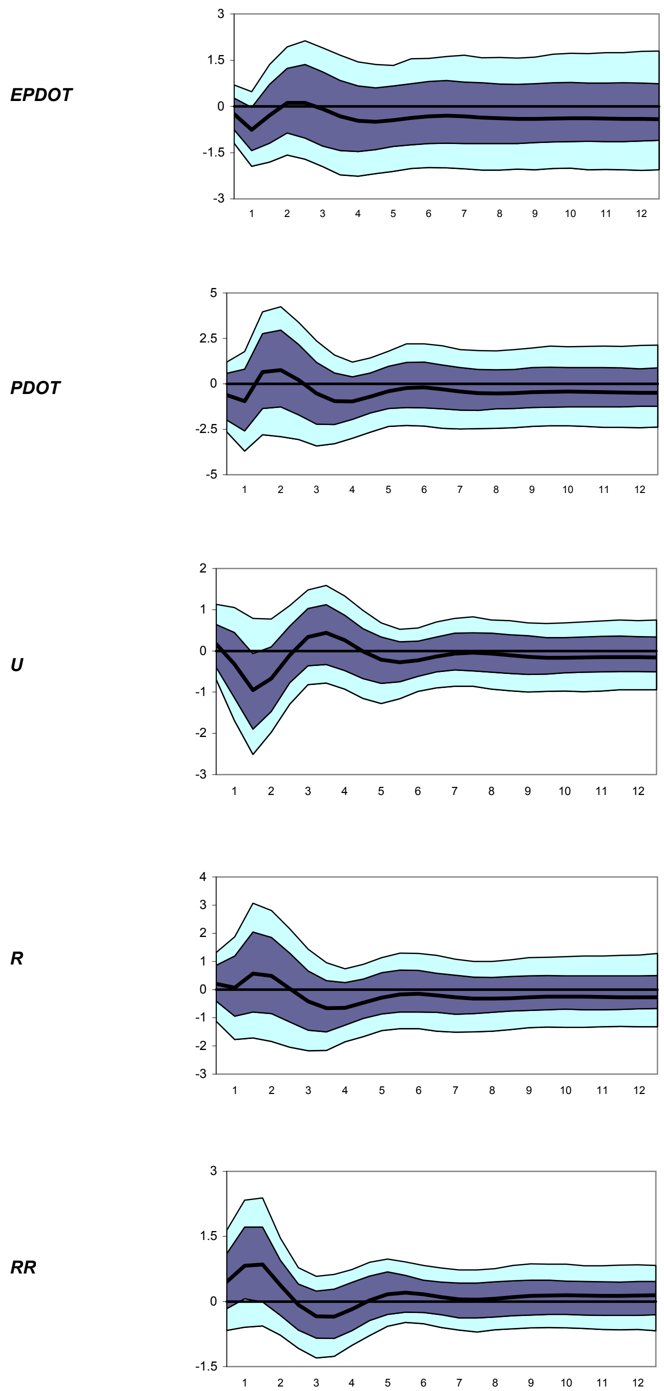
Figure 3. Responses to an Oil Shock



The responses were generated from a VAR with expected inflation (EPDOT), actual inflation (PDOT), a commodity price index (PCOM), the unemployment rate (U), the three-month T-Bill rate (R), and the Hamilton oil dummy variable. The figure also shows the response of the real interest rate (RR). To conserve space, we do not report the response of commodity prices. All the responses are expressed in percentage terms. The pre-1979 period is 1952:1 to 1979:1 and the post-1979 period is 1979:2 to 2001:1. The x-axis denotes years. In each chart, the darker area represents the 68% confidence interval, while the sum of the darker and lighter areas denote the 90% confidence interval.

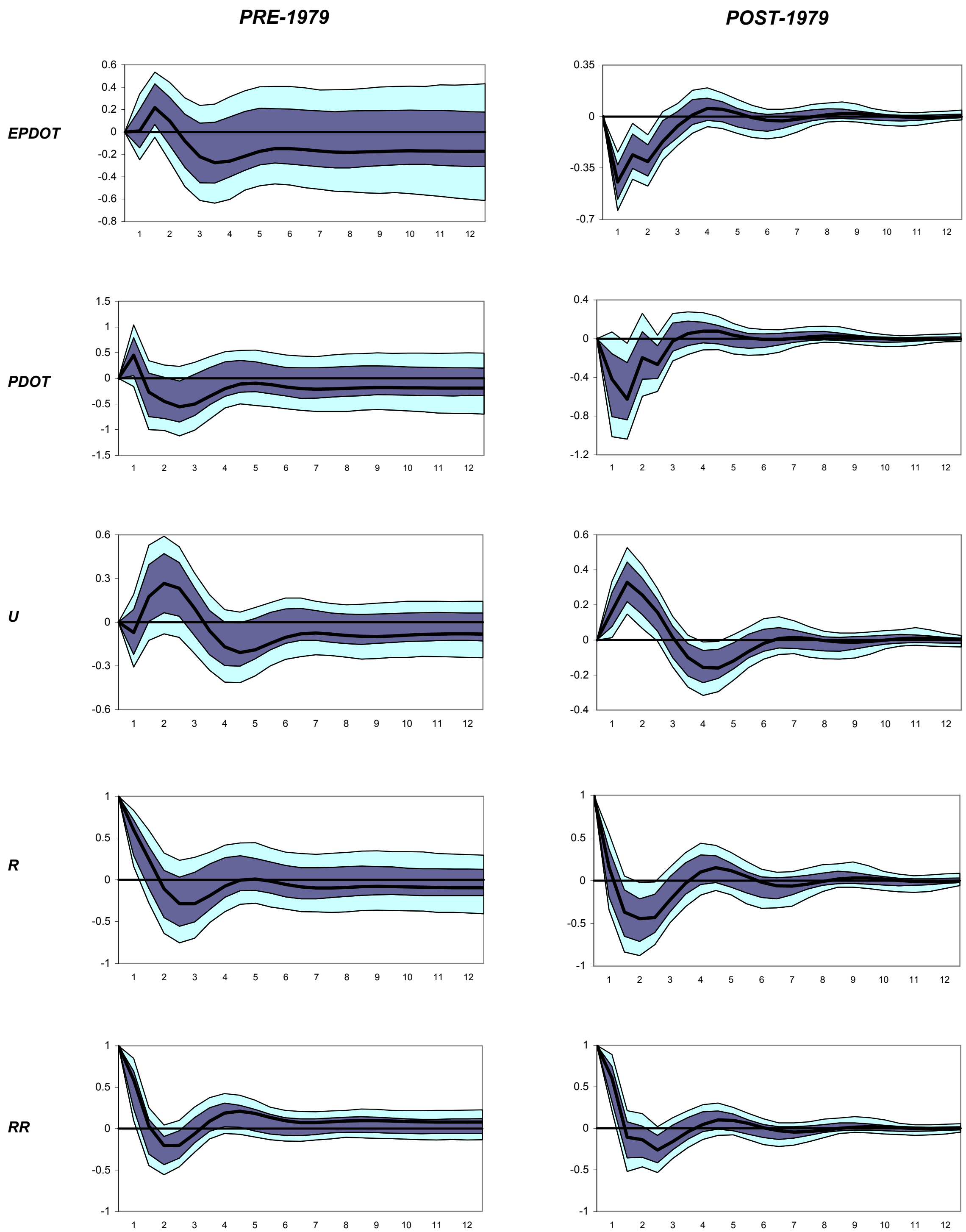
Figure 4. Responses to an Fiscal Shock

PRE-1979



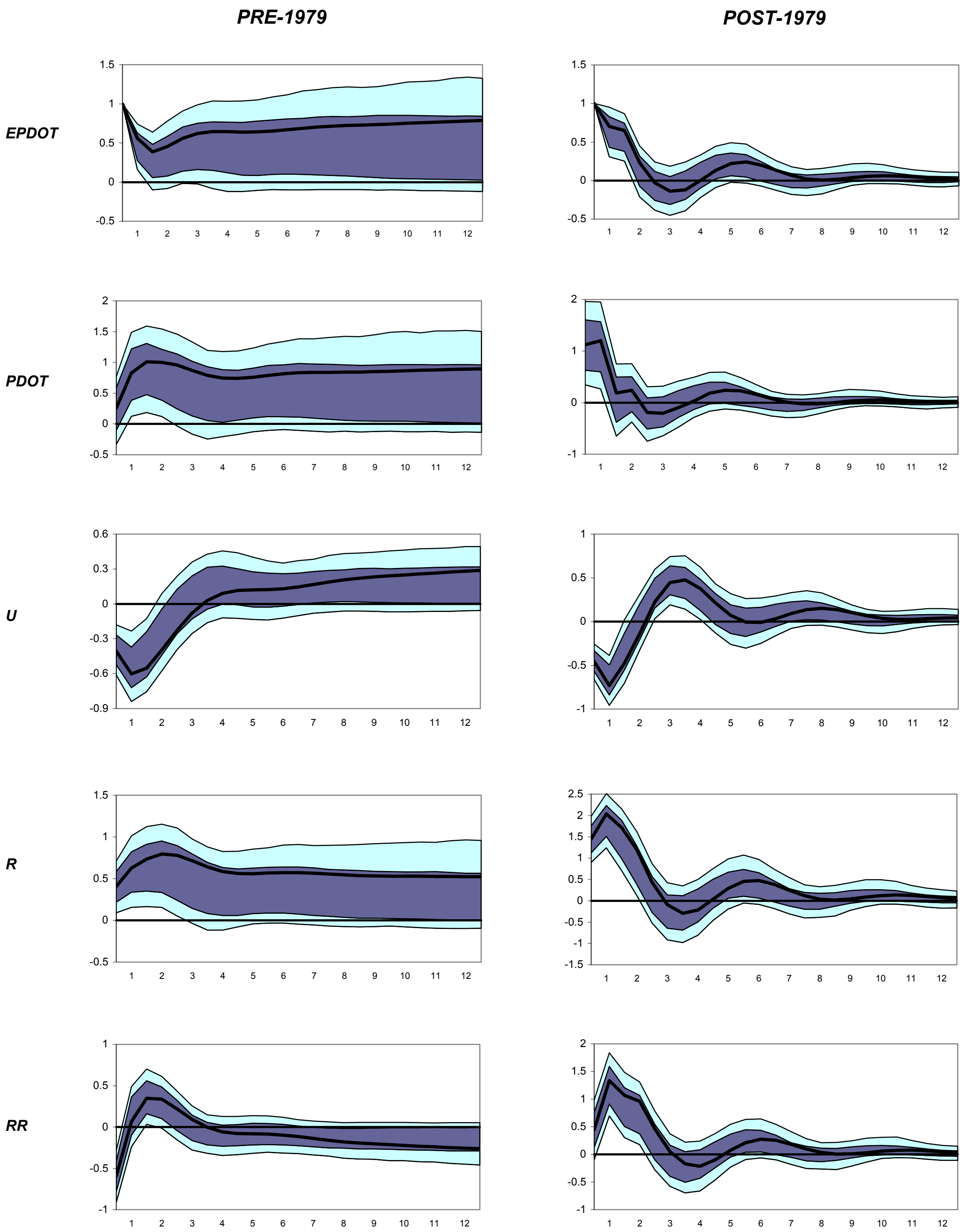
The responses were generated from a VAR with expected inflation (EPDOT), actual inflation (PDOT), a commodity price index (PCOM), the unemployment rate (U), the three-month T-Bill rate (R), and the Ramey-Shapiro dummy variable for fiscal policy. The figure also shows the response of the real interest rate (RR). To conserve space, we do not report the response of commodity prices. All the responses are expressed in percentage terms. The pre-1979 period is 1952:1 to 1979:1. The x-axis denotes years. In each chart, the darker area represents the 68% confidence interval, while the sum of the darker and lighter areas denote the 90% confidence interval.

Figure 5. Responses to a Monetary Policy Shock



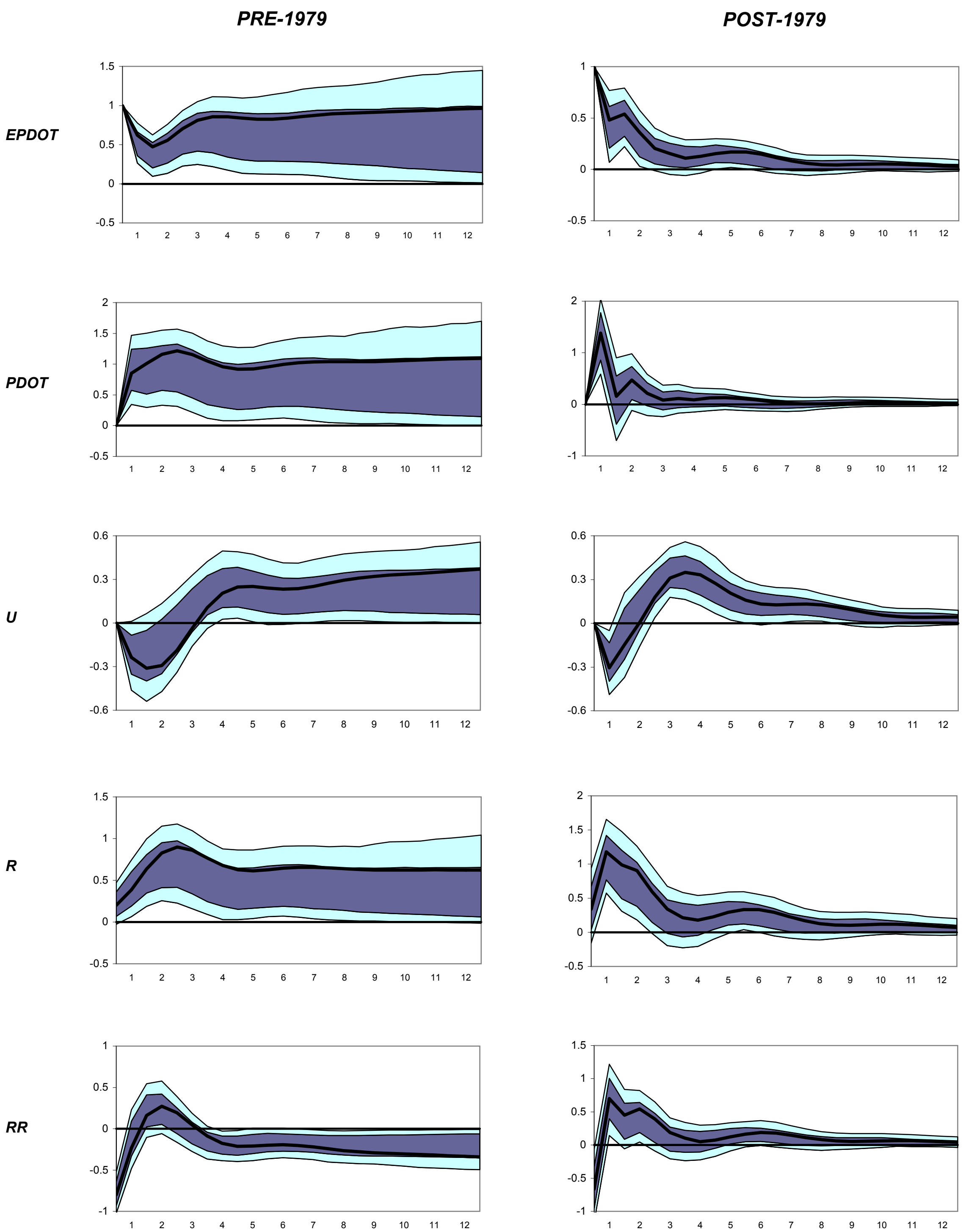
The responses were generated from a VAR with expected inflation (EPDOT), actual inflation (PDOT), a commodity price index (PCOM), the unemployment rate (U), the three-month T-Bill rate (R), and the Hamilton oil dummy variable. The figure also shows the response of the real interest rate (RR). To conserve space, we do not report the response of commodity prices. All the responses are expressed in percentage terms. The pre-1979 period is 1952:1 to 1979:1 and the post-1979 period is 1979:2 to 2001:1. The x-axis denotes years. In each chart, the darker area represents the 68% confidence interval, while the sum of the darker and lighter areas denote the 90% confidence interval.

Figure 6. Responses to a Shock to Expected Inflation



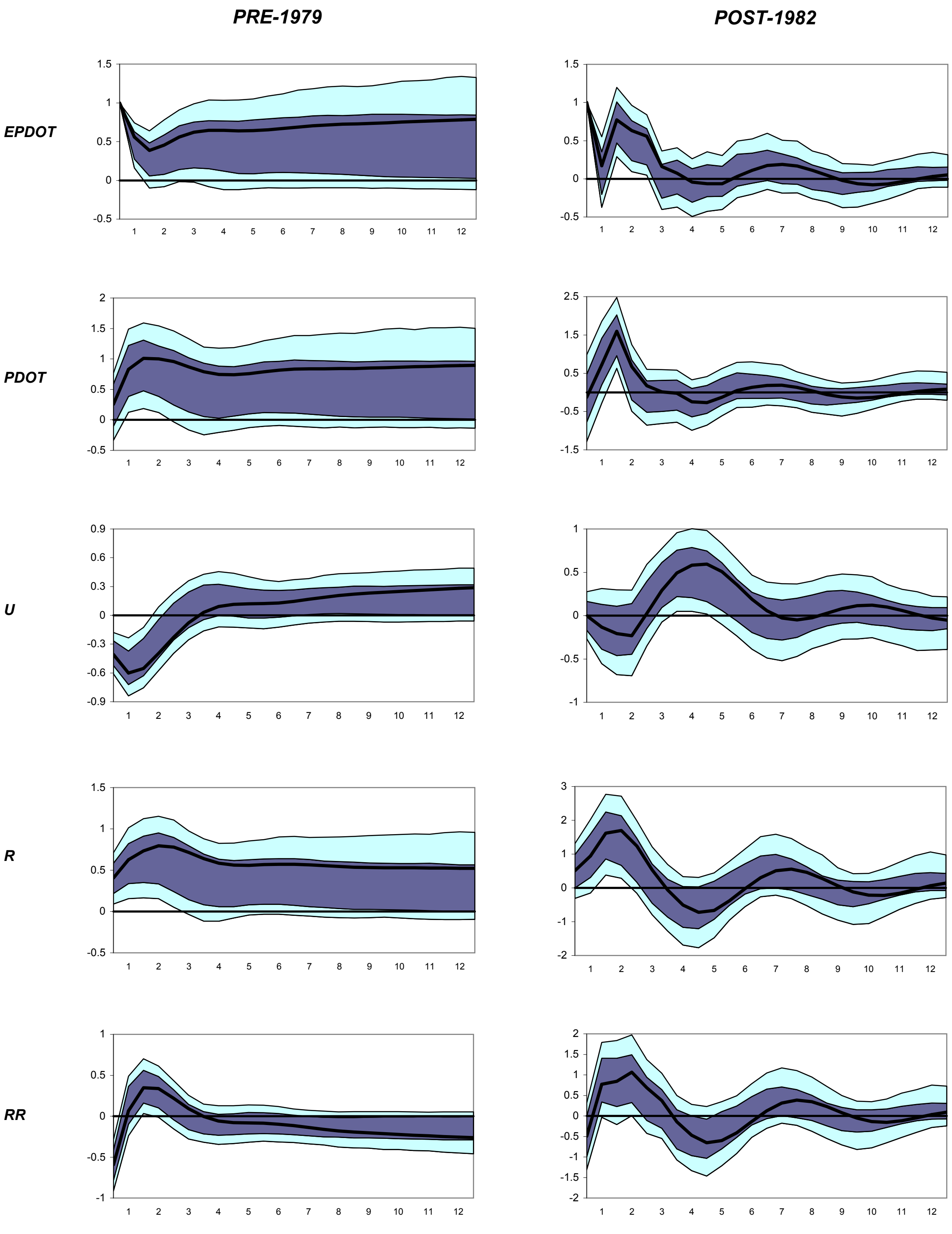
The responses were generated from a VAR with expected inflation (EPDOT), actual inflation (PDOT), a commodity price index (PCOM), the unemployment rate (U), the three-month T-Bill rate (R), and the Hamilton oil dummy variable. The figure also shows the response of the real interest rate (RR). To conserve space, we do not report the response of commodity prices. All the responses are expressed in percentage terms. The pre-1979 period is 1952:1 to 1979:1 and the post-1979 period is 1979:2 to 2001:1. The x-axis denotes years. In each chart, the darker area represents the 68% confidence interval, while the sum of the darker and lighter areas denote the 90% confidence interval.

Figure 7. Responses to a Shock to Expected Inflation (Alternative Ordering)



The responses were generated from a VAR with actual inflation (PDOT), a commodity price index (PCOM), the unemployment rate (U), expected inflation (EPDOT), the three-month T-Bill rate (R), and the Hamilton oil dummy variable. The figure also shows the response of the real interest rate (RR). To conserve space, we do not report the response of commodity prices. All the responses are expressed in percentage terms. The pre-1979 period is 1952:1 to 1979:1 and the post-1979 period is 1979:2 to 2001:1. The x-axis denotes years. In each chart, the darker area represents the 68% confidence interval, while the sum of the darker and lighter areas denote the 90% confidence interval.

Figure 8. Responses to a Shock to Expected Inflation



The responses were generated from a VAR with expected inflation (EPDOT), actual inflation (PDOT), a commodity price index (PCOM), the unemployment rate (U), the three-month T-Bill rate (R), and the Hamilton oil dummy variable. The figure also shows the response of the real interest rate (RR). To conserve space, we do not report the response of commodity prices. All the responses are expressed in percentage terms. The pre-1979 period is 1952:1 to 1979:1 and the post-1982 period is 1982:2 to 2001:1. The x-axis denotes years. In each chart, the darker area represents the 68% confidence interval, while the sum of the darker and lighter areas denote the 90% confidence interval.