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A Monetary Interpretation of Inflation

In this era of shortages, there is a definite glut in at least one market: the supply of explanations for the current inflation greatly exceeds the demand at current prices. It could be that this is just a manifestation of increased specialization in the country. In the old days of 1972, only two products were offered seriously in this market: cost-push and demand-pull inflation. We are now offered a choice among anchovy inflation, interest rate inflation, commodity inflation, imported inflation, wage inflation, gouging inflation, and even divine inflation for those who have lost all hope of finding a worldly explanation.

Our concern in this paper is with the role of the rate of money growth as a factor leading to our nation's accelerating inflation since the mid-1960s. The analysis is based on a modified version of the St. Louis model. The original St. Louis model was based on a monetarist view of the influence of monetary actions (measured by changes in the money stock) and fiscal actions (measured by highemployment government expenditures) on total spending, output, and the price level. The model incorporates a recursive view of the macroeconomic process: monetary and fiscal actions determine changes in total spending (measured by nominal gross national product), which in turn is divided into price and output changes. A research strategy of specifying and estimating reduced form equations was employed in developing the original model.

The recursive nature of the original model is maintained in the modified version used here: one block determines changes in nominal GNP, and a second block determines the division of a given change in nominal GNP into changes in output and in the price level. A major difference is that in each block structural equations are specified and their parameters are estimated in place of direct estimation of reduced form equations. A second difference is that all equations are specified as log-linear instead of linear in the variables. The modified model also includes additional exogenous variables, thereby introducing factors other than the direct influences of monetary and fiscal actions as possible causes of inflation.

The model used in the paper is still in process of development. It is not complete, inasmuch as it does not contain a block explaining the market rate of interest, which is an explanatory variable in the block determining GNP. Also, work is continuing on the structural equations in the other two blocks. The model is used here as an expository device, a means of quantifying a monetary view of the recent inflation.

Our paper is divided into two main sections. In the first, a modified version of the St. Louis model is developed and estimates of the parameters of its structural equations are printed. Then the model, in conjunction with actual events since the mid-1960s, is used to evaluate the role of monetary growth as a cause of the inflation.

THE MODEL

At this point in its development, the model consists of two blocks. The first is for the determination of nominal aggregate spending (nominal GNP). This block is built around the proposition that private nominal spending (consumption plus investment) changes in response to a discrepancy between actual and desired nominal money balances. The second block determines the division of a given change in nominal aggregate spending between changes in the price level and real output. This block has many points in common with the price-level determination process postulated in many large-scale econometric models. It includes structural equations that are intended to explain price, wage, and employment decisions in the private sector of the economy. Unit labor costs are considered explicitly, and various expectations variables play a key role in the model.

Block I: Aggregate Nominal Spending

Aggregate nominal spending (Y_t) in an economy for the acquisition of domestically produced final goods and services is defined as the sum of nominal outlays by domestic households and business firms for consumption and investment (Y_t^d), by all units of government for goods and services (G_t), and by foreigners for domestic product (X_t), less domestic outlays for foreign-produced goods and services (IM_t).

(1) $$Y_t = Y_t^d + G_t + X_t - IM_t$$

Government spending and exports are assumed to be exogenous variables; and aggregate spending, private spending, and imports are assumed to be endogenous.

It is postulated that the amount of nominal money balances desired (M_t^*) is positively related to the expected level of aggregate nominal spending (Y_t^e) and the nominal short-term rate of interest (r_t), and negatively related to the technical efficiency of the system of making money payments (I_t). The expected rate of inflation is not included as an argument; its influence is presumed to be captured to the extent that the expected rate of inflation is embodied in the nominal interest rate.

Assuming that the function for desired money balances is linear in logarithms, the desired amount of money balances is written in the following form:

(2) $$\ln M_t^* = \alpha_1 \ln I_t + \alpha_2 \ln Y_t^e + \alpha_3 \ln r_t$$

The coefficients α_1 and α_3 are postulated to be negative; and the coefficient α_2, positive.

Expectations regarding the level of aggregate nominal spending are postulated to be formed on the basis of a weighted average of past levels of aggregate spending:

(3) $$\ln Y_t^e = \sum_{i=1}^{n} u_i \ln Y_{t-1}$$

It is presumed in this study that the technical efficiency of the payments system, i.e., the amount of nominal money balances required to carry out a given volume of money payments, has increased along with the general rise in the productivity of producing goods and services. It is asserted that, on average, the efficiency of the payments system increases at a constant rate, given by the function $I_t = be^{ct}$. The logarithm of this function is

(4) $$\ln I_t = \ln b + ct$$

The nominal stock of money (M_t) is assumed to be exogenous, determined by monetary authorities. Therefore, holders of money balances, in the aggregate, cannot adjust their holdings when a discrepancy occurs between actual and desired money balances. Instead, individual holders of money balances attempt to acquire (reduce) money balances by reducing (increasing) their rate of spending on goods and services or selling (buying) financial assets, or both. Changes in quantities or prices, or both, occur in these markets until, in the aggregate, the desired level of money equals the actual level.

When a positive (negative) discrepancy occurs between actual and desired money balances, there is said to exist a positive (negative) "excess supply" of money, which implies positive (negative) "excess demand" in markets for goods and services and for financial assets. It is postulated that private nominal spending (Y_t^d) is the variable that adjusts to eliminate this discrepancy, responding positively to an excess supply of money balances. This adjustment process is assumed to be log-linear. The coefficient π is the response of private domestic spending to an excess supply of money and is postulated to be positive.

(5) $$\Delta \ln Y_t^d = \pi(\ln M_t - \ln M_t^*)$$

It is assumed that imports are a constant ratio (δ) to $Y_t^d + G_t + X_t$. It is expressed as

(6) $$IM_t = \delta(Y_t^d + G_t + X_t)$$

At this point, the block for aggregate spending determination consists of seven endogenous variables—four expressed in logarithmic terms ($\Delta \ln Y_t^d$, $\ln Y_t^e$, $\ln I_t$, and $\ln M_t^*$) and three expressed in arithmetic terms (Y_t, Y_t^d, and IM_t).

A new variable, Z_t, is defined as equal to $G_t + X_t$. Using this definition and substituting equation 6 into equation 1 yields:

(7) $$Y_t = (1 - \delta)(Y_t^d + Z_t)$$

Finally, an identity is developed that transforms equation 7, containing variables expressed arithmetically, into an equation expressed in logarithms. Using the proposition that for small differences the percent change in a variable is approximately equal to the first difference of logarithms of the variable, the following two equations are derived:

$$(8) \qquad \Delta \ln Y_t = w_t \, \Delta \ln Y_t^d + (1 - w_t) \, \Delta \ln Z_t$$

$$(9) \qquad w_t = (1 - \delta) \, Y_{t-1}^d / Y_{t-1} = \text{antilog} \, (\ln (1 - \delta) + \ln Y_{t-1}^d - \ln Y_{t-1})$$

Equations 2 through 5 are next solved to yield an equation for changes in private spending in terms of exogenous variables:

$$(10) \qquad \Delta \ln Y_t^d = \pi \ln M_t - \pi\alpha_1 (\ln b + ct) - \pi\alpha_2 \sum_{i=1}^{n} w_i \ln Y_{t-1} - \pi\alpha_3 \ln r_t$$

The block for determination of aggregate nominal spending in its final form consists of equations 8, 9, and 10.[1] These equations can be solved for the three endogenous variables ($\Delta \ln Y_t$, $\Delta \ln Y_t^d$, and w_t) in terms of the exogenous variables ($\ln M_t$, $\ln r_t$, $\ln Z_t$, and t) and of the lagged endogenous variables ($\ln Y_{t-1}$) and ($\ln Y_{t-1}^d$).

An examination of the variables in this set of equations indicates that changes in aggregate nominal spending are influenced by changes in five factors: the money stock, government expenditures, exports, the rate of interest, and the average technical efficiency of the payments system. The change in aggregate nominal spending in response to any of these changes is also influenced by initial conditions measured by past levels of spending and the ratio of private spending to total spending. Furthermore, the response of aggregate spending is distributed over time because there is a lagged adjustment to a discrepancy between actual and desired money balances, and expected aggregate spending is postulated to depend on past aggregate spending.

Block I: Estimates of Structural Parameters

A first-difference transformation of equation 10 was estimated as a means of reducing possible statistical problems in regression analysis, stemming from multicollinearity in the level of the variables and from their autocorrelation:

$$(10') \qquad \Delta \ln Y_t^d - \Delta \ln Y_{t-1}^d = a_0 + a_1 \Delta \ln M_t + a_2 \sum_{i=1}^{n} w_i \, \Delta \ln Y_{t-1} + a_3 \Delta \ln r_t$$

The parameters of equation 10′ are estimated using quarterly observations of the data for 1955I–1973IV. Aggregate nominal spending is measured by nominal GNP. Private nominal spending is measured by GNP minus government spending and exports and plus imports. Money is the sum of demand deposits and currency held by the nonbank public. The nominal interest rate is measured by the 4-to-6-month commercial paper rate. The constant term in 10′ is the response of private domestic spending to the average quarterly increase in the technical efficiency of the payments system ($\pi\alpha_1 c$) in the sample period. Two zero-one dummy variables are included for the average influence of major strikes on private domestic spending: $D_1 = 1$ for the quarter in which the strike occurs, and $D_2 = 1$ for the quarter following a strike.

An Almon lag is used in estimating the coefficients for lagged changes in aggregate nominal spending. A third-degree polynomial is used, with the coefficient for $t - n - 1$ constrained to zero. The length of the lag (four quarters) is selected to minimize the standard

TABLE 1 Block I Regression Coefficients (dependent variable: $\Delta^2 \ln Y_t^d$)

Variable	With Interest Rate	Without Interest Rate
D_1	−1.871*	−1.979*
D_2	2.144*	2.201*
$\Delta \ln M_t$	0.690*	0.637*
$\Delta \ln r_t$	0.018†	—
$\Delta \ln Y_{t-1}$	−0.841*	−0.697*
$\Delta \ln Y_{t-2}$	−0.076	−0.060
$\Delta \ln Y_{t-3}$	−0.008	−0.020
$\Delta \ln Y_{t-4}$	−0.147	−0.145
$\Sigma\Delta \ln Y_{t-i}$	−1.072*	−0.922*
Constant	1.066*	0.907*
R^2	0.550	0.533
SE	0.898	0.915
DW	2.028	1.999

NOTE: R^2 = coefficient of multiple determination; SE = standard error of estimate; DW = Durbin-Watson statistic. For identification of variables, see description of Block I in the accompanying text. The data are identified in "Block I: Estimates of Structural Parameters."

*Significant at 5 percent level.

†Significant at 10 percent level.

error of estimate. The estimated parameters are presented in Table 1. All the coefficients have the expected signs.

Step-ahead simulations of quarterly percent changes in aggregate nominal spending (at annual rates) over the sample period were conducted for Block I. The import ratio δ (see equation 6) was held at its average value over the sample period. The root-mean-square error for the step-ahead simulation was 2.64 percent at an annual rate.

Block II: Wages, Prices, and Employment

The equations that explain wages, prices, and employment are based on the premise that business firms are on average price searchers in the goods market and price takers in the market for labor services.[2] Consequently, consumers are presumed to determine the current wage rate, subject to their best estimates of the prices that will prevail in the market for goods and services. Thus, prices and wages are presumed to be determined on the supply side in each market, at least in the short run. The actual quantities exchanged at these prices are then determined by demand factors.

Neither firms nor individuals have perfect information about conditions in the goods and labor markets; and, therefore, demand and supply decisions are presumed to be based on expectations in both markets. The interaction of expectations and actual demand provides the dynamics to this section.

Prices are assumed to be determined by wealth-maximizing considerations; and following standard maximizing procedures, prices are derived as a function of unit labor costs. It is not actual output that enters into the calculation of cost, however, but an estimate of the longer-term rate of sales that will maximize net worth at current prices and with the existing capital stock. The price equation is

$$\ln P_t = \rho_0 + \rho_1 t + \rho_2(\ln W_t + \ln N_t - \ln \overline{EQ}_t) \tag{11}$$

where P_t is the price in the current period t, W_t is the current wage rate, N_t is the amount of labor services employed in the current period, and $\overline{EQ}_t$ is the estimate of the rate of output that will be taken in the market, on average, at the price P_t. Firms are presumed to incur costs in changing prices, and therefore do not change prices in response to short-term changes in demand, even where such changes are expected. Thus; this expected demand ($\overline{EQ}_t$) is not the amount expected in the current period, which may include some estimate of factors which affect demand in the short run. $(\overline{EQ}_t)$ is defined as a distributed lag function of expected demand in the current period (EQ_t):

$$\ln \overline{EQ}_t = \sum_{i=0}^{m} \beta_i \ln EQ_{t-i} \tag{12}$$

The demand for labor services is determined jointly with price in the maximizing decision. With capital stock treated as a completely fixed factor, the amount of labor services demanded is a function of the scale of output only. As in the price equation, the output variable that enters this decision is the longer-term sales expectations of the firm. Labor is treated as a quasi-fixed factor with positive costs of adjustment. The labor demand function is

$$\ln N_t = n_0 + n_1 t + n_2 \ln \overline{EQ}_t \tag{13}$$

The amount of labor services supplied to the market is postulated to be a function of the expected real wage:

$$\ln N_t^s = s_0 + s_1 t + s_2(\ln W_t - \ln EP_t) \tag{14}$$

where EP_t is the price expected to prevail in the goods market in the current period.

Uncertainty about demand conditions in the labor market is incorporated with the adjustment equation:

$$\Delta \ln W_t = \lambda_1(\ln W_t^* - \ln W_{t-1}) \tag{15}$$

where W^* is the wage rate that would clear the market in the current period. This equation reflects the postulate that labor adjusts its wage demands less than instantaneously to discrepancies between amounts demanded and supplied in the labor market.

This system of equations is in equilibrium only when the price expected by labor, and on which labor supply decisions are based, actually prevails in the goods market, and the amount of goods and services demanded at that price is the rate expected by business firms.

This block of equations is completed by the addition of three functions, two of which define the mechanism by which expectations are formed:

$$\Delta \ln EP_t = \lambda_2(\ln P_t - \ln EP_{t-1}) \tag{16}$$

$$\Delta \ln EQ_t = \lambda_3(\ln Q_t - \ln EQ_{t-1}) \tag{17}$$

$$\ln Y_t = \ln P_t + \ln Q_t \tag{18}$$

The only variable strictly exogenous to this block is the rate of aggregate nominal spending. As in the original St. Louis model, output is determined as a residual.

In this form, this block contains two variables for which no direct measures are available: current labor supply (N_t^s) and the equilibrium wage (W_t^*). In order to get around this problem, equations 13 and 14 are solved for W^* by setting $\ln N_t$ equal to $\ln N_t^s$. The result is then inserted into equation 15. By this procedure both W^* and N^s are eliminated from the system.

$$(15') \quad \Delta \ln W_t = \frac{\lambda_1}{s_2} [(n_0 - s_0) + (n_1 - s_1)t + n_2 \ln \overline{EQ}_t + s_2 \ln EP_t] - \lambda_1 \ln W_{t-1}$$

One further substitution is made. Equations 11, 13, and 15′ are solved simultaneously to yield two new equations defining W and P:

$$(11') \quad \ln P_t = \gamma_0 + \gamma_1 t + \gamma_2 \ln EP_t + \gamma_3 \ln \overline{EQ}_t + \gamma_4 \ln W_{t-1}$$

where

$$\gamma_0 = (1/s_2)[s_2(\rho_2 n_0 + \rho_0) + \rho_2\lambda_1(n_0 - s_0)]$$

$$\gamma_1 = (1/s_2)[s_2(\rho_2 n_1 + \rho_1) + \rho_2\lambda_1(n_1 - s_1)]$$

$$\gamma_2 = \rho_2\lambda_1$$

$$\gamma_3 = (\rho_2/s_2)[s_2(n_2 - 1) + n_2\lambda_1]$$

$$\gamma_4 = \rho_2(1 - \lambda_1)$$

$$(15'') \quad \ln W_t = \omega_0 + \omega_1 t + \omega_2 \ln EP_t + \omega_3 \ln \overline{EQ}_t + \omega_4 \ln W_{t-1}$$

where

$$\omega_0 = (\lambda_1/s_2)(n_0 - s_0)$$

$$\omega_1 = (\lambda_1/s_2)(n_1 - s_1)$$

$$\omega_2 = \lambda_1$$

$$\omega_3 = \lambda_1 n_2/s_2$$

$$\omega_4 = 1 - \lambda_1$$

This latter transformation allows testing of the specification of the structural equations since several of the parameters in equations 11′ and 15″ are functionally related. Specifically, $\gamma_4 = 1 - \gamma_2$ and $\omega_4 = 1 - \omega_2$.[3] Empirical tests yielded results which did not contradict these constraints, and thus the following two equations are included in the model:

$$(19) \quad \ln W_t - \ln W_{t-1} = \alpha_0 + \alpha_1 t + \alpha_2(\ln EP_t - \ln W_{t-1}) + \alpha_3 \sum_{i=0}^{n} w_i \ln EQ_{t-i}$$

(20) $$\ln P_t - \ln W_{t-1} = \beta_0 + \beta_1 t + \beta_2(\ln EP_t - \ln W_{t-1}) + \beta_3 \sum_{i=0}^{n} w_i \ln EQ_{t-i}$$

One further equation is added, defining unit labor costs (U):

(21) $$\ln U_t = \ln W_t + \ln N_t - \ln Q_t$$

This block, then, is composed of the seven equations 13 and 16 through 21, where the endogenous variables are $\ln W$, $\ln P$, $\ln Q$, $\ln N$, $\ln U$, $\ln EP$, and $\ln EQ$.

Block II: Estimates of Structural Parameters

The coefficients in this block are estimated using quarterly data for 1955I–1973IV. The wage, price, employment, and output variables are measured by national income accounts data adjusted to remove compensation of government employees. This adjustment is made on the presumption that the behavior postulated in this block is not representative of government employment practices. In addition, this procedure eliminates from the data the artificial effect on price movements of the treatment given government pay increases in the national income accounts. We have not yet incorporated government employment practices into the model, and we treat compensation of government employees (N_g) as an exogenous variable, included in G. Equation 18 is rewritten as $\ln Y_t^p = \ln P_t + \ln Q_t$, where Y^p is aggregate spending on goods and services produced in the private sector. This block is then linked to Block I by the identity $Y_t^p = Y_t - N_{gt}$.

The expectations variables (EP) and (EQ) are derived from the Livingston surveys, using the forecast of the consumer price index and the index of industrial production. The estimates of the coefficients are presented in Table 2.

Step-ahead simulations of Block II as a unit are performed, as in the case of Block I. The root-mean-square errors for percent changes in the endogenous variables (at annual rates) are reported in Table 3.

Blocks I and II: Model Simulations

To ascertain the simulative ability of the model over the sample period, step-ahead simulations combining both blocks are performed. The exogenous variables driving the model are changes in

TABLE 2 Block II Regression Coefficients

Predetermined Variables	Dependent Variables				
	$\ln P - \ln W_{-1}$	$\ln W - \ln W_{-1}$	$\ln N$	$\Delta \ln EP$	$\Delta \ln EQ$
$\ln EQ$	0.004	0.016	0.267*		
$\ln EQ_{-1}$	0.009	0.023*	0.174*		
$\ln EQ_{-2}$	0.011†	0.025*	0.101*		
$\ln EQ_{-3}$	0.010	0.022†	0.047*		
$\ln EQ_{-4}$	0.006	0.013	0.013		
$\ln EP - \ln W_{-1}$	0.874*	0.222*			
$\ln P - \ln EP_{-1}$				0.590*	
$\ln Q - \ln EQ_{-1}$					0.679*
t	−0.001*	0.001	−0.002*		
Constant	−0.107	−0.483*	1.939*		
$\hat{\rho}$	0.290	0.041	0.957	−0.578	−0.583
$\bar{R}^2$	0.999	0.214	0.997	0.571	0.686
SE	0.003	0.006	0.004	0.003	0.008
DW	1.960	1.969	1.731	2.371	2.365

NOTE: For identification of variables, see description of Block II in the accompanying text.
*Significant at 5 percent level.
†Significant at 10 percent level.

money, government spending, exports and government payrolls, and time. The root-mean-square errors for percent changes (at annual rates) are presented in Table 3.

TABLE 3 Step-Ahead Simulation within Sample Period (root-mean-square errors for percent change in quarterly data at annual rates)

Dependent Variable	Block II	Blocks I and II
Price level	1.74%	1.74%
Wage payments	3.11	3.10
Man-hours worked	1.94	2.06
Output	1.74	3.56
Unit labor costs	3.76	4.14
Output per man-hour	2.13	3.19
Aggregate spending	—	2.64

Since this study focuses on inflation, the ability of Block II to simulate the annual rate of change in the price level over four quarters is examined. Overlapping four-quarter dynamic simulations are performed, starting from each quarter between 1955II and 1972III. Root-mean-square errors in the percent quarterly changes (at annual rates) are calculated for all the sets of first-, second-, third-, and fourth-quarter simulations. For the entire sample period, the errors are 1.50, 1.50, 1.27, and 1.31 percent. The model does not take into consideration the imposition and subsequent relaxation of price-wage controls or any special factors; when the simulations are stopped at 1971II, root-mean-square errors of 1.32, 1.26, 0.99, and 0.98 percent are obtained.

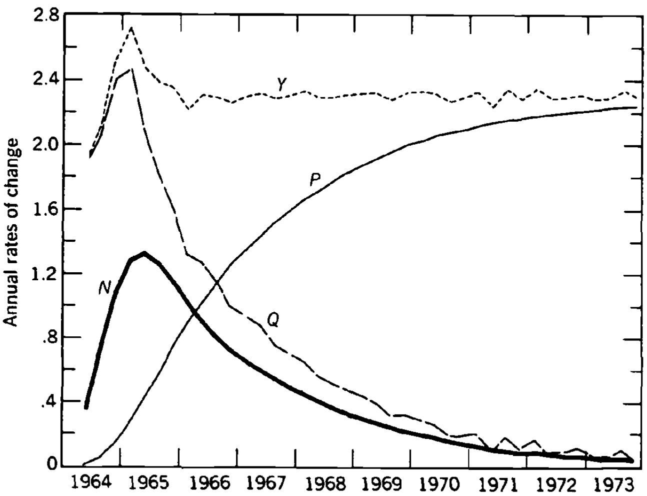
MONEY GROWTH AND INFLATION

The model responses of the price level and the other endogenous variables to different growth rates of money are ascertained by hypothetical dynamic simulations for the period 1964–1973. These simulations, to the extent that the model is an accurate portrayal of macroeconomic processes, shed light on the influence of money growth on inflation. They also demonstrate the responses of unit labor costs, wage payments, and productivity—the variables underlying the traditional cost-push view of inflation—to different growth rates of money.

The simulations start from 1964II. Since the interest rate block is not specified, equation 10′ is re-estimated with the interest rate excluded (Table 1). In these simulations it is assumed that no strikes occurred. In the first simulation it is assumed that the exogenous variables increase at their average annual rates from 1955 to 1964; i.e., $\Delta M/M = 3$ percent, $\Delta Z/Z = 6$ percent, and $\Delta Ng/Ng = 7$ percent. In the second simulation it is assumed that $\Delta M/M = 6$ percent, its average annual rate from 1964 to 1973, and that the other two exogenous variables increase as in the previous simulation.

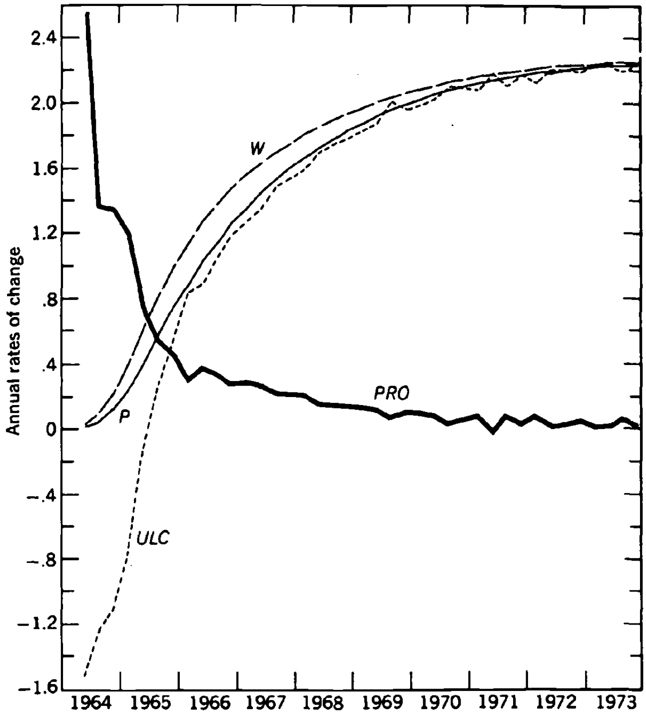
The contribution of the faster money growth to the annual rate of increase in each endogenous variable is measured by the difference between a 3 percent and 6 percent annual rate of money growth. These differences are presented in figures 1 and 2.

FIGURE 1 Differential Response of Endogenous Variables[a] (differences in annual rates of change)



[a] Response to a 6 percent annual rate of money growth minus response to 3 percent annual rate of money growth. Y = nominal aggregate spending, P = price level, N = employment, and Q = output.

FIGURE 2 Differential Response of Endogenous Variables[a] (differences in annual rates of change)



[a] Response to a 6 percent annual rate of money growth minus response to a 3 percent rate. *W* = wage payments, *PRO* = output per man-hour worked. *ULC* = unit labor costs, and *P* = price level.

Response of Price Level

The model simulations indicate that aggregate nominal spending (Y) would have increased at an annual rate 2.3 percentage points more with a 6 percent rate of money growth than with a 3 percent rate (Figure 1). In addition, the price level (P) would have risen at an annual rate of 2.3 percentage points more by the end of 1973 with 6 percent money growth than with 3 percent growth. Finally, while growth of output (Q) would have been initially greatly affected by the difference between the two rates of money, by the end of 1973, real output would have been rising at the same rate in both cases.[4]

Simulations were also performed holding money growth at 3 percent and assuming that Z grows at a rate of 10 percent, its average annual rate from 1964 to 1973. The results indicate that after a few quarters both the level of Y and its rate of change are virtually the same as in the simulation with 3 percent money growth and 6 percent growth of Z. As a result, the higher rate of growth of Z has little influence on the price level and the other endogenous variables in Block II.[5]

Implications for the Cost-Push View of Inflation

According to the model, changes in the growth of money cause changes in unit labor costs, wage payments, and productivity—the variables underlying a cost-push view of inflation. The hypothetical dynamic simulations produce movements in these three variables and in the price level that are consistent with the cost-push analysis, but these simulated movements are the result of one common factor—changes in the growth of money.

The difference in the rate of increase in wage payments (*W*) for 6 percent money growth over that for 3 percent growth rises sharply for about two years, then decelerates slowly. By the end of 1973, the difference has stabilized at about 2.2 percentage points higher (Figure 2). On the other hand, the difference in growth of output per man-hour worked (*PRO*) is substantial in the first quarter of the comparison, dropping sharply for about the next two years. Thereafter, the difference slowly narrows to approximately zero. The difference in the rates of increase of unit labor costs (*ULC*) are at first substantially below the difference for wage payment, but after the second year, the differences are nearly the same for both. The difference in the rates of increase in the price level (*P*) closely parallels that for unit labor costs after the second year.

These movements are consistent with the cost-push view of inflation that unit labor costs determine the price level and that an increase in wage payments exceeding growth of output per man-hour worked increases unit labor costs. According to the model, however, the simulated movements in these four variables are the result of the economy's adjustment over time to a higher growth of money. Also, when the results of a 6 percent money rate of growth for 1973 are compared with those for 3 percent money growth, higher rates of increase are indicated in the price level, unit labor costs, and wage payments. The cost-push view would attribute the higher rate of inflation to the higher rate of increase in unit labor costs resulting from the faster rate of increase in wage payments. The monetary view of inflation incorporated in the model would attribute the higher rates of increase in these variables to the faster growth of money.[6]

CONCLUSIONS

A structural model was specified, based on a monetary view of inflation, and its structural parameters were estimated. To the extent that the model captures macroeconomic processes, it demonstrates that the growth rate of money is a basic cause of inflation. An increase in money growth increases aggregate nominal spending. Market behavior of firms and suppliers of labor services, in turn, results in a faster rate of price increase. Model simulations also indicate that the faster growth of aggregate spending produces movements in the price level, unit labor costs, wage payments, and output per man-hour, that typically have been incorporated in a cost-push explanation of inflation. Thus, according to the model, the so-called cost-push phenomenon is to a considerable extent a reflection of the economy's adjustment to changes in the rate of money growth.

NOTES

1. For an earlier version of Block I see Leonall C. Andersen, "Comment on 'A Note on the Effects of Government Finance on Aggregate Demand for Goods and Services,'" *Public Finance,* November 3–4, 1973.
2. The analysis that underlies this section is drawn from previous work. See Denis S. Karnosky, "The Effect of Market Expectations on Employment, Wages, and Prices," Working Paper 17, Federal Reserve Bank of St. Louis, August 1973.
3. The implication of $\delta_4 = 1 - \delta_2$ is that $\rho_2 = 1.0$. This postulate was confirmed in tests not presented here. See ibid., pp. 74–79.
4. Since the difference in growth of real output never falls below zero, the model implies a permanent increase in the level of output from that implied by 3 percent money growth. This characteristic of the model is under further investigation.
5. For an extended report of similar simulations, see Andersen, "Comment."
6. Maximizing behavior and competitive markets underlie the equations in Block II. Empirical estimates of the structural parameters in this block are consistent with those implied by the theory. Consequently, this theory of price level movements is accepted and offered as an alternative to a cost-push theory of inflation based on market behavior of union and business monopolies. See Karnosky, "Effect of Market Expectations."

COMMENTS

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Complex problems, it appears, often beget simplistic explanations and solutions. In these difficult times of rampaging inflation in the midst of shortages, we are offered a diverse menu of explanatory choices, many of which are cited by Andersen and Karnosky. There is anchovy inflation, agricultural commodity inflation, world business cycle inflation, OPEC inflation, business- and labor-gouging inflation, local government wage-rate inflation, federal-spending inflation, and other more exotic forms. Of course, some analysts still adhere to traditional generalized cost-push or demand-pull inflation causes.

However, Andersen and Karnosky will have none of this and instead offer us their own special concoction. They say that the basic cause of inflation is simply the growth rate of money. Moreover, cost-push phenomena are said to be a reflection of the economy's adjustment to changes in the rate of money growth. Other than hard-core monetarists, it is doubtful that many economists would find these conclusions palatable. It is one thing to say that "money matters" in understanding movements in aggregate price levels. It is another to aver that the root cause of inflation since the mid-1960s is only money.

Andersen and Karnosky reach this conclusion on the basis of simulations with a modified version of the St. Louis Federal Reserve Bank model. The new model, like the old, is recursive. An initial block of equations relates nominal GNP to the nominal money supply, defined as M_1 (demand deposits plus currency). A subsequent block then splits changes in nominal GNP into price and real components, and provides, too, estimates of wage rates, man-hours, unit labor costs, and expected prices and outputs.

There are two major differences between the modified and original models. First, the equations are said to be specified and parameters estimated on a structural basis rather than as reduced forms. Second, most equations are log-linear rather than linear in variables. There are also some different exogenous variables, and interest rates are, at present, treated exogenously, a deficiency which may be removed in subsequent versions.

At this point in its development, Block I of the model takes the following form. Total spending is defined by Andersen-Karnosky in their equation 1 as the sum of private domestic spending, government spending, and exports less imports. Desired nominal money balances are made a function of technical efficiency of the monetary system (represented by an exponential time trend), the expected level of aggregate nominal spending (represented by a moving average of past spending), and nominal interest rates (equations 2, 3, and 4). The expected rate of inflation is not explicitly included as an argument, since it is assumed that expected prices are relevant only in periods of hyperinflation. (However, expected prices, of course, enter implicitly, since expected spending must include quantity and price components.)

Actual money balances are assumed to be determined by the Federal Reserve. Therefore, when there is a discrepancy between actual and desired money stocks, holders of money balances in the aggregate are said to adjust their rate of spending and holdings of other financial assets to eliminate the gap. In the present version of the model (equation 5), it is postulated that only private domestic spending adjusts to eliminate the discrepancy (recall that interest rates are exogenous).

In equation 6, imports (IM) are taken to be a constant proportion (δ) of the sum of private domestic spending (Y_t^d) plus government outlays (G_t) plus exports (X_t), with the last two exogenous. Letting $Z_t = G_t + X_t$, the authors can now describe total spending (equation 1) as:

$$Y_t = (1-\delta)(Y_t^d + Z_t) \tag{7}$$

or, for small changes (following equation 8),

$$\Delta \ln Y_t = (1-\delta)\{(Y_{t-1}^d/Y_{t-1})\Delta \ln Y_t^d + [1-(1-\delta)(Y_{t-1}^d/Y_{t-1})]\Delta \ln Z_t\}$$

By combining equations 2 through 5 and performing a first-difference transformation, a final estimating equation is obtained (following 10′):

$$\Delta \ln Y_t^d - \Delta \ln Y_{t-1}^d = a_0 + a_1 \Delta \ln M_t + a_2 \sum_{i=1}^{n} w_i \Delta \ln Y_{t-1}$$
$$+ a_3 \Delta \ln r_t + a_4 D_1 + a_5 D_2$$

Dummy variables (D) are included to account for the average influence of major strikes, and an Almon lag (third-degree polynominal, far-end zero constraint) is used for the aggregate spending term. The length of lag (four quarters) was selected to minimize the standard error of estimate.

The parameters of the equation were estimated using quarterly data for the period 1955–1973. Private spending is taken as nominal GNP less government spending and exports plus imports; money supply, as demand deposits plus currency; aggregate spending, as nominal GNP; and interest rates, as the 4-to-6–month commercial paper rate. $R^2 = 0.55$, and most coefficients are significant at the 5 percent level. The interest rate coefficient is small, and is significant only at the 10 percent level. An ex post dynamic simulation with equations 8 and 10′ shows that nominal GNP is tracked reasonably well.

Block II of the model explains wages, prices, and man-hours. Prices and wage rates are presumed to be set on the supply side in the short run, with the quantities of output and labor determined by demand factors. Prices are a log-linear function of productivity (represented by a time trend), wage rates, man-hours, and expected sales (at the long-run profit-maximizing price). Firms are presumed to incur costs in changing prices in response to short-run demand shifts, even where such changes are expected. Price and expected sales (EQ) are given by equations 11 and 12, respectively. The demand for labor man-hours depends on a time trend (a proxy for productivity?) and on expected sales or output (equation 13). The supply of labor man-hours depends on a time trend (a proxy for population and increased participation rates of women?), wage rates, and expected prices (equation 14). Since actual wage rates may differ from those which would clear the labor market (demand = supply), there is a partial adjustment mechanism (equation 15).

The second block of structural equations is completed by partial adjustment functions for expected prices (EP) and output and a nominal income-price-output identity (equations 16, 17, and 18).

Since labor supply (N_t^s) and the equilibrium wage (W_t^*) are unobservable, labor demand and supply (equations 13 and 14) are equated and solved for the equilibrium wage. The result is then inserted into the wage adjustment function, yielding equation 15′. Substituting for expected sales or output (cf. equation 12) in equation 15′, leads to equation 19.

Similarly, solving for the equilibrium wage rate, substituting for W and N (from equation 13) in equation 11, and using a distributed lag for expected output yields:

$$\text{(20)} \quad \ln P_t - \ln W_{t-1} = \beta_0 + \beta_1 t + \beta_2(\ln EP_t - \ln W_{t-1}) + \beta_3 \sum_0^n w_i \ln EQ_{t-i} + (\rho_2 - 1) \ln W_{t-1}$$

(The last term is dropped erroneously from the Andersen-Karnosky formulation because of the assumption that $\rho_2 = 1$.) Finally, in equation 21, unit labor costs are defined.

Taken as a whole, Block II contains five stochastic equations and two identities for the seven endogenous variables: wage rates, prices, man-hours, unit labor costs, real output, expected prices, and expected output. The last two are measured and estimated from the Livingston surveys. The exogenous variables are time and aggregate nominal spending. Lagged endogenous (predetermined) variables are expected prices, expected output, and wage rates.

Equation parameters in this block are estimated using quarterly observations for 1955–1973 with data from the national income accounts, adjusted to remove compensation of government employees (N_g) from all variables (it is not clear how this is done). In the solutions, equation 18 is rewritten as $\ln Y_t^p = \ln P_t + \ln Q_t$, where $Y_t^p = Y_t + N_{gt}$. The coefficients and explained variances obtained in the empirical estimates of the equations in this block reveal reasonable degrees of significance.

In contrast to Andersen and Karnosky's opinion that simulated paths reflect very well actual movements in each variable, ex post dynamic simulations of Block II show relatively large errors compared to simulations with other models for prices, output, man-hours, and unit labor costs over most of the 1955–1973 simulation period.[1] Prices and unit labor costs have large upward biases; and outputs and man-hours, large downward biases. The results generally are slightly worse when blocks I and II are combined in complete model solutions. Only wage rates are predicted reasonably accurately, but these rise along a fairly smooth path. The largest errors in levels of variables are 4.6 percent for prices and for output in the fourth quarter of 1973, 3.6 percent for wage rates in the first quarter of 1961, 7.3 percent for man-hours in the second quarter of 1956, and 6.6 percent for unit labor costs in the fourth quarter of 1973.

Responses of prices and other endogenous variables in the model are obtained from dynamic simulations for 1964–1973. The simulations were run with a growth rate of the sum of nominal government outlays and exports of 6 percent, compensation of government employees of 7 percent, and alternative rates of growth of M_1 of 3 and 6 percent, respectively. With 3 percent money growth, total spending (nominal GNP) increases at a steady 5.9 percent starting in 1967; with 6 percent money growth, the increase is at 8.2 percent. For both rates of money growth, real output grows at 3.9 percent in 1973 (thus, the respective rates of growth of prices at that time are 2.0

and 4.3 percent). Little change was found in the 3 percent money growth simulation when exogenous expenditures (government plus exports) were allowed to grow at 10 rather than 6 percent.

As noted by Andersen and Karnosky, changes in the growth of money cause changes in wage rates, productivity, and unit labor costs. In the 6 percent money growth case for 1973, wage payments rise steadily to a rate of increase of 7.4 percent, and output per man-hour first jumps sharply and then declines steadily to a 2.3 percent rate of increase in 1973. As a consequence, unit labor costs rise at a 5.1 percent rate at the same time. Given the nature of the price function, movements of the price level closely parallel those of unit labor costs.

While such movements may be consistent with a cost-push view of inflation, Andersen and Karnosky attribute the impact on prices as a result of the economy's adjustment in 1964–1973 to a higher growth rate of money (6 percent, which approximates the actual M_1 growth rate, in contrast to a hypothetical 3 percent).[2]

Given the instructions of the chairman that discussants are first to summarize authors' papers, I have up to this point for the most part resisted the temptation to criticize the analysis. On its face, it probably seems plausible and perhaps convincing to many, especially to those who have a monetarist bias to begin with. Yet, difficulties with the analysis and its execution abound.

To begin with, there is the fundamental proposition that domestic spending is the variable that adjusts to eliminate discrepancies between actual and desired money balances. Keynesian and portfolio theory would suggest that much, if not all, of the adjustment would occur in the form of shifts in demand for earning assets. Because there is no interest rate block, the present version of the St. Louis model makes no provision for adjustments on the asset side. This is a major deficiency in what is billed as a monetarist model.

Other than to posit that expected price increases are embodied in the nominal rate of interest, little exception can be taken to the specification of the equation for desired money stocks. In fact, when this function is combined with the other equations in Block I, the resultant function relating changes in income to changes in money stocks and interest rates can, when renormalized, be viewed as a typical nominal money demand function. The difficulty with this interpretation is that the terms for expected prices and for time deposit interest rates are missing.

Andersen and Karnosky undertake a first-difference transformation of this equation as a means of reducing possible multicollinearity and serial correlation of residuals. But this procedure is statistically efficient only in highly selected cases. Moreover, it has the effect of creating an unusual dependent variable: $Y_t^d Y_{t-2}^d/(Y_{t-1}^d)^2$.

Estimates of the coefficients of the equation, while they may be statistically significant (it would have been desirable to show t statistics rather than simply to state this) also are unusual. The coefficient of adjustment, with a value of 0.69, is approximately twice the size found in other studies (cf. Stephen Goldfeld's excellent study in *Brookings Papers on Economic Activity*). It gives almost complete adjustment of spending to changes in money stocks within a one-year period. Even more troublesome is the implied income elasticity of desired money balances, which, with or without the interest rate term, appears to be in the neighborhood of 1.5. The size of this coefficient may account for the substantially stronger short-run response of spending to changes in the money stock in the modified St. Louis model than in other models.

Turning to Block II, I find it surprising that no account is taken of the wage-price control program of recent years, especially because ad hoc strike dummy variables are included in the spending function of Block I. While controls may have had little long-run effect on the rate of inflation, it seems inconceivable that they did not have at least a significant short-run impact.

Aside from elimination of a wage rate term in the derivation of the final price function, the basic specification of the initial price equation can be seriously questioned. The purpose of including a time trend is not evident, nor is the absence of materials costs justified.

On the St. Louis model, serious reservations might also be raised on statistical grounds. The authors do not say how parameters are estimated. If the method of ordinary least squares is used, the estimated coefficients for this simultaneous equation system are biased and inconsistent. There are identification problems in both blocks.

Given these and other difficulties, I find it hard to accept the simulation results and the conclusions of the authors. However, they are to be thanked for an interesting and provocative paper, and we should wish them well in the pursuit of their goal of proving that money is the root of all evil, or at least of inflation. In fact, their own simulations would appear to belie this conclusion. The differential long-run response of prices to a 6 percent annual rate of money growth versus a 3 percent rate is 2.3 percent inflation. Since the long-run response of differential real output is negligible, there must be a drop in velocity and, presumably, a smaller increase in interest rates than in the rate of change of prices, which may have consequences for the composition of output. Another fascinating implication of the simulations is that monetary policy is powerful and effective for short-run stabilization of real output and employment. In the first year of a shift in money growth, there are limited price effects but substantial impacts on real output.

NOTES

1. These comments pertain to the original version of the paper, which included charts of predicted versus actual values. Only root-mean-square errors are shown in the present version. Since the model in the latest version is the same as in the original, presumably the errors are identical.
2. Only differential responses are shown in the present version; the earlier one included paths of variables.