The Short-Run Dynamics of Long-Run Inflation Policy

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Introduction

Currently, some economists, legislators, and policymakers are recommending that the Federal Reserve adopt price stability or an explicit price-index target as its primary long-term monetary policy objective.[1] This recommendation is based on three ideas. First, high and uncertain inflation leads to an inefficient allocation of resources. Second, inflation is ultimately a monetary phenomenon, so controlling inflation over the long term would be the sensible goal for monetary policy. Finally, a positive inflation trend provides no net long-run benefit to the economy.

The dynamic effects of monetary policy are difficult to understand for many reasons, the most important of which is simply that the term "monetary policy" can be interpreted in different ways. It may be defined in terms of the short-run interest-rate policy of the Federal Reserve, the growth rates of the monetary aggregates, or the ultimate policy objectives mandated by Congress through the Humphrey-Hawkins Act.

Our purpose in this paper is to ascertain the short- and long-term implications of an inflation policy for real output. Although a complete cost-benefit analysis is not provided, we do present one basis for assessing the short-run costs of lowering trend inflation, based on the estimated dynamic relationship between output and inflation. The simple framework developed here abstracts from issues concerning the implementation of monetary policy. We do not specify a policy reaction function, nor do we include interest rates or the money supply, variables normally associated with monetary policy. Rather, an inflation policy is defined in terms of a disturbance that exclusively determines trend inflation.

In order to isolate this permanent inflation disturbance, we adopt an identification method developed by Blanchard and Quah (1989). Using a model of output growth and unemployment, they identify two independent disturbances that they interpret as shocks to aggregate demand

■ 1 See House Joint Resolution 409, introduced by U.S. Congressional Representative Stephen L. Neal of North Carolina, and testimony in support of the resolution by Hoskins (1990).

and aggregate supply. Their identifying assumption is that only the supply shock has permanent effects on output, while neither supply nor demand disturbances affect the trend rate of unemployment. Using a model of inflation and output, we identify two independent disturbances that we interpret as innovations to inflation policy and real output. Our identifying assumption is that only the inflation shock affects trend inflation. Innovations to real output may affect the path of inflation in the short run, but the inflation shock alone determines the inflation trend.

Sims (1986) discusses how estimated disturbances can be interpreted as reflecting government policy choices in the context of a VAR model. Policy actions are associated with prediction errors in the corresponding policy variables. We interpret the shocks that drive the inflation trend as reflecting innovations accommodated by policy. We then compute the impulse-response functions and variance decompositions for real output in order to determine how these inflation-policy shocks contribute to real GNP fluctuations.

To understand our purposes, consider an economy characterized by the classical dichotomy. In such an economy, the processes driving inflation and output could be identified by restricting inflation so that it would have no effect on real output. The estimated nominal disturbances would then unambiguously reflect monetary policy actions, albeit irrelevant ones for real economic activity.

Similarly, this study attempts to disentangle the disturbances associated with inflation policy from the real disturbances driving the macroeconomy. It does not, however, require adherence to the classical dichotomy in either the short or the long run. Our specification allows both estimated shocks to influence output and inflation in the short run.

To impose our assumption that only the inflation shock determines the inflation trend, we constrain the model so that the output disturbance has only a transitory effect on inflation. Inflation shocks are interpreted as policy innovations that can affect both the short- and long-run dynamics of the system. Thus, our key identifying assumption is consistent with a large variety of economic structures, including all of the major macroeconomic theories.

In examining the dynamic consequences of these two fundamental shocks, we expect that innovations in the inflation trend will have an effect—although not a substantial one—on output. One reason for this is that the failure to index taxes on capital gains in the United States creates a situation in which raising the inflation trend would increase the marginal tax rate on capital. Thus, a higher inflation trend creates an incentive to substitute current consumption for capital accumulation.[2]

Our results indicate that inflation-policy shocks have small effects on real GNP over both long and short horizons. In the long run, the effect is negative. Thus, a policy action that would reduce the inflation trend would be associated with a long-run increase in the level of real output but with only negligible short-run costs.

We recognize the preliminary nature of these results and discuss some qualifications below; for example, the zero restriction that we place on the long-run impact of real output shocks on inflation is not strongly supported by the data. To investigate the sensitivity of our results to this restriction, we compare them to the findings obtained in two recursive VAR systems that do not restrict the long-run relationship between inflation and output. Even though both of these systems show that output shocks have a small positive impact on the inflation trend, the estimated effect of inflation on real output is essentially the same as in our model.

I. Framework for Identification

To identify the innovations to real output and the inflation trend, we apply an approach developed by Blanchard and Quah (1989) and Shapiro and Watson (1988) to a simple two-variable system that includes inflation and output. It is assumed that there are two fundamental disturbances in the system—e_p, an inflation shock, and e_y, an output shock—and that they are uncorrelated at all leads and lags. The system is

2 In a general-equilibrium framework, we would also expect work effort to be substituted for capital in the production process. Thus, labor productivity would fall, hours worked would rise, and the net effect on output would be ambiguous. See Jarrett and Selody (1982) and Bryan (1990).

TABLE 1

Unit Root Descriptive Statistics

	Augmented Dickey–Fuller T-Statistics[a]	
Series	**With a Time Trend**	**Without a Time Trend**
y_t	-0.22	-2.16
dp_t	-3.08	-2.47
dy_t	-4.23[b]	-4.24[b]
ddp_t	-3.99[b]	-4.00[b]
Residual y	-3.17	-1.07
Residual dp	-3.12	-3.14[b]

a. The Dickey–Fuller t-statistics were calculated from a regression that included six lags of the differenced data. All regressions included a constant, and there were 144 observations. See Fuller (1976, p. 373) for a tabulation of the distribution of this statistic.

b. The null hypothesis of a unit root is rejected at the 10 percent significance level.

NOTE: The series "residual y" is the residual from a regression of y_t on a constant and dp_t. The series "residual dp" is the residual from a regression of dp_t on a constant and y_t. If both y_t and dp_t are $I(1)$ and the residual contains a unit root, then y and dp cannot be cointegrated.

SOURCE: Authors' calculations.

identified by imposing the restriction that only the inflation shock may affect the inflation rate in the long run. The output disturbance is a composite of real supply and real demand shocks that may affect inflation only in the short run.[3]

Let dp denote the inflation rate and y denote the log level of output. In vector notation, let X be (dp, y) and e be (e_p, e_y). We assume that there is some n for which X follows a stationary process, given by

$$(1) \quad (1-L)^n X(t) = A(0)\,e(t) + A(1)\,e(t-1) + \ldots = A(L)\,e(t),$$

where $A(L)$ is a matrix of polynomials in lag operators.

Results of unit root tests that use the augmented Dickey–Fuller procedure are presented in table 1. These statistics do not reject the null hypothesis that the elements of X are $I(1)$; that is, the inflation rate and output each contain one unit root. Therefore, we difference the inflation and output series once before estimating the model.[4] Tests for cointegration of dp and y suggest that these two variables do not share a common trend.

Under our restriction that the long-run impact of e_y on inflation is zero, the sum of the coefficients in the upper-right polynomial in $A(L)$ must equal zero. Under our assumptions, the variance $(e) = I$ and the contemporaneous effect of e on X is given by $A(0)$. Thus, our framework allows for bidirectional causality, even though the effect of an output innovation on inflation must dissipate in the long run.

Because e is not observable, $A(L)$ cannot be estimated directly. In practice, $A(0)$ can be identified in a variety of ways.[5] We use the instrumental variables approach described by Shapiro and Watson (1988), which allows the system in equation (1) to be estimated directly in autoregressive form:

$$(2) \quad B(L)(1-L)X(t) = u(t),$$

where, in general, the u's are combinations of structural disturbances that, by construction, may be correlated contemporaneously but not across time. We estimate e_p and e_y by imposing our assumptions on this autoregressive form. Because the matrix of long-run multipliers is assumed to be lower triangular, the sum of the coefficients in the upper-right polynomial in $B(L)$ must also equal zero. In practice, this restriction is imposed by including first differences of the current value and n-1 lags of output growth as regressors:

■ 3 As Blanchard and Quah show in the appendix to their 1989 paper, there are some common identification problems in low-dimension dynamic systems. For example, if the aggregate shocks are composites of many different types of disturbances, as is the case here, then our decomposition may be invalid. We intend to address this issue in subsequent work by adding more economic structure (and more variables) to the basic framework.

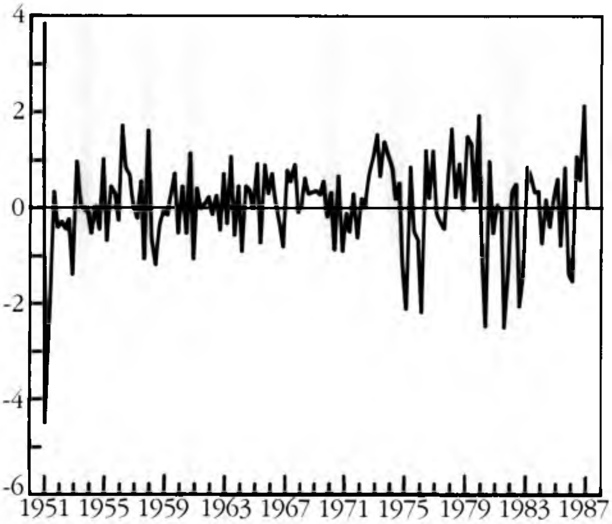
■ 4 King et al. (1989) and Shapiro and Watson (1988) find a unit root in inflation. We could not reject the null hypothesis of a unit root in inflation using the Dickey–Fuller t-statistic, but other tests, including the Dickey–Fuller normalized bias, the Phillips–Perron normalized bias, and the Phillips–Perron t-statistic, did reject the null hypothesis. See Phillips and Perron (1988), Said and Dickey (1985), and Schwert (1987) for arguments in favor of using the normalized bias t-statistic. We assume the existence of a unit root because the particular constraint that we impose to achieve identification requires that the model be specified in first differences of inflation and output. We could have specified the model in output growth and inflation, but doing so would have required policy shocks to be defined as the sole determinant of the price level. Preliminary work with this specification resulted in a time series of policy shocks that had extremely large negative effects on real GNP: An increase in the price level led to an implausibly large decline in real GNP. We suspect that any problems caused by possible overdifferencing in our model are small relative to the difficulties that would be induced by the alternative specification.

■ 5 See Blanchard and Quah (1989), Shapiro and Watson (1988), Bernanke (1986), Sims (1986), Litterman and Weiss (1985), Judd and Trehan (1989), and Boschen and Mills (1989).

FIGURE 1

Innovations to Output and Inflation: Model Imposing Long-Run Constraint on Output Shocks

A. Estimated Innovations to the Inflation Rate



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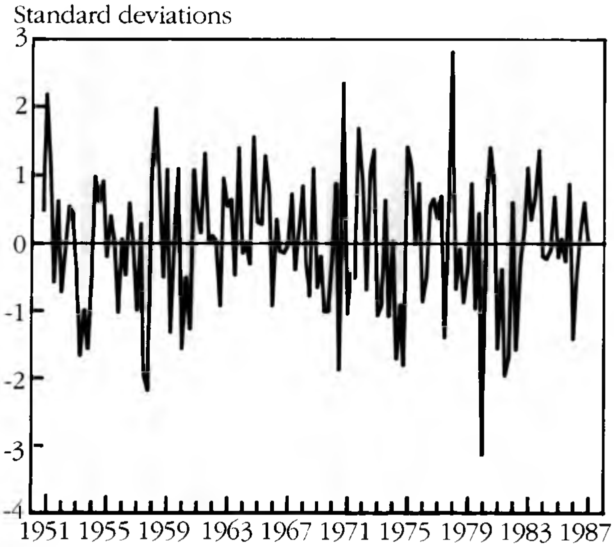


NOTE: Shaded bars indicate National Bureau of Economic Research business cycles.
SOURCE: Authors' calculations.

$$(2') \quad ddp_t = c_1 + \sum_{i=1}^{n} b_{11}^{i} ddp_{t-i} + \sum_{i=0}^{n-1} \delta_{12}^{i} ddy_{t-i} + e_{pt}$$

$$dy_t = c_2 + \sum_{i=1}^{n} b_{21}^{i} ddp_{t-i} + \sum_{i=1}^{n} b_{22}^{i} dy_{t-i} + b_{20}\hat{e}_{pt} + e_{yt},$$

where the long-run constraint has been incorporated by replacing

$$\sum_{i=0}^{n} b_{12}^{i} dy_{t-i} \text{ with } \sum_{i=0}^{n-1} \delta_{12}^{i} ddy_{t-i}$$

in the *ddp* equation.

Contemporaneous effects of the inflation-policy shock are allowed to enter the equation for output growth.[6] Because the *ddp* equation includes a current value of the change in real output, we use an instrumental variables estimator. The instrument list includes six lagged values of *ddp* and *dy*, as well as the contemporaneous and six lagged values of the relative oil price; the price of oil is assumed to be exogenous in this model. Essentially, this two-stage procedure replaces dy_t with the ordinary least squares projection of this variable on the list of instruments. Then, by including the residual from the price equation in the output equation, the real output shock can be identified.

II. Results

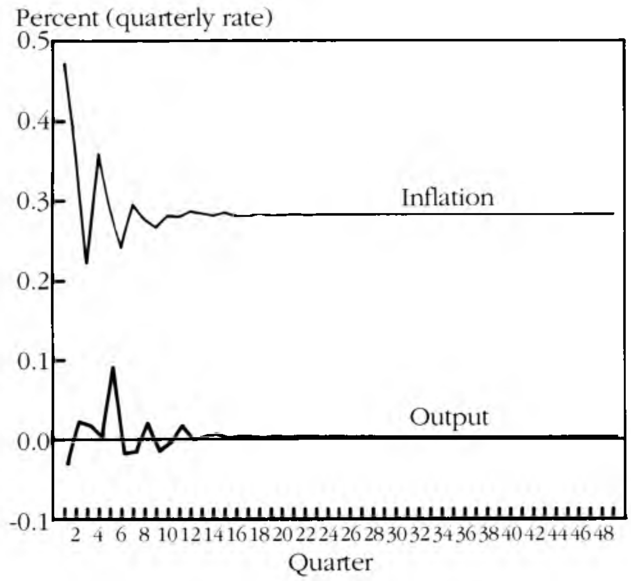
In this paper, inflation is measured as the change in the logarithm of the Consumer Price Index (CPI), and output is measured as the logarithm of real GNP. Monthly CPI data were averaged to determine the quarterly series, and data from the sample period 1951:IQ to 1987:IIQ were used to estimate equation (2′). The estimated series for e_p and e_y are shown in figure 1. A cursory look at these two series reveals an output shock that exhibits its largest negative values in the midst of

6 This program was written in Regression Analysis Time Series (RATS) Version 3.10. We thank Mark Watson for sending us the data and program used to identify supply shocks in Shapiro and Watson (1988).

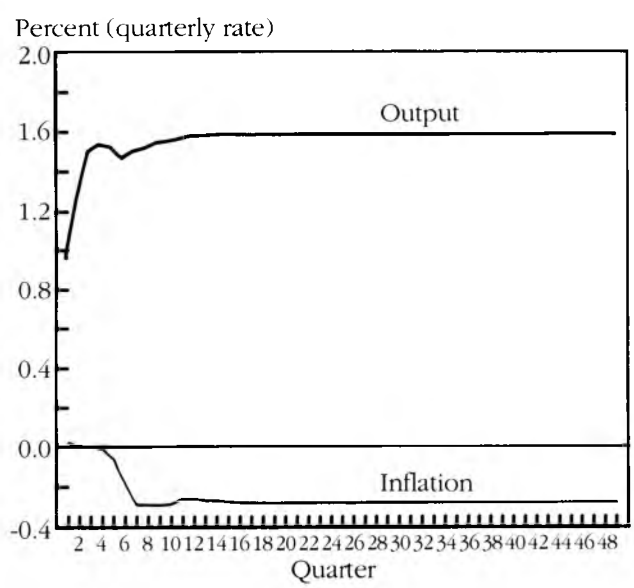
FIGURE 2

Impulse-Response Functions

A. Response of the Inflation Rate to Innovations in:



B. Response of Real Output to Innovations in:



SOURCE: Authors' calculations.

recessions; however, a clear cyclical pattern is not evident for the inflation-policy shock. On average, the inflation-policy shock was positive during the 1973-75 recession and negative during the 1981-82 recession.

Impulse-response functions for inflation, shown in figure 2A, indicate the response of inflation to a one-standard-deviation shock in the error vector. Taken at face value, our results suggest that the output shock has small short-run effects on inflation when the long-run effect is constrained to be zero. A standard-deviation shock to inflation (about 2 percent at an annual rate [a.r.]) raises the rate slightly more than 1 percent (a.r.) in the long run.

The impulse-response functions for output are shown in figure 2B. A one-standard-deviation shock to output results in increased output throughout the first year. In the long run, output rises by more than one and one-half times the initial shock, a gain that is nearly complete after the first year.

Inflation-policy shocks have a small but positive short-run effect on real GNP. After the second quarter, the sign becomes negative and remains that way. Thus, a policy action that lowers the inflation trend would initially have a negative effect on real output, but would raise the level in the long run.

Interpreting our results structurally, a decline in the inflation trend from 4 percent to zero would have a negligible damping effect on output in the first two quarters—less than 2/10ths of 1 percent. After the second quarter, the effect would become positive, and in the long run (after about two years), the output level would have increased about 2.5 percent.[7]

Another way to examine the dynamic effects of inflation shocks on output is to decompose the variance of output into the part caused by variation in the separate shocks. The variance decompositions for different time horizons are shown in the top section of table 2. Note that most of the variance in the two series, inflation and output, is explained by their own independent shocks. The output shock never explains more than 2 percent of the variance in the inflation rate, and the inflation shock explains almost none of the variance in output (in the long run, it accounts for only about 3 percent). Although raising the inflation trend reduces the

7 Note that this long-run effect is qualitatively and quantitatively similar to that produced by the failure to index capital-gains income for tax purposes. See Altig and Carlstrom (1990).

TABLE 2

Variance Decompositions

Quarter	Percent of Output Variance Explained by Shock to: Real Output	Inflation Rate	Percent of Inflation Variance Explained by Shock to: Real Output	Inflation Rate
Decomposition with Long-Run Constraint on Output Shocks				
1	100.0	0.0	0.5	99.5
4	100.0	0.0	0.3	99.7
8	98.7	1.3	1.2	98.8
12	98.0	2.0	0.9	99.1
20	97.5	2.5	0.6	99.4
36	97.2	2.8	0.4	99.6
49	97.1	2.9	0.3	99.7
Choleski Decomposition with Inflation as the Lead Equation				
1	99.7	0.3	0.0	100.0
4	99.5	0.5	3.4	96.6
8	97.3	2.7	10.6	89.4
12	96.3	3.7	12.7	87.3
20	95.7	4.3	14.9	85.1
36	95.4	4.6	16.7	83.3
49	95.2	4.8	17.4	82.6
Choleski Decomposition with Output as the Lead Equation				
1	100.0	0.0	0.3	99.7
4	99.9	0.1	2.3	97.7
8	98.5	1.5	8.5	91.5
12	97.8	2.2	10.1	89.9
20	97.4	2.6	12.0	88.0
36	97.2	2.8	13.4	86.6
49	97.1	2.9	13.9	86.1

SOURCE: Authors' calculations.

level of output, the increase explains little of the variation in the series.

Other research suggests that these results are not dependent on the small size of our model. King et al. (1989) also find that the permanent inflation shock never explains more than 3 percent of output variance over any horizon.[8]

III. Some Caveats

There are at least three potentially important caveats that may limit the validity of our findings. First, our identifying restriction—that the long-run impact of an output disturbance on inflation must be zero—is only weakly supported by the data. Second, the real shock is clearly an amalgamation of supply and demand shocks. Third, it may not be inappropriate to difference the inflation rate. Differencing may wash out some important short-term relationships between output and inflation. The second and third problems will be addressed in future research.

As noted above, our identifying restriction is not strongly rejected by the data. The likelihood-ratio statistic for our restricted model is 3.12, which implies that this hypothesis is rejected at the 7.7 percent significance level. Evidence provided below indicates that our empirical results do not depend critically on this identifying assumption.

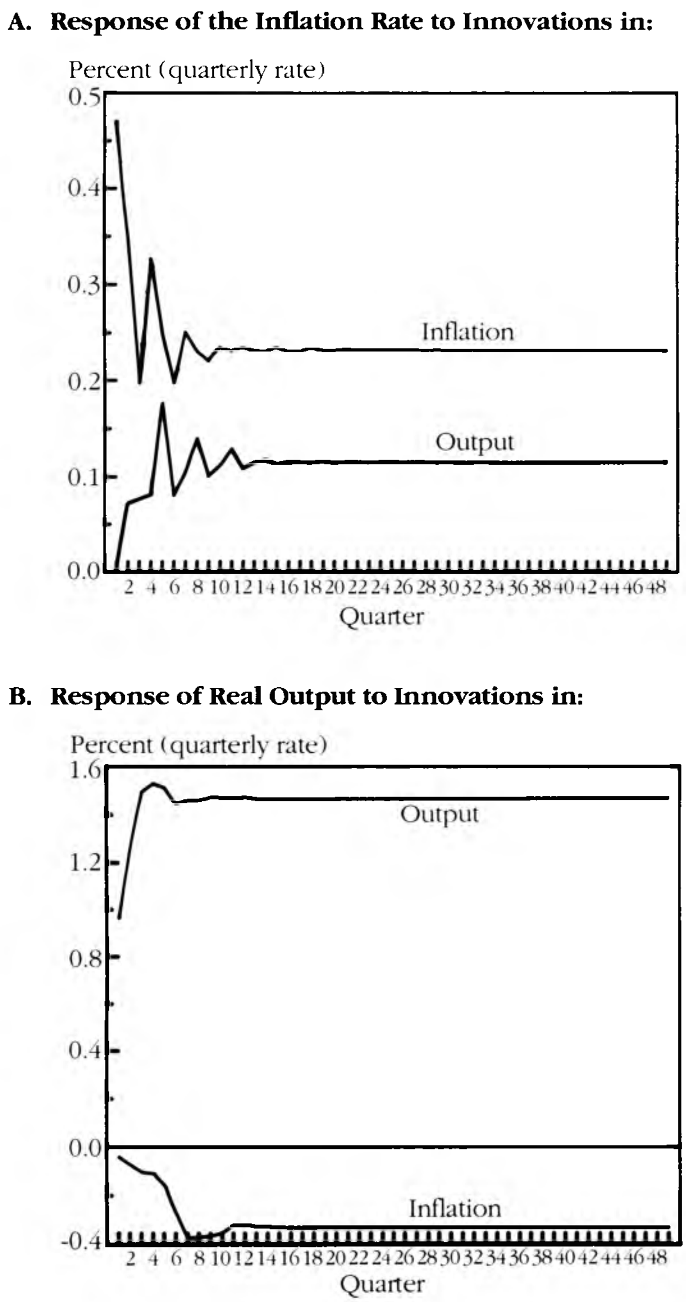
To examine the implications of this restriction, we contrast our results against those obtained using a standard VAR approach; that is, we estimate equation (2) with $B(0)$ equal to the identity matrix. The contemporaneous relationships between output growth and the change in inflation are thereby captured in the variance-covariance matrix of the estimated residuals. These residuals are then transformed into orthogonal series in order to examine the dynamic consequences of independent disturbances to output and inflation.

The conventional method of orthogonalization (based on the Choleski decomposition of the variance-covariance matrix) restricts the transformation matrix to be lower triangular. While this decomposition achieves an orthogonalization of the residuals, it also imposes a recursive structure on the system. In contrast to

■ 8 See table 8b, King et al. (1989, p. 25). It should be noted that one of their identifying assumptions is that the permanent inflation shock does not affect output in the long run.

FIGURE 3

Impulse-Response Functions: Recursive System with Inflation as Exogenous Shock



SOURCE: Authors' calculations.

our method of identification, this decomposition places no long-run restrictions on the model. In this study, we have only two variables and hence only two potential orderings. Each alternative decomposition corresponds to an alternative ordering of the variables.

We then compare the structural implications of the two alternative recursive systems (table 2) to our restricted model. In the first specification, we assume that the first-stage residual (u_1 in matrix equation [2]) in the *ddp* equation is the structural disturbance e_p. Any correlation between u_1 and u_2 is assumed to be caused by u_1, the inflation-policy shock. The output shock, e_y, is defined as the variation in the first-stage VAR residual, u_2, that is not correlated with e_p. In the second specification, the order of the equations, and hence the assumption about the direction of causation among the contemporaneous errors, are reversed.

Figures 3 and 4 show the impulse-response functions for these two specifications. The major difference is that real shocks now affect the trend inflation rate. One explanation for this result could be that monetary policy actions are not aimed exclusively at achieving a specific inflation trend. Suppose that the Federal Reserve were following a strict money growth rule. Under such a rule, higher real output growth would result in lower inflation. However, the positive relationship in figure 3A is probably the consequence of a monetary policy that tries to smooth money market interest rates in the absence of an explicit inflation target.

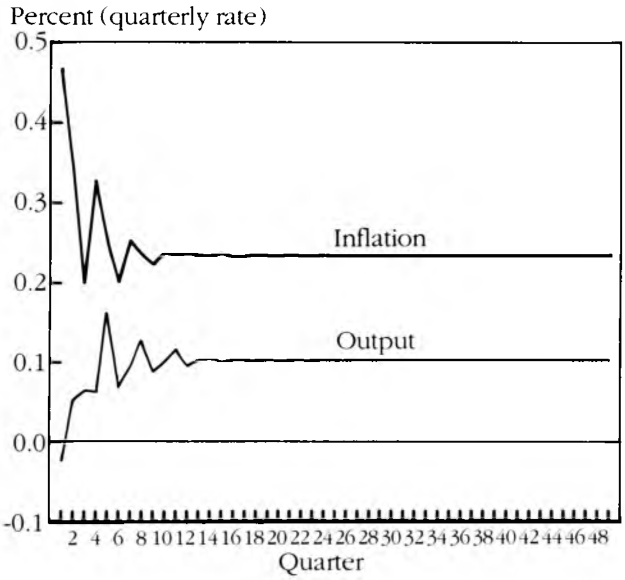
For example, whenever the investment–demand function shifts to the right, the economy experiences a transitory period of capital accumulation and relatively higher real returns. In order to prevent an increase in the federal funds rate, the Federal Reserve automatically increases the money growth rate and thereby raises the inflation rate. Unless it consciously reverses this accommodative money growth, the long-run inflation trend will be positively related to output shocks.

Although the real shock affects long-run inflation in the unrestricted model, the estimated effect of an inflation shock on output is essentially the same as in our model. Lowering the 4 percent inflation trend to zero would raise long-run output more than 3 percent in the first

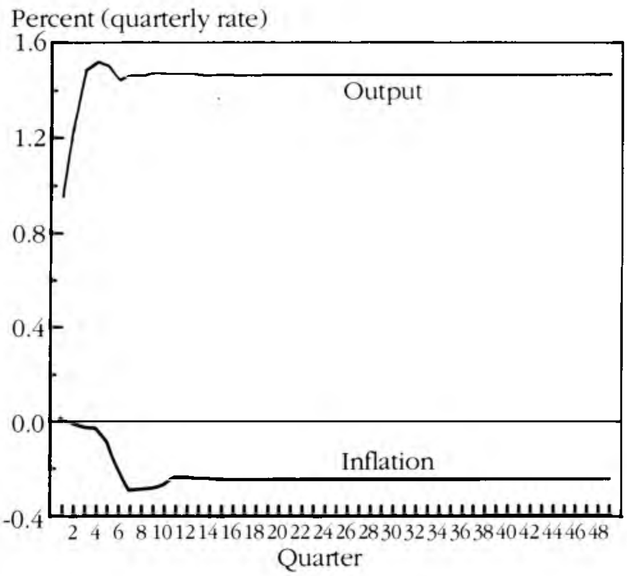
FIGURE 4

Impulse-Response Functions: Recursive System with Output as Exogenous Shock

A. Response of the Inflation Rate to Innovations in:



B. Response of Real Output to Innovations in:



SOURCE: Authors' calculations.

case and slightly more than 2 percent in the second. In both instances, the estimated long-run benefits of eliminating inflation outweigh the estimated short-run costs.

In some sense, it should not be surprising that simple time-series models of output and inflation would exhibit an inverse long-run relationship when estimated over the post-WWII period. After all, income growth was higher and inflation was lower before 1965. If, however, output has a substantial random-walk component, output growth could vary significantly by chance. Thus, the estimated inverse link between output and inflation could be spurious. Moreover, our model does not include other variables that might account for the productivity (and hence output) slowdown.

IV. Conclusion

We assume that two types of disturbances generate inflation and output dynamics—an inflation shock and an output shock—both of which are defined by identification restrictions. The inflation shock is allowed to have transitory and permanent effects on both output and inflation. Although the output shock may have only transitory effects on inflation, it may have both transitory and permanent effects on output.

We interpret the inflation shock to be a consequence of monetary policy given our restriction that it alone determines the inflation trend. Under this interpretation, the estimated policy shocks have minimal real effects. Although the results concerning the impact of inflation policy on real output are produced in a small and very simple model, we suspect that they will hold up in future extensions of this work. One indication can be found in King et al. (1989), who find similar results using a larger and theoretically richer model.

The policy implications of our findings are encouraging. Not only would a policy aimed at lowering the inflation trend raise the output level in the long run, but a structural interpretation of our VAR indicates that the short-run output loss associated with such a policy may be negligible. Our results thus suggest that there is a sequence of feasible policy actions that could lower trend inflation in such a way that the benefits would outweigh the costs. This seems to be the case on the margin—that is, where policy might succeed in offsetting inflation shocks marginally more than it did on average over the estimation period.

This study does not address the question of how such a policy would be implemented, however. Specifically, we do not consider how policymakers would control the inflation shock or to what extent they should offset it. Since the inflation-policy innovations are estimated over a period in which monetary policy largely accommodates quarterly disturbances to inflation, it is questionable whether our findings would apply in those circumstances where policy largely offsets inflation shocks. Conventional econometric evidence suggests that the underlying structure of the economy is unlikely to remain invariant to a monetary policy procedure that does not accommodate a large part of inflation shocks.

In light of this evidence, extreme policy measures could lead to greater output losses than our results suggest. Any attempt to largely offset a positive inflation shock within a quarter, however, would seem to be infeasible from a practical standpoint, if not from a technical one. On the other hand, the experience of the 1970s suggests that policymakers can also be too timid in implementing a strategy to combat inflation shocks. On balance, these results suggest that the benefits of a monetary policy aimed at achieving gradual disinflation would probably outweigh the costs. One avenue for future research would be to extend the framework presented here to include variables more closely associated with policy actions so that policy implementation issues might be investigated.

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