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THE VARIANCE AND ACCELERATION OF INFLATION IN THE 1970s: ALTERNATIVE EXPLANATORY MODELS AND METHODS

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ABSTRACT

The paper attributes the behavior of U.S. inflation to four sets of factors: aggregate demand shifts; government intervention in the form of the Nixon price controls and changes in the social security tax rate and the effective minimum wage; external supply shocks that include the impact of the changing relative prices of food and energy, the depreciation of the dollar, and the aggregate productivity slowdown; and inertia that makes the inflation rate depend partly on its own lagged vlaues.

Considerable attention is given to alternative methods of measuring the impact of government intervention, including the Nixon controls, Kennedy-Johnson guideposts, and the Carter pay standards. The results imply that direct intervention has been futile, since the guidelines and pay standards had no effect at all on inflation, while the Nixon-era controls had only a temporary impact that stabilized both the inflation rate and the level of real output.

Some previous studies have had a problem in explaining why inflation was so rapid in 1974 and have been forced to conclude that the termination of the Nixon controls raised prices more than the imposition of controls had lowered them. We find that much of the explanation of rapid inflation in 1974 is the same as that in 1979-80: the shortfall of productivity growth below its ever-slowing trend rate of growth raised business costs and forced extra price increases, and the depreciation of the dollar in 1971-73 and 1978 boosted the prices of exports and import substitutes. Rapid demand growth, the 1979-80 oil shock, the depreciation of the dollar, the productivity slowdown, and payroll tax increases all help to explain why the inflation rate accelerated between 1976 and 1980 by much more than was generally expected two or three years ago.

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I. INTRODUCTION

In the past decade inflation has been both the leading macroeconomic problem and the bane of forecasters. Not only has the inflation rate been higher on average than in any earlier peacetime decade, but it has accelerated from roughly 5 percent in 1970 to 10 percent in 1980, and it has exhibited an unprecedented variability throughout the decade. Sensible advice to policymakers on anti-inflation strategy requires that economists be able to decompose the inflation of the 1970s among its principal causes.

At the beginning of the decade the standard explanation of inflation was based on an expectational Phillips curve (EPC) equation in which there was typically one aggregate demand variable, usually representing the tightness of labor markets, and one variable representing inertia and gradual price adjustment, usually the influence of lagged prices on current wages and prices. The basic inflation equation developed in this paper supplements the simple EPC approach with an extra aggregate demand variable and six types of supply shifts. The demand variable is the rate of change of nominal aggregate demand. The supply variables include the effect of government intervention in the inflation process (particularly during the Nixon control era), the impact of changing relative prices of food and energy, of minimum wage changes, and of payroll tax changes, the change in the effective foreign exchange rate of the dollar, and, finally, the effect of changes in both the actual and trend growth rates of labor productivity.[1]

Thus the main themes of the paper are that inflation cannot be explained simply as the result of excessive aggregate demand stimulation, nor of a single type of supply shock, nor of the effect of inertia by itself. An adequate explanation of postwar U. S. inflation, both before and after 1970, requires treatment of several different channels by which aggregate demand influences inflation, of several different episodes of government intervention, of several types of supply shocks, and of the inertia in the inflation process that limits the speed with which prices can adjust to demand and supply shifts.

A central topic in this paper is the interaction between the estimated effects of the Nixon controls and of the other variables. As Blinder and Newton (1978) discovered, some traditional price change equations that freely estimate separate coefficients for the impact of the controls and for the effect of their removal--hereafter labelled the "on" and "off" coefficients--yield the conclusion that the 1974 "off" effect was substantially larger than the 1971-72 "on" effect. Stated another way, price change equations with a traditional specification cannot explain why inflation was so high in 1974, and the introduction of a free dummy variable for the 1974 removal of controls often leads to the estimate of a large coefficient for this "off" effect. The more complete specification in this paper that includes additional variables provides an improved explanation of inflation in 1974 and yields "on" and "off" coefficients that are of roughly the same size. The fully specified equation has the important by-product that it is able to explain why the inflation rate for products other than food and energy accelerated so much between 1977 and 1980.

The preferred price change equation developed in this paper is contrasted with two simpler approaches. The first is a naive ARIMA model that explains inflation entirely by its own past values. The ARIMA model represents an extreme view that the inflation process is entirely dominated by inertia and is unaffected by changes in current exogenous variables. Nevertheless, an ARIMA price change equation provides an interesting standard of comparison for a more complete specification and provides a link to the early evaluation of the Nixon controls program by Feige and Pearce (1976) that used the ARIMA technique.

The second alternative approach is a simple monetarist equation that makes the rate of change of prices depend only on a distributed lag of past changes in the money supply. While this framework is taken more seriously by journalists and laymen than by academic economists, a "money only" explanation of inflation is implicit in some recent tests of the classical equilibrium approach to macroeconomics.[2] We shall see that the residuals of both the ARIMA and money-only approaches yield an estimate that the Nixon controls had a significant effect on the timing of inflation, just as does the more complete specification.

This paper attempts to do more than simply present a preferred inflation equation. In addition it attempts to characterize the nature of changes in the inflation process during the past decade. The effect of each variable is examined both in an equation estimated for the full 1954-80 period and for the shorter 1954-71 period. Post-sample dynamic simulations of the short-period equations help to reveal the particular aspects of inflation in the past decade that are explained by shifts in coefficients in the full-period equations.

Several limitations are imposed to control the size of the paper. First, no attention is paid to alternative specifications of the impact of aggregate demand on the inflation process; the impact of alternative "supply" variables are studied within a single demand specification.[3] Second, all equations explain the rate of change of prices in relation to lagged price changes, and there is no attention given to the determinants either of the change in wages or in the relation of prices to wages. Third, with one exception all of the price equations use a single dependent variable, the fixed-weight GNP deflator.[4] Without these restrictions the paper would grow to book length, since there is an almost infinite number of possible combinations of dependent variables (different measures of wages and prices) and independent variables.

II. CHARACTERISTICS OF DATA AND FORM OF EQUATIONS

Summary Statistics Describing the Data to be Explained

The basic features of inflation in the 1970s--both its overall acceleration and its high variance--stand out in Table 1. Means, standard deviations, and simple correlations are presented there for quarterly rates of change of prices, of nominal GNP, and of the money supply (M1B), and the level of the "output ratio," that is, the ratio of actual to natural real GNP.[5] Five twenty-quarter (half-decade) intervals are compared for the period between 1954 and 1979.

The table suggests that all three rate of change variables accelerated by about five percentage points between the earliest and latest of the five intervals. The fact that inflation accelerated between the first and last halves of the 1970s seems to conflict with the substantial negative value of the output ratio recorded in the last half; this may suggest either that the output ratio is mismeasured or that other variables like

TABLE 1

Basic Statistics on
Inflation and Demand

	Quarterly Rates of Change at Annual Rates: Fixed Weight GNP Deflator (1)	Nominal GNP (2)	M1B (3)	Level of the Output Ratio (4)
1. Means				
a. 1955:Q1-1959:Q4	2.37	5.49	1.69	-1.01
b. 1960:Q1-1964:Q4	1.25	5.39	2.65	-2.02
c. 1965:Q1-1969:Q4	3.62	7.78	4.80	3.15
d. 1970:Q1-1974:Q4	6.34	8.42	5.90	0.07
e. 1975:Q1-1979:Q4	7.16	10.51	6.72	-2.84
2. Standard Deviations				
a. 1955:Q1-1959:Q4	1.22	5.39	2.34	2.41
b. 1960:Q1-1964:Q4	0.59	3.48	1.98	1.67
c. 1965:Q1-1969:Q4	1.28	2.54	2.73	0.79
d. 1970:Q1-1974:Q4	2.84	3.58	2.05	2.04
e. 1975:Q1-1979:Q4	1.68	3.91	2.19	2.19
3. Simple Correlations with Inflation Rate				
a. 1955:Q1-1959:Q4	----	.24	-.06	.60
b. 1960:Q1-1964:Q4	----	-.36	.08	.10
c. 1965:Q1-1969:Q4	----	-.12	.06	.26
d. 1970:Q1-1974:Q4	----	-.10	-.35	-.24
e. 1975:Q1-1979:Q4	----	.14	.34	.43

the rate of change of nominal GNP or money are important in explaining changes in the inflation rate.

The middle section of Table 1 indicates that the variance of inflation was greater in both halves of the 1970s than in earlier periods, and that the variance was especially high during the first half of the decade. In contrast the variance of nominal GNP and money growth were not unusually high during the 1970s. Fluctuations in the output ratio in 1970-79 were similar in magnitude to those during 1955-64, as contrasted with a temporary period of stability in 1965-69.

How were the alternative demand variables correlated with the inflation rate during the five periods? The relatively high positive correlations between inflation and the output ratio--the traditional Phillips curve relationship--are evident for 1955-59 and 1975-79, while the appearance of a perversely sloped Phillips curve shows up in the data for 1970-74. The correlations with nominal GNP change are weak throughout, with a surprising negative correlation in the early 1960s. The negative correlation of inflation with money growth in the first half of the 1970s contrasts with the positive correlation in the last half.

Table 1, then, provides a preview in crude form of some of the conclusions we reach later: the data for the early 1970s, including the high variance of inflation and the negative correlation with demand variables, suggest an important role for supply shocks in the inflation process. The data for the late 1970s imply not only that a traditional demand-based explanation of inflation may be relevant, but that the negative average level of the output ratio during 1975-79 may give a misleading indication of slack demand.

"Structural" versus Reduced-Form Approaches

The study of inflation in most past research has been based on a two-equation approach, one for wages and one for prices. The wage equation typically adhered to the EPC specification described above, and the price equation illustrated the tendency for the price level to be "marked up" over some concept of unit labor cost, that is, the wage rate divided by labor productivity. Often the wage and price equations were part of a supply-side block in a large-scale econometric model that also included equations explaining key labor market variables like the unemployment and labor force participation rates. The wage equation was generally taken to represent the outcome of events in the labor market, with the influence of aggregate demand channeled through "labor market tightness" variables like the unemployment rate, while the price equation was generally taken to reflect events in the commodity market, with the influence of aggregate demand channeled through proxy variables like inventory-sales ratios and unfilled orders.

In recent years, however, it has become apparent that the two-equation approach is both misleading and inconvenient. First, wage and price equations cannot be distinguished as truly structural equations applying to behavior in particular markets. The behavior of wages, for instance, can be explained just as well by real GNP as by labor market variables like unemployment, suggesting that the wage equation does not provide us with any special insight about the working of labor markets.[6] Second, traditional wage and price equations are particularly prone to simultaneous equations bias. If current prices explain wages and current wages explain prices, then the coefficient on a variable that influences both simultaneously--whether a demand proxy like real GNP or a supply variable like price-control effects--may be biased downward.[7] For instance, if the true impact of controls on wages and prices differs each quarter, while their effect is restricted in an econometric equation to operate through dummy variables that are uniform each quarter, much of the true impact may be soaked up by the price coefficient in the wage equation and wage coefficient in the price equation rather than by the coefficient of the dummy variable. Third, the use of two equations leads to an artificial separation of the variables that "belong" in each equation. For instance, the payroll tax has often entered wage equations, but never price equations. Thus the large impact effect of the employers' portion of the payroll tax in raising unit labor cost is implicitly assumed to be shifted forward into prices by the same coefficient as an average wage change. Any absorption of some of the tax burden by firms will be missed unless the payroll tax variable is entered symmetrically into both the wage and price equations. Finally, the two-equation approach is inconvenient and clumsy. The full impact of a variable on the inflation rate cannot be learned from the simple inspection of a table, but requires multiplying and adding coefficients. The answer to virtually any interesting question requires the computation of model simulations that must include the auxiliary equations needed to generate the labor market variables typically included in the wage equation.

On all of these counts a simple reduced-form inflation equation, which relates the rate of price change to its own lagged values and other variables, seems superior. The equation is openly a convenient characterization of the data rather than an attempt to describe structural behavior;

it is less prone to (though not immune from) simultaneous equations bias; it automatically includes the effect of every variable on both wages and profits; and it is easier to inspect, interpret, and simulate. Subsequent work on separate wage and price mark-up equations can help to allocate the effects of particular variables between wage and profit behavior, but this seems a distinctly secondary research task to building an improved understanding of the inflation process itself.

Choice of Dependent Variable and Sample Period

The GNP deflator seems the natural choice as dependent variable in a study of the basic U. S. inflation process. Given any specified path of nominal GNP and "natural" (or potential) real GNP, determination of the path of the GNP deflator automatically yields as a residual the ratio of actual to natural real GNP (hereafter "the output ratio"), the key indicator of the economy's utilization rate and cyclical performance. The output ratio, in turn, leads to predictions of the unemployment rate as long as Okun's law remains reasonably accurate.

We have selected for analysis the *fixed-weight* rather than the *implicit* GNP deflator. Two arguments support this choice. First, the implicit deflator, based on current-period expenditure weights, confounds price changes with changes in the mix of output. Just as studies of wage inflation now commonly use a fixed-weight wage index, we believe that studies of aggregate U. S. inflation should use the fixed-weight GNP deflator in order to insulate true price changes from shifts between expenditure categories.

A second disadvantage of the implicit GNP deflator arises below in section VI, where we begin to include nominal GNP growth as an explanatory variable.

The level of the implicit GNP deflator can shift from quarter to quarter as the weight of particular expenditure categories shifts. In quarters when there are large changes in a particular type of expenditure, e.g., during the quarter of an automobile strike, nominal GNP and the deflator could exhibit a positive correlation, even if there were no effect of nominal GNP changes on any individual price change. Use of the fixed-weight deflator eliminates this source of spurious correlation between inflation and nominal demand changes.

The sample period of the inflation equations developed in this paper runs from 1954:Q2 to 1980:Q2. The starting date is chosen to retain comparability with previous papers and to simplify the presentation by omitting consideration of the peculiar impact of speculation and government intervention during the 1950-53 Korean War period.[8] The ending date is the latest quarter of data available when most of this research was carried out. Each alternative specification considered below has also been estimated for the shorter sample period 1954:Q2 - 1971:Q2 in order to use post-sample dynamic simulations to evaluate price behavior during the Nixon controls period. Equations examined in section VI also are estimated for 1954:Q2-1977:Q4, in order to determine the ability of various equations to forecast the acceleration of inflation between 1977 and 1980.

III. METHODOLOGY AND MODELS

Problems in Estimating the Impact of Controls

Our various reduced-form inflation equations are of the general form:

$$(1) \qquad p_t = f(x_t, x_{t-i}, p_{t-i}),$$

where p_t is the rate of inflation, x_t is a vector of explanatory variables (some of which may be endogenous in the context of a large econometric model), and the subscript "t-i" refers to variables lagged one or more periods. The two primary purposes of equations like (1) are retrospective and prospective policy evaluation. Once the coefficients of the f( ) function have been estimated, the effects of different policies in the past or future can be represented by the calculation of alternative values of price change (p_t), providing that the policy shifts can be interpreted as a change in one or more of the explanatory variables. Thus the estimated f( ) function can be used to calculate:

$$(2) \qquad p^*_t = f(x^*_t, x^*_{t-i}, p^*_{t-i}),$$

where the hypothetical alternative values of the relevant explanatory variables are designated by an asterisk.

The measurement of the effects of wage-price control policies differs from that of monetary or fiscal policies for two basic reasons. First, there is no long continuous relationship between the quantitative "x" variable and the dependent variable to allow a coefficient for controls to be estimated. During most periods in the past there were no controls. Even when they were in effect, there is generally no official measure of the impact of the program for inclusion as an explanatory variable.[9] Second, the existence of separate control programs in past periods, e.g., guidelines in 1963-66 and Nixon controls in 1971-74, prevents us from treating each separate program or even each phase of a program as a single continuous zero-one dichotomous variable, since controls programs differed in their comprehensiveness and tightness.[10] Thus there seems little alternative to the two basic techniques used in this paper, (1) the introduction of separate dummy variables for each program, and (2) the construction of post-sample simulations to evaluate a program based on coefficients estimated from a previous no-controls interval.

There are numerous pitfalls in the use of either the dummy variable or simulation technique:

1. The model may be erroneously specified and omit one or more explanatory variables. Movements in the omitted variable during the controls period may be correlated with the imposition and/or removal of controls and thus bias the controls coefficient in either direction. For instance, since aggregate demand growth (either money or nominal GNP) speeded up during the 1971-72 controls imposition period and slowed down during the 1974 controls removal period, the omission of this negatively correlated variable will tend to bias downward the effect of controls estimated by either the dummy variable or simulation technique.

2. Sometimes a misspecification can bias the conclusion of the simulation technique more than that of the dummy variable technique. A simulation designed to evaluate the 1971-74 controls program is usually based on a set of coefficients for the f( ) function estimated to the pre-1971 period. Unfortunately 1971-72 marks the beginning not only of the controls, but also of flexible exchange rates. Since there was little variability in the foreign exchange rate of the dollar before 1971, a post-sample simulation records errors in years like 1974 and may attribute them to controls rather than to the impact of the omitted variable. In contrast the dummy variable technique allows use of the full post-1971 sample period and allows any

variable to enter, even if it exhibited no variance before 1971.

3. There are corresponding disadvantages of dummy variables. First, a choice must be made of the applicable dates of the program. This choice is particularly difficult for the "rebound" impact of the termination of controls on the price level, since this impact may be spread out over several quarters after the legal termination date. For semi-voluntary programs like the Kennedy-Johnson guidelines, there was no legal implementation or termination date.[11] Second, a dummy variable that is set at a uniform value for the whole period of a program's implementation forces its impact to be uniform each quarter. While the varying comprehensiveness of implementation can be tracked by the Blinder-Newton variable that shows the percentage of prices controlled each month between 1971 and 1974, their variable does not measure the tightness of controls or indicate how promptly firms responded to changes in the rules.

4. Some parameters in price equations are measured with wide confidence intervals. In other cases the data cannot distinguish between alternative hypotheses. Thus alternative specifications that fit equally well may yield differing evaluations of the efficacy of a particular program of controls. However, this source of ambiguity in evaluating the effect of controls is no different from that found in many time-series econometric studies.

5. The measured impact of a control program depends on what is taken to be exogenous. If the "output ratio" is the only exogenous demand variable, then the coefficient on a controls dummy measures the downward displacement of a short-run Phillips curve. If nominal GNP growth is held constant when controls are implemented, then any such downward displacement will raise the

the output ratio and, if the short-run Phillips curve linking inflation and the output ratio is positively sloped, will cause actual inflation to decrease less than the vertical downward displacement measured by the controls dummy. In short, the actual behavior of inflation reflects the combined influence of the controls in *shifting* the Phillips curve and in causing the economy to *move along* the curve. Coefficients on controls effects measured in equations that contain the output ratio or other demand variables isolate the shift in the curve. This approach seems correct, since if aggregate demand policy allowed the displacement effect of the controls to be dissipated by movements along the curve, this should not be taken to mean that the controls "had no impact."

6. Measurement errors may be important if controls cause distortions in price measurement. To the extent that controls are binding and are accompanied by rationing, there is some vector of shadow prices at which the rationed quantities would be preferred, utility-maximizing amounts of those goods (Tobin and Houthakker, 1950-51). In this welfare sense, the "true" GNP deflator that is relevant for individual utility functions is then a weighted average of actual prices for uncontrolled goods and the shadow prices of controlled goods. Such a price concept rises during a control period relative to the actual deflator. Thus to the extent that rationing is important, the use of the actual deflator overstates real income in the welfare sense and hence understates the "true" rate of price increase. The main impact of controls measured below occurs in 1971-72, when there were few reported cases of shortages. The main impact of the removal of controls on measured prices occurred in 1974. Since there were widespread shortages reported in 1973, the actual beneficial impact of controls may have evaporated

in 1973 instead of in 1974. But this point seems only to influence timing and not to deny the two main conclusions reached below--that the controls did have an impact on prices in 1971-72, and that the beneficial impact was only temporary.

Choice of Evaluation Techniques and Explanatory Models

The most common technique used to evaluate the impact of the Nixon controls during the first round of research in 1971-73 was the comparison of the actual path of inflation with the path projected in the dynamic simulation of a model estimated for the pre-controls period. This technique is used again here, with equations estimated for the period ending in 1971:Q2 simulated to evaluate the Nixon controls and for the period ending in 1977:Q4 used to evaluate the voluntary Carter pay standards. The results from the dynamic simulations of the 1954-71 equations are supplemented with an alternative evaluation based on the coefficients of dummy variables included in equations for the full 1954-80 period, in order to use information from the decade of the 1970s on the impact of variables that were important during the Nixon controls interval but not before 1971, especially the effect of flexible exchange rates.

The "basic" equation developed below in section VI represents our best effort to describe the inflation process during 1954-80 using a single reduced-form equation. The specification developed there has already proved its usefulness in studies of a longer historical period stretching back to the late nineteenth century. In addition, sections IV and V present for the sake of comparison two much simpler models. Section IV presents an ARIMA model of the inflation process that imposes no structure at all on the data, except for the restrictive assumption that inflation depends only on its own lagged values. Section V presents a model in which the only explanatory variables are current and lagged changes in the money supply, thus forcing the impact of inertia to work through the coefficients on lagged money, and excluding the impact of other variables that play a role in the complete specification of section VI.

IV. THE ARIMA MODEL

Methodology and Specification

A straightforward way to view the evolution of any time series is as a univariate stochastic process. Following Quenouille (1957), Zellner and Palm (1974) provide a justification for this practice. We start from a linear dynamic equation system relating jointly covariance stationary variables,

$$H(B)x_t = F(B)e_t, \quad (3)$$

where H(B) and F(B) are finite polynomial matrices in the lag operator, x_t is the vector of variables, and e_t is a vector of independent white noise disturbances. Under the usual assumption that H is invertible, we can write

$$x_t = H^{-1}(B)F(B)e_t = \frac{H^*(B)}{|H(B)|} F(B)e_t. \quad (4)$$

This implies

$$|H(B)|x_t = H^*(B)F(B)e_t,$$

where H^* is adjoint to H. The i^{th} variate has the representation

$$|H(B)|x_{it} = \alpha_i' e_t,$$

where $|H(B)|$ is a scalar polynomial and α_i' is the i^{th} row of $H^*(B)F(B)$. Because the sum of independent moving average processes of order q is also a moving average process of order q, x_i has the ARMA (autoregressive moving average) representation

$$\phi(B)x_{it} = \theta_i(B)a_{it}, \qquad (5)$$

where a_{it} is scalar white noise, $\phi(B) = |H(B)|$, and $\theta_i(B)$ is a finite polynomial in the lag operator.

It is clear that the a_i will be, in general, correlated. Because this fact is overlooked in univariate time series work, such models must be inferior to multiple time series models that exploit these correlations. Feige and Pearce (1976) have used univariate ARIMA models to assess the effects of the Nixon controls.[12] While we find univariate ARIMA models inadequate to quantify the dynamics of the inflation process, this approach is useful as a point of departure for our more complete specification developed in section VI.

Our ARIMA analysis concentrates on second differences of the logarithm of the quarterly fixed-weight GNP deflator $((1-B)p_t)$. The data plot and autocorrelation function of $(1-B)p_t$ show no indication of nonstationarity. The autocorrelation function and partial autocorrelation function each have a single significant peak at lag 1; the partial autocorrelation function has smaller peaks at lags 3 and 5. These facts suggest, but do not demand, an ARIMA (0,1,1) model, i.e., $(1-B)p_t = (1-\theta B)a_t$.[13] This accords with the finding of Granger and Newbold (1977) that appropriately differenced economic time series are often well represented by low order moving average processes.

When a variety of low order ARIMA models were fit to the data for quarters excluding the Nixon controls interval (i.e., 1954:Q1-1971:Q2 plus 1975:Q2-1980:Q2), we obtained the following estimates. [14]

Line	Model Designation	Parameter Estimates: Autoregressive		Parameter Estimates: Moving Average		S.E.E.	Q
1.	(0,1,0)	----	----	----	----	1.20	27.2
2.	(2,1,0)	-.43*	-.12	----	----	1.06	16.5
3.	(1,1,0)	-.42*	----	----	----	1.08	15.1
4.	(1,1,1)	-.35	----	.10	----	1.08	14.5
5.	(0,1,1)	----	----	.52*	----	1.07	10.1
6.	(0,1,2)	----	----	.51*	.02	1.08	9.9

*Indicates significance at the 95 percent level.

While line 2 has the lowest standard error, its Q statistic is higher than the models listed on lines 3 through 6.[15] The fact that the second autoregressive parameter of line 2 is not significantly different from zero mirrors the fact that the standard error of line 2 is not significantly less than line 3. Therefore, line 3 is preferred to line 2. Line 5 dominates line 3, so the ARIMA (0,1,1) model is selected as an adequate univariate representation of the inflation process. When estimated only over the pre-controls period 1954:Q1-1971:Q2, this model has as its single parameter $\theta = .57$, a standard error of estimate of 1.00, and Q = 10.0.

Estimated Controls Effects

As is true throughout this paper, both the dummy variable and post-sample dynamic simulation techniques are used to evaluate the impact of the Nixon control program. Both methods require that we establish the timing of the program, since both dummy variables and calculations of post-sample simulation errors must be dated. Because the controls program began as a surprise, there is no reason to believe it had any effect before August 15, 1971, and thus it is assumed that the program had an immediate impact on inflation beginning in 1971:Q3.

As for its duration, the controls program is alternatively assumed to restrain inflation through Freeze I only (1971:Q4), through Phase II (1972:Q4), and through Freeze II (1973:Q3). Periods of catchup inflation due to the removal of controls are assumed alternatively to begin immediately after the periods above, and after the end of Phase IV (1974:Q2). In any event, the rebound effect from the controls program is assumed to have run its course a year after the final dismantling of the controls program (1975:Q1).

The use of dummy variables in ARIMA models, i.e., intervention analysis, is slightly more complicated than in usual regression (see Box and Tiao, 1975). Suppose non-controls inflation follows $(1-B)p_t = (1-\theta B)a_t$, and controls and the subsequent rebound are thought to depress and increase mean inflation. Then,

$$(6) \qquad p_t = \frac{1-\theta B}{1-B}a_t + \omega_1 ON_t + \omega_2 OFF_t,$$

and

$$(7) \qquad \frac{(1-B)p_t}{1-\theta B} = \frac{(1-B)\omega_1 ON_t}{1-\theta B} + \frac{(1-B)\omega_2 OFF_t}{1-\theta B} + a_t,$$

in which a_t is a white noise, justifying conventional multiple regression. Because

$$\frac{1-B}{1-\theta B} = 1 - B(1-\theta)(1+\theta B+\theta^2 B^2+ \ . \ . \ .),$$

each variable in (7) is first transformed by deducting an exponential weighted moving average of prior values.[16]

Estimated coefficients of "on" and "off" controls effects from equations estimated for the interval 1954:Q2 through 1980:Q2 are reported in the upper part of Table 2. The standard error and Durbin-Watson statistic for a regression without transformed intervention dummies is reported in column (1). These statistics compare unfavorably with those associated with the ARIMA models reported in the previous section because of the addition to the sample period of the control quarters 1971:Q3-1975:Q1. The statistics also compare unfavorably with those of the other columns in Table 2, suggesting that some modeling of the controls episode is preferable to none.

In columns (2) through (5) the reported coefficients are of the total cumulative effect of the program on the price level. That is, the "on" and "off" variables are scaled so that they add to 4.0 over the full period they are in effect. Column (2), for example, estimates that by the end of Phase II prices were 2.9 percent lower than they would have been had there been no controls. The catch-up inflation beginning after Freeze II more than eliminated this gain, and in the price level wound up 1.53 percent higher than otherwise (i.e., 1.53 equals the 4.43 "off" effect minus the 2.90 "on" effect). The equations in columns (4) and (5) also display significant restraint of inflation in the controls period, while all of the equations in columns (2) through (5) exhibit a significant post-controls rebound effect.

The bottom of Table 2 exhibits results from a dynamic simulation in which the ARIMA parameter estimated for the period ending in 1971:Q2 is used to generate post-sample forecasts, with forecast rather than actual values used as the lagged dependent variable for all quarters after 1971:Q2.

TABLE 2

Alternative Estimates of Nixon Controls Effects
in ARIMA Models Estimated to the Period 1954:Q2-1980:Q2[a]

	(1)	(2)	(3)	(4)	(5)
1. "On" Effect					
a. 1971:Q3-1971:Q4	----	----	-0.64	----	----
b. 1971:Q3-1972:Q4	----	-2.90*	----	-3.14*	----
c. 1971:Q3-1973:Q3	----	----	----	----	-4.22*
2. "Off" Effect					
a. 1973:Q4-1975:Q1	----	4.43*	----	----	----
b. 1974:Q2-1975:Q1	----	----	2.50*	2.46*	2.24*
3. Regression Statistics					
a. S.E.E.	1.25	1.12	1.19	1.15	1.16
b. D.W.	1.62	2.16	1.89	2.07	2.01
4. Corresponding Errors in Dynamic Simulations of Equations Estimated for 1954:Q2-1971:Q2					
a. "On" Error	----	-1.94	-0.81	-1.93	-0.70
b. "Off" Error	----	7.46	5.28	5.28	5.28

[a]The dependent variable is 400 times the quarterly first difference of the log of the fixed weight deflator, filtered as described in the text.

*Indicates significance at 95 percent level.

The resulting simulated values of p_t are the best estimate that can be produced by the ARIMA model of the inflation that would have occurred after 1971:Q2 based on information available at that date. The numbers displayed in lines 4a and 4b of Table 2 represent the difference between the actual and simulated values for the various sub-periods designated in lines 1 and 2. Thus the simulation error in each column corresponds to the time period of the dummy variable used in the intervention analysis shown in the same column.

The ARIMA model estimated does much better in explaining why there was so little inflation during mid-1971 through mid-1973 than in explaining why there was so much inflation between mid-1973 and early 1975. In short, the total amount of inflation between mid-1971 and early 1975 is underpredicted by the dynamic simulations.

Why does the underprediction occur in the dynamic simulation but not in the intervention analysis in the upper part of Table 2? In contrast to the simulated value, which uses a parameter estimated from the 1954-71 period to generate the lagged dependent variable, the dummy variables are estimated in equations for 1954-80 in which the *actual* lagged dependent variable is used. Thus any variables other than the controls that influenced actual inflation after 1971, e.g., oil and food prices, are implicitly taken into account in the intervention analysis in the upper part of the table but not by the simulation analysis in the lower part. This, of course, is one of the disadvantages of the simulation technique cited in our methodological discussion above.

V. A "MONEY-ONLY" EXPLANATION OF INFLATION

Recently a great deal of attention in the U. S. empirical macroeconomics literature has been focussed on models in which the price change process is driven by little other than current and lagged changes in the money supply.[17] In such models there is no role for supply shifts, either in the form of the Nixon controls or changing relative prices of food and energy, and any inertia in the price-setting process is forced to enter through the lagged money terms rather than through lagged price terms, which are excluded by assumption.

Column (1) of Table 3 is based on an equation for 1954-80 that explains price change as a function only of a constant, the current rate of change of M1B, and 27 lagged changes in money, where the lagged coefficients are estimated by the polynomial distributed lag technique. As is evident in a comparison of column (1) in Tables 2 and 3, the ARIMA and money-only models fit the data equally well, with respective standard errors of 1.25 and 1.27 percentage points (recall that the dependent variable is expressed as a percentage annual rate). We shall see in section VI that these standard errors are relatively large, in the sense that the standard error in explaining the same dependent variable for the same sample period can be cut almost in half by using a more complete specification of the inflation process.

The rest of Table 3 is arranged exactly like Table 2. Lines 1 and 2 exhibit coefficients on dummy variables estimated for various "on" and "off" periods in equations that also include current and past monetary changes. The general pattern of the dummy variables is very close to that of Table 2; all "on" dummy coefficients are within 0.50 of each other in the two tables,

TABLE 3

Alternative Estimates of Nixon Controls Effects in Equations Explaining Inflation by Current and Lagged Monetary Growth Estimated to the Period 1954:Q2-1980:Q2[a]

	(1)	(2)	(3)	(4)	(5)
1. "On" Effect					
a. 1971:Q3-1971:Q4	----	----	-1.00*	----	----
b. 1971:Q3-1972:Q4	----	-3.26*	----	-3.31*	----
c. 1971:Q3-1973:Q3	----	----	----	----	-3.92*
2. "Off" Effect					
a. 1973:Q4-1975:Q1	----	4.07*	----	----	----
b. 1974:Q2-1975:Q1	----	----	3.04*	3.07*	3.06*
3. Sum of Coefficients on Current and Lagged Money[b]	1.47*	1.43*	1.41*	1.46*	1.47*
4. Regression Statistics					
a. S.E.E.	1.27	1.04	1.13	1.05	1.07
b. D.W.	1.06	1.54	1.38	1.60	1.54
5. Corresponding Errors in Dynamic Simulations of Equations Estimated for 1954:Q2-1971:Q2					
a. "On" Error	----	-3.46	-1.10	-3.46	-3.75
b. "Off" Error	----	5.34	4.09	4.09	4.09

[a] The dependent variable is 400 times the quarterly first difference of the log of the fixed weight deflator.

[b] Sum of 28 distributed lag coefficients constrained to lie on a fifth degree polynomial with zero end constraint.

*Indicates significance at 95 percent level.

and all "off" coefficients are within 1.00 of each other. It is interesting that columns (2), (4), and (5) in Table 3 display "on" and "off" coefficients that are fairly close in absolute value, indicating that there is no puzzle of unexplained high inflation in 1974 from the point of view of these equations. A final remark on the 1954-80 results is that the standard errors of the money equations in Table 3 that include dummy variables are uniformly better than the corresponding equations of Table 2. Although there is more evidence of positive serial correlation in the money results, this is to be expected in view of the bias in Durbin-Watson statistics present when a lagged dependent variable is included, as in Table 2, but not Table 3.

Lines 5a and 5b of Table 3 display errors in post-sample simulations of equations estimated for 1954-71 that include only a constant term and current and lagged money. In contrast to the simulation results in Table 2, there does not seem to be a serious problem of underprediction of price change during the 1971-75 period. In column (5), which includes all but two of the quarters between 1971:Q3 and 1975:Q1, the cumulative "on" error and "off" error are about equal in absolute value, whereas in Table 2 the corresponding column indicates a cumulative underprediction of about 4.5 percentage points.

Why should the post-sample simulations of the money-only equations be more adequate in explaining cumulative inflation during 1971-75? The answer is implied by the simple summary statistics of Table 1. The naive ARIMA model is forced to predict inflation in 1971-75 only on the basis of information available about inflation during 1954-71 and thus has no basis upon which to explain the high average rate of inflation during 1971-75. In contrast the money-only version explains high inflation during 1971-75 through the contribution of the acceleration in average monetary growth that occurred in the early 1970s, as well as through the contribution of its long lag distribution when multiplied by the relatively rapid rate of money growth that occurred in the late 1960s. In short, the money-only post-sample simulation has a piece of evidence on what actually happened in the early 1970s, the acceleration of money growth, whereas the ARIMA simulation has no information at all on what actually happened in the early 1970s. This interpretation also helps to explain why the dummy variable and simulation techniques give roughly the same results in Table 3 and not in Table 2. In Table 3 the two techniques use essentially the same information and differ only on the estimated coefficients; in contrast in Table 2 the two techniques are based both on different information and on different coefficients.

VI. A MORE COMPLETE SPECIFICATION OF THE INFLATION PROCESS

Relation of the Reduced-Form Specification to Conventional Wage and Price Equations

The two previous sections examined the effect of government intervention in the price-setting process within the context of two extremely restricted models. The ARIMA specification implies that inflation depends only on its own past values, i.e., that "inertia" is the only element in the inflation process. The money-only approach combines a pure demand framework in its introduction of current monetary changes with a role for inertia through the inclusion of lagged monetary changes. Yet both specifications exclude many variables that may in fact help to explain inflation, especially supply factors like oil and food prices, productivity growth, payroll taxes, and the minimum wage. We may also ask whether there is any role in the inflation process for the traditional Phillips curve variable that represents the impact of aggregate demand, i.e., the level of the unemployment rate or the output ratio.

Our more complete specification begins with separate equations explaining wage change and the relation of prices to wages, which we then combine to eliminate the wage variable. In the subsequent discussion upper-case letters represents logs of levels of variables and lower-case letters represent rates of change; where possible the notation is chosen to correspond to that in Gordon (1980a). Our basic demand variable, representing the effect on inflation of labor-market tightness and the pressure of excess commodity demand, is the output ratio ($\hat{Q}_t$), the log of the ratio of actual real GNP (Q_t) to "natural" real GNP (Q_t^*), i.e., $\hat{Q}_t = Q_t - Q_t^*$. The role of excess demand is always entered both as a level ($\hat{Q}_t$) and also as a rate of change ($\hat{q}_t$).

The rate of change of wages (w_t) is assumed to depend on lagged price changes (p_{t-1}) plus the "equilibrium" growth in the real wage (λ_t), the level and rate of change of the output ratio, supply shifts in the wage equation (z_{wt}), and an error term (ε_{wt}):

$$w_t = \alpha_0(p_{t-1} + \lambda_t) + \alpha_1\hat{Q}_t + \alpha_2\hat{q}_t + \alpha_3 z_{wt} + \varepsilon_{wt}. \quad (8)$$

The actual growth in the real wage rate (relative to last period's inflation rate) will not be at the equilibrium rate unless $\alpha_0 = 1$ and all the other variables in the equation ($\hat{Q}_t$, $\hat{q}_t$, z_y, and ε_{wt} have realizations equal to zero. Among the supply shifts (z_{wt}) that might enter the wage equation are the impact of government controls and of changes in the payroll tax and minimum wage rate. Because w_t is the same variable that enters the price equation, it is implicitly defined as "gross employer labor cost" including employer-financed fringe benefits and payroll taxes.

The price mark-up equation relates current price change (p_t) to the current change in "standard" unit labor cost ($w_t - \sigma_t$), the same demand variables as appear in (8), a vector of supply shift variables (z_{pt}) that influence the level of prices relative to wages, and an error term (ε_{pt}):

$$(9) \qquad p_t = \beta_0(w_t - \sigma_t) + \beta_1\hat{Q}_t + \beta_2\hat{q}_t + \beta_3 z_{pt} + \varepsilon_{pt}.$$

The fact that the current wage enters the price equation, but only lagged price change enters the wage equation, is an expositional convenience that is not essential for what follows. Among the supply shift variables (z_{pt}) that could enter into the price equation are government controls, changes in foreign exchange rates and in the relative prices of food and energy, and shifts in indirect tax rates. In principle, capital costs should enter into the price equation, as in Gordon (1975), but capital costs complicate the exposition without providing any substantial improvement in the explanation of inflation that is provided below.

When (8) is substituted into (9), we obtain a reduced-form inflation equation:

$$(10) \qquad p_t = \beta_0\alpha_0 p_{t-1} + \beta_0(\alpha_0\lambda_t - \sigma_t) + (\beta_1+\beta_0\alpha_1)\hat{Q}_t + (\beta_2+\beta_0\alpha_2)\hat{q}_t$$
$$+ \beta_3 z_{pt} + \beta_0\alpha_3 z_{wt} + \varepsilon_{pt} + \beta_0\varepsilon_{wt}.$$

The long-run equilibrium properties of (10) can be seen more easily if we combine the separate z variables, error terms, and coefficients from the wage and price equations:

(11) $$p_t = \gamma_0 p_{t-1} + \gamma_0(\lambda_t - \sigma_t) + (\gamma_0 - \beta_0)\sigma_t + \gamma_1 \hat{Q}_t + \gamma_2 \hat{q}_t + \gamma_3 z_t + \varepsilon_t,$$

where $\gamma_0 = \beta_0\alpha_0$; $\gamma_1 = \beta_1 + \beta_0\alpha_1$; $\gamma_2 = \beta_2 + \beta_0\alpha_2$; $z_t = \beta_3 z_{pt} + \beta_0\alpha_3 z_{wt}$;

and $\varepsilon_t = \varepsilon_{pt} + \beta_0\varepsilon_{wt}$.

What are the conditions necessary for (11) to generate a constant equilibrium rate of inflation? First, the coefficient on lagged price change (γ_0) must be unity. Second, the equilibrium real wage term in the wage equation and standard productivity growth in the price equation must be equal ($\lambda_t - \sigma_t = 0$). Third, the coefficient on standard unit labor cost in the price equation must be unity ($\gamma_0 = \beta_0 = 1$).[18] Fourth, the level and rate of change of the output ratio, as well as every supply shift variable, must also be equal to zero ($\hat{Q}_t = \hat{q}_t = z_t = 0$). Correspondingly (11) lays out those events that can cause the inflation rate to accelerate, including an excess of λ_t over σ_t, a level of the log of the output ratio above zero, a positive rate of growth of the output ratio, and any adverse supply shock. Clearly $\hat{Q}_t = 0$ (i.e., $Q_t = Q_t^*$), represents the "natural rate of output" only if all of the other conditions stated in the previous sentence are valid. If there is, for instance, an adverse supply shift ($z_t > 0$), inflation can accelerate even if $\hat{Q}_t = 0$. In other words an excess of λ_t over σ_t or a positive realization of any z_t variable, pushes the "constant inflation" level of output below the value of Q_t^* from which $\hat{Q}_t$ is calculated. Thus the framework of equation (11) has the potential of explaining why inflation accelerated during the 1970s, despite the fact that the measure of $\hat{Q}_t$ summarized in Table 1 was negative on average during the decade.

Two additional elements could be introduced into the model of (8) and (9), but are not pursued here to simplify the paper. First, the workings of inertia in (8) could take the form of a dependence of wages on lagged wages rather than lagged prices. In this case lagged wages would enter (10), and thus a wage equation as well as a price equation would have to be estimated in order to close the model. Second, wages could depend on consumer prices, which differ from the value-added prices determined by (9), since the former include imports. Such a specification would bring the difference between consumer and value-added prices into (10) as an additional variable. During the decade of the 1970s, this difference is highly correlated with the food-energy supply shift variable introduced below, so that our reduced-form implicitly captures most of the impact of consumer prices on wages.

There is one rather subtle obstacle to the estimation of (11). We would expect the rate of inflation to respond positively to the speed of economic expansion, $\hat{q}_t$. But there are two reasons why p_t and $\hat{q}_t$ may have a negative correlation that results in a downward bias in the coefficient γ_2. One reason is measurement error; since nominal GNP and prices are measured independently, with real GNP as a residual, any error in the measurement of prices introduces an opposite movement in $\hat{q}_t$. Second, for any given growth rate of nominal GNP, a supply shock ($z_t > 0$) raises p_t and reduces $\hat{q}_t$; any errors in measurement of the z_t variables may introduce a spurious negative correlation between p_t and $\hat{q}_t$. To avoid this problem we use the identity $p_t + \hat{q}_t = \hat{y}_t$, where the latter variable stands for the excess of nominal GNP growth over the growth in natural real GNP ($\hat{y}_t = y_t - q_t^*$). When this identity is substituted for $\hat{q}_t$ in (11), we can factor out p_t and obtain our final estimating equation:

$$(12) \qquad p_t = \frac{1}{1+\gamma_1+\gamma_2}[\gamma_0 p_{t-1} + (\gamma_1+\gamma_2)\hat{y}_t + \gamma_1\hat{Q}_{t-1} + \gamma_0(\lambda_t-\sigma_t) + \gamma_3 z_t + \varepsilon_t],$$

where for convenience we assume $\beta_0 = \gamma_0$.

(12) is the final form for which we provide estimates in this section of the paper. All that remains is to specify the productivity term ($\lambda_t - \sigma_t$) and the exact variables to represent the supply shock terms (z_t). We note that the long-run equilibrium properties of (12) differ slightly from those of (11). If the sum of coefficients on lagged prices in (11) is unity ($\gamma_0 = 1$), then in (12) it will be the sum of the coefficients on lagged prices and on $\hat{y}_t$ that equal unity.

Stepwise Introduction of Individual Variables

The basic inflation equation to be examined, analyzed, and simulated in the rest of this paper contains a number of variables, some of which are unconventional. To make our approach easier to understand, we present in Table 4 eight equations which introduce the explanatory variables one at a time. Our explanation of the method of construction of each variable accompanies the discussion of the equation where that variable is introduced.

1. *Lagged Inflation.* Column (1) of Table 4 presents an extremely simple equation in which the inflation rate is explained only by its own lagged values. The dependent variable and sample period are identical to Tables 2 and 3, and the only difference between this equation and the ARIMA equation in column (1) of Table 2 is the method of specifying the lag distribution. Here in Table 4 the coefficient of 1.04 is not a single coefficient for a single lagged dependent variable, but rather the sum of 24 lag coefficients constrained to lie along a fourth degree polynomial. Comparing the first columns of Table 2 and Table 4, we note that the latter has a slightly lower standard error, indicating that the flexibility provided by the polynomial distributed lag (PDL) technique provides enough of an improvement of fit to offset the extra degrees of freedom required.

2. *Nixon Control Dummies.* Tables 2 and 3 presented estimates of Nixon controls effects using dummy variables for several alternative time periods. Here we choose 1971-Q3 through 1972:Q4 for the "on" effect and 1974:Q2 through 1975:Q1 for the "off" effect, both because these periods seemed to provide the best fit in our preliminary research, and because the same periods were used in earlier papers. Column (2) suggests that dummy variables for these periods added to the pure autoregression of column (1) have insignificant coefficients. This result contrasts with the significant dummies estimated in the equivalent column (4) of Table 2, a difference that

TABLE 4

Stepwise Introduction of Variables into a Reduced-Form Inflation Equation Estimated for 1954:Q2-1980:Q2 a/

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Lagged Dependent Variable b/	1.04 (17.3)	1.05 (17.5)	1.26 (20.5)	1.16 (18.0)	1.08 (16.8)	1.00 (15.9)	0.93 (17.3)	0.94 (17.4)
2. "On" Dummy 1971:Q3-1972:Q4 c/	----	-1.16 (-1.59)	-2.22 (-3.43)	-2.43 (-4.00)	-2.52 (-4.38)	-1.70 (-3.33)	-1.58 (-3.48)	-1.45 (-3.18)
3. "Off" Dummy 1974:Q2-1975:Q1 c/	----	0.75 (0.99)	2.84 (4.46)	2.99 (5.07)	3.16 (5.65)	2.38 (4.57)	1.29 (2.34)	1.52 (2.53)
4. Lagged Output Ratio ($\hat{Q}_{t-1}$)	----	----	0.31 (5.56)	0.29 (5.40)	0.27 (5.42)	0.24 (4.43)	0.23 (4.94)	0.23 (4.79)
5. Nominal GNP Growth ($\hat{y}_t$)	----	----	----	0.09 (3.74)	0.09 (3.90)	0.20 (6.91)	0.18 (6.97)	0.17 (6.74)
6. Food and Energy Prices	----	----	----	----	0.29 (3.43)	0.26 (3.53)	0.27 (4.04)	0.29 (4.21)
7. Productivity Deviation d/	----	----	----	----	----	-0.43 (-5.86)	-0.39 (-5.95)	-0.38 (-5.91)
8. Effective Exchange Rate d/	----	----	----	----	----	----	-0.11 (-3.99)	-0.09 (-3.33)
9. Social Security Tax d/	----	----	----	----	----	----	----	0.43 (2.19)
10. Minimum Wage Rate d/	----	----	----	----	----	----	----	0.02 (1.47)
11. a. S.E.E.	1.23	1.19	0.99	0.92	0.88	0.75	0.67	0.65
b. D.W.	1.54	1.63	2.01	2.11	2.26	2.29	2.17	2.22

Notes to Table 4

a. The dependent variable is the same as that in Table 3. The numbers in parentheses are t statistics.

b. The coefficient shown is the sum of 24 distributed lag coefficients constrained to lie along a fourth degree polynomial with a zero end-point constraint.

c. The dummy variables are constrained to add up to 4.0 (reflecting the conversion of quarterly changes of all variables to annual rates). Thus the "on" dummy is equal to 2/3 for the six quarters listed, and the "off" dummy is equal to 1.0 for the four quarters listed.

d. The coefficient shown is the sum of a set of unconstrained coefficients on the current and lagged values, with four lags included on lines 7, 9, and 10, and two lags included on line 8.

All regressions contain an insignificant constant.

may be explained by the ability of the PDL distribution to twist around enough to explain partially the slowdown of inflation of 1972 and acceleration of 1974.[19]

3. *The Lagged Output Ratio* ($\hat{Q}_{t-1}$). Column (3) adds the lagged output ratio, one of the two "demand" variables that appear in equation (12). This traditional Phillips curve variable is highly significant; its coefficient of 0.31 indicates that a one percentage point excess of actual real GNP above natural real GNP causes an acceleration of inflation of 0.31 percentage points at an annual rate per quarter. The total acceleration over the first year of such an excess would be greater than 0.31 percentage points, because after the first quarter the additional inflation would begin to feed through the lagged dependent variable. Two important features of column (3) are the jump in the size and significance of the Nixon control dummies, and the increase in the sum of coefficients on the lagged dependent variable. The former reflects the negative correlation of $\hat{Q}_{t-1}$ and the inflation rate in the early 1970s (see Table 1), i.e., in column (3) the "computer cannot understand" why inflation accelerated in 1974 when $\hat{Q}_{t-1}$ was dropping and thus assigns a positive and significant dummy to the controls "off" variable that is in effect at the same time. The latter shift results from the failure of inflation to slow down in the 1970-71 recession, so that the lagged dependent variable must be assigned a greater role when the $\hat{Q}_{t-1}$ variable (which fell from 1969 to 1970-71) is introduced.

4. *Adjusted Nominal GNP Growth* ($\hat{y}_t$). The nominal GNP growth variable that appears in equation (12) is defined net of natural real GNP growth. The same natural real GNP variable is used in level form to define

the output ratio ($\hat{Q}_t$) and in growth-rate form to adjust the officially measured rate of nominal GNP growth. The introduction of $\hat{y}_t$ in column (4) further increases the size of the Nixon control dummy coefficients without having any impact on the theoretical γ_0 coefficient, which is now measured as the sum of the coefficients displayed on line 1 and line 5. Note that a slowdown in the trend growth rate of productivity will reduce natural real GNP growth and raise $\hat{y}_t$, so that this variable represents the combined effects of demand stimulation and long-run productivity growth.

5. *Relative Prices of Food and Energy*. The first of the supply shock variables to be introduced in Table 4 is the contribution to inflation of changes in the relative prices of food and energy. This effect is measured by the difference between the rate of change of the private business deflator and that of an alternative deflator that attempts to "strip out" the impact of the changing relative prices of food and energy.[20] While this variable is significant and makes a contribution to the fit of the equation without causing appreciable changes in the size of the other coefficients, its own coefficient seems surprisingly low. This probably reflects errors in the measurement of the true food-energy contribution; our variable exhibits substantial jumps from quarter to quarter that may miss the actual timing of the impact of food and energy prices. Also our dependent variable in this paper is the fixed-weight GNP deflator, which differs both in coverage and in weighting from the implicit deflator for private business used to construct the food-energy variable.

6. *Productivity Deviation*. The second supply variable is the deviation of the rate of growth of nonfarm labor productivity from its trend,

estimated in a regression of the quarterly growth rate of nonfarm productivity for 1954-80 that contains a constant and a single trend beginning in 1970. This trend falls from a growth rate of about 2.5 percent to zero over the 1970-80 decade, and a distributed lag of residuals from the productivity equation is entered in line (6) into the inflation equation. The justification for the appearance of this variable stems from our inability to observe the productivity variable that firms actually use in adjusting labor costs when making their pricing decisions. Let us imagine that the productivity variable in the wage equation (λ_t) is a constant representing a straight time trend, t_w, whereas the "standard" productivity variable in the price equation (σ_t) is a weighted average of the actual growth rate of productivity (ρ_t) and another constant trend (t_p):

$$(13) \qquad \lambda_t = t_w,$$

$$(14) \qquad \sigma_t = \mu(\rho_t) + (1-\mu)t_p,$$ [21]

so that the productivity variable that appears in equation (12) becomes:

$$(15) \qquad \lambda_t - \sigma_t = t_w - t_p - \mu(\rho_t - t_p).$$

The $(t_w - t_p)$ term becomes absorbed in the constant of the inflation equation and is indistinguishable from the other possible source of a non-zero constant term, the mismeasurement of the level of natural real GNP.

The introduction of the productivity deviation variable in column (6) of Table 4 yields a highly significant estimate of μ=0.43, indicating that firms base their pricing decisions on a productivity variable that combines actual productivity with a 43 percent weight and a time trend with a 57 percent weight. Coefficients on several other variables change in response to the introduction of the productivity deviation. The Nixon controls effect becomes substantially smaller, because the rapid growth of productivity in 1972 and the decline in productivity in 1974 both help to explain why inflation was relatively low in 1972 and high in 1974, thus requiring less of a contribution from the controls dummies. The other major changes are a doubling in the coefficient on $\hat{y}_t$ and a further reduction in the sum of coefficients on the lagged dependent variable.[22]

7. *Effective Exchange Rate.* The depreciation of the dollar during the 1970s has not been included as an explanatory variable in previous studies, mainly because it has been difficult to find a statistically significant effect for changes in the exchange rate. We believe that this previous insignificance of the exchange rate stems from the impact of the Nixon controls in delaying the adjustment of U. S. domestic prices to the dollar depreciation that occurred in two stages between 1971 and 1973. We have created a new variable which is equal to the actual change in the effective exchange rate of the dollar (i.e., the number of units of a market basket of foreign currencies that the dollar can buy each quarter) starting in 1974:Q3, but which is set equal to zero before 1974 and thus forces the entire 16 percent decline in the effective exchange rate that occurred between 1971:Q3 and 1974:Q2 to occur in two quarters, 1974:Q1 and 1974:Q2. Column (7) of Table 4 indicates that this new effective exchange rate variable is highly significant and substantially weakens the Nixon controls "off" effect, in effect implying that the delayed impact of dollar depreciation rather than the termination of controls *per se* explains why inflation accelerated so much during 1974.

8. *Payroll Tax.* Discussions of economic policy in the past five years have devoted much attention to "self-inflicted wounds," whereby the government has introduced policies that directly worsen the inflation rate. One of these factors, changes in the effective social security tax rate, is entered into our basic equation as a five-quarter unconstrained distributed lag in column (8) of Table 4.[23] A sum of coefficients of 1.00 on this variable would indicate that all changes in the effective tax rate, which includes both the employee and employer shares of the tax, are shifted forward into prices. The coefficient of 0.43 in column (8) indicates a shifting effect that is only partial but by no means negligible.

9. *Effective Minimum Wage Rate.* Another much-discussed "self-inflicted wound" has been increases in the effective minimum wage rate, defined as the ratio of the statutory minimum wage to average hourly earnings in the nonfarm private economy. This variable, also entered as a five-quarter unconstrained lag, has only a marginal inflationary impact in column (8). The sum of coefficients of 0.02 means that the cumulative 8 percent increase in the effective minimum wage rate during the four quarters of 1978 accounted for an acceleration of inflation of about 0.16 percentage points. In section IX below we examine the quantitative impact of the "self-inflicted wounds" in accounting for the variance and overall acceleration of inflation in the 1970s.

Conclusion to Section VI.

The final equation presented in Table 4 has a standard error of 0.65, little more than half of the standard error of the pure autoregression in column (1) or of the pure ARIMA or money-only equations presented in Tables

2 and 3. The fraction of the total variance of the dependent variable that remains unexplained drops from 16.4 percent in column (1) to 3.6 percent in column (8). Thus the more complete model substantially improves our ability to explain the behavior of the 1954-80 inflation rate.

VII. ESTIMATED IMPACT OF CONTROLS, PAY STANDARDS, AND GUIDELINES

Our methodological discussion in section III compared two methods of estimating the effects of price controls and other types of government intervention. Dummy variables, such as those included in Table 4, have the advantage that all of the available historical data can be included in equations that are used to estimate their coefficients, and the disadvantage that they force the effect of a particular intervention program to have a uniform impact each quarter. The other alternative method, post-sample dynamic simulations, has the advantage that arbitrary decisions regarding the timing of the program can be avoided, and the disadvantage that the impact of important variables that operate only in the post-sample period cannot be assessed. If these left-out variable effects interact with the controls, then the post-sample dynamic simulations can give quite different answers than the dummy variable technique.

A method introduced by Blinder (1979) estimates an equation for the entire sample period, taking advantage of all the data as in the dummy variable technique, but instead of using dummy variables, constructs a new variable to represent the impact of the controls that is equal to the fraction of the CPI subject to price controls in each month, based on government records. The Blinder approach has two advantages over the dummy variable technique. First, there is no need to make arbitrary decisions regarding timing, as must be done in dating dummy variables, since the constructed variable contains its own independent information on timing. Second, the controls are allowed to have varying effects each quarter rather than the uniform effect imposed by our "on" and "off" dummies. Below we shall examine the consequences of replacing our dummy variables with the Blinder variables and compare the assessment of the controls implied by the two techniques.

Evaluating the Nixon Controls Period with Simulations and Dummy Variables

Table 5 provides the information needed to compare alternative methods of evaluating the quantitative impact of the Nixon controls program. Below in this section we shall also examine the implications of the same techniques for an assessment of the Kennedy-Johnson guidelines and the Carter pay standards. The basic inflation equation is presented in three pairs. Each of the three pairs is estimated for a different sample period, in every case starting in 1954:Q2 and ending, respectively, in 1971:Q2, 1977:Q4, and 1980:Q2. For each sample period the left column presents an unconstrained estimate, and the right column presents a variant that constrains γ_0 (i.e., the sum of the coefficients on $\hat{y}_t$ and on the lagged dependent variable) to be unity. As in previous research we find that unity constraints are necessary for equations to yield adequate post-sample simulations, since the unconstrained versions tend to contain estimates of γ_0 that exceed unity and thus make the equations dynamically unstable.[24]

The first pair of columns in Table 5 presents unconstrained and constrained equations for the portion of the sample period ending in 1971:Q2, that is, just before the imposition of controls. The unconstrained equation

TABLE 5

Unconstrained and Constrained Versions of the Basic Inflation Equation Estimated for Alternative Sample Periods a/

	1954:Q2-1971:Q2 b/		1954:Q2-1977:Q4		1954:Q2-1980:Q2	
	Unconstrained	Constrained	Unconstrained	Constrained	Unconstrained	Constrained
	(1)	(2)	(3)	(4)	(5)	(6)
1. Lagged Dependent Variable	1.26 (7.20)	0.85	0.93 (14.01)	0.85	0.94 (17.37)	0.85
2. "On" Dummy	----	----	-1.34 (-2.93)	-1.25	-1.45 (-3.18)	-1.29
3. "Off" Dummy	----	----	0.82 (1.10)	1.20	1.52 (2.53)	1.43
4. Lagged Output Ratio ($\hat{Q}_{t-1}$)	0.26 (3.23)	0.26	0.23 (4.72)	0.21	0.23 (4.79)	0.20
5. Nominal GNP Growth ($\hat{y}_t$)	0.17 (4.90)	0.16	0.17 (5.75)	0.16	0.17 (6.74)	0.16
6. Food and Energy Prices	0.45 (3.47)	0.35	0.29 (3.89)	0.32	0.29 (4.21)	0.36
7. Productivity Deviation	-0.30 (-3.33)	-0.37	-0.36 (-4.96)	-0.33	-0.38 (-5.91)	-0.36
8. Effective Exchange Rate	----	----	-0.14 (-3.59)	-0.14	-0.09 (-3.33)	-0.11
9. Social Security Tax	0.49 (2.05)	0.34	0.43 (2.11)	0.50	0.43 (2.19)	0.48
10. Minimum Wage Rate	0.035 (2.40)	0.028	0.027 (1.87)	0.028	0.021 (1.47)	0.024
11. Constant	-0.64 (-1.82)	0.30	-0.01 (-0.09)	0.21	-0.03 (-0.18)	0.27
12. a. S.E.E.	.615	.662	.647	.658	.646	.664
b. D.W.	2.17	1.85	2.15	2.04	2.22	2.10
13. Cumulated Errors from Dynamic Simulation within Specified Intervals c/						
a. "On" 1971:Q3-1972:Q4	-2.85	-1.23	-1.34	-1.25	-1.45	-1.29
b. "Middle" 1973:Q1-1974:Q1	-2.12	0.44	-0.05	0.02	0.04	0.06
c. "Off" 1974:Q2-1975:Q1	0.65	3.08	0.82	1.20	1.52	1.43
d. 1978:Q1-1980:02 " "	-13.89	3.98	-1.32	-0.06	-0.13	-0.03

Notes to Table 5

a. All variables are the same as in Table 4. The numbers in parentheses are t statistics. No t statistics are shown for the constrained equations, since these are not calculated correctly by standard regression programs.

b. The constraint is that γ_0, the sum of coefficients on adjusted nominal GNP growth and lagged inflation, be 1.0; our iterative procedure described in footnote 25 stopped just short of convergence (0.85 + 0.16 = 1.01).

c. Cumulated errors are divided by 4 to make the estimates of controls effects commensurate with dummy variable coefficients. Columns (3), (4), (5) and (6) report dummy variable coefficients on lines a and c and cumulated regression residuals on line b. Columns (5) and (6) report cumulated regression residuals on line d.

in column (1) can be compared with the equivalent full-sample equation in column (5), which duplicates the final column of Table 4. The main difference in the shorter sample period is the extremely high sum of coefficients on the lagged dependent variable; this phenomenon results from the failure of inflation to slow down in the 1969-70 recession in the face of a substantial decline in the contribution to inflation of the $\hat{Q}_{t-1}$ and $\hat{y}_t$ variables. In the longer sample period the sum of the coefficients on the lagged dependent variable is much closer to unity, in order to allow the equation to remain on track in the 1970s.

As would be expected in an equation that is as dynamically unstable as that in column (1), a post-sample dynamic simulation substantially overpredicts the actual rate of inflation that occurred between 1971 and 1980. Thus the negative simulation errors in 1971-73 have the misleading implication that the controls had a major effect in holding down the inflation rate, while the small positive errors in the 1974 "off" interval imply a very small rebound as compared with the estimate of "what would have happened otherwise." We do not believe that these simulation results can be taken seriously in light of the steadily growing drift of the simulated values away from the actual values as the decade proceeds.

Column (2) constrains the γ_0 coefficient to be unity, and this results in a substantial deterioration in the standard error during the equation's sample period, but a marked improvement in the ability of the post-sample dynamic simulation to track the inflation rate during the 1970s.[25] In contrast to the cumulative overprediction of inflation of 4.32 percentage points between 1971:Q3 and 1975:Q1 in column (1), inflation in column (2) for that interval is now underpredicted by 2.29 percentage points, with the implication that the "off" effect had a greater effect in raising prices than the "on" effect had in lowering prices.

Why does this result differ from the dummy variable estimates of column (6) of Table 5, where the cumulative "on" and "off" effects are about the same size? The other coefficients in the constrained short-sample and full-sample equations, columns (2) and (6), are amazingly close to each other, with the exception of the effective exchange rate, which does not appear in the short-sample equation. The post-sample simulation in column (2), which is given no information on the exchange rate, makes an underprediction error in 1974 that confuses the true controls "off" effect with the unobserved depreciation of the dollar, whereas the full-period equation in column (6) has the extra information necessary to attribute separate effects to controls and the exchange rate.

Below in the final section of the paper we run dynamic simulations that allow us to assess the separate impact of each explanatory variable to the inflation that occurred between 1970-80; those results indicate that the 1970-80 depreciation of the dollar accounted for a cumulative extra increase in the price level of 2.7 percentage points between 1978:Q1 and 1980:Q2, as opposed to a hypothetical alternative of fixed exchange rates throughout the decade. That figure can be compared to the 4.0 percentage point cumulative underprediction of inflation for the same interval in the constrained short-period equation in column (2) that does not include the exchange rate. The remaining portion of the cumulative 1978-80 simulation error in column (2) that is not due to the omission of the foreign exchange variable is only 1.4 percentage points, and this seems remarkably small for an equation that is being asked to forecast inflation between seven and nine years after the end of its sample period.[26]

The Carter Pay Standards and Other Events During 1978-80

Did the Carter pay standards, which were introduced in the fourth quarter of 1978, have any impact on the inflation rate? This question can be assessed, as in the case of the Nixon controls, either by use of the post-sample simulation or dummy variable technique. An equation estimated to the end of 1977 is used for post-sample dynamic simulations and is displayed in columns (3) and (4) of Table 5 in both unconstrained and constrained form. The coefficients are very close to those in the full-period equations displayed in columns (5) and (6), and because of this similarity we would not expect the 1954-77 equations to go seriously astray in post-sample simulations of the 1978-80 interval.

The cumulative 1978-80 simulation errors for the unconstrained and constrained versions are, respectively, -1.32 and -0.06 percentage points. Thus the unconstrained version, with its implied dynamic instability (γ_0 = 1.10), overpredicts 1979-80 inflation at about a 0.5 percent annual rate, whereas the constrained version is almost exactly on track. Within the five quarters when the first phase of the pay standards was in effect, 1978:Q4-1979:Q4, the respective cumulative errors are -0.86 and -0.18 percentage points. In light of the dynamic instability of the unconstrained equation, the implication of the constrained equation--that the pay standards had virtually no impact on the inflation rate--seems more reliable.

The alternative method of evaluating the Carter pay standards is to introduce one or more dummy variables for the period during which they were in effect. We have taken our "basic equation" from Table 4, column (8) and Table 5, column (5), and have introduced two dummy variables for the periods

1978:Q4-1979:Q4 and 1980:Q1-1980:Q2, respectively. The first dummy can be interpreted as the effect on inflation of the initial year of the pay standards, while the second dummy can be interpreted either as the effect of the second phase of the pay standards or of the "post-controls rebound" following the first stage. The resulting coefficients and t statistics are:

Carter dummy I (1978:Q4-1979:Q4)	-0.67	(-1.08)
Carter dummy II (1980:Q1-1980:Q2)	0.05	(0.18)

Both variables are insignificantly different from zero, so that the dummy variable technique supports the post-sample simulation technique in assessing the pay standards as having no impact. Both the post-sample simulations and dummy variables suggest that there was nothing unusual about the inflation experience between late 1978 and mid 1980, and that the other variables in the equation are capable of tracking the data.

Kennedy-Johnson Guidelines

Another episode of government intervention occurred during the Kennedy and Johnson administration, when there were quasi-voluntary guidelines established for wage increases. These guidelines, first mentioned in the 1962 Economic Report of the President, are generally assumed to have been in effect between early 1963 and mid-1966, when the pressure of excess demand and the victory of the airline machinists union in obtaining a large wage increase led the Administration to abandon the program. Some investigators, e.g., Perry (1980), have found that the guidelines indeed did hold down wage increases. Because the guidelines occurred relatively early in our sample period, we do not have sufficient degrees of freedom available to estimate an equation ending in 1962 for the purpose of post-sample dynamic simulations, and we are forced to rely on the dummy variable technique as were other investigators who assessed the guidelines in the past.

Our guidelines "on" variable is assumed to be in effect between 1963:Q1-1965:Q4.[27] Despite the substantial evidence presented above and elsewhere that the Nixon controls had a substantial post-control "rebound" effect, previous studies have not examined the possibility of a post-guidelines rebound. Thus we enter a separate dummy variable for the three-year period beginning in 1966:Q1 to assess the possibility that part of the 1966-68 acceleration in the inflation rate was due to the end of the guidelines rather than a general state of excess demand in the economy. When these dummy variables are included in our basic unconstrained inflation equation, the resulting coefficients and t statistics are:

Guidelines dummy I (1963:Q1-1965:Q4)	0.01	(0.01)
Guidelines dummy II (1966:Q1-1968:Q4)	0.60	(0.61)

In light of the verdict of these coefficients that the guidelines program had no significant effect on inflation, two questions remain. First, how does the basic equation explain the relatively low 1.4 average annual percentage rate of inflation during 1963-65 in light of the acceleration of nominal demand growth and increase in the output ratio that occurred during that interval? The degree of demand stimulation was minor as measured by our variables. $\hat{Q}_t$ did not exceed zero until mid-1964 and prior to that time acted to decelerate the inflation rate. Adjusted annual nominal GNP growth ($\hat{y}_t$) was at the relatively modest rate of 3.7 percent. The positive influence of the excess of $\hat{y}_t$ over the inherited past rate of inflation was almost completely offset, at least until 1965, by the negative influence on inflation of rapid productivity growth.

A second question about the guidelines era concerns the relation of prices to wages. If the guidelines had a significant effect in holding down the rate of change of wages, as the work of Perry and others implies, but had no effect on the rate of price change, as the results in this section imply, then an important side effect of the guidelines policy was to create a boom in the profits share. This is exactly the outcome that labor unions fear will occur when wage guidelines are proposed, and the guidelines era with its accompanying stock market boom may be looked upon as a golden age of state-supported capitalism. The interpretation that the guidelines policy temporarily reduced the share of labor income in GNP may also help to explain the anomalous rise in that share in the late 1960s; the shift in shares may have been the result of a guidelines impact followed by a post-guidelines rebound. In the absence of the guidelines and Nixon controls, the step-like increase in the share of employee compensation observed in the late 1960s and early 1970s might otherwise have looked more like a time trend.

The Blinder Technique for the Assessment of the Nixon Controls Period

As discussed above, the Blinder technique that develops an independent explanatory variable for the Nixon controls period seems superior in principle to either the post-sample simulation or the dummy variable techniques. But Blinder's method is not available to assess the impact of the Kennedy-Johnson guidelines, the Carter pay standards, or other programs in pre-1954 history or in the future. Thus our main question in this section is whether the conclusions reached using the Blinder technique contradict or support our preferred estimates, that is, those using dummy variables within the constrained version of the basic equation in Table 5, column (6).

Since a detailed presentation is available in Blinder (1979), we present here only the minimum explanation required to provide an understanding of our comparisons. From government data Blinder constructed a monthly time-series variable for the interval between August 1971 and May 1974, showing the fraction of items in the CPI subject to the price controls in each month. This variable, δ_t, is equal to zero before and after the controls interval and reaches a maximum of 0.91 in Phase I during the autumn of 1971. In addition to including this variable in his inflation equation, Blinder also defines a "catch-up" variable C_t as the change in δ_t in those months when the controlled fraction was decreasing:

$$C_t = \begin{cases} \delta_t - \delta_{t-1}, & \Delta\delta_t < 0 \\ 0 \quad , & \Delta\delta_t \geq 0. \end{cases}$$

The details of Blinder's study differ radically from ours. His dependent variable is the change in the CPI. He fits a price mark-up equation with the wage rate as an explanatory variable rather than a reduced-form equation for inflation. He adjusts for food and energy inflation by subtracting these components from the dependent variable. His demand effect is represented by the inventory-sales ratio, and he does not include our exchange rate, productivity, social security tax, or minimum wage variables. Since the first two of these left-out variables explain a substantial portion of the 1974 inflation in our basic equation, it is not surprising that Blinder's results yield an "off" effect that substantially exceeds the controls "on" effect. This evaluation is performed by comparing two within-sample simulations, one that sets δ_t and C_t equal to their actual values, and an alternative simulation that sets both equal to zero.

Although Blinder's review of earlier literature criticizes studies that restrict dummy variables to alter the constant rather than interacting with every explanatory variable, he discovers that there are insufficient degrees of freedom within the controls period to allow any interaction effects at all. Thus his δ_t variable is introduced linearly, and his C_t variable is allowed to enter as a linear distributed lag to allow for delays in the catch-up process. We have exactly duplicated his method within our specification of the inflation process, replacing our Nixon controls "on" and "off" dummy variables with quarterly averages of δ_t and C_t, where the former enters only as a current variable, while the latter enters both as a current variable and as an unconstrained lag on four past values. The sample period is the same as in our basic equations, 1954:Q2 through 1980:Q2. As in all of our equations, the lagged dependent variable is adjusted to subtract out the estimated impact of the controls variables. This improves the fit and boosts the estimated impact of controls with the Blinder variables, just as in our basic equations.

Because in the Blinder version of our equations the non-controls variables have coefficients that are almost identical to those in Table 5, we save space here by omitting a detailed tabular presentation. The coefficients of the Blinder variables are significant but are hard to interpret by themselves, so we follow Blinder below by evaluating the estimated impact of the controls program in dynamic simulations. The following is a comparison of the standard errors of the alternative equations.

	No Constraint	$\gamma_0 = 1$ Constraint
Table 5, columns (5) and (6)	.646	.664
Alternative timing of "off" dummy	.638	.651
Blinder versions	.649	.660

Three pairs of equations are presented, both unconstrained and constrained. The first pair--copied from Table 5--fits about as well as the Blinder versions, i.e., the Blinder variables add sufficient explanatory power to balance the extra degrees of freedom required without improving the equation's standard error. An inspection of the Blinder simulation results indicates that the estimated timing pattern of the controls is almost identical to that of our dummy variables, except that the "off" effect occurs one quarter later. When our "off" dummy is retimed to apply to 1974:Q3 through 1975:Q2, the standard error drops well below that of the Blinder versions, as shown by the middle pair above.

Several aspects of our basic constrained equation and the Blinder constrained version are illustrated in Figure 1. The upper frame compares the actual rate of inflation, shown by a solid line, with a dashed line showing the fitted value of a dynamic simulation of our basic constrained equation from Table 5, column (6). The dotted line shows an alternative dynamic simulation of the same equation with the controls dummies set to zero. The shaded areas indicate the estimated impact of the controls on the inflation rate. It is interesting to note that the dotted line suggests that most of the acceleration of inflation in 1973-74 is attributed to factors other than the termination of controls.

The bottom frame of Figure 1 compares the implications of our approach and

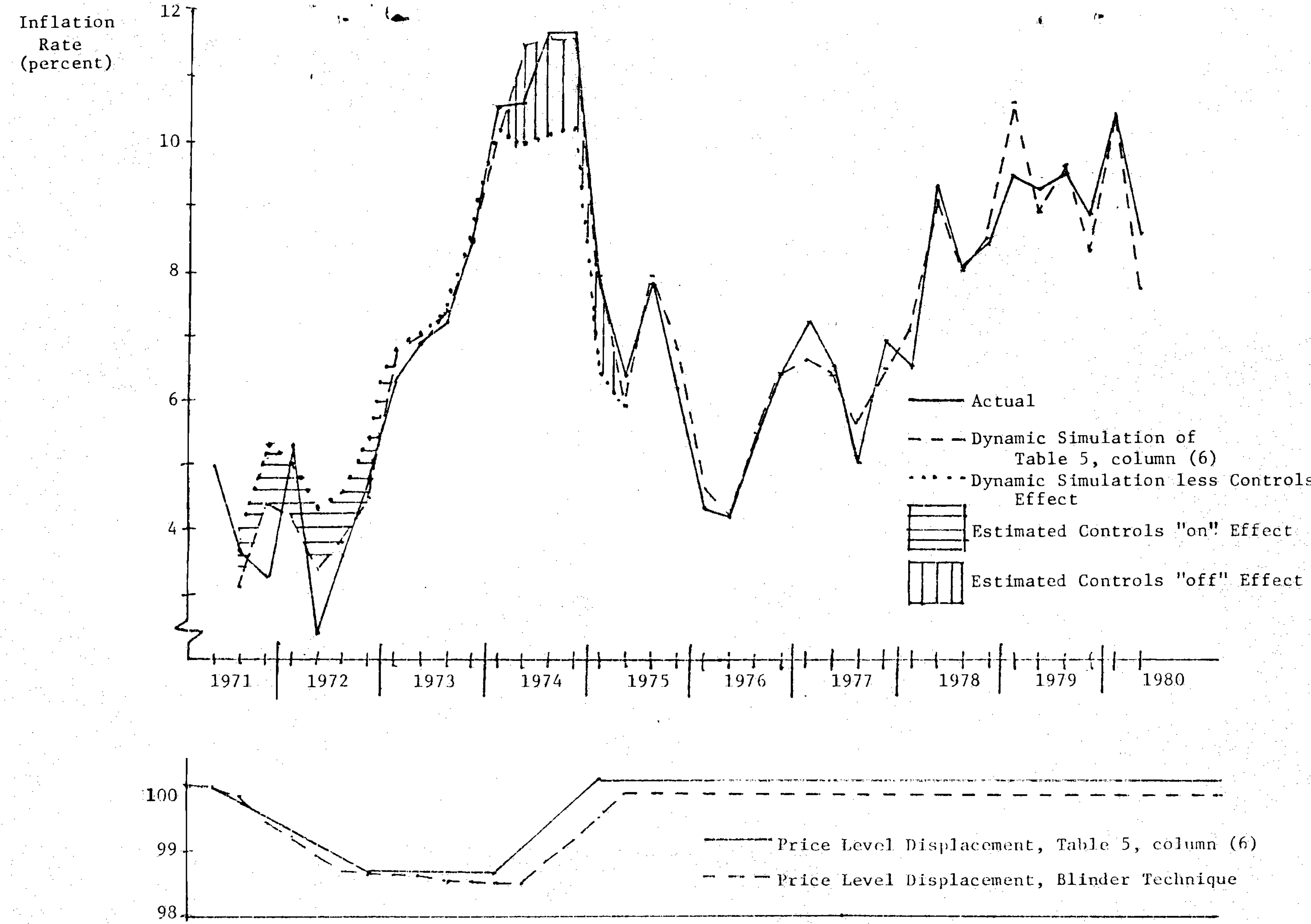
Inflation
Rate
(percent)
12
10
8
6
4
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
Actual
Dynamic Simulation of Table 5, column (6)
Dynamic Simulation less Controls Effect
Estimated Controls "on" Effect
Estimated Controls "off" Effect
100
99
98
Price Level Displacement, Table 5, column (6)
Price Level Displacement, Blinder Technique

FIGURE 1

Blinder's for the displacement of the price level caused by the controls. The solid line shows that the cumulative downward displacement of the price level implied by the controls "on" dummy coefficient in the constrained version is -1.29 percentage points, i.e., from a base index value of 100 in 1971:Q2 to 98.71 in 1972:Q3. The simulation of the constrained Blinder version with and without the controls variables indicates a maximum downward displacement of 1.48 points, i.e., from 100 to 98.52. The Blinder "off" effect eliminates slightly less than all of the "on" effect, raising the price level to 99.87 percent of its no-controls value, whereas our "off" dummy coefficient of 1.45 raises the price level to 100.16 percent of its no-controls value.

In short, the Blinder technique--despite the extra research required for construction of the new variable and its lack of applicability to other episodes of government intervention--provides neither a better fit nor an evaluation of the Nixon controls that differs from our simple dummy variable approach. It suggests only a single minor improvement in our basic equation, a shift in timing by one quarter of the Nixon "off" dummy variable.

VIII. A DECOMPOSITION OF THE INFLATION OF THE 1970s

Decomposition Methodology

The plot of actual and fitted values in Figure 1 suggests that our basic equation provides an extremely tight fit of the highly variable inflation rate of the past decade. In fact the root-mean squared error in the dynamic simulation is just 0.53 percentage points at an annual rate, less than the standard error of our best equation estimated to the less turbulent 1954-71 period. Since this dynamic simulation is based on actual values of explanatory variables, an interesting decomposition of inflation can be created when the explanatory variables one-by-one are set equal to alternative hypothetical values.

Inflation in the first quarter of 1971 was 5.0 percent as measured by our dependent variable, the fixed-weight GNP deflator. Thus we decided to create a hypothetical path for each explanatory variable that would have allowed the inflation rate to settle down to a 5.0 percent long-run equilibrium path. All the z_t variables listed in lines 6 through 10 of Table 5, as well as the Nixon control dummy variables, must be set equal to zero, and the paths of $\hat{y}_t$ and $\hat{Q}_t$ must be specified as well. Obviously an assumed value of adjusted nominal GNP growth of five percent is required to produce a long-run equilibrium inflation path of 5 percent. As for $\hat{Q}_t$, the log of the output ratio, a value of zero would appear to be required. However, the constrained equation contains a positive and significant constant term, indicating that inflation will accelerate when $\hat{Q}_t = 0$. This constant term could indicate either that our measure of natural real GNP is overstated, and thus $\hat{Q}_t$ is understated, or it could at least partly be caused by a value of real wage aspirations (t_w) in excess of the trend productivity variable that appears in the structural price equation above (t_p). Since t_w and t_p are not observed, our steady-inflation simulation must set $\hat{Q}_t = -1.35$ percent.

The details of the decomposition are presented in Table 6. The first two lines show, respectively, the actual values and those computed in a

TABLE 6

Contributions of Explanatory Variables to the Inflation Rate,
Selected Intervals, 1971:1-1980:1, Using Equation from Table 5, column (6)

	1971:1	1971:1-1972:3	1972:3	1972:3-1974:4	1974:4	1974:4-1976:2	1976:2	1976:2-1980:1	1980:1	1971:1-1980:1
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A. Actual and Simulated Inflation Rates										
1. Actual Rate	5.54	----	3.61	----	11.65	----	4.21	----	10.41	----
2. Rate Simulated with Complete Equation	5.00	----	3.49	----	11.40	----	3.97	----	10.20	----
3. Solution with $\hat{y}$=5.0, $\hat{Q}$=-1.4, and all other variables = 0.	4.65	----	4.56	----	4.82	----	4.85	----	5.00	----
B. Contribution of Variables to Change over Intervals										
1. Nixon Controls	----	-0.86	----	+2.30	----	-1.44	----	0.00	----	0.00
2. Deviation of $\hat{Q}$ from -1.4	----	+0.57	----	-0.09	----	-0.57	----	+0.20	----	+0.11
3. Deviation of $\hat{y}$ from 5.0	----	-0.71	----	-0.19	----	+0.04	----	+1.06	----	+0.20
4. Food and Energy Prices	----	+0.40	----	-0.16	----	+0.01	----	+1.24	----	+1.47
5. Productivity Deviation	----	-0.70	----	+2.25	----	-2.74	----	+1.90	----	+0.71
6. Effective Exchange Rate	----	0.00	----	+2.39	----	-2.17	----	+1.24	----	+1.44
7. Social Security Tax	----	+0.01	----	+0.48	----	-0.11	----	+0.46	----	+0.84
8. Minimum Wage	----	-0.13	----	+0.67	----	-0.44	----	-0.02	----	+0.08
9. Dynamic Adjustment	----	-0.09	----	+0.26	----	+0.03	----	+0.15	----	+0.35
10. Equals: Dynamic Simulation	----	-1.51	----	+7.91	----	-7.43	----	+6.23	----	+5.20
11. Plus: Error	----	-0.42	----	+0.13	----	-0.01	----	-0.03	----	-0.33
12. Equals: Actual Value	----	-1.93	----	+8.04	----	-7.44	----	+6.20	----	+4.87

dynamic simulation of the basic constrained equation that starts in 1970:Q4. The hypothetical alternative simulation of a path of the explanatory variables compatible with a steady inflation of 5.0 percent is shown in line A3. The quarters shown are chosen to mark peaks and troughs of inflation during the past decade. The remaining section of the Table compares successive simulations that make the transition between lines A.3 and A.2 occur one variable at a time. For instance, line B.1 shows the difference in the estimated change in the inflation rate between 1971:Q1 and 1972:Q3 in two simulations, the one presented on line A.3 that is compatible with 5 percent steady inflation, and a second that adds the Nixon control dummy variables multiplied by their estimated coefficients. Then line B.2 adds in the actual value of $\hat{Q}_{t-1}$ in place of the assumed value of -1.4, runs another dynamic simulation, and calculates the different in the fitted values. Finally, after converting step-by-step to the actual values of all explanatory variables, we obtain the dynamic simulation presented on line A.2. Thus the sum of lines B.1 through B.9, displayed in line B.10, equals the change between the specified quarters in the dynamic simulation shown on line A.2.[28]

Decomposition Results

The explanation of the inflation of the past decade laid out in section B of Table 6 is an intriguing one. Several factors are singled out to explain the acceleration of inflation that occurred during 1972-74 and again during 1976-80, as well as the sharp 1974-76 deceleration. The right-hand column provides an overall explanation of the acceleration of inflation between the beginning and end of the decade.

The simulated values explain only about three-quarters of the slowdown in the rate of inflation between 1971:Q1 and 1972:Q3. Of this, the most important causes are the Nixon controls and the rapid growth of productivity relative to trend. The 1972:Q3 through 1974:Q4 acceleration of inflation is explained by the termination of controls, the 1974 decline in productivity, the cumulated dollar depreciation between 1971 and 1974, and the lagged effects of the 1973 increase in the social security tax and of the 1974 increase in the minimum wage rate. Surprisingly, increases in food and energy prices explain nothing, because their impact operates without a lag and according to our variable has been completed by 1974:Q4.

Only a small part of the slowdown of inflation between 1974:Q4 and 1976:Q2 can be explained by the recession itself, that is, the slump in $\hat{Q}_{t-1}$. Instead, most of the slowdown is accounted for by a reversal of the elements that caused the temporary acceleration in 1974--especially the end of the controls termination effect, the shift from negative to positive productivity growth, and the appreciation of the dollar. Finally, the acceleration of inflation between 1976:Q2 and 1980:Q1 has a multiplicity of causes, including rapid nominal GNP growth and the slowdown in natural real GNP growth (the difference between which equals $\hat{y}_t$), the explosion of energy prices; the slump in productivity growth, the 1978-79 depreciation of the U. S. dollar, and the increase in the effective social security tax rate.

Why did inflation accelerate so far above 5 percent during the period between 1971 and 1980? The four most significant factors over the decade taken as a whole were food and energy prices, the productivity slowdown, the depreciation of the dollar, and the social security tax increases. The contribution of nominal GNP growth is surprisingly small, partly because the quarter chosen to begin the simulation already had a large growth rate of nominal GNP.[29] These results help to suggest why economic policymakers have been forced in 1980 to foster restrictive demand growth and deliberately to induce a recession. Because so many adverse supply elements have caused inflation to accelerate over the past few years, demand restriction seems the only available anti-inflationary policy. Of the major contributors to the acceleration of inflation in the 1970s, only the social security tax is under the immediate control of policymakers in Washington.

Qualifications

The decomposition in Table 6 is obviously sensitive to the size of the estimated coefficients in the basic equation and would change if those coefficients were to change. Thus it is reassuring to turn back to Table 5 and scan the constrained versions of the equations estimated for three alternative sample periods in columns (2), (4) and (6). With the exception of the effective exchange rate, which does not appear in the short-period equation estimated for 1954-71, the coefficients are surprisingly stable. This indicates that a decomposition very similar to that of Table 6 would be produced by the 1954-71 equation, if allowance were made for an exchange rate effect.

In any multivariate analysis of economic time series, we may ask whether a particular explanatory variable has a consistent impact throughout the sample period or whether its coefficient is heavily influenced by a particular year or quarter. One technique available for this assessment is the estimation of alternative sample periods that "roll forward" several years at a time. We have reestimated our basic unconstrained equation for twelve year "rolling" sample periods, e.g., 1954-66, 1956-68, etc. Most of the coefficients appear

appear to be quite stable and are statistically significant throughout, including those of the output ratio, adjusted nominal GNP growth, food and energy prices, and the productivity deviation. The coefficient on the social security tax varies between about 0.25 and 0.5, depending on the sample period chosen. This is not surprising, since there were long periods when the tax rate did not change appreciably. The least robust variable is the minimum wage rate, which seems to obtain most of its significance from the year 1956, when the minimum wage rate jumped from $0.75 to $1.00.

Does the foreign exchange rate have an impact throughout the 1974-80 period, or is it just acting as a dummy variable for the first half of 1974? We compared two dynamic simulations of our basic constrained equation, one with the actual values of effective exchange rate changes and another with those changes set equal to zero except for 1974:Q1 and 1974:Q2. The first simulation has a much better ability to fit the data for the late 1970s, with a decline in the root-mean-squared simulation error from 0.627 to 0.415 for the interval 1976:Q3 through 1978:Q2, and from 0.791 to 0.562 for the interval 1978:Q3 through 1980:Q2. In addition to their contribution in 1974, changes in the exchange rate help to explain why the inflation rate was so low in early 1976 and why it accelerated in early 1979.

The food and energy variable deserves further scrutiny. One surprising feature of Table 5 is that its coefficient is actually larger before 1971 than afterwards, indicating that fluctuations in those relative prices made a contribution to the explanation of inflation before 1971 that has been neglected in previous research. Another puzzle is the small size of the coefficient, only 0.36 in the full-period constrained equation. We have experimented with another food and energy variable which we call FAE, the direct contribution to the consumption deflator of changes in the relative prices of food and energy. It performs almost as well in our basic equation as the variable used in Tables 4 and 5, which we call BDP, and it has about the same coefficient. We have also experimented with alternative dependent variables, including the implicit deflator for business product and the implicit deflator for personal consumption expenditures. When the former dependent variable is used, the coefficients on both FAE and BDP are similar to those in our basic equations, about 0.3. When the latter is used, the coefficient on both FAE and BDP rises to about 0.55, and to about 0.9 when lagged values are included. We conclude that changes in the relative prices of food and energy are fully passed into consumer prices but not into GNP prices, due partly to the exclusion of import prices from the latter and due partly to the inability of our BDP series to capture the precise timing of the adjustment necessary to remove the impact of imported oil prices.

IX. CONCLUSIONS

An adequate explanation of both the variance and overall acceleration of inflation in the 1970s requires a model that includes effects of aggregate demand, government intervention, external supply shocks, and inertia in the adjustment of prices. Our basic reduced-form inflation equation relies on the contribution of two variables for its aggregate demand effect, the lagged level of the output ratio and the change in nominal GNP adjusted for changes in natural real GNP. Three forms of government intervention influence inflation, the Nixon-era controls, changes in the effective social security tax rate and effective minimum wage. External supply shocks include changes in the relative prices of food and energy, the influence of changes in the effective exchange rate of the dollar, and deviations of productivity from trend. Finally, inertia is represented by the influence of lagged inflation on the current inflation rate. This classification of variables is partly arbitrary, since the relative price of food and energy depends partly on government policies; the foreign exchange rate responds both to domestic demand management as well as to external events; and productivity deviations also respond both to demand management and external events.

Because changes in demand policy influence not only the growth rate of nominal GNP and the lagged output ratio but also the effective foreign exchange rate and the productivity deviation, the inflation equation developed in this paper cannot yet be used to compute policy simulations that show the impact on inflation of alternative demand management policies. Further research will be necessary to produce auxiliary equations relating the exchange rate and productivity deviation to output and prices before such research on alternative demand strategies can be undertaken.

Instead, the central focus of this paper has been on the interaction of the estimated impact of the Nixon-era controls with the inclusion or exclusion of important demand and supply factors. Previous studies have estimated substantial effects of the controls in holding down inflation in 1972 and causing inflation to accelerate in 1974, and in many cases have found that the implied impact of the removal of controls in raising inflation in 1974 was greater than the initial impact of the controls in holding down inflation in 1972. Several of the variables that play an important role in our basic equation, especially the productivity deviation and exchange rate, help to explain the actual inflation performance of 1972 and 1974 and thus assign a smaller role to the Nixon controls. In this sense part of the impact of the Nixon controls in some previous studies confound the actual influence of the controls and the influence of left-out variables.

We have presented detailed results of alternative models and methods for estimating the impact of episodes of government intervention, including the Nixon controls, Kennedy-Johnson guidelines, and Carter pay standards. We conclude that ARIMA and money-only models are inadequate for this kind of research because they omit many variables that play an important role in the inflation process, and therefore they yield biased estimates of intervention effects. Three different methods are used to assess the impact of the Nixon-era controls within the context of our basic reduced-form inflation equation. Post-sample dynamic simulations of equations estimated to the pre-controls period are misleading unless the equations are constrained to be dynamically stable. Simulations of such constrained equations tend to underpredict inflation in 1974 more than they overpredict inflation in 1972, partly because there was no role of the effective exchange rate before 1971. The second technique, the inclusion of dummy variables for the imposition and removal of the controls, has the advantage of using all of the information available in the full sample period, including that on the impact of the effective exchange rate. Dummy variables indicate that the Nixon controls held down the price level by about 1.3 percent between mid-1971 and late 1972, and then allowed a rebound of about 1.4 percent to occur in 1974 and early 1975. A third technique, introduced by Alan Blinder, replaces the dummy variables with a variable that measures the fraction of prices that were actually controlled each quarter. Although this variable seems conceptually superior, it does not alter the conclusions of the dummy variable technique, yielding almost exactly the same standard error of estimate and the same estimated magnitude and timing of the impact of controls on the price level.

The model developed here can be used to answer the basic questions posed at the beginning of the paper. Why was inflation so variable between 1971 and 1980? And why did inflation accelerate from 5 percent in early 1971 to 10 percent in early 1980? Our basic equation explains the high variance of inflation mainly as a result of swings in the effect of Nixon controls, the deviation of productivity from trend, the relative prices of food and energy, and the effective exchange rate, with an additional minor contribution made by the aggregate demand variables and by social security tax changes. The overall acceleration of inflation during the past decade is explained by the adverse contribution of most of the variables. Only the output ratio, Nixon controls, and minimum wage made no contribution to the excess of 1980 over 1971 inflation. The paper also concludes that the 1978-79 Carter pay standards had no effect at all on the inflation rate, just as the Kennedy-Johnson guidelines made no impact during the 1963-65 period (although in both cases wage growth and the distribution of income may have been altered.

The conclusions of the paper send a mixed message to policymakers in Washington. On the one hand, much of the acceleration of inflation in recent years has been caused by factors, especially food and energy prices and the productivity slowdown, over which domestic policymakers have little control in the short run. On the other hand, there seems to be substantial potential for achieving a deceleration of inflation. Restrictive demand policies have a strong impact on inflation, working not only through the output ratio and nominal GNP growth variables, but also through the indirect impact of demand management policy on inflation through the effective exchange rate. And the relatively large coefficients on the social security tax suggest some anti-inflationary potential for a tax substitution. But direct intervention in the inflation process is strongly condemned by the results; the guidelines and Carter pay standards had no effect at all on inflation, while the Nixon-era controls had only a temporary impact that destabilized both the inflation rate and the level of real output.

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FOOTNOTES

1. The introduction of these additional explanatory elements is not pure hindsight; all but the dollar depreciation, food-energy effects, and the minimum wage were present in earlier papers, e.g., Gordon (1971) (1972).

2. See especially Barro (1978) and Barro-Rush (1980).

3. A sequel to this paper, to be presented in November 1980 to the Brookings Conference on Labor Market Tightness and Inflation, will explore the sensitivity of the results to alternative specifications of the demand side, e.g., the effects of unemployment variables compared with those of the output ratio.

4. We also assess the effects of changes in the relative prices of food and energy on the personal consumption deflator.

5. The source of the natural real GNP series is Perloff and Wachter (1979).

6. See Gordon (1977), Table 3 on pp. 266-7 and the discussion on p. 279.

7. Most published wage equations enter prices only in lagged form, but many published price equations (including Gordon 1971, 1975, and 1977) include the current wage rate.

8. Inflation equations back to 1892 are presented for annual data in Gordon (1980a) and for quarterly data in Gordon (1980b). The choice of 1954:Q2 rather than 1954:Q1 has been made in papers extending back to Gordon (1971) and reflects an inexplicable jump in the price level in 1954:Q1 that has a substantial impact on several coefficients.

9. An exception is the ingenious controls impact variable constructed by Blinder and Newton (1978) and Blinder (1979). This variable is discussed and tested below.

10. Pencavel (1980) obtains substantially different conclusions regarding the efficacy of past incomes policies when he first constrains four programs to have the same effect and then allows each to have a different effect.

11. This ambiguity is evident in the work of Perry, who in a recent paper (1980) chose 1964:Q1-1965:Q4 as the dates for his guideline dummy, but in early papers had extended the dummy between 1963 and mid-1966.

12. If $x_{it} = (1-B)^d X_{it}$, then X_{it} is said to be an integrated process of order d whose univariate representation is an ARIMA (autoregressive integrated moving average) model.

13. In the notation (p,d,q) the p term is the number of autoregressive parameters, the d term is the degree of differencing, and the q term is the number of moving average parameters.

14. The inflation rate is scaled throughout this paper as an annual rate.

15. The Q statistic, analogous to the Durbin-Watson statistic, is a measure of the degree to which the residual sequence is observed to depart from serial independence.

16. In principle, more precise estimates of all parameters could be obtained by simultaneous estimation of θ and the two regression coefficients. In practice, little refinement is apt to arise from adding 15 observations to the 90 used to estimate θ, so the computational simplicity of the two step procedure is favored.

17. The closest to a pure money-causes-price model is presented by Barro and Rush (1980, Table 2.2, columns 4 and 5). Here the price level is explained by the current level of money (in logs), a distributed lag of past

money "surprises," the current share of government spending in real GNP, and a time trend (an interest rate term is insignificant). The money surprises, in turn, are residuals from an equation that explains quarterly changes in money as a function of six lagged dependent variables, a federal spending variable, and lagged unemployment. The implied reduced form thus basically explains price changes by money changes, the two government spending variables, lagged unemployment, and the time trend. There is no consideration of any of the supply factors discussed below in Section VI.

18. This does not deny a role for the prices of other inputs, e.g., capital or raw materials, since these variables can be entered as relative prices. See the more complete specification of the price mark-up equation in Gordon (1975, p. 620).

19. In column (2) and all of the other equations presented in this paper the lagged dependent variable is adjusted to remove the estimated impact of the controls. Thus we assume that the impact of the termination of controls in raising 1974 inflation does not carry over in making inflation higher in 1975. This adjustment marginally improves the standard error of estimate of the basic equation in column (8), and has the advantage that the effects of controls may be seen in the coefficient estimates, rather than in the alternative dynamic simulations necessary if the controls have persistent effects.

20. The exact method of performing the "stripping" process is described in Gordon (1975, pp. 656-660). This variable was updated using the methods described in that source to the end of 1976, and has been extrapolated using a regression of the 1954-76 variable on current and lagged values of the deflators of consumer direct expenditures on food and energy.

21. For previous uses of this specification, see Gordon (1971, pp. 128-9) and (1975, pp. 619-20).

22. The interaction with $\hat{y}_t$ comes in years like 1975-76, when the equation in column (5) "cannot understand" why inflation declined despite an acceleration in $\hat{y}_t$, but in column (6) has the rapid growth of actual productivity available as an included variable to help explain the inflation slowdown. The interaction with the lagged dependent variable comes in 1969-70, when column (5) "needs" a high sum of coefficients on lagged inflation to explain high inflation but in column (6) has the help of the 1969-70 productivity slowdown.

23. The variable is calculated as the percentage change in $(1/(1-\tau))$, where τ is the ratio of total Federal and state social security contributions to total wage and salary income in the national income accounts.

24. Gordon (1977) in Tables 2 and 3 shows that unity constraints substantially improve the ability of equations estimated to the 1954-71 period to track the 1971-76 period in post-sample simulations.

25. Constraining the sum of the coefficients on the lagged dependent variable (LDV) and on $\hat{y}_t$ to sum to unity is not straightforward if the shape of the polynomial lag distribution is to be freely estimated in the constrained equation. We have used an iterative procedure in which the freely estimated coefficients on the LDV and $\hat{y}_t$ are divided by their joint sum, and that part of inflation not explained by unity constrained LDV and $\hat{y}_t$ is regressed on the other right-hand variables. The fitted value of this first regression equation represents the contribution of the other variables to the explanation of inflation. The next step is to run a second regression explaining the difference between the actual dependent variable and the

fitted value from the first step (i.e., the portion of inflation that cannot be explained by the other variables) in which the right hand variables are $\hat{y}_t$ and a polynomial distributed lag on the LDV. The process is repeated until the sum of squared residuals in the two equations converge.

26. Since the cumulative error over 2.5 years is 1.4 percentage points, the simulation after adjustment for the exchange rate effect underpredicts the annual inflation rate during 1978-80 by about 0.6 percentage points on average.

27. Perry's most recent research (1980) limits the guidelines dummy to 1964 and 1965, in contrast to his earlier work that included 1963.

28. Line B.9, "Dynamic Adjustment," shows the change in the equilibrium simulation of line A.3.

29. Nominal GNP growth was rapid in 1971:Q1 due to the rebound effect from the 1970 General Motors strike.