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In This Issue . . .

This *Review* contains two articles that represent variations on a common theme. The theme is that, because "money matters," its influence should be incorporated explicitly in macroeconomic analysis if better policy decisions are to be made. Both articles use comparative economic studies to demonstrate the validity of this approach.

In the first article, Dallas S. Batten and R. W. Hafer use a modified form of the "St. Louis equation" to assess the relative importance of monetary and fiscal actions on economic activity in several developed countries. The purpose of this cross-country comparison is to determine whether the well-known results for the United States—that monetary actions have a permanent influence on GNP growth while fiscal actions have no lasting influence whatsoever—are unique to the United States, or whether they apply to other economies as well. To adjust for the importance of international trade (for the respective economies), Batten and Hafer modify the St. Louis equation, which relates growth in GNP to monetary and fiscal influences, by adding a third influence on GNP growth, the growth of merchandise exports.

When Batten and Hafer examine the effects of monetary and fiscal actions on GNP growth for Canada, France, Germany, Japan, the United Kingdom and the United States, they find that the U.S. results are generally supported across the other nations. Monetary actions have a significant and lasting effect on GNP growth in all six countries. Fiscal actions, on the other hand, are important only in two countries: France and the United Kingdom.

Further, Batten and Hafer examine the stability of the money-GNP growth relationship in each country over the change from fixed to floating exchange rates in the early 1970s. They find that this international policy shift had no effect on the significant money-GNP growth relationship in any of the six countries examined. The stability of this relationship in the face of "one of the most significant international policy shifts in the past two decades" provides evidence of the robustness of the money-GNP relationship and demonstrates that the economic relationships summarized in the "St. Louis equation" generally describe the economies of developed nations.

In the second article, Keith M. Carlson and Scott E. Hein compare the long-run characteristics of three well-known econometric models — Chase, DRI and Wharton — to those of the St. Louis model. The purpose of this comparison is to determine whether the St. Louis model — an explicitly monetarist model — provides different implications about the long-run effects of monetary policy from those generated by non-monetarist econometric models.

The comparisons were based on the impacts of four alternative monetary policy scenarios on simulations of a number of economic variables — including inflation rates, real GNP growth and nominal GNP growth. The simulations from the four models cover the period from 1987 to 1991, which represents the last five years of a ten-year simulation for the 1982–1991 period. These simulations were chosen to

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represent the "long-run" policy simulations; differences in the simulations across the models represent differences in the long-run characteristics of the models. These long-run simulations also were compared to the actual relationships between money growth and the same economic variables over the period from 1955 to 1981 to determine their consistency with the historical record. Significant deviations from the historical pattern is taken as evidence that there is some "problem" with the model's ability to capture the long-run consequences of monetary policy actions.

Carlson and Hein find that none of the four models consistently matches the historical record for *all* of the relationships assessed. For example, none of the large scale models' simulations of nominal income growth is generally consistent with the historical record; only the St. Louis model provides simulations that fit with past experience. On the other hand, the St. Louis model alone shows significant long-run variation in real output growth related to different monetary scenarios. This result runs counter to the historical evidence that long-run money growth has no lasting impact on real output.

Despite the variation among the models' long-run characteristics, one particularly useful policy conclusion emerges from the comparative evaluation: there are no long-run economic gains from faster money growth. This conclusion holds, in general, whether the structure of the model is explicitly "monetarist" or not.

The Relative Impact of Monetary and Fiscal Actions on Economic Activity: A Cross-Country Comparison

DALLAS S. BATTEN and R. W. HAFER

CONSIDERABLE research has been devoted to assessing the empirical relationship between both monetary and fiscal actions and economic activity in the United States. Much of this research was sparked by the controversial results obtained from investigating the impact of monetary and fiscal actions on GNP using the "St. Louis equation."[1] The St. Louis results can be summarized neatly: monetary actions have a significant, permanent effect on nominal GNP growth, while fiscal actions exert no statistically significant, lasting influence.

Substantially less work has been conducted within this framework for countries other than the United States.[2] Consequently, it is uncertain whether the St. Louis approach can be used universally in evaluating the economic impact of monetary and fiscal actions on income growth.

This study investigates the generality of the St. Louis approach by applying it to other countries. Based on evidence generated from the study of six developed countries — Canada, France, Germany, Japan, the United Kingdom and the United States — we conclude that money growth is more important than fiscal actions in determining GNP growth. Moreover, our results are robust across the "fixed" and "flexible" exchange rate regimes that characterized the past two decades.

ESTIMATING THE ST. LOUIS EQUATION ACROSS COUNTRIES

The St. Louis equation typically estimated for the United States consists of only three variables: nominal

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[1]The original articles presenting the controversial results are Leonall C. Andersen and Jerry L. Jordan, "Monetary and Fiscal Actions: A Test of Their Relative Importance In Economic Stabilization," this *Review* (November 1968), pp. 11–24; and Leonall C. Andersen and Keith M. Carlson, "A Monetarist Model for Economic Stabilization," this *Review* (April 1970), pp. 7–25.

Early critics include Frank De Leeuw and John Kalchbrenner, "Monetary and Fiscal Actions: A Test of Their Relative Importance in Economic Stabilization — Comment," this *Review* (April 1969), pp. 6–11; Richard G. Davis, "How Much Does Money Matter? A Look at Some Recent Evidence," Federal Reserve Bank of New York *Monthly Review* (June 1969), pp. 119–31; and Edward M. Gramlich, "The Usefulness of Monetary and Fiscal Policy as Discretionary Stabilization Tools," *Journal of Money, Credit, and Banking* (May 1971), pp. 506–32.

More recent sparring over the same issues is reported in Benjamin M. Friedman, "Even the St. Louis Model Now Believes in Fiscal Policy," *Journal of Money, Credit, and Banking* (May 1977), pp. 365–67; Keith M. Carlson, "Does the St. Louis Equation Now Believe in Fiscal Policy?" this *Review* (February 1978), pp. 13–19; and R. W. Hafer, "The Role of Fiscal Policy in the St. Louis Equation," this *Review* (January 1982), pp. 17–22.

[2]Two exceptions are Michael W. Keran, "Monetary and Fiscal Influences on Economic Activity: The Foreign Experience," this *Review* (February 1970), pp. 16–28; and William G. Dewald and Maurice N. Marchon, "A Modified Federal Reserve Bank of St. Louis Spending Equation for Canada, France, Germany, Italy, the United Kingdom and the United States," *Kredit und Kapital* (Heft 2 1978), pp. 194–212.

Our approach differs from these and other works in that a) we focus solely on the growth-rate version of the St. Louis equation (see footnote 6); b) we jettison the commonly used polynomial estimation technique for unconstrained ordinary least squares (see footnote 8); c) we explicitly examine the stability of the underlying relationships from each country over time; and d) we extend the sample period studied.

GNP, a variable summarizing monetary actions and one summarizing fiscal actions. Because the equation is formulated solely to test the relative efficacy of monetary and fiscal actions, it is not intended to incorporate all of the exogenous forces that affect nominal GNP. Conceptually, therefore, the equation is misspecified. This conceptual misspecification poses a statistical problem, however, *only if* the omitted exogenous variables are correlated with the policy measures used in the equation.[3] If, as assumed generally, the "missing" exogenous variables are neither policy variables nor closely correlated with the variables representing monetary and fiscal actions, their omission does not pose a serious statistical problem.[4]

This discussion implicitly assumes that the domestic economy being analyzed is relatively "closed" to the rest of the world. While this may adequately characterize the United States, it is not true for countries whose exports account for a large proportion of their GNP. In addition, because monetary and fiscal actions obviously affect the foreign sector, the correlation between external and domestic influences on GNP rises as the economy becomes more open. Consequently, these external influences should be included in analyzing the relative impacts of monetary and fiscal actions on GNP in such "open" economies.

In response both to past criticism of the St. Louis equation and the likely interrelation of domestic and external influences on GNP in other countries, the following modified version of the St. Louis equation is used:

$$(1) \quad \dot{Y}_t = \alpha_0 + \sum_{i=0}^{J} m_i \dot{M}_{t-i} + \sum_{i=0}^{K} g_i \dot{G}_{t-i}$$

$$+ \sum_{i=0}^{L} e_i \dot{EX}_{t-i} + \varepsilon_t,$$

where Y, M, G and EX represent GNP, narrow money (M1), federal government expenditures and merchandise exports, respectively.[5] The dots above each variable indicate that the equation is estimated in growth rate form.[6] The appropriate lag lengths (J, K and L) are determined using an orthogonal regression procedure with sequential hypothesis testing.[7]

Finally, one additional modification is made in estimating the equation. The St. Louis equation typically is estimated with each distributed lag's coefficients restricted to lie on a fourth-degree polynomial with endpoints constrained to equal zero. Because these constraints may not be valid across countries, we esti-

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[3]For examples of the specification error argument, see Franco Modigliani and Albert Ando, "Impacts of Fiscal Actions on Aggregate Income and the Monetarist Controversy: Theory and Evidence," in Jerome L. Stein, ed., *Monetarism*, vol. 1, Studies in Monetary Economics (North-Holland, 1976), pp. 17–42; and Robert J. Gordon, "Comments on Modigliani and Ando," in *Monetarism*, pp. 52–66.

To understand the necessary condition for bias due to misspecification, consider the following equation:

$(1') \quad Y_t = a_0 + a_1 X_t + e_t.$

Now if equation $1'$ is not the "true" model, but some other exogenous variable, Z, has been omitted, the true model is:

$(2') \quad Y_t = b_0 + b_1 X_t + b_2 Z_t + \eta_t.$

Estimating equation $1'$ instead of $2'$ yields an estimate of a_1 with an expected value of $a_1 + \hat{\lambda}_1 b_2$ where $\hat{\lambda}_1$ is obtained by estimating

$(3') \quad Z_t = \lambda_0 + \lambda_1 X_t + \phi_t.$

Obviously, the estimate of a_1 is biased only if $\hat{\lambda}_1 \neq 0$, but $\hat{\lambda}_1$ equals $r_{xz} (\frac{S_z}{S_x})$ where

r_{xz} = the simple correlation coefficient between X and Z, and

S_i = the standard deviation of i.

Consequently, $\hat{\lambda}_1 \neq 0$ only if $r_{xz} \neq 0$; that is, X and Z must be correlated before the omission of Z results in a specification error.

[4]This point also is made in Andersen and Jordan, "Monetary and Fiscal Actions," p. 24.

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[5]Even though many countries included in this study do not explicitly target the narrow (M1) definition of money, this definition provides a consistent and comparable set of explanatory variables across countries. Also, to remove the impact of cyclical changes, high-employment government expenditures is the measure of fiscal policy action typically included in the estimation for the United States. Because comparable measures of government expenditures do not exist for the other countries in the sample, federal government expenditures that are *not* adjusted for cyclical changes are used for each country. It should be noted, however, that using either measure for the United States did not alter the conclusions reached in this paper.

Furthermore, a criticism frequently leveled at using OLS to estimate equation 1 is that the right-hand-side variables are not exogenous with respect to GNP, resulting in simultaneous equation bias. This issue is addressed in an earlier, expanded version of this paper through the use of Granger-type causality tests. These tests did not indicate any causal relationship from income growth to money growth or government expenditure growth in any of the countries analyzed. Alternatively, income growth appears to "cause" export growth in France and the United States, but not in the remaining countries. Statistically speaking, then, the estimated parameters of equation 1, as specified for the United States and France, may be biased. This does not appear to be the case for the rest of the sample.

[6]Carlson, "Does the St. Louis Equation Now Believe in Fiscal Policy?" demonstrates that the original first-difference form of the model, when updated through the 1970s, is plagued by heteroscedasticity. This problem is not evident in the growth-rate version, however.

[7]This procedure involves a Gram-Schmidt orthogonalization of the data and the use of a testing procedure introduced by Marcello Pagano and Michael J. Hartley, "On Fitting Distributed Lag Models Subject to Polynomial Restrictions," *Journal of Econometrics* (June 1981), pp. 171–98; and extended by Dallas S. Batten and Daniel L. Thornton, "Polynomial Distributed Lags and the Estimation of the St. Louis Equation," this *Review* (forthcoming).

Table 1
Summary of Estimation Results[1]

Coefficient	Country and Sample Period					
	Canada II/66–IV/81	France II/65–III/81	Germany II/63–I/82	Japan II/60–II/80	United Kingdom II/66–I/81	United States II/62–I/82
Constant	−.006 (0.90)	.007 (1.43)	.007 (1.31)	.010 (1.65)	.001 (0.21)	.007 (1.94)
$\Sigma\dot{M}$	.726[2] (3.41)	.289[2] (1.75)	.518[2] (3.50)	.552[2] (3.76)	.419[2] (2.50)	1.094[2] (4.29)
$\Sigma\dot{G}$	−.011 (0.09)	.192[2] (1.90)	−.225 (1.44)	.006 (0.87)	.345[2] (2.90)	−.199 (1.21)
$\Sigma\dot{EX}$	.543[2] (3.04)	.246[2] (3.21)	.276[2] (2.48)	.067 (1.65)	.209[2] (3.02)	.114 (1.64)
$\bar{R}^2$	.49	.82	.29	.19	.59	.41
SE	.006	.008	.011	.016	.013	.008
DW	1.92 (.30)[3]	2.09	1.91	1.79	2.04	2.24

[1]Absolute values of t-statistics in parentheses. $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom; SE is the standard error of the regression; and DW is the Durbin-Watson test statistic.

[2]Statistically significant at the 5 percent level using a one-tailed test.

[3]Estimate of rho, the first-order serial correlation coefficient.

mate equation 1 using unconstrained ordinary least squares (OLS) instead of subjecting the data to potentially invalid polynomial restrictions.[8]

Equation 1 is estimated using quarterly data from Canada, France, Germany, Japan, the United Kingdom and the United States.[9] A summary of the OLS regression results is reported in table 1. (The detailed results can be found in the appendix.) The sample periods differ due to differences in data availability. The regressions exhibit a relatively wide range of explanatory power in describing GNP growth in the

different economies: the $\bar{R}^2$ varies from a high of .82 in France to a low of .19 in Japan. The Durbin-Watson statistics indicate that the estimates generally are not plagued by first-order serial correlation problems. In only one instance, that of Canada, is a first-order serial correlation correction technique necessary. As shown in table 1, this correction (rho is estimated to be .30) adequately removes the problem.

The United States

The "standard" results appear to hold for the United States; that is, they are not affected significantly by our modifications. The summed impact of money growth is significantly positive (t = 4.29) and does not differ from unity (t = 0.37). This means that a 1 percentage-point increase in money growth leads to a permanent 1 percentage-point rise in GNP growth. Moreover, the estimated coefficients for the individual lag terms (see appendix) suggest a large effect of money on income during the first three quarters, with a varying impact throughout the remaining lag terms.

The estimated coefficients for the fiscal measure are interesting because they indicate only a minor initial effect on income growth with a mostly negative impact thereafter. This is supported by the cumulative effect

[8]For a discussion of the possible effects of using polynomial and endpoint restrictions, see Peter Schmidt and Roger N. Waud, "The Almon Lag Technique and the Monetary Versus Fiscal Policy Debate," *Journal of the American Statistical Association* (March 1973), pp. 11–19.

The imposition of polynomial and endpoint constraints is motivated primarily by the desire to estimate more precisely coefficients of highly colinear variables (a common characteristic of distributed lag models). Our concern, in contrast, is the total or cumulative impact of monetary and fiscal actions on GNP growth. Consequently, OLS will yield estimates of linear combinations of coefficients that are as precise as those obtained by imposing polynomial and endpoint restrictions. See Henri Theil, *Principles of Econometrics* (John Wiley and Sons, Inc., 1971), pp. 147–52.

[9]When estimated for France, equation 1 also contains a dummy variable representing the student riots and subsequent nationwide strikes that occurred in II/1968.

of fiscal policy being negative and negligible ($\Sigma g = -0.199$), and statistically insignificant ($t = -1.21$).

The results obtained for exports are similar to those for fiscal actions: none of the individual coefficients are large in absolute magnitude compared with those of $\dot{M}$ or $\dot{G}$, and most are statistically insignificant. Moreover, the cumulative effect of export growth on GNP growth is not statistically significant at any conventional level.

Thus, the standard St. Louis equation results continue to hold for the United States even with the changes in the specification: money growth exerts a significant, lasting impact on income growth; government expenditure growth and export growth have only transitory influences at best. With these results forming the basis for comparison, we will now examine what the application of this framework produced in the other countries.

The Impact of Money

Looking first at the effects of changes in money growth, we observe that the qualitative results for each country are quite similar to those for the United States. Specifically, changes in money growth have a statistically significant, permanent impact on nominal income growth in each country.[10] The quantitative results, however, exhibit some differences. The cumulative impact of money growth for each country except Canada is noticeably smaller than it is for the United States. For Canada, the cumulative impact is not statistically different from one ($t = 1.29$). Thus, while changes in money growth exert a positive, statistically significant influence on the growth of income across all the economies studied, a 1 percentage-point increase in money growth results in a *less* than 1 percentage-point rise in income growth for all of the countries except the United States and Canada.

The Impact of Fiscal Actions

The results of changes in fiscal actions are interesting because they tend to confirm the U.S. findings. The cumulative impact of a change in the growth of government expenditures on income growth is statistically significant for the United Kingdom and France. For the remaining countries, however, the cumulative impact is negligible and, for Canada and Germany the variable takes on an unexpected negative sign. Moreover, the cumulative impact of a change in fiscal

actions is *smaller* than that of a change in money growth in each country.

The Impact of Exports

Not surprisingly, export growth is an important factor in explaining GNP growth for the countries in our sample other than the United States and Japan.[11] The cumulative impact is statistically significant and ranges in magnitude from 0.54 in Canada to 0.21 in the United Kingdom. Consequently, it appears that the inclusion of export growth is an important modification of the St. Louis equation for explaining economic activity in open economies.[12]

IT WORKS, BUT IS IT STABLE?

The comparison of the empirical results from a variety of countries indicates that the St. Louis equation is useful in assessing the relative impact of monetary and fiscal actions, and that its explanatory power can be increased with the addition of export growth as an explanatory variable. Furthermore, the evidence here suggests that changes in money growth have a permanent and significant influence on GNP growth. The evidence does not provide a similar conclusion for fiscal actions, except for the United Kingdom and France.

The usefulness of any equation that purports to explain macroeconomic phenomena depends crucially on the stability of the estimated relationship. This issue is even more significant if some of the right-hand-side variables in the estimated equation are policy-determined.[13] Consequently, it is always important to

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[10]Because the expected *cumulative* impact of each variable in equation 1 is positive, one-tailed hypothesis tests are employed.

[11]The export results for Japan are not surprising, even though the general perception of Japan is that of a large exporter. Japan's export sector as a percent of nominal GNP is actually quite low relative to other countries in our sample. For example, in 1980 Japan's exports accounted for only 12 percent of GNP. In comparison, the figures for the other countries are: United States (8 percent); Canada (27 percent); United Kingdom (21 percent); France (18 percent); and Germany (24 percent).

[12]When equation 1 is estimated excluding the distributed lag of export growth, the qualitative results for France are the only ones affected. In that case, the cumulative impact of a change in money growth is no longer statistically significant (even at the 10 percent level). Furthermore, there is little change in the quantitative results concerning the cumulative impacts of either monetary or fiscal actions. This finding is comforting given the discussion in footnote 5.

[13]The argument is that if estimated parameters change with policy changes, then there is no stable foundation upon which policymakers may project the outcome of today's actions into the future. This argument is presented in Robert E. Lucas, Jr., "Econometric Policy Evaluation: A Critique," in Karl Brunner and Allan A. Meltzer, eds., *The Phillips Curve and Labor Markets*, vol. 1 (1976), The Carnegie-Rochester Conference Series on Public Policy, Supplement to the *Journal of Monetary Economics*, pp. 19–46.

examine the statistical stability of the estimated parameters across alternative policy rules if the equation is being used in policy analysis.

Although the determination of each policy shift in each country is a task well beyond the scope of this paper, there is a single event common to all of the countries that can be used to assess the stability of the estimated relationships. That event, which occurred during the early 1970s, is the collapse of the Bretton Woods system. In general, the period before the second quarter of 1973 is viewed as a fixed exchange rate regime while the period since then usually is characterized as a floating exchange rate period.[14] While one may quibble about this characterization, the early 1970s would seem to mark a significant turning point in the implementation of domestic monetary and fiscal policies for the open economies in our sample. Consequently, this apparent policy shift provides a useful point to test the stability properties of the estimated income relationships.[15]

It is essential to understand that we are investigating the stability of the relationship that explains the transmission of changes in money growth and government expenditure growth, *however determined*, to changes in GNP growth. We are not concerned with how or why a change in money growth or government expenditure growth occurs; we simply wish to determine the extent to which these variables affect the growth of nominal GNP. Consequently, the use of the exchange rate regime change does not require monetary or fiscal actions to have any greater or lesser effect on GNP growth after the break than before. The change in

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Table 2

Stability Test Results

Country	Absolute values of t-statistics	
	$\dot{M}$	$\dot{G}$
Canada	0.26	0.40
France	1.44	1.08
Germany	1.65	0.68
Japan	0.70	1.55
United Kingdom	0.07	2.24[1]
United States	0.61	1.35

[1]Statistically significant at 5 percent level.

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exchange rate regimes is chosen as a likely break in the income equations primarily because of its universality.

To examine the stability of the estimated income relationships, (0,1) dummy variables are used to form multiplicative slope-dummy terms for the money growth and government expenditure growth variables. Stability is investigated by testing the hypothesis that the cumulative impact of each dummied variable's distributed lag is significantly different from zero.[16] If the resulting t-statistic is less than a predetermined critical value, the null hypothesis that these coefficients are stable across exchange rate regimes cannot be rejected.

The calculated t-statistics for each variable's stability test are reported in table 2. The break point for the United States, France, Germany and Japan is I/1973, the widely accepted timing of the breakdown of the

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[14]The break points for the United Kingdom and Canada tested are slightly different from the I/1973 point. See text.

[15]It is typically thought that during a fixed exchange rate regime the reserve currency country determines monetary policy for the rest of the world. If this were the case, the measured influence of monetary actions on economic activity during the Bretton Woods period actually would indicate actions motivated by the reserve currency country, not by the domestic monetary authorities. To test this proposition, we performed Granger-type causality tests to see if changes in U.S. money growth "caused" changes in foreign money growth during the fixed exchange rate period. These tests results did *not* indicate any systematic relationship between U.S. money growth and money growth in any of the countries included in our sample. Our results support those of Edgar L. Feige and James M. Johannes, "Was the United States Responsible for Worldwide Inflation Under the Regime of Fixed Exchange Rates?" *Kyklos* (Fasc. 2 1982), pp. 263–77; and Edgar L. Feige and Kenneth J. Singleton, "Multinational Inflation Under Fixed Exchange Rates: Some Empirical Evidence From Latent Variable Models," *The Review of Economics and Statistics* (February 1981), pp. 11–19. Consequently, connecting observed money growth with monetary policy decisions in these countries, even during the fixed exchange rate period, appears to have some empirical support.

[16]This approach is suggested by Damodar Gujarati, "Use of Dummy Variables in Testing for Equality Between Sets of Coefficients in Linear Regressions: A Generalization," *The American Statistician* (December 1970), pp. 18–22. We employ this method by constructing a slope-dummy term for each variable in the distributed lag of $\dot{M}$ and of $\dot{G}$ (e.g., $\overline{\dot{DM}}_t = D \cdot \dot{M}_t$ where D = 0 in the fixed-rate period and 1 in the floating-rate period). The hypothesis that the cumulative impact of $\dot{M}$ has changed with the movement of float-

ing exchange rates is then investigated by testing $\sum_{i=0}^{K} \overline{\dot{DM}}_{t-i} = 0$.

A similar procedure is used for $\dot{G}$.

This approach is chosen over the more commonly used Chow test, because the Chow test examines the stability of the entire relationship. Thus, the coefficients of one variable may change dramatically over time, while the Chow test will not reject the hypothesis of stability if that variable's explanatory power is weak relative to that of other variables whose coefficients are relatively stable. The dummy variable approach circumvents this potential problem.

Smithsonian extension of the Bretton Woods system. Because the United Kingdom and Canada had refused earlier to peg the value of their currencies to the U.S. dollar, the break points tested are II/1972 and II/1970 for the United Kingdom and Canada, respectively. The results reported in table 2 support the hypothesis that in each country the cumulative impact of a change in money growth is stable across the break in exchange rate regimes. The cumulative impact of a change in the growth of government expenditures exhibits instability only for the United Kingdom.

The results for the United Kingdom indicate that the estimated equation does not reliably capture the relationship between changes in the growth of government expenditures and GNP growth. Furthermore, a shift in the trend rate of velocity growth (captured by the constant term) is detected. To correct for both of these deficiencies, equation 1 is re-estimated for the full-sample period with the coefficients of government expenditure growth and the constant term allowed to take on different values during the two exchange rate periods. The re-estimated United Kingdom equation is (absolute value of t-statistics in parentheses):

$$\dot{Y} = 0.008 - \underset{(1.90)}{0.024}\ D1 + \underset{(2.12)}{0.679}\ \overset{11}{\underset{i=0}{\Sigma}}\ \dot{M}_{t-i}$$

$$- \underset{(0.19)}{0.043}\ \overset{2}{\underset{i=0}{\Sigma}}\ \dot{G}^{I}_{t-i} + \underset{(3.39)}{0.530}\ \overset{2}{\underset{i=0}{\Sigma}}\ \dot{G}^{II}_{t-i}$$

$$+ \underset{(2.95)}{0.200}\ \overset{2}{\underset{i=0}{\Sigma}}\ \dot{EX}_{t-i}$$

$$\bar{R}^2 = 0.66 \quad SE = 0.012 \quad DW = 2.15$$

These results indicate that, after separating the influence of government expenditures and the constant term into the two periods, the cumulative effect of changes in British money growth increases in magnitude and remains positive and significant and now is not statistically different from one (t = 1.00).

This suggests that the failure to incorporate the secular decline in the trend rate of velocity growth since 1973 seriously understated the initially estimated impact of changes in money growth. Export growth continues to influence GNP growth significantly, although the summed coefficient indicates a slight decline.

The United Kingdom estimates indicate that the government expenditure results in table 1 are capturing the post-II/1972 effects. For the period II/1966 to II/1972, fiscal actions have no significant lasting effect on income growth. The post-II/1972 results, on the other hand, point to a significant and fairly substantial fiscal effect. The post-II/1972 results indicate that increasing the growth of government expenditures by 1 percentage point will permanently increase income growth by about one-half as much. Thus, in contrast to the evidence presented for the other countries examined, the cumulative impact of fiscal actions is highly significant only in the United Kingdom, and then only after II/1972.

SUMMARY

The results in this paper demonstrate that the St. Louis equation can be applied to a variety of other countries and that monetary actions dominate fiscal actions in determining the pace of economic activity in these countries. Estimating a modified St. Louis equation for six different countries, our results indicate that changes in money growth have a significant and lasting impact on nominal income growth in all six cases. Of equal importance, the money-GNP link was stable in each country across one of the most significant international policy shifts of the last two decades — the move from fixed to floating exchange rates.

In contrast, fiscal actions are significant only in the United Kingdom and France. Moreover, this effect does not appear to be stably related to income in the United Kingdom where fiscal actions have exerted a lasting impact on income growth only during the recent floating exchange rate period.

Appendix
Detailed Estimation Results[1]

	Constant	$\dot{M}$	$\dot{G}$	$\dot{EX}$	Summary statistics
Canada	−.006 (0.90)	.142 (2.51)[2]	.006 (0.31)	.063 (2.73)[2]	
Lag 1		.205 (3.15)[2]	−.035 (1.48)	.124 (4.36)[2]	$\bar{R}^2$ = .49
Lag 2		.131 (2.03)[2]	−.007 (0.25)	.025 (0.94)	
Lag 3		−.033 (0.51)	−.011 (0.39)	.000 (0.00)	
Lag 4		.215 (3.05)[2]	−.005 (0.16)	.029 (1.03)	SE = .006
Lag 5		.154 (2.25)[2]	.041 (1.92)	.076 (2.68)[2]	
Lag 6		−.134 (2.00)		.025 (0.92)	
Lag 7		−.069 (1.00)		.036 (1.31)	DW = 1.92 (.30)[4]
Lag 8		.115 (1.73)		.051 (1.88)	
Lag 9				−.003 (0.12)	
Lag 10				.021 (0.85)	
Lag 11				.073 (2.64)[2]	
Lag 12				.023 (1.00)	
Sums		.726 (3.41)[3]	−.011 (0.09)	.543 (3.04)[3]	
France	.007 (1.43)	−.036 (0.57)	−.039 (1.47)	.066 (1.64)	
Lag 1		.132 (2.01)[2]	−.002 (0.08)	.035 (1.16)	
Lag 2		.075 (0.98)	.003 (0.10)	.052 (1.83)	$\bar{R}^2$ = .82
Lag 3		−.034 (0.43)	.042 (1.55)	.001 (0.03)	
Lag 4		.030 (0.37)	.047 (1.78)	.024 (0.83)	SE = .008
Lag 5		.088 (1.17)	.065 (2.48)[2]	.025 (0.89)	
Lag 6		.015 (0.19)	.049 (2.00)[2]	.043 (1.53)	DW = 2.09
Lag 7		−.058 (0.77)	.027 (1.43)		
Lag 8		.077 (1.08)			
Sums		.289 (1.75)[3]	.192 (1.90)[3]	.246 (3.21)[3]	
Germany	.007 (1.31)	.087 (0.67)	.022 (0.53)	.202 (4.71)[2]	$\bar{R}^2$ = .29
Lag 1		.024 (0.16)	−.028 (0.66)	.045 (1.16)	
Lag 2		.407 (3.06)[2]	−.064 (1.46)	−.017 (0.45)	SE = .011
Lag 3			−.024 (0.56)	−.018 (0.49)	
Lag 4			−.062 (1.50)	.064 (1.45)	DW = 1.91
Lag 5			−.069 (2.09)[2]		
Sums		.518 (3.50)[3]	−.225 (1.44)	.276 (2.48)[3]	
Japan	.010 (1.65)	.013 (0.13)	.006 (0.87)	.067 (1.65)	$\bar{R}^2$ = .19
Lag 1		.161 (1.44)			
Lag 2		.289 (2.54)[2]			SE = .016
Lag 3		−.120 (1.03)			
Lag 4		.209 (1.83)			DW = 1.79
Sums		.552 (3.76)[3]	.006 (0.87)	.067 (1.65)	
United Kingdom	.001 (0.21)	−.007 (0.07)	.274 (3.11)[2]	.156 (4.86)[2]	
Lag 1		.335 (3.31)[2]	−.094 (1.24)	.117 (3.42)[2]	
Lag 2		.069 (0.64)	.165 (2.19)[2]	−.064 (1.81)	$\bar{R}^2$ = .59
Lag 3		−.274 (2.76)[2]			
Lag 4		.190 (1.81)			SE = .013
Lag 5		−.113 (1.07)			
Lag 6		−.041 (0.38)			
Lag 7		.108 (1.04)			DW = 2.04
Lag 8		.160 (1.45)			
Lag 9		−.169 (1.60)			
Lag 10		−.016 (0.15)			
Lag 11		.177 (1.75)			
Sums		.419 (2.50)[3]	.345 (2.90)[3]	.209 (3.02)[3]	

(continued on next page)

Appendix Continued[1]

	Constant	$\dot{M}$	$\dot{G}$	$\dot{EX}$	Summary statistics
United States	.007 (1.94)	.709 (4.14)[2]	.065 (1.22)	.022 (1.28)	
Lag 1		.425 (2.70)[2]	.055 (1.04)	.015 (0.86)	
Lag 2		.380 (2.64)[2]	−.121 (2.28)[2]	.005 (0.31)	
Lag 3		−.255 (1.74)	.030 (0.56)	.000 (0.01)	$\bar{R}^2$ = .41
Lag 4		.204 (1.29)	−.063 (1.17)	−.009 (0.54)	
Lag 5		−.369 (2.08)[2]	−.049 (0.93)	.006 (0.36)	SE = .008
Lag 6			.079 (1.49)	−.009 (0.51)	
Lag 7			−.028 (0.49)	.015 (0.87)	DW = 2.24
Lag 8			−.076 (1.28)	−.016 (0.91)	
Lag 9			−.091 (1.61)	.015 (0.84)	
Lag 10				.030 (1.73)	
Lag 11				.040 (2.41)[2]	
Sums		1.094 (4.29)[3]	−.199 (1.21)	.114 (1.64)	

[1]See notes accompanying table 1.

[2]Statistically significant at the 5 percent level using a two-tailed test.

[3]Statistically significant at the 5 percent level using a one-tailed test.

[4]Estimate of rho, the first-order serial correlation coefficient.

Four Econometric Models and Monetary Policy: The Longer-Run View

KEITH M. CARLSON and SCOTT E. HEIN

ONE key element in the making of an informed economic policy decision is the accuracy with which policymakers can gauge the longer-run consequences of their policy actions and strategies. Crucial to such attempts to grasp these policy consequences is the use of econometric models. Whether current econometric models are useful in this respect depends upon their "long-run" characteristics; unfortunately, until recently, there had been virtually no study of the comparative long-run properties of the major econometric models currently in use. Most analyses instead have dealt with how well these models forecast a few quarters ahead.

This situation changed with the publication of a recent study by the Joint Economic Committee (JEC) of Congress that focused explicitly on the economic impact of alternative long-run monetary strategies using three well-known econometric models.[1] Missing from the JEC study, however, was an econometric assessment using an explicit monetarist model. The purpose of this paper is to extend the JEC study by comparing their results with those obtained for the St. Louis model. Analysis of the St. Louis model according to criteria used in the JEC study is informative for two reasons. First, it indicates whether a monetarist framework provides additional insight into the long-run effects of monetary policy. Second, it provides policymakers the opportunity to compare the long-run properties of a monetarist model with those of the major nonmonetarist models.

FEATURES OF THE JEC STUDY

The JEC study examined the simulated performance of certain key macroeconomic variables under four different long-run monetary strategies. Three large-scale econometric models were analyzed: those of Chase Econometrics, Data Resources Incorporated

(DRI) and Wharton, the best-known and most widely used models.

Four separate monetary strategies were considered over a 10-year simulation period (1982 through 1991), using the fourth quarter of 1981 and an M1 growth rate of 5.8 percent as points of departure:

(1) a sudden deceleration of M1 growth to zero percent in one year, and then held at zero;

(2) gradual deceleration of M1 growth to zero percent over a five-year period, and then held at zero;

(3) sudden deceleration of M1 growth to 3 percent in one year, and then held at 3;

(4) gradual acceleration of M1 growth to 10 percent over a five-year period, and then held at 10.

In addition, each model's proprietor was asked to run a baseline projection with freedom to choose the monetary strategy.[2]

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[2]The baseline simulations thus represented each model's assumption about the future course of monetary policy as of March 1982. These assumptions were as follows:

	M1 Growth Rate: 1982–91
Chase	6.3%
DRI	4.5
Wharton	5.2

The model proprietors were further instructed to simulate each of the four monetary strategies twice: first, without making any judgmental adjustments, and second, making any adjustments deemed necessary to ensure consistency and generate results that were considered sensible. These adjustments were at the discretion of the individual model proprietor and involved no contact with the JEC staff. The JEC labeled these two sets of simulations "pure" and "managed."

The JEC study concluded, on the basis of the pure simulations, that none of the models can be used by themselves to decide among the monetary strategies. The results of these pure simulations were termed "puzzling," because the links between the money growth and the key macroeconomic variables ran counter to historical experience.

The JEC conclusions about the managed simulations were more positive. While there still remained some inconsistencies with historical relationships, the managed simulations were judged to provide a better basis for considering the longer-run policy implications of alternative monetary aggregate growth strategies. Thus, in the discussion to follow, only the managed simulation results from the large scale models are considered.

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[1]Robert E. Weintraub, *Three Large Scale Model Simulations of Four Money Growth Scenarios*, a staff study prepared for the use of the Subcommittee on Monetary and Fiscal Policy of the Joint Economic Committee of Congress (Government Printing Office, 1982).

The St. Louis Model

The basic structure of the St. Louis model, developed in the late 1960s, has remained essentially unchanged since then.[1] The model consists of five equations and two identities (see appendix). The foundation of the model and the basis for its monetarist label is the GNP equation. The growth rate of GNP is specified as a function of current and lagged values of M1 growth and current and lagged values of the growth of high-employment federal expenditures. The monetarist label stems primarily from the estimated coefficients: the sum of the coefficients on money growth is about unity and the sum of the coefficients on high-employment expenditure growth is about zero.

The price equation relates the rate-of-change of prices to current and lagged values of demand pressure, current and lagged values of changes in the relative price of energy, and a measure of anticipated price change. Demand pressure is defined as the growth of output relative to the growth of high-employment output. Anticipated price change is a weighted sum of past price changes with the weights obtained by estimating the corporate Aaa rate as a function of past inflation. Output growth (real GNP) is determined residually via the GNP identity; nominal GNP growth is the sum of real GNP growth and the rate of change of prices.

The model's remaining equations provide estimates of three other macroeconomic variables. Unemployment is estimated as a function of the gap between actual output and high-employment output. The Aaa bond rate is a function of past inflation. The 4-month commercial paper rate is a function of contemporaneous M1 growth and current and lagged values of changes in the relative price of energy, output and prices.

[1]Leonall C. Andersen and Keith M. Carlson, "A Monetarist Model for Economic Stabilization," this *Review* (April 1970), pp. 7–25. Minor changes which have been made include: (1) a respecification in rate-of-change form from the original first difference form; (2) the addition of energy prices as an exogenous variable; and (3) a change in estimation procedure from ordinary least squares to generalized least squares for those equations in which serial correlation is evident. See Keith M. Carlson and Scott E. Hein, "An Analysis of a Modified St. Louis Model," a paper prepared for the Spring Conference on Comparing the Predictive Performance of Macroeconomic Models at Washington University in St. Louis (April 20, 1982).

Though the instructions were specified in terms of M1, none of the models permitted direct control of this monetary aggregate. Both Chase and DRI specify the control of money growth through nonborrowed reserves. Thus, nonborrowed reserves were manipulated to achieve the desired M1 growth.[3] For the Wharton model, the target variable is M2 instead of M1. The Wharton simulations were conducted using M2 target rates of 4 percent, 7 percent and 14 percent,

respectively, whereas the JEC specified M1 targets of zero percent, 3 percent and 10 percent.[4]

Simulation of the St. Louis model for the long-run monetary strategies outlined in the JEC study required assumptions about other exogenous variables: potential output was assumed to grow 2.5 percent per year, high-employment expenditures to increase at a steady 8 percent rate, and the change in the relative price of energy to be zero. To determine a baseline strategy, an average of the baseline strategies for the large-scale models was constructed. What this amounted to was a gradual reduction in M1 growth from a 5.8 percent rate in fourth quarter 1981 to 5.0 percent in 1991.

[3]DRI has an iterative procedure that allowed them to hit M1 targets exactly as specified by the JEC. Chase, on the other hand, used a trial and error procedure, and was unable to achieve M1 targets precisely.

Since the simulations were run in March 1982, Chase Econometrics has revised their model to incorporate a new monetary sector to reflect changes in Federal Reserve policy procedures in October 1979. At the time the simulations were run, the Chase model used an index of credit rationing as the primary channel of monetary influence.

[4]M1 is an endogenous variable in the model, however, so there is a basis for comparing the Wharton model with the other models. The resulting M1 growth rates were generally, but not precisely, consistent with the JEC's instructions.

PROPERTIES OF THE MODELS AS REVEALED BY THE SIMULATION RESULTS

This study follows the general format of the JEC study, using the U.S. economic experience from 1956 through 1981 as a guide in comparing the models. If certain systematic relationships among key variables have held over the past 26 years, the simulation results for the next 10 years should be roughly consistent with that experience if one is to place much faith in the model. Deviations from historical experience place the burden of explanation on the individual model proprietor.

Simulation results relating money growth to (1) nominal GNP growth, (2) inflation and (3) real output growth are considered first. Then, the relationships between real output growth and unemployment, and between nominal interest rates and inflation are evaluated. Since the longer-run relationships are of primary interest and since short-run adjustments make the results difficult to interpret, the results for the last five years of the simulations, 1987–91, are investigated.

GNP, Money and Velocity

With simulations of the four long-run monetary strategies and a baseline simulation, five observations characterizing the 1987–91 period were generated for each model, providing a basis for examining the relationship between money growth and nominal GNP implicit in each. This relationship is referred to conventionally as the velocity of money. The well-known equation of exchange portrays this as

$$MV \equiv Y, \text{ or } V \equiv \frac{Y}{M},$$

where M is money stock, Y is nominal GNP, and V is the velocity of money. In its growth rate form,

$$\dot{M} + \dot{V} \equiv \dot{Y}.$$

Although velocity growth is influenced by many variables, it has shown considerable stability during the 1956–81 period. The implication of this stability is that, in the long run, nominal GNP growth is related closely to the growth of M1. The stability of velocity growth further suggests that a 1 percent change in rate of growth of money should coincide generally with a 1 percent change in the rate of growth of nominal GNP.

The large-scale econometric models do not specify GNP as a direct function of money. In these models,

money affects GNP indirectly via interest rates and wealth or real balance effects. Despite this, the large models still yield systematic relationships between money and GNP.

Chart 1 summarizes the money-GNP simulation results. Each model is summarized by plotting the average growth of simulated nominal GNP for the 1987–91 period against the average growth rate of M1 for the same period. Each point represents model results for a particular long-run monetary strategy.[5] As noted above, these strategies are stated in terms of M1 growth, and include (1) a sudden deceleration to zero percent, (2) a gradual deceleration to zero percent, (3) a sudden deceleration to 3 percent, (4) a gradual acceleration to 10 percent, and (5) a baseline strategy chosen by the model proprietor.

The historical line is derived by regressing the five-year average growth rate of nominal GNP on the five-year average growth rate of M1. The parallel lines depict the regression estimate plus or minus one standard error of the equation. If velocity growth is totally independent of money growth, then the slope of the historical line would be 45 degrees. The estimated slope, in fact, is not significantly different from 45 degrees.

Comparing the different models with historical experience suggests that none of the large-scale models is generally consistent with the actual past. Only four of the 15 simulated cases for these models fall within the historical band. The DRI and Chase simulations indicate that velocity growth is related negatively to money growth, so that higher rates of money growth do not yield proportionally higher nominal GNP growth. On the other hand, simulation results for the Wharton model indicate that higher money growth results in more than a proportional increase in GNP growth. This result, however, follows from the nature of the financial sector in the Wharton model. On the basis of M2, which is Wharton's actual monetary target variable, velocity growth is related negatively to money growth as in the Chase and DRI models.

Not surprisingly, the St. Louis model falls clearly within the historical band; after all, the GNP equation

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[5] For the M1 growth rate associated with each strategy, refer to the accompanying table. The points on the chart are connected for each model in ascending order of M1 growth. Consequently, the results for the Chase and Wharton models are not charted with the JEC's slowest growth strategy farthest to the left. See also footnote 3.

Chart 1
Money and GNP

$\dot{M}$ and $\dot{Y}$ are average rates for 1987–91.
Historical relationship:
$\dot{Y} = 3.07 + 1.04 \dot{M}$ $\bar{R}^2 = 0.90$
(7.76) (13.46)   SE = 0.68

Table 1
GNP, Money and Velocity (1987–91)

Model and Strategy	Average Annual Results		
	$\dot{M}$	$\dot{Y}$	$\dot{V}$
Chase			
1	3.0%	8.1%	5.1%
2	1.1	8.0	6.9
3	2.8	8.3	5.5
4	10.6	11.5	1.0
Baseline	6.4	9.4	3.0
DRI			
1	0.0	7.2	7.2
2	0.0	7.3	7.3
3	3.0	9.1	6.0
4	10.0	13.5	3.2
Baseline	4.1	9.6	5.3
Wharton			
1	3.0	5.8	2.8
2	1.5	6.4	4.8
3	3.2	7.5	4.2
4	6.5	12.5	5.7
Baseline	4.9	9.8	4.6
St. Louis			
1	0.0	2.8	2.8
2	0.1	2.9	2.8
3	3.0	6.2	3.1
4	9.9	14.0	3.7
Baseline	5.2	8.7	3.3

is constructed to be consistent with this historical experience.[6] The proprietors of the other models offer no explanation as to why their models predict that velocity behavior in the future will be different from the past.[7]

Inflation and Money

Economists generally agree that, over the long run, inflation is related directly to money growth.[8] In terms of the equation of exchange, with rates of change of prices and output $(\dot{P} + \dot{X})$ substituted for $\dot{Y}$,

$$\dot{M} + \dot{V} \equiv \dot{P} + \dot{X}.$$

A justification of the money-inflation relationship is that $\dot{V}$ and $\dot{X}$ are not related systematically to $\dot{M}$ over the long run. Consequently, variations in $\dot{M}$ eventually are reflected in $\dot{P}$.

To evaluate the money-inflation relationship for the different models, the simulation results are summa-

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[6]The St. Louis model simulations do show a weak positive relationship between velocity growth and money growth. This result occurs because the estimated sum of the coefficients on $\dot{M}$ in the GNP equation is slightly greater than unity.

[7]The JEC study suggests that the reason the large-scale models run contrary to historical velocity experience is that they are built to short-run specifications, that is, their focus is on forecasting for short periods into the future. Such an explanation might be appropriate for the Chase model, but the DRI and Wharton models are annual models. The results suggest that something more fundamental is awry. In addition, the St. Louis model, which is a quarterly model, does not exhibit any departure from historical long-run velocity behavior.

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[8]For example, Barro and Fischer introduced their 1976 survey of monetary theory with the following statement:

"Perhaps the most striking contrast between current views of money and those of 30 years ago is the rediscovery of the endogeneity of the price level and inflation and their relation to the behavior of money."

Robert J. Barro and Stanley Fischer, "Recent Developments in Monetary Theory," *Journal of Monetary Economics* (April 1976), p. 133.
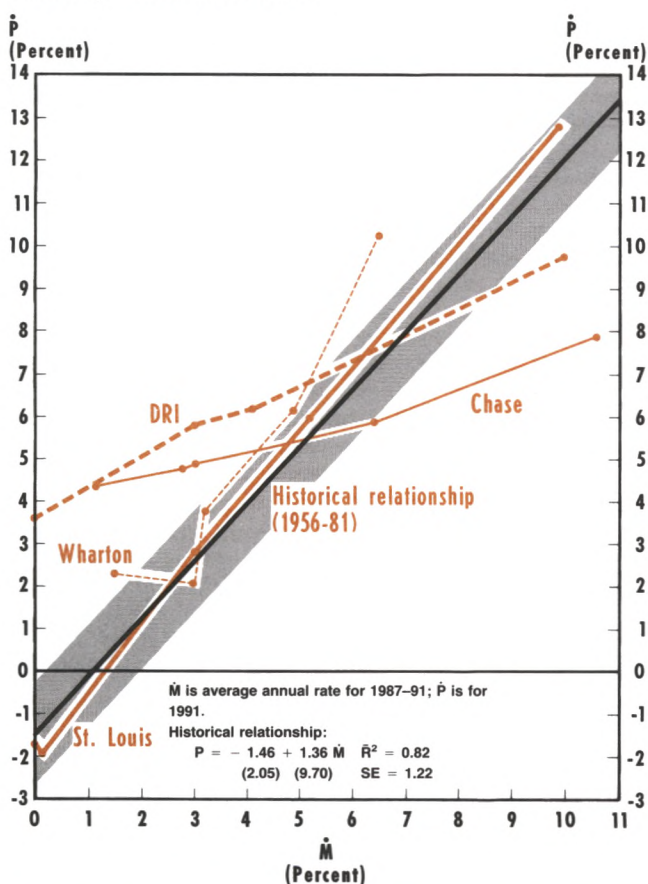
Chart 2
Money and Inflation

Ṗ
(Percent)

Ṁ is average annual rate for 1987–91; Ṗ is for 1991.

Historical relationship:

$$P = -1.46 + 1.36 \dot{M} \quad \bar{R}^2 = 0.82$$
$$(2.05) \quad (9.70) \quad SE = 1.22$$

Ṁ
(Percent)

Table 2
Inflation and Money (1987–91)

Model and Strategy	Average Annual Results		Final Year
	Ṁ	Ṗ	Ṗ
Chase			
1	3.0%	4.8%	4.9%
2	1.1	4.9	4.4
3	2.8	5.2	4.8
4	10.6	7.8	7.9
Baseline	6.4	6.3	5.9
DRI			
1	0.0	4.0	3.6
2	0.0	4.0	3.6
3	3.0	6.1	5.8
4	10.0	10.4	9.8
Baseline	4.1	6.5	6.2
Wharton			
1	3.0	2.9	2.1
2	1.5	3.4	2.3
3	3.2	4.2	3.8
4	6.5	9.8	10.3
Baseline	4.9	6.6	6.2
St. Louis			
1	0.0	−2.7	−1.7
2	0.1	−0.9	−1.9
3	3.0	1.6	2.8
4	9.9	10.0	12.8
Baseline	5.2	5.2	6.0

rized in chart 2. Without exception, all four models show a direct relationship between monetary growth and inflation. There is substantial variation, however, in the degree of sensitivity among the models. The Chase model shows a difference in inflation forecasts of only 3.5 percent between the slowest and fastest monetary growth strategies. DRI shows a 6.2 percentage point differential and Wharton a differential of 8.2 percentage points. The St. Louis model shows the largest differential of 14.5.

To provide a basis for historical comparison, the inflation rate was regressed on the average of money growth over the previous five years for the 1956–81 period. Comparing the simulation results of the four models with this historical line suggests that there is some bias in each. The Chase and DRI models exhibit a sensitivity of inflation to money growth that appears too low, while the Wharton and St. Louis models show

a sensitivity that appears too high. While the models generally are inside the historical band for money growth rates in the neighborhood of the 1956–81 average of 4.7 percent, a wide range of results occurs for monetary strategies that lie at the extremes of historical experience.[9]

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[9]An explanation of these diverse results would require a detailed analysis of the inner workings of each model. For the most part, the large-scale models estimate the price level primarily by marking up some measure of labor costs. Consequently, the insensitivity of inflation to money growth developments in the Chase and DRI models might be related to the stickiness of wages. This explanation does not seem to explain the Wharton results, however. The Wharton model shows considerable sensitivity in the 3 percent to 7 percent range for money growth, yet the price determination process apparently is similar to that for Chase and DRI. The St. Louis model differs from the large-scale models in that prices are determined directly by demand pressure and past prices. The influence of past prices tends to capture effects operating through wages, yet inflation remains sensitive to money growth throughout the full range.
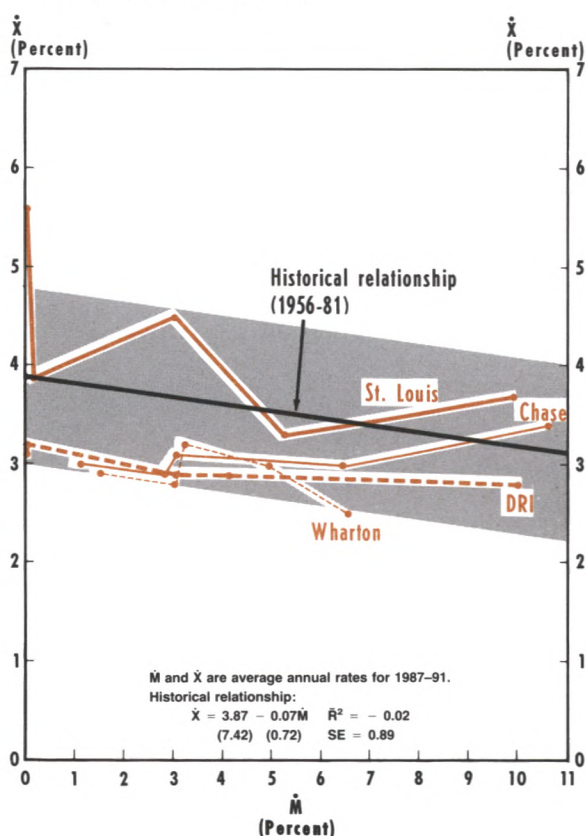
Chart 3
Money and Real GNP

$\dot{X}$
(Percent)

Historical relationship
(1956-81)

St. Louis

Chase

DRI

Wharton

$\dot{M}$ and $\dot{X}$ are average annual rates for 1987–91.
Historical relationship:
$\dot{X} = 3.87 - 0.07\dot{M}$ $\bar{R}^2 = -0.02$
  (7.42) (0.72)   SE = 0.89

$\dot{M}$
(Percent)

Table 3
Real GNP Growth and Money (1987–91)

Model and Strategy	Average Annual Results	
	$\dot{M}$	$\dot{X}$
Chase		
1	3.0%	3.1%
2	1.1	3.0
3	2.8	2.9
4	10.6	3.4
Baseline	6.4	3.0
DRI		
1	0.0	3.0
2	0.0	3.2
3	3.0	2.9
4	10.0	2.8
Baseline	4.1	2.9
Wharton		
1	3.0	2.8
2	1.5	2.9
3	3.2	3.2
4	6.5	2.5
Baseline	4.9	3.0
St. Louis		
1	0.0	5.6
2	0.1	3.9
3	3.0	4.5
4	9.9	3.7
Baseline	5.2	3.3

Real GNP and Money

A corollary to the long-run, money-inflation relationship is the hypothesis that the trend growth of real GNP is not systematically related to long-term money growth. Money may affect the growth of real GNP in the short run, but if inflation rises one-for-one with accelerated money growth, as the equation of exchange indicates, there are no cumulative effects on real GNP.

Chart 3 summarizes the money-real GNP relationship from the simulations of the four models. The three large-scale models all show real GNP growth rates in the neighborhood of 3 percent, regardless of which monetary strategy is considered. The St. Louis model, on the other hand, shows greater variation of real GNP growth among the strategies. This is because the dynamic lag structure of the St. Louis model is such that, after 10 years, the model is still a considerable time away from steady-state equilibrium in growth

terms. Given more time to adjust, the St. Louis model tends to approach about 3 percent real growth, regardless of money growth.

The historical line in chart 3 is based on five-year growth rates of both money and real GNP. The slope of the line is not significantly different from zero, and the standard error is quite large relative to the mean. The results for the three large-scale models are virtually identical. Relative to the large-scale models, the St. Louis model is the outlier, though four of the five simulated observations are well within the historical band; only the strategy of sudden deceleration of M1 to zero yields real output growth that is outside the historical band. Again, this makes sense because of the long adjustment process in the St. Louis model; very weak output growth in the early years under the zero money growth strategy is offset by very strong output growth in the 1987–91 period.

In general, the simulation results suggest that money has a neutral effect on real output growth in the
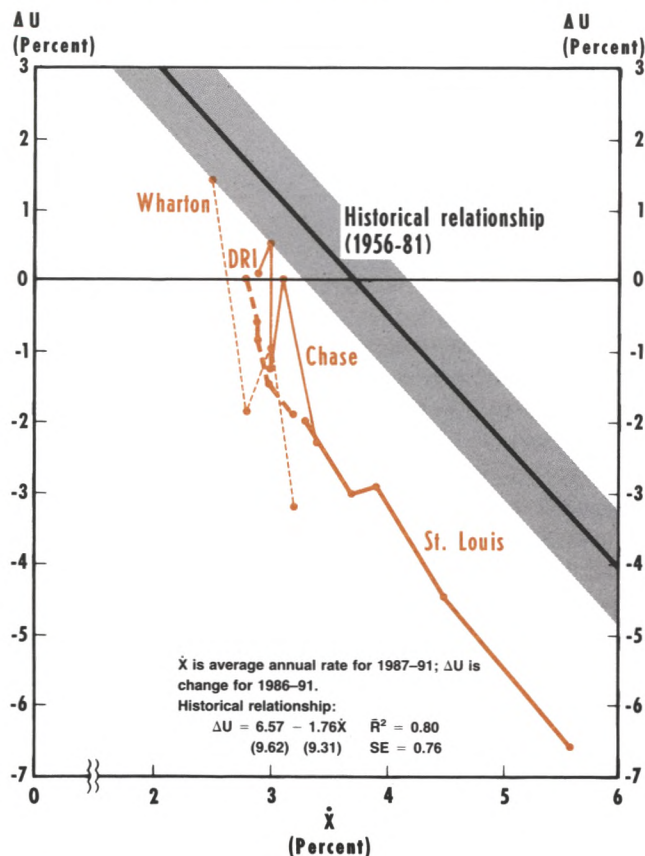
Chart 4
Real GNP and Unemployment Rate

ΔU (Percent)

Wharton

DRI

Historical relationship (1956-81)

Chase

St. Louis

Ẋ is average annual rate for 1987–91; ΔU is
change for 1986–91.
Historical relationship:
$$\Delta U = 6.57 - 1.76\dot{X} \qquad \bar{R}^2 = 0.80$$
$$(9.62) \ (9.31) \qquad SE = 0.76$$

Ẋ (Percent)

Table 4
Real GNP Growth and Unemployment (1987–91)

Model and Strategy	Average Annual Rate Ẋ	Change in U: 1986–91
Chase		
1	3.1%	0.0%
2	3.0	0.5
3	2.9	0.1
4	3.4	−2.3
Baseline	3.0	−1.3
DRI		
1	3.0	−1.5
2	3.2	−1.9
3	2.9	−0.9
4	2.8	0.0
Baseline	2.9	−0.6
Wharton		
1	2.8	−1.9
2	2.9	−1.4
3	3.2	−3.2
4	2.5	1.4
Baseline	3.0	−1.0
St. Louis		
1	5.6	−6.6
2	3.9	−2.9
3	4.5	−4.5
4	3.7	−3.0
Baseline	3.3	−2.0

long run. A sustained change in the money growth rate has little or no effect on the long-run growth rate of real GNP.

Real GNP and Unemployment

Another relationship of interest in macroeconomics is the one between real GNP growth and the unemployment rate. All three of the large-scale models show essentially the same rates of real growth for each of the monetary strategies. Thus, Okun's law, which relates unemployment to deviations of actual from potential output, suggests that the change in the unemployment rate would be approximately equal for all strategies.[10]

Such is not the case. Each of the large-scale models shows considerable variation in the change in the un-

[10]Arthur M. Okun, "Potential GNP: Its Measurement and Significance," *1962 Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, pp. 98–104.

employment rate despite near-equal rates of real GNP growth. What is not known, of course, are the assumed growth rates for the labor force and other determinants of potential output in these models. Nevertheless, when the strategies are compared across models, the results of a sudden deceleration of M1 growth to zero range from no change in the unemployment rate for the Chase model to a 1.9 percentage point decline for the Wharton model. The results for the opposite extreme, gradual acceleration of M1 to 10 percent, show even greater variation—from a 2.3 percentage drop in the unemployment rate for the Chase model to a 1.4 point increase for the Wharton model.

The St. Louis model also shows considerable variation in the change in unemployment across monetary strategies; however, this is due to substantial variation in the growth rate of real GNP. All the unemployment changes are negative, because the simulated real growth rates exceed the assumed growth rate of 2.5 percent for potential GNP. Moreover, because the St.

Chart 5
Inflation and Long-Term Interest Rate

RL
(Percent)

$\dot{P}$ is average annual rate for 1987–91; RL is MA
corporate bond rate for 1991.
Historical relationship:
RL = 2.68 + 1.03 $\dot{P}$　$\bar{R}^2$ = 0.83
　(5.28) (10.04)　　SE = 1.09

Historical relationship
(1956-81)

$\dot{P}$
(Percent)
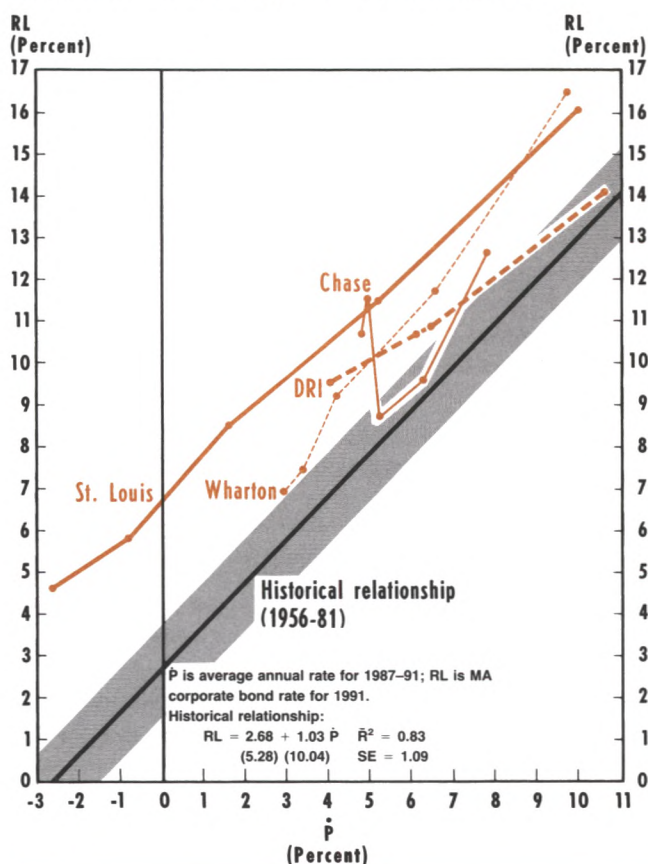
Table 5
Inflation and Interest Rates (1987–91)

Model and Strategy	Average Annual Results				Final Year
	$\dot{M}$	$\dot{P}$	RL	RS	RL
Chase					
1	3.0%	4.8%	11.5%	16.3%	10.7%
2	1.1	4.9	11.5	15.8	11.6
3	2.8	5.2	9.5	10.6	8.7
4	10.6	7.8	11.6	9.0	12.7
Baseline	6.4	6.3	10.0	8.4	9.6
DRI					
1	0.0	4.0	10.1	8.0	9.5
2	0.0	4.0	10.1	7.8	9.5
3	3.0	6.1	11.1	9.5	10.7
4	10.0	10.4	14.8	12.4	14.1
Baseline	4.1	6.5	11.4	10.0	10.9
Wharton					
1	3.0	2.9	8.8	6.5	6.9
2	1.5	3.4	8.1	6.2	7.4
3	3.2	4.2	10.7	8.6	9.2
4	6.5	9.8	16.0	13.8	16.5
Baseline	4.9	6.6	12.3	9.4	11.7
St. Louis					
1	0.0	-2.7	5.6	1.9	4.6
2	0.1	-0.9	7.6	2.8	5.8
3	3.0	1.6	8.4	4.9	8.5
4	9.9	10.0	14.0	11.3	16.1
Baseline	5.2	5.2	11.3	7.3	11.5

Louis model simulates very strong 1987–91 real output growth in conjunction with the sudden deceleration of money growth to zero, sizable reductions in unemployment go hand in hand with such a policy.

The historical line in chart 4 is estimated by regressing the change in the unemployment rate over five-year periods on the five-year growth rate of real GNP. The historical band encompasses only one observation from the 20 that are charted. The models' failure to replicate history may not be as bad as appears in the chart, however. Potential output supposedly grew faster in the 1956–81 period than it is assumed to be growing in 1987–91. The simulation results suggest an implied growth rate of potential output of 2.5 percent to 3.0 percent for 1987–91, instead of the 3.6 percent rate calculated for 1956–81. Nevertheless, the large-scale models show the inverse relationship between real growth and unemployment suggested by Okun's law. In contrast to the St. Louis model, however, the degree of sensitivity is not well defined.

Inflation and Interest Rates

The relationship between inflation and nominal interest rates is the final relationship considered. The inflationary experience of the last 15 years provides an ample basis for examining the nature of this relationship.

Monetary theory suggests that nominal interest rates reflect inflationary expectations. These expectations can be modeled as a function of past inflationary experience. The question examined here is whether the econometric models incorporate such a relationship.

Chart 5 summarizes graphically the simulation results for inflation and long-term interest rates. The Chase model does not appear to show any consistent relationship between inflation and long-term interest rates. The Wharton model displays a peculiar kink at relatively low rates of inflation, while the DRI and St. Louis models display a strong positive relationship.
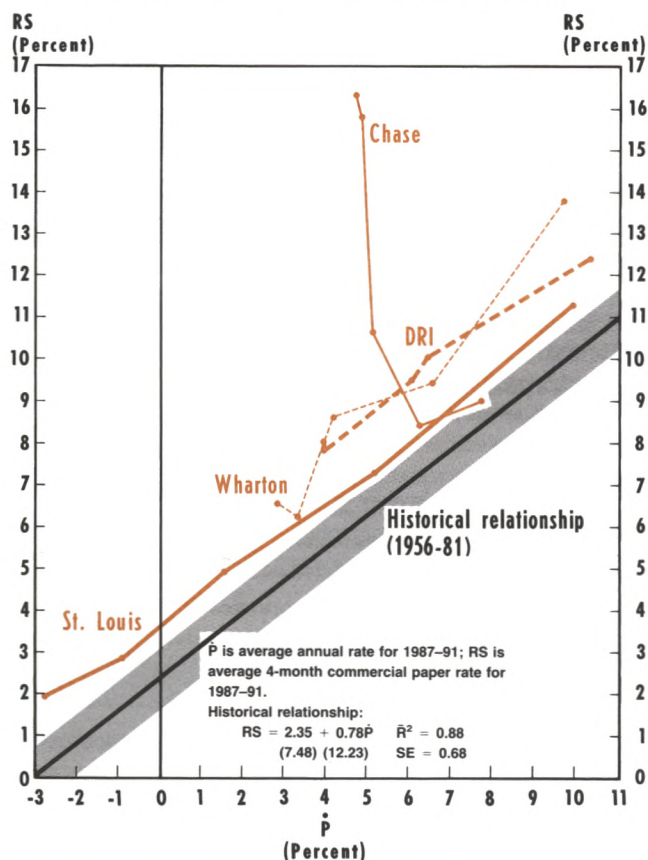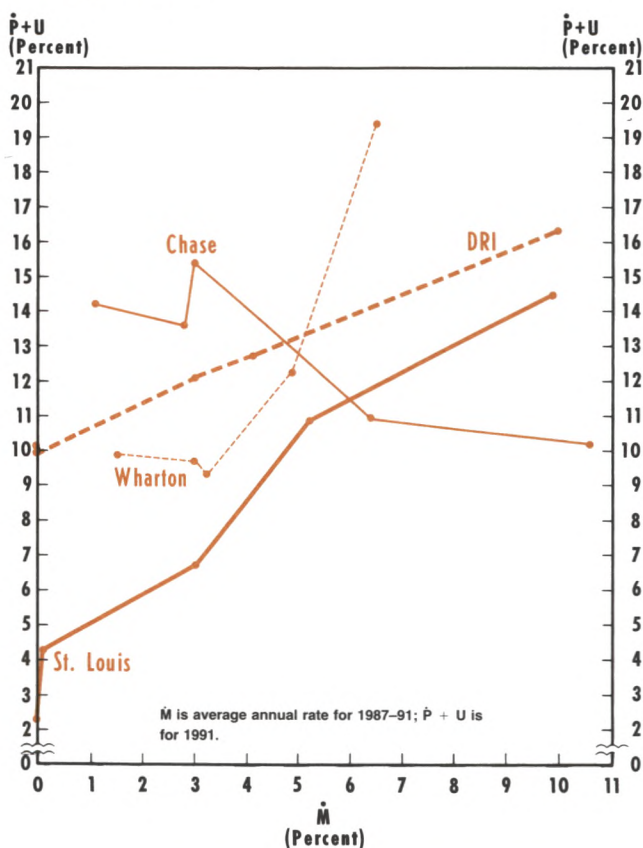
Chart 6
Inflation and Short-Term Interest Rate

RS (Percent)

Chase

DRI

Wharton

Historical relationship (1956-81)

St. Louis

$\dot{P}$ is average annual rate for 1987–91; RS is average 4-month commercial paper rate for 1987–91.
Historical relationship:
RS = 2.35 + 0.78$\dot{P}$ $\bar{R}^2$ = 0.88
(7.48) (12.23)   SE = 0.68

$\dot{P}$ (Percent)

Chart 7
Misery Index

$\dot{P}$+U (Percent)

Chase

DRI

Wharton

St. Louis

$\dot{M}$ is average annual rate for 1987–91; $\dot{P}$ + U is for 1991.

$\dot{M}$ (Percent)

What is most obvious from the chart is the inconsistency with historical experience. The slopes of the simulation results are roughly consistent, but the general level is vastly different. For the St. Louis model, the inconsistency arises because of the use of the serial correlation adjustment in the simulations. With long-term rates in late 1981 well above the inflation rate, this differential only gradually disappears during the simulation period. It appears that the large-scale models are following a similar procedure. In this regard, it seems that most of the models would do much better at predicting the *change* in long-term rates, rather than the level itself.

Chart 6 plots the simulation results for inflation and short-term interest rates. Again, with the exception of the Chase model, the models demonstrate substantial similarities. The St. Louis model tends to simulate the lowest level of short-term rates for a given rate of inflation. The historical line, as in the case of long-term rates, is below all the model results, but the discrepan-

cy is not as great as that for long-term rates. All the models, with the exception of the Chase model, incorporate an inflation premium into short-term rates, suggesting that the lower the inflation rate, the lower short-term interest rates will be.

THE POLICY IMPLICATIONS OF THESE SIMULATION RESULTS

The discussion above emphasized the long-run properties of econometric models as revealed by the simulation results. What remains to be determined are the implications of these results for long-run monetary policy. From this longer-run perspective, do the models' simulation results favor a strategy of slow M1 growth, fast M1 growth or something in between?

To aid in this assessment, a crude index, called a "misery index," is constructed to summarize the results. The index is simply the sum of the inflation rate

Table 6

Misery Index (1987–91)

Model and Strategy	Average Annual Result M̊	Final Year Ṗ	Final Year U	Misery Index Ṗ + U
Chase				
1	3.0%	4.9%	10.5%	15.4%
2	1.1	4.4	9.8	14.2
3	2.8	4.8	8.8	13.6
4	10.6	7.9	2.3	10.2
Baseline	6.4	5.9	5.0	10.9
DRI				
1	0.0	3.6	6.5	10.1
2	0.0	3.6	6.4	10.0
3	3.0	5.8	6.3	12.1
4	10.0	9.8	6.6	16.4
Baseline	4.1	6.2	6.5	12.7
Wharton				
1	3.0	2.1	7.6	9.7
2	1.5	2.3	7.6	9.9
3	3.2	3.8	5.5	9.3
4	6.5	10.3	9.1	19.4
Baseline	4.9	6.2	6.1	12.3
St. Louis				
1	0.0	− 1.7	3.9	2.2
2	0.1	− 1.9	6.2	4.3
3	3.0	2.8	3.9	6.7
4	9.9	12.8	1.7	14.5
Baseline	5.2	6.0	4.9	10.9

and the unemployment rate at some point in time.[11] Construction of such an index is, of course, simplistic, yet it provides general information for evaluating the effect of the alternative monetary strategies.

Chart 7 summarizes this misery index for the 1987–91 period for the four econometric models. In general, the simulation results indicate that there is a long-run payoff from following a slow M1 growth strategy; the results from the Chase model provide the only exception. There seems to be little basis for choosing between sudden and gradual deceleration to zero money growth, however, because the misery index differs little when these strategies are compared. An evaluation of these strategies would involve a more detailed analysis of the adjustment path of inflation and unemployment.

The general levels of the misery index for the four models indicate substantial variation in the predicted effects of alternative monetary strategies. For the slow M1 growth scenarios, the St. Louis model is by far the most optimistic, and the Chase model is the most pessimistic. For the fast M1 growth strategy, Chase is most optimistic and Wharton is most pessimistic. Thus, using this set of results, a policymaker is confronted with a disturbing diversity of opinion. Yet, three of the four models show a definite payoff from following a strategy of slow to moderate growth of M1.

SUMMARY AND CONCLUSIONS

This article, extending recent work by Robert Weintraub at the Joint Economic Committee, has compared simulation results from various econometric models to

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[11]This simple index originated with the late Arthur Okun, although he called it a "discomfort index." The term "misery index" is used by Jerome L. Stein, *Monetarist, Keynesian and New Classical Economics* (New York University Press, 1982), p. 159.

the historical record of the last 26 years. The emphasis is on the longer-run economic impact of alternative money growth scenarios. No single model was found to be consistent with the historical record on all counts.

The simulation results generally show, however, the positive consequences of following a slow M1 growth strategy. Higher rates of money growth are associated with higher rates of spending growth, which eventually are reflected in higher inflation rates. Using a simple social loss function called the misery index, three of the four models indicate that, over the long run, unem-ployment gains, if any, are insufficient to offset the increase in inflation.

Consequently, this article — like the JEC study before it — concludes that there are no long-run economic gains from higher rates of money growth. This is true even though the models run counter to historical experience in some important aspects. Moreover, the results indicate that higher inflation rates are associated with higher levels of both short- and long-term interest rates, so that interest rates tend to be higher when the faster monetary strategies are followed.

Appendix
Revised Form of St. Louis Model

The version of the St. Louis model used for the simulations in this article is summarized in table 1, with the coefficients given in table 2. Equations 1–4 are estimated with Almon constraints on the coefficients.

Equation 5 is estimated with ordinary least squares. Three characteristics differentiate this model from the original version published in 1970: (1) most variables are entered in rate-of-change form rather than first-difference form; (2) the demand slack variable is entered in real rather than nominal terms; and (3) where relevant, the model's equations have been corrected for serial correlation problems.

Table 1
The Model

(1) $\dot{Y}_t = C1 + \sum\limits_{i=0}^{4} CM_i (\dot{M}_{t-i}) + \sum\limits_{i=0}^{4} CE_i (\dot{E}_{t-i}) + \varepsilon1_t$

(2) $\dot{P}_t = C2 + \sum\limits_{i=0}^{4} CPE_i (\dot{PE}_{t-i}) + \sum\limits_{i=0}^{5} CD_i (\dot{X}_{t-i} - \dot{XF}^*_{t-i})$
$+ CPA (\dot{PA}_t) + CDUM1 (DUM1)$
$+ CDUM2 (DUM2) + \varepsilon2_t$

(3) $RL_t = \sum\limits_{i=0}^{20} CPRL_i (\dot{P}_{t-i}) + \varepsilon3_t$

(4) $RS_t = \sum\limits_{i=1}^{2} CPERS_i (\dot{PE}_{t-1}) + CMRS (\dot{M}_t)$
$+ \sum\limits_{i=0}^{16} CXRS_i (\dot{X}_{t-i})$
$+ \sum\limits_{i=0}^{16} CPRS_i (\dot{P}_{t-i}) + \varepsilon4_t$

(5) $U_t - UF_t = CG (GAP_t) + CG1 (GAP_{t-1}) + \varepsilon5_t$

(6) $\dot{PA}_t = \sum\limits_{i=1}^{21} CPRL_i (\dot{P}_{t-i})$

(7) $Y_t = (P_t/100) (X_t)$

(8) $\dot{Y}_t = ((Y_t/Y_{t-1})^4 - 1) 100$

(9) $\dot{X}_t = ((X_t/X_{t-1})^4 - 1) 100$

(10) $\dot{P}_t = ((P_t/P_{t-1})^4 - 1) 100$

(11) $GAP_t = ((XF_t - X_t)/XF_t) 100$

(12) $\dot{XF}^*_t = ((XF_t/X_{t-1})^4 - 1) 100$

Y	= nominal GNP
M	= money stock (M1)
E	= high employment expenditures
P	= GNP deflator (1972 = 100)
PE	= relative price of energy
X	= output in 1972 dollars
XF	= potential output (Rasche/Tatom)
RL	= corporate bond rate
RS	= commercial paper rate
U	= unemployment rate
UF	= unemployment rate at full employment

Table 2
In-Sample Estimation: I/1955–IV/1981 (absolute value of t-statistic in parentheses)

(1) $\dot{Y}_t = 2.81 + 1.13 \sum\limits_{i=0}^{4} \dot{M}_{t-i} - 0.01 \sum\limits_{i=0}^{4} \dot{E}_{t-i}$
　　　　(3.11)　　(6.91)　　　　　(0.06)

$\bar{R}^2 = 0.40$　　$SE = 3.72$　　$DW = 2.13$

(2) $\dot{P}_t = 1.12 + 0.06 \sum\limits_{i=1}^{4} \dot{PE}_{t-1} + 0.08 \sum\limits_{i=0}^{5} (\dot{X}_{t-i} - \dot{XF}^*_{t-i})$
　　　　(3.27)　　　　　(5.00)

$+ 1.13 \dot{PA}_t - 0.80 DUM1_t + 1.72 DUM2_t$
　(11.44)　　　(1.33)　　　　(2.79)

$\bar{R}^2 = 0.76$　　$SE = 1.28$　　$DW = 2.00$　　$\hat{\rho} = 0.16$

(3) $RL_t = 0.87 \sum\limits_{i=0}^{20} \dot{P}_{t-i}$
　　　　(3.50)

$\bar{R}^2 = 0.12$　　$SE = 0.32$　　$DW = 1.76$　　$\hat{\rho} = 1.00$

(4) $RS_t = 0.05 \sum\limits_{i=1}^{2} \dot{PE}_{t-i} - 0.08 \dot{M}_t + 0.77 \sum\limits_{i=0}^{16} \dot{X}_{t-i}$
　　　　　　　　　(2.84)　　　(3.22)

$+ 0.97 \sum\limits_{i=0}^{16} \dot{P}_{t-i}$
　(5.62)

$\bar{R}^2 = 0.32$　　$SE = 0.90$　　$DW = 1.83$　　$\hat{\rho} = 0.89$

(5) $U_t - UF_t = 0.29 GAP_t + 0.14 GAP_{t-1}$
　　　　　　(14.85)　　　　(6.84)

$\bar{R}^2 = 0.70$　　$SE = 0.19$　　$\hat{\rho}_1 = 1.33$　　$\hat{\rho}_2 = -0.44$