THE P* MODEL OF INFLATION REVISITED

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Abstract:

Error-correction M2-demand and inflation equations are estimated simultaneously in a combined model that includes the P* model and the Federal Reserve Board's M2 model as special cases. The ability of the combined model to explain movements in inflation is significantly better than that of the standard P* model. However, the forecasting performance of the combined model breaks down in the 1990s. A reformulation of the M2-demand equation markedly improves the model's in-sample and out-of-sample performance. Even in the post-1990 period, M2 growth is explainable and serves as a reliable indicator of future inflation.

1. Introduction

By the late 1980s, the M2 monetary aggregate had taken center stage in Federal Reserve policy making. Researchers at the Board of Governors had isolated an error-correction model of the demand for money that appeared to reliably link the M2 aggregate to nominal spending (Moore, Porter, and Small 1990). Similarly, the Federal Reserve Board's P* model established a connection between M2 growth and future inflation (Hallman, Porter, and Small 1991). Policymakers used the M2 demand and P* models in deriving target growth rates for the money supply and as a framework for their Federal Open Market Committee deliberations.

Recently, evidence of breakdowns in its M2-demand and P* models has forced the Federal Reserve to demphasize M2 in the policy making process (Federal Reserve 1993). The standard Board money demand model has been consistently overpredicting M2 growth by large amounts (Duca 1993; Koenig 1993). The inflation underpredictions of the P* model have been equally consistent, though smaller in magnitude (Becsi and Duca 1994).

In an earlier paper, I showed that a small number of intuitively plausible changes to the standard Board M2-demand equation are capable of significantly improving that equation's ability to explain pre-1990 movements in money growth while largely eliminating the post-1990 money-growth shortfall (Koenig 1993). Here, I show how the modified M2-demand equation developed in my earlier paper can be combined with a version of the P* model to yield reliable inflation forecasts.

The standard formulation of the P* model's inflation equation is independent of the parameters of the M2 demand equation. How is it, then, that modifying the M2 demand equation can yield more reliable inflation forecasts? The key to the improvement is a change in the definition of P*. In the standard model, P* is the price level consistent with the current money supply, zero slack in the output market, and a velocity of money equal to its long-run average. Here, in contrast, the long-run velocity that enters the definition of P* is identical to the long-run velocity that enters the error-correction term of the money-demand equation.[1] As such, the long-run velocity that defines P* is allowed to respond to changes in interest rates. As in the standard P* model, inflation increases if the current price level is below P*.

There is no good theoretical rationale for assuming that the velocity of money is stationary. Even if the stationarity assumption appears to be empirically valid for a particular monetary aggregate over a particular sample period, there is no good theoretical rationale for assuming that interest-rate-induced changes in velocity have the same impact on inflation as

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[1] Feldstein and Stock (1993) include a similar velocity error-correction term in forecasting equations for nominal GDP growth. They use a two-step procedure, first estimating a long-run velocity equation, then estimating a nominal GDP forecasting equation that includes the velocity residuals as a right-hand-side variable. Here, the long-run velocity equation is embedded in a model of the short-run dynamics of money demand that is estimated *simultaneously* with the inflation forecasting equation.

changes in velocity arising from other sources. Showing that a relaxation of these assumptions results in improved inflation forecasts is one of this paper's principal contributions.

The plan of the paper is as follows. First, I demonstrate that the pre-1991 performance of the Board's P* model can be significantly improved by relaxing the definition of P* and estimating the resultant inflation equation in conjunction with the Board's model of M2 demand. Unfortunately, both the inflation equation and the money-demand equation break down after 1990. Second, I modify the Board's M2-demand model along the lines discussed in my earlier paper, and estimate the modified model simultaneously with a P* model of non-durables and services consumer price inflation. The resultant combined model of money growth and inflation performs well in both the pre-1990 and post-1990 periods. Next, I demonstrate that the modified model is helpful in generating forecasts of an index of consumer prices that is broader in coverage than the implicit non-durables and services deflator. Finally, I summarize and evaluate the paper's principal findings.

2. An Encompassing Model of Money Demand and Inflation

As developed by Hallman, Porter, and Small (1991), the P* model of inflation takes the form

$$(1) \qquad \Delta\pi_t = \gamma_1\Delta\pi_{t-1} + \gamma_2\Delta\pi_{t-2} + \gamma_3\Delta\pi_{t-3} + \gamma_4\Delta\pi_{t-4} + \phi(p^*_{t-1} - p_{t-1}) + z^P_t$$

where p and π denote the log-level and log-change in the implicit GDP deflator, Δ is the first-difference operator, and z^p_t is an error term. The long-run price level, p*, is defined by

(2) $$p^* \equiv m + v^* - q^*,$$

where m is the logarithm of the M2 money supply, q* is the logarithm of potential real GDP (as calculated by the Federal Reserve Board), and v* is the long-run velocity of money.

After taking great pains to demonstrate that the income-velocity of M2 has been stationary over the post-WWII period, Hallman, Porter, and Small assume that v* equals the sample mean of $v \equiv p + q - m$, where q is the logarithm of real GDP. But the historical stationarity of v may be only a happy coincidence. It seems likely--on theoretical grounds--that a permanent increase in the rate of money growth would permanently increase v. Any deterioration in the efficiency of the banking system would, by widening the gap between market and M2 deposit rates, have similar effects. More generally, it is not *a priori* obvious that deviations of v away from its mean will have the same impact upon inflation regardless of their source.

Accordingly, in this Section I explore an alternative definition of v*. In particular, I examine whether it might not be appropriate to use the same definition of v* in the P* model that is used in the Board's model of M2 demand. In the Board's M2 model

$$(3) \qquad v^*_t = \upsilon_0 + \upsilon_1 t + \upsilon_2 DMMDA_t + \upsilon_3 oc_t,$$

where DMMDA is a dummy variable that equals one after the introduction of money market deposit accounts and zero otherwise, and where oc is the logarithm of the difference between the rate of return on three-month Treasury bills and the rate of return on M2 deposits.

For estimation purposes, equation 3 is embedded in a model of the short-run dynamics of money demand. This model takes the form:

$$(4) \qquad \Delta^2 m_t = \alpha_0(\Delta x_t - \Delta m_{t-1}) + \alpha_1(\Delta x_{t-1} - \Delta m_{t-1}) + \alpha_2(\Delta x_{t-2} - \Delta m_{t-1})$$
$$+ \beta_0 \Delta v^*_t + \delta_A D83Q1 + \delta_B D83Q2 + \delta_C DCON + \epsilon(u_{t-1} - v^*_{t-1})$$
$$+ z^m_t$$

where

D83Q1 ≡ dummy equal to 1 in 1983:Q1 to control for MMDAs

D83Q2 ≡ dummy equal to 1 in 1983:Q2 to control for MMDAs

DCON ≡ 1 in 1980:Q2 when credit controls imposed

-1 in 1980:Q3 after credit controls lifted

$u \equiv \ln[\frac{1}{2}(\text{nominal GDP} + \text{nominal GDP}_{-1})/(\text{nominal M2})]$

$x \equiv \ln(\text{nominal personal consumption expenditures})$, and z^m_t is an error term.[2] For further discussion, see Moore, Porter, and Small (1990) or Koenig (1993).

By generalizing equation 1 slightly, it can be made to encompass both the current formulation of the P* model and the traditional formulation as special cases. In particular, if one writes

$$\text{(5)} \qquad \Delta\pi_t = \gamma_1\Delta\pi_{t-1} + \gamma_2\Delta\pi_{t-2} + \gamma_3\Delta\pi_{t-3} + \gamma_4\Delta\pi_{t-4} + \phi_1(q_{t-1} - q^*_{t-1}) + \phi_2(v^m - v_{t-1}) + \phi_3(v^*_{t-1} - v^m) + z^p_t,$$

where v^m is the sample mean of v and v* is defined as in equation 3, then the Hallman-Porter-Small version of the P* model corresponds to the case in which $\phi_1 = \phi_2$ and $\phi_3 = 0$, while the alternative P* model proposed here has $\phi_1 = \phi_2 = \phi_3$. More generally, if $\phi_3 > 0$, inflation responds less strongly to interest-rate-induced variation in velocity than to variation arising from other sources.

Column 2 of Table 1 presents simultaneous estimates of equations 3, 4, and 5.[3] The sample period runs from 1964:Q1

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[2] Each right-hand-side variable in this and subsequent equations is expressed either as a deviation from its sample mean (in those cases where the right-hand-side variable is mean stationary) or as a deviation from a linear time trend (in those cases where the right-hand-side variable is trend stationary).

[3] To save space in this and subsequent tables, I do not report the estimated values of constant terms. Nor do I report estimated coefficient values for the dummy variables that appear in the money-demand equation.

through 1991:Q2.[4] Note that ϕ_3 is positive and significant. Indeed, one cannot reject the hypothesis that it is deviations of velocity from v* that drive inflation rather than deviations of velocity from its sample mean. (The relevant test statistic is $\chi^2(2) = 5.209$.) Constrained estimates of equations 3, 4, and 5 are presented in column 3 of Table 1.

Unfortunately, the predictive performance of the combined error-correction model of M2 demand and inflation breaks down during the 1990s. Figures 1a and 1b illustrate this breakdown. To construct the figures, parameter estimates displayed in column 3 of Table 1 were used to generate a series of one-quarter-ahead forecasts of money growth and inflation over the period from 1991:Q3 through 1993:Q4. There is a clear and consistent tendency for the combined model to overpredict money growth and underpredict inflation in the out-of-sample period. This tendency is also evident in column 4 of Table 1, which extends the model estimation period through the end of 1993 while including post-1991:Q2 additive dummy variables as additional right-hand-side variables in equations 4 and 5. The coefficient on the money growth dummy indicates that the model overpredicts money growth by an average of about 1.6 percentage points per quarter since the middle of 1991. Similarly, the model

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[4] The starting date for the sample is that typically used by the Board staff in estimating their M2-demand model (Moore, Porter, and Small, 1990). Koenig (1993) demonstrates that the Board model does a poor job explaining pre-1964 money growth movements. Hetzel (1992, p. 14) notes a reduction in the interest-sensitivity of M2 demand beginning in 1964.

underpredicts inflation by an average of 0.4 percentage points per quarter. The coefficient on the money growth dummy is statistically significant at the one-percent level, while the coefficient on the inflation dummy is statistically significant at the five-percent level.

3. An Alternative Model

In Koenig (1993), I showed that a few intuitively plausible changes to the standard Board M2-demand equation are capable of substantially improving that equation's ability to explain pre-1990 movements in money growth while largely eliminating the post-1990 money-growth shortfall. First, I generalized the definition of the opportunity cost of M2 to allow for the fact that long-term bonds are a substitute for some M2 deposits. In particular, I let

$$(6) \qquad oc_t \equiv \ln[\theta R_{10Y} + (1 - \theta)R_{3M} - R_{M2}],$$

where R_{10Y}, R_{3M}, and R_{M2} are, respectively, the rates of return on 10-year Treasury bonds, 3-month Treasury bills, and M2 deposits, and where θ is a parameter to be estimated. Second, I generalized equation 3 to allow for the possibility of a gradual acceleration in the pace of financial innovation:

$$(3') \qquad v^*_t = \upsilon_0 + \upsilon_1 t + \upsilon_1' t^2 + \upsilon_2 DMMDA_t + \upsilon_3 oc_t .$$

Finally, I chose to use personal consumption expenditures on non-durables and services as both the long-run and the short-run scale variable in equation 4:[5]

$$(4') \qquad \Delta^2 m_t = \alpha_0(\Delta x_t - \Delta m_{t-1}) + \alpha_1(\Delta x_{t-1} - \Delta m_{t-1}) + \alpha_2(\Delta x_{t-2} - \Delta m_{t-1})$$
$$+ \beta_0 \Delta v^*_t + \beta_1 \Delta v^*_{t-1} + \delta_A D83Q1 + \delta_B D83Q2 + \delta_C DCON$$
$$+ \epsilon(v_{t-1} - v^*_{t-1}) + z^m_t,$$

where x now denotes household spending on non-durables and services and where $v \equiv x - m$.

The use of non-durables and services consumption as a scale variable is consistent with the view that permanent income, rather than current income, is the driving force behind the demand for money. Alternatively, household purchases of non-durables and services may be unusually money intensive.[6]

The price measure that corresponds to the scale variable, x, in equation 4' is the implicit deflator for non-durables and services consumption expenditures. Accordingly, I substituted this deflator for the implicit GDP deflator in equation 5, then estimated equations 3', 4', 5, and 6 simultaneously. Evident serial correlation in the error term in equation 5 led me to revise the equation by including lagged output growth and lagged

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[5] An additional lag of Δv^* is also included in the equation.

[6] For further discussion--and empirical evidence--see Mankiw and Summers (1986) and Elyasiani and Nasseh (1994).

velocity growth as additional right-hand-side variables:

$$(5') \qquad \Delta\pi_t = \gamma_1\Delta\pi_{t-1} + \gamma_2\Delta\pi_{t-2} + \gamma_3\Delta\pi_{t-3} + \gamma_4\Delta\pi_{t-4} + \phi_1(q_{t-1} - q^*_{t-1}) + \phi_2(v^m - v_{t-1}) + \phi_3(v^*_{t-1} - v^m) + \varsigma\Delta q_{t-1} + \zeta\Delta v_{t-1} + z^P_t.$$

Results from simultaneous estimation of equations 3', 4', 5', and 6 are presented in Table 2.

Column 2 of Table 2 presents estimates of equations 3', 4', 5', and 6 in which the error-correction coefficients ϕ_1, ϕ_2, and ϕ_3 are unconstrained. Several features of the estimates are worthy of note. First, the model's ability to explain movements in M2 growth is improved substantially as a result of the modifications discussed above: the adjusted R^2 of the money growth equation rises five percentage points relative to the R^2 reported in the corresponding column of Table 1. Consistent with results reported in my earlier paper, the coefficients (υ_1' and θ) attached to time-squared in the velocity equation and to the long-term-bond rate in the opportunity cost formula are highly statistically significant.

In the inflation equation, ϕ_3 is again statistically significant. Furthermore, the point estimates of ϕ_2 and ϕ_3 are very close, suggesting that it is deviations of velocity away from v* that drive inflation, rather than deviations of velocity away from its sample mean. The output-gap coefficient, ϕ_1, is not significantly different from ϕ_2 and ϕ_3 (albeit, also not significantly different from zero), indicating that the P* approach to modeling inflation remains valid.[7] Column 3 of Table 2 presents estimates of equations 3', 4', 5', and 6 in which the restriction $\phi_1 = \phi_2 = \phi_3$ is imposed.

As shown in the results presented in column 3, lagged velocity growth and lagged output growth have effects on inflation that are independent of P*. For example, the estimated value of ζ indicates that a 1.0-percentage-point increase in the velocity of money results, after one quarter, in a 0.15-percentage-point decline in the quarterly rate of inflation. Similarly, the estimated value of ς implies that a 1.0-percentage-point increase in quarterly output growth results, one quarter later, in a 0.25-percentage-point increase in quarterly inflation.[8]

Column 4 of Table 2 displays parameter estimates obtained when the sample period is extended through the end of 1993, with post-1991:Q2 additive dummies included as additional right-hand-side variables. Although they are estimated more precisely than in column 4 of Table 1, the coefficients of the dummy variables are now statistically insignificant. Thus, there is no discernable systematic bias in the money growth and inflation forecasts of the modified model during the post-1991:Q2 period. Figures 2a and 2b--constructed in the same manner and plotted on the same scales as Figures 1a and 1b--provide additional

[7] The relevant test statistic is $\chi^2(2) = .688$.

[8] The tendency for consumer price inflation to increase in response to rising output is also noted by Kuttner (1993).

perspective. The improved out-of-sample performance of the model is quite striking. This improved performance is also evident in a comparison of the out-of-sample root-mean-square errors reported in column 3 of Tables 1 and 2.

4. Predicting an Alternative Price Index

One weakness of the P* approach to modeling inflation is that implicit price deflators do a poor job of measuring period-by-period changes in the price level (Kuttner 1990, p. 6). Even if all prices rise by X percent between periods t and t + 1, an implicit deflator may rise by more than X percent or less than X percent, depending on fluctuations in relative quantities.

Chain-weight price indexes, in contrast, are well-suited to measuring period-by-period price level changes. The gross percentage change in a chain-weight Laspeyres (Paasche) price index equals the cost of yesterday's (today's) bundle of goods at today's prices divided by the cost of yesterday's (today's) goods at yesterday's prices. Since the quantities that enter the numerator and the denominator of the inflation rate are the same, shifts in expenditure patterns do not distort inflation as measured by the index: if all prices rise by X percent between periods t and t + 1, the chain-weight index will rise by exactly X percent. If prices do not rise proportionately, greatest weight is placed upon changes in the prices of those goods that take up the largest share of period t (period t + 1) spending. Unlike the quantity weights in a fixed-weight price index, which-

-as the name suggests--are the same regardless of the time periods being compared, the weights used to calculate price changes in the chain-weight methodology are always representative of recent spending patterns.

In this section, I show that the inflation forecasts of the model developed above have marginal explanatory power for the Fisher ideal chain-weight price index for personal consumption expenditures. The Fisher ideal chain-weight price index is a geometric average of the Laspeyres and Paasche chain-weight price indexes, and is a member of the class of "superlative index numbers."[9] In coverage, the chain-weight consumption price index is broader than the non-durables and services consumption deflator analyzed in Section 3, but narrower than the GDP deflator analyzed in Section 2. Compared to the more familiar consumer price index (CPI), the chain-weight consumption price index has the advantage that it is available on a consistent basis over a longer time period. (Consistent data for the CPI are only available back through 1967, whereas the chain-weight consumption price index extends back through 1959.) Furthermore, the chain-weight consumption price index covers all consumers rather than just consumers located in urban areas. Finally, the CPI is a fixed-weight index, with weights that become increasingly inappropriate the farther away one is from the 1982-

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[9] For further discussion of the construction and properties of Fisher ideal chain-weight indexes, see Young (1992) and Triplett (1992).

84 survey which serves as the index's base.

If the chain-weight consumption price index were cointegrated with the non-durables and services deflator, it would be appropriate to estimate an error-correction model linking the two indices. The indices, however, fail standard cointegration tests. Accordingly, I tied movements in the chain-weight index to forecasted movements in the implicit deflator via an equation of the form:

$$(7) \qquad \Delta\pi'_t = \gamma_0' + \gamma_1'\Delta\pi'_{t-1} + \gamma_2'\Delta\pi'_{t-2} + \gamma_3'\Delta\pi'_{t-3} + \gamma_4'\Delta\pi'_{t-4} + \phi_1'(q_{t-1} - q^*_{t-1}) + \varsigma'\Delta q_{t-1} + \psi\Delta\pi^f_t + z^{PP}_t,$$

where $\Delta\pi'$ denotes the change in inflation as measured by the chain-weight consumption price index, $\Delta\pi^f$ is a forecast of the change in inflation as measured by the implicit non-durables and services consumption deflator, and z^{PP}_t is an error term.

Equation 7 is similar to equation 5' in that it allows changes in inflation to be related to lagged changes in inflation, capacity pressures, and lagged output growth. The combined P*/money-demand model developed in Section 3 (consisting of equations 3', 4', 5', and 6) feeds into equation 7 through $\Delta\pi^f$. Only if the estimated value of ψ is significantly different than zero do the inflation forecasts of the combined model have marginal explanatory power for changes in chain-weight inflation.

Column 2 of Table 3 reports results obtained from simultaneous estimation of equations 3', 4', 5', 6, and 7.

Including equation 7 in the set of estimated equations leads to an improvement in the in-sample fit of the money demand equation but, also, to some deterioration in the in-sample fit of the P* equation. Thus, comparing the summary statistics listed at the bottom of Table 3 to those listed at the bottom of Table 2, the standard error of the money demand equation (equation 4') falls from .00396 to .00380, while the standard error of the P* equation (equation 5') rises from .00317 to .00335. The standard error of the chain-weight forecasting equation (equation 7) is comparable to that of the P* equation. The estimated value of ψ is positive and significant, indicating that the inflation forecasts of the combined model do indeed have marginal explanatory power for changes in chain-weight inflation.

The parameter estimates displayed in column 2 of Table 3 were used to generate a series of one-quarter-ahead forecasts of M2 growth, non-durables and services consumption inflation, and chain-weight consumer price inflation over the period from 1991:Q3 through 1993:Q4. These out-of-sample forecasts are plotted in Figures 3a, 3b, and 3c, along with actual money growth and actual inflation. The expanded model obviously does very well in the out-of-sample exercises. Indeed, the M2 growth and implicit deflator forecasts generated by the model are superior to those displayed in Figures 2a and 2b. (Compare the out-of-sample root-mean-square errors reported in column 2 of Table 3 to the corresponding errors reported in column 3 of Table 2.)

The satisfactory out-of-sample performance of the extended model is confirmed by the results displayed in column 3 of Table 3. These results are based on a sample period that extends through 1993:Q4. Post-1991:Q2 additive dummy variables are included on the right-hand-sides of equations 4', 5', and 7, to test for systematic bias. Note that each dummy variable has an estimated coefficient that lies within one standard error of zero.

V. Summary and Conclusions

The standard P* inflation model assumes not just that movements in M2 velocity are predictable, but that M2 velocity tends toward a constant long-run value. One can relax the constancy assumption by estimating the P* model simultaneously with a model of M2 demand.

When the generalized P* model is estimated simultaneously with the M2 demand equation used (until recently) by the Federal Reserve Board, the pre-1991 inflation forecasting performance of the combined model is significantly better than that of the standard P* model. However, the *recent* performance of the combined model is unacceptably poor. The model substantially overpredicts money growth and substantially underpredicts inflation.

When the Board's M2 demand equation is replaced by the consumption-based M2 demand equation developed by Koenig (1993), the performance of the combined model of inflation and money demand improves markedly. Thus, the out-of-sample money-growth forecasts generated by the revised model exhibit little of the "missing money" problem evident in the results generated by the Board's M2 demand equation. The out-of-sample inflation forecasts of the revised model also appear to be unbiased.

One weakness of the P* approach to modeling inflation is that it generates forecasts of changes in an implicit price deflator. Implicit deflators are notoriously noisy measures of inflation. Their movements reflect shifts in the composition of output as much as they do price changes. One method for overcoming this weakness is to estimate a forecasting equation for a chain-weight price index simultaneously with M2-demand and P* equations. This expanded model appears to be quite successful at predicting changes in the chain-weight price index, as well as at predicting implicit price inflation and money growth.

The evidence presented here suggests that movements in the M2 monetary aggregate--appropriately interpreted--remain a reliable indicator of future inflation. Whether M2 is sufficiently under the Federal Reserve's control to serve as an intermediate *target* variable remains an open question.

Figure 1A
M2 Growth: Actual and as Predicted by the Board Model

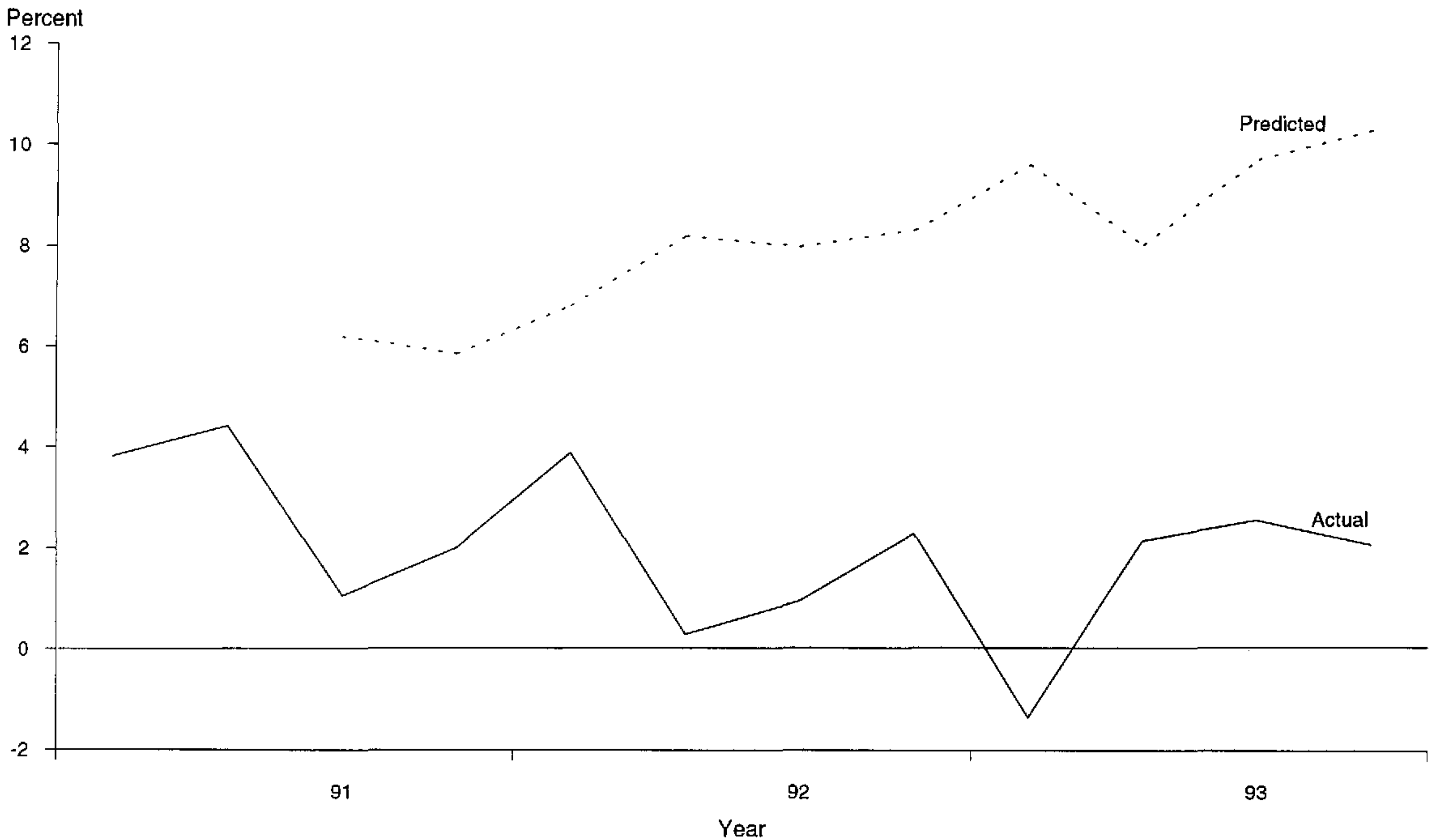

Figure 1B
Inflation: Actual and as Predicted by the Board Model

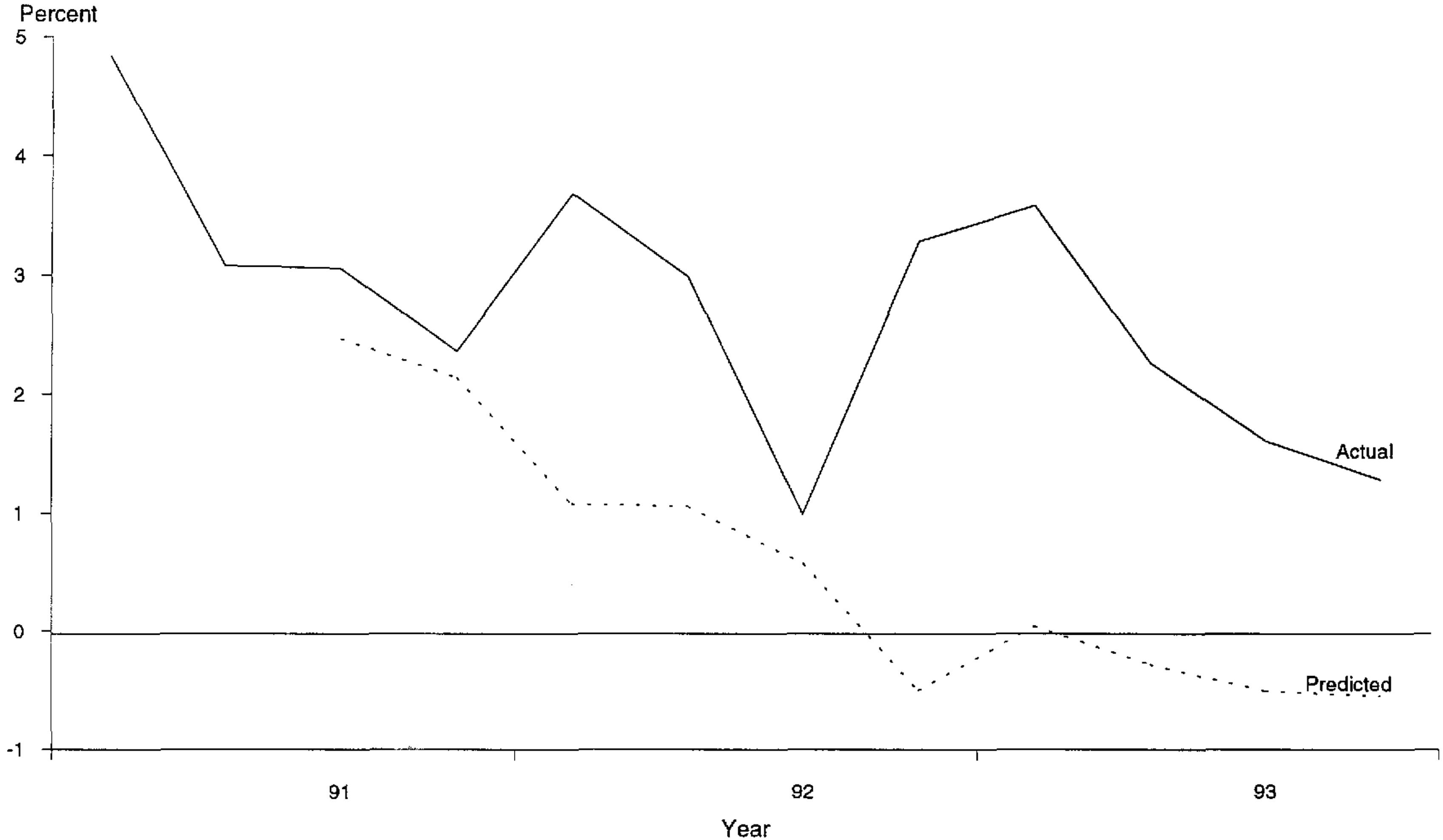

Figure 2A
M2 Growth: Actual and Predicted

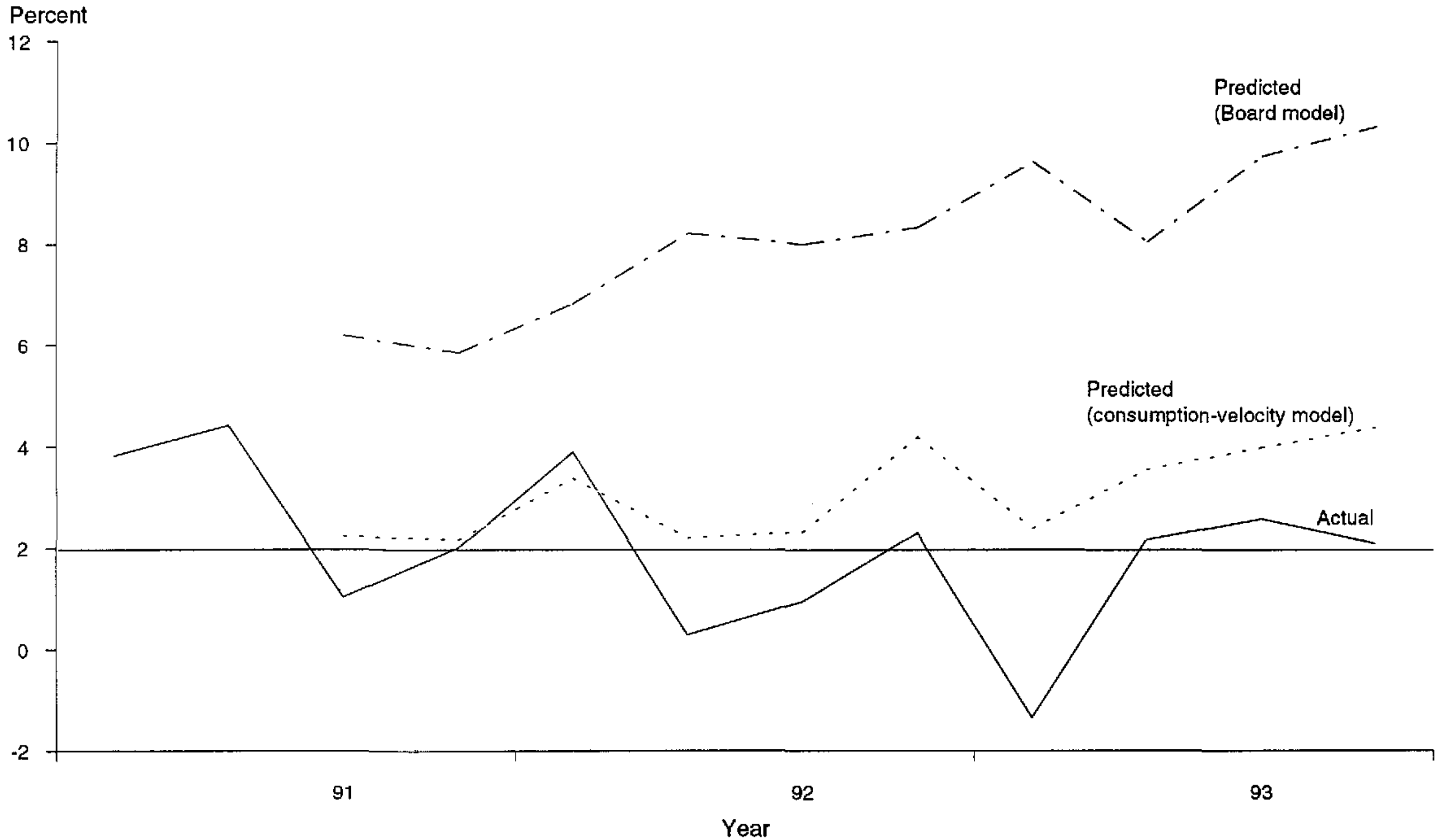

Figure 2B
Inflation: Actual and as Predicted by the Consumption-Velocity Model

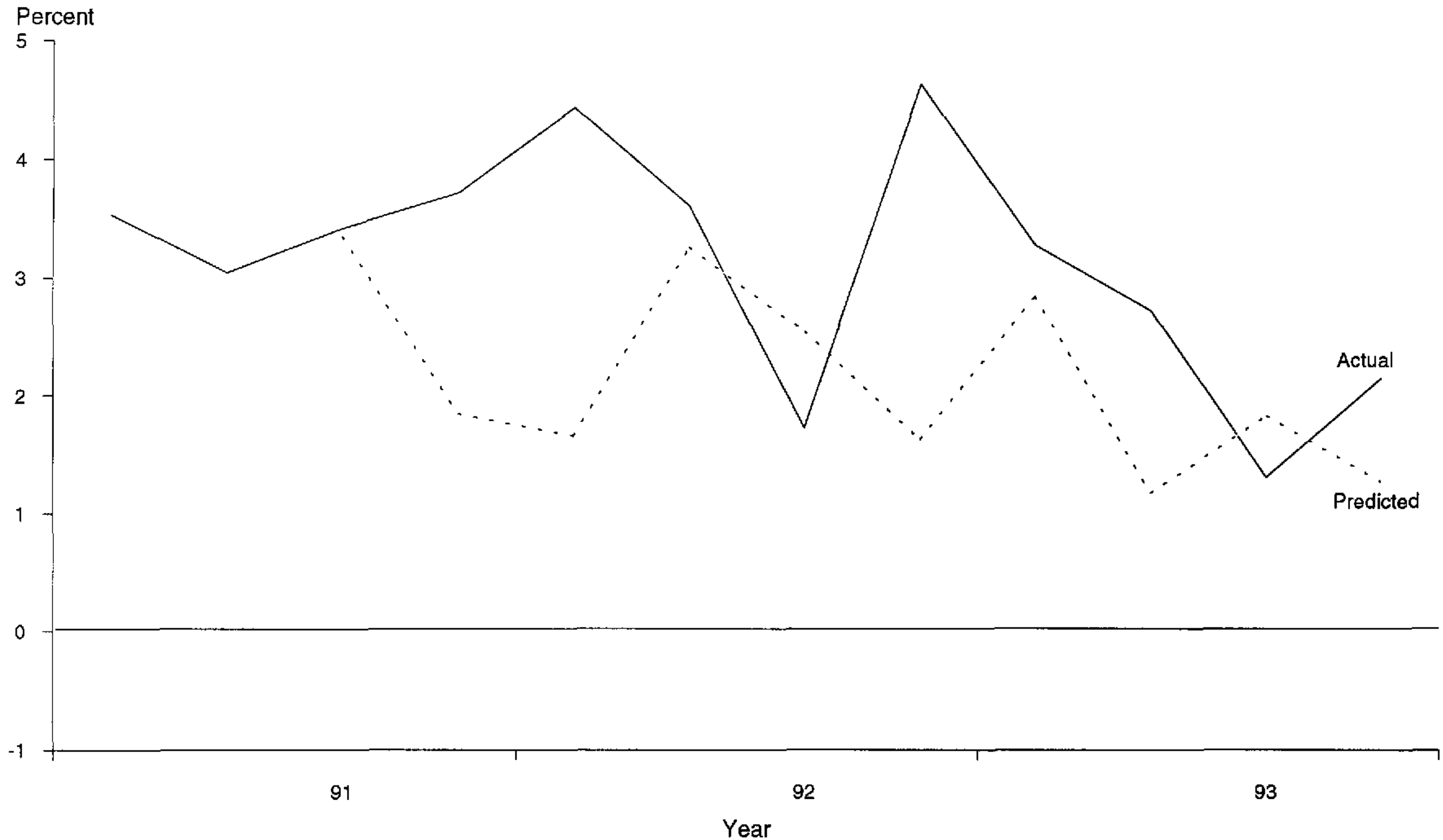

Figure 3A
M2 Growth: Actual and as Predicted by the Consumption-Velocity Model

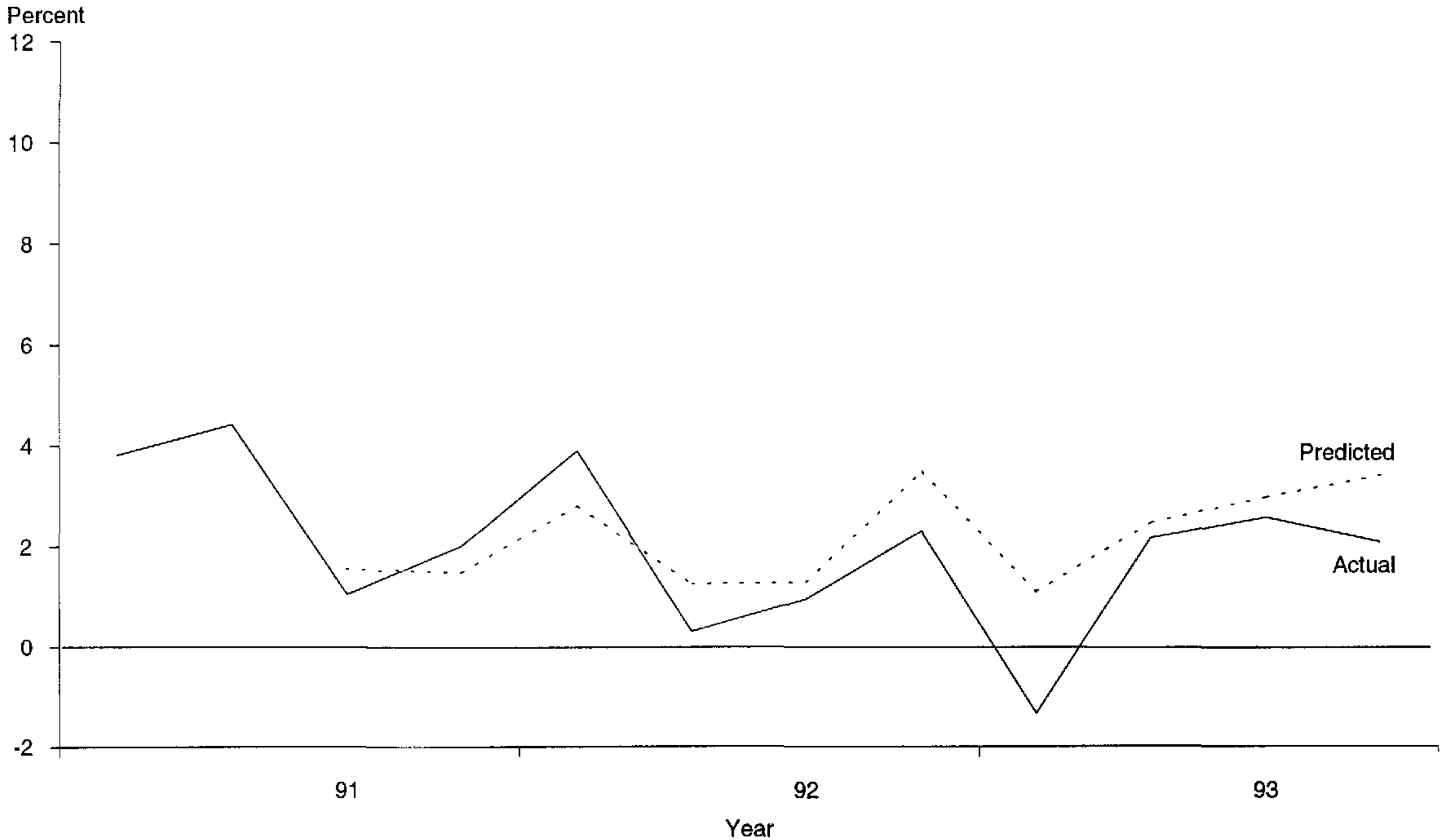

Figure 3B
Inflation: Actual and as Predicted by the Consumption-Velocity Model

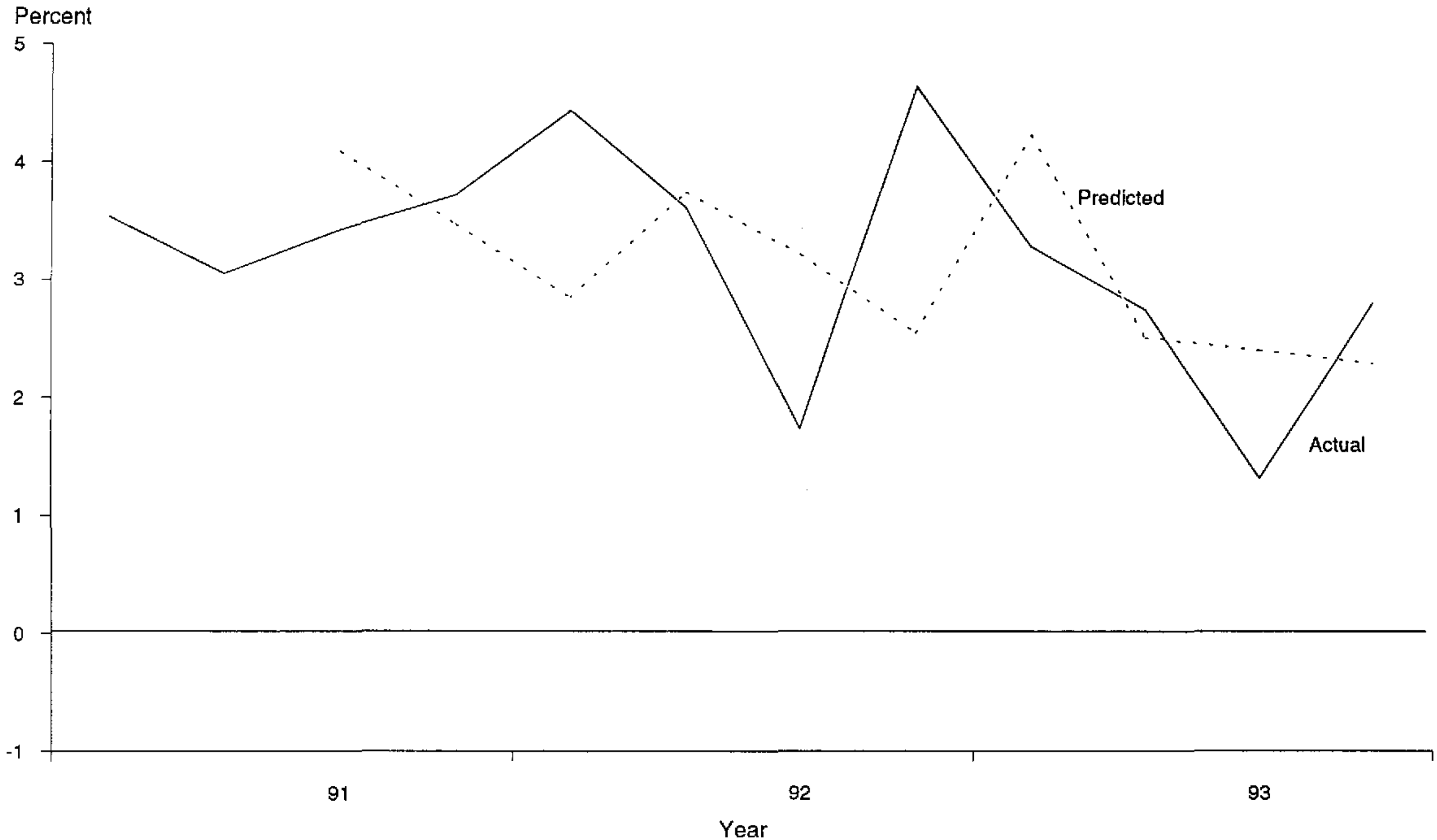

Figure 3C
Chain -Weight Inflation: Actual and as Predicted by the Consumption-Velocity Model

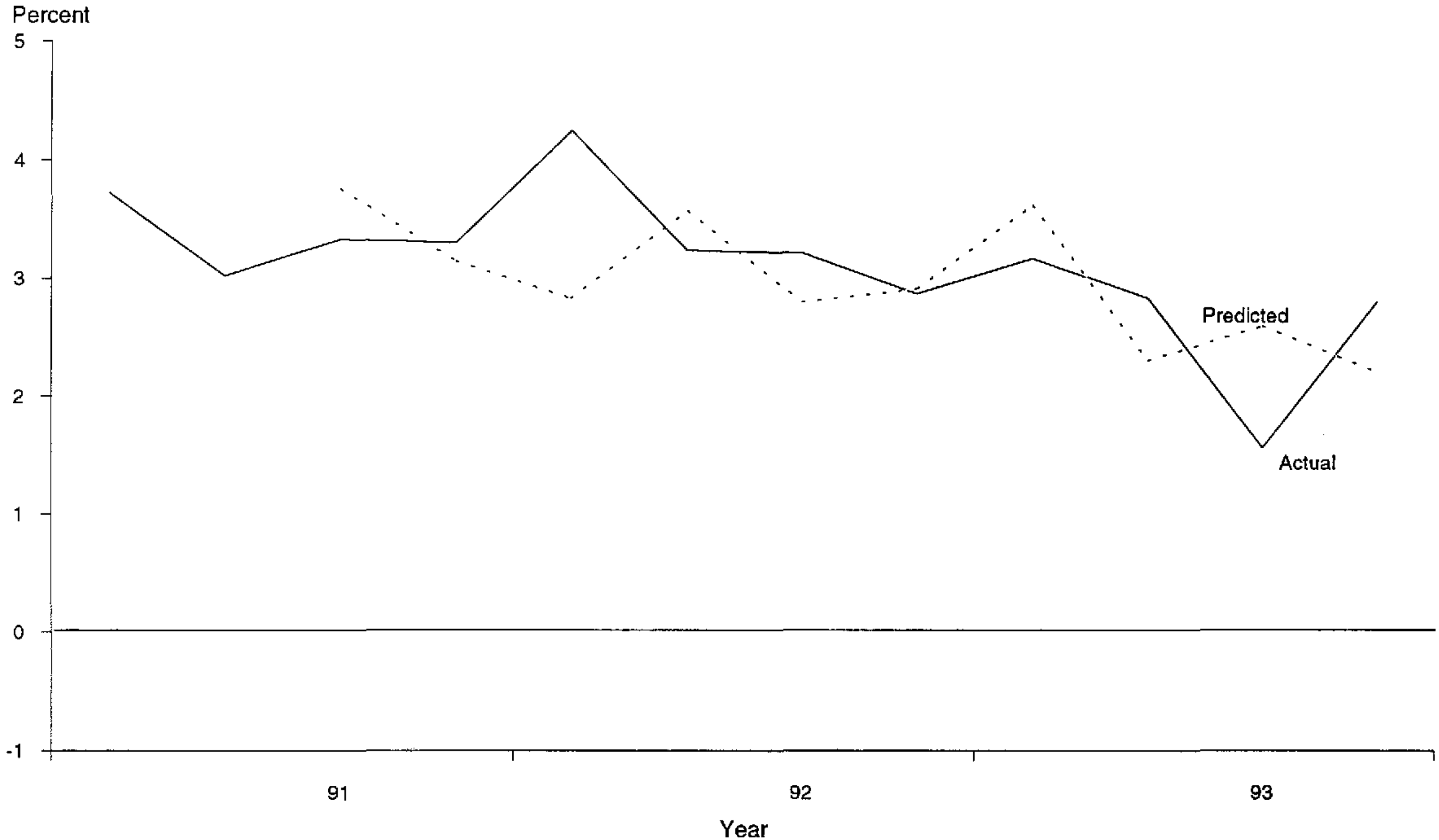

TABLE 1. Joint Estimation of the Money Demand and P* Models

Parameter	64:Q1-91:Q2	64:Q1-91:Q2	64:Q1-93:Q4
Equation 3--Long-Run Velocity			
υ_1	$.6411\times10^{-3}$** ($.1363\times10^{-3}$)	$.6172\times10^{-3}$** ($.1290\times10^{-3}$)	$.6225\times10^{-3}$** ($.1554\times10^{-3}$)
υ_2	-.0125 (.0100)	-.0129 (.0095)	-.0122 (.0114)
υ_3	.0550** (.0062)	.0515** (.0055)	.0525** (.0065)
Equation 4--Money Demand			
α_0	.2568** (.0649)	.2578** (.0651)	.2748** (.0647)
α_1	.1893* (.0743)	.1813* (.0738)	.1300 (.0727)
α_2	.0718 (.0555)	.0634 (.0554)	.0588 (.0551)
ß	-.1325 (.0697)	-.1367 (.0705)	-.1341 (.0696)
ϵ	.1709** (.0251)	.1760** (.0250)	.1495** (.0227)
Post-1991:Q2 Dummy	---	---	-.0163** (.0026)
Equation 5--Inflation			
γ_1	-.7142** (.0975)	-.6936** (.0973)	-.6731** (.0938)
γ_2	-.5065** (.1168)	-.4930** (.1170)	-.4781** (.1120)
γ_3	-.2680* (.1220)	-.2755* (.1236)	-.2531* (.1181)
γ_4	-.0692 (.1001)	-.0839 (.1013)	-.0672 (.0975)
ϕ_1	.0552** (.0158)	.0524** (.0132)	.0457** (.0124)
ϕ_2	.0649** (.0198)	ϕ_1	ϕ_1
ϕ_3	.0359* (.0174)	ϕ_1	ϕ_1
Post-1991:Q2 Dummy	---	---	.0040* (.0018)

Summary Statistics--Equation 4

Adjusted R^2	.6436	.6419	.6084
Standard Error	.00428	.00429	.00442
Q(4)	5.974	5.832	10.214*
Q(12)	15.725	15.771	18.981
Out-of-Sample RMSE	---	.01974	---

Summary Statistics--Equation 5

Adjusted R^2	.3520	.3328	.3122
Standard Error	.00362	.00367	.00364
Q(4)	1.878	2.019	1.741
Q(12)	13.032	14.496	14.330
Out-of-Sample RMSE	---	.00533	---

Standard errors in parentheses
* Significant at 5% level
** Significant at 1% level

TABLE 2. Joint Estimation of the New Money Demand and P* Models

Parameter	64:Q1-91:Q2	64:Q1-91:Q2	64:Q1-93:Q4
Equation 6--Opportunity Cost			
θ	.3541** (.0783)	.3614** (.0799)	.3703** (.0763)
Equation 3'--Long-Run Velocity			
υ_1	-.0058** (.0012)	-.0060** (.0014)	-.0064** (.0014)
υ_2	-.0635** (.0142)	-.0630** (.0155)	-.0664** (.0158)
υ_3	.0955** (.0141)	.1003** (.0151)	.1013** (.0152)
υ_1'	$.3129\times10^{-4}$** ($.0530\times10^{-4}$)	$.3222\times10^{-4}$** ($.0575\times10^{-4}$)	$.3362\times10^{-4}$** ($.0576\times10^{-4}$)
Equation 4'--Money Demand			
α_0	.3330** (.1001)	.3282** (.0997)	.3524** (.0914)
α_1	-.1310 (.0946)	-.1267 (.0945)	-.1794* (.0880)
α_2	.2632** (.0838)	.2667** (.0836)	.2837** (.0771)
β_0	-.0941 (.0996)	-.0922 (.0990)	-.0884 (.0896)
ϵ	.1250** (.0314)	.1217** (.0310)	.1132** (.0283)
β_1	-.0887* (.0351)	-.0863* (.0337)	-.0964** (.0332)
Post-1991:Q2 Dummy	---	---	-.0030 (.0023)
Equation 5'--Inflation			
γ_1	-.3936** (.1017)	-.4066** (.0961)	-.4228** (.0932)
γ_2	-.1487 (.1171)	-.1717 (.1109)	-.1823 (.1066)
γ_3	.0611 (.1106)	.0385 (.1073)	-.0123 (.1015)
γ_4	.1109 (.1020)	.0813 (.0978)	.0402 (.0917)

Table 2. Continued

	Equation 5'--continued		
ϕ_1	.0315 (.0174)	.0427** (.0101)	.0442** (.0099)
ϕ_2	.0564** (.0209)	$\phi_2 = \phi_1$	$\phi_2 = \phi_1$
ϕ_3	.0603** (.0180)	$\phi_3 = \phi_1$	$\phi_3 = \phi_1$
ζ	-.1633** (.0497)	-.1473** (.0445)	-.1474** (.0443)
ς	.2970** (.0825)	.2629** (.0687)	.2479** (.0663)
Post-1991:Q2 Dummy	---	---	.0021 (.0013)
	Summary Statistics--Equation 4'		
Adjusted R^2	.6941	.6947	.7010
Standard Error	.00396	.00396	.00387
Q(4)	4.171	4.293	5.013
Q(12)	11.250	11.443	11.913
Out-of-Sample RMSE	---	.00421	---
	Summary Statistics--Equation 5'		
Adjusted R^2	.3352	.3360	.3206
Standard Error	.00317	.00317	.00317
Q(4)	1.755	1.502	0.616
Q(12)	15.103	14.339	13.234
Out-of-Sample RMSE	---	.00378	---

Standard errors in parentheses
* Significant at 5% level
** Significant at 1% level

TABLE 3. Joint Estimation of the New Money Demand and P* Models

Parameter	64:Q1-91:Q2	64:Q1-93:Q4
Equation 6--Opportunity Cost		
θ	.4308** (.0761)	.4327** (.0726)
Equation 3'--Long-Run Velocity		
υ_1	-.0071** (.0014)	-.0073** (.0014)
υ_2	-.0753** (.0162)	-.0759** (.0159)
υ_3	.1042** (.0160)	.1043** (.0157)
υ_1'	$.3667\times10^{-4}$** ($.0616\times10^{-4}$)	$.3733\times10^{-4}$** ($.0596\times10^{-4}$)
Equation 4'--Money Demand		
α_0	.3780** (.0920)	.4032** (.0848)
α_1	-.1869* (.0882)	-.2285** (.0824)
α_2	.2552** (.0791)	.2689** (.0729)
β_0	-.0844 (.0912)	-.0810 (.0830)
ϵ	.1020** (.0283)	.0990** (.0263)
β_1	-.1005** (.0341)	-.1084** (.0338)
Post-1991:Q2 Dummy	---	-.0018 (.0021)
Equation 5'--Inflation		
γ_1	-.4749** (.0807)	-.5112** (.0795)
γ_2	-.3854** (.0838)	-.4029** (.0835)
γ_3	-.2527** (.0832)	-.2300** (.0821)
γ_4	-.0445 (.0716)	-.0528 (.0662)

Table 3. Continued

	Equation 5'--continued	
ϕ_1	.0202** (.0066)	.0236** (.0068)
ζ	-.0349 (.0213)	-.0385 (.0238)
ς	.2314** (.0623)	.1810** (.0545)
Post-1991:Q2 Dummy	---	-.0000 (.0011)
	Equation 7--Chain-Weight Inflation	
γ_1'	-.5730** (.0733)	-.6487** (.0716)
γ_2'	-.3776** (.0726)	-.3889** (.0694)
γ_3'	-.2606** (.0738)	-.2609** (.0714)
γ_4'	-.1359* (.0620)	-.1443* (.0579)
ϕ_1'	.0297** (.0093)	.0334** (.0095)
ς'	.1408* (.0599)	.0869 (.0503)
ψ	.2534* (.1273)	.3735** (.1299)
Post-1991:Q2 Dummy	---	.0002 (.0010)
	Summary Statistics--Equation 4'	
Adjusted R^2	.7239	.7311
Standard Error	.00380	.00369
Q(4)	5.828	5.488
Q(12)	13.295	12.597
Out-of-Sample RMSE	.00275	---

Table 3. Continued

Summary Statistics--Equation 5'

Adjusted R^2	.2672	.2836
Standard Error	.00335	.00328
Q(4)	6.275	5.787
Q(12)	23.662*	22.726*
Out-of-Sample RMSE	.00274	---

Summary Statistics--Equation 7

Adjusted R^2	.1907	.1968
Standard Error	.00326	.00314
Q(4)	6.812	5.601
Q(12)	28.583**	24.804*
Out-of-Sample RMSE	.00166	---

Standard errors in parentheses
* Significant at 5% level
** Significant at 1% level

References

Becsi, Zsolt and John V. Duca (1994) "Adding Bond Funds to M2 in the P-Star Model of Inflation," **Economics Letters** 42, ??-??.

Duca, John V. (1993) "RTC Activity and the 'Missing M2'," **Economics Letters** 41, 67-72.

Elyasiani, Elyas and Alireza Nasseh (1994) "The Appropriate Scale Variable in the U.S. Money Demand: An Application of Nonnested Tests of Consumption Versus Income Measures," **Journal of Business and Economic Statistics** 12, 47-55.

Federal Reserve (1993) "Monetary Report to the Congress," **Federal Reserve Bulletin** 79, 167-96.

Feldstein, Martin and James H. Stock (1993) "The Use of Monetary Aggregate to Target Nominal GDP," National Bureau of Economic Research Working Paper No. 4304.

Hallman, Jeffrey J., Richard D. Porter, and David H. Small (1991) "Is the Price Level Tied to the M2 Monetary Aggregate in the Long Run?" **American Economic Review** 81, 841-58.

Hetzel, Robert L. (1992) "How Useful is M2 Today?" Federal Reserve Bank of Richmond **Economic Review**, September/October, 12-26.

Koenig, Evan F. (1993) "Searching for a Stable M2-Demand Equation," Federal Reserve Bank of Dallas Research Paper No. 9339.

Kuttner, Kenneth N. (1990) "Inflation and the Growth Rate of Money," Federal Reserve Bank of Chicago **Economic Perspectives**, January/February, 2-11.

_____(1993) "An Unobserved-Components Model of Constant-Inflation Potential Output," Federal Reserve Bank of Chicago Working Paper No. WP-93-2.

Mankiw, N. Gregory and Lawrence H. Summers (1986) "Money Demand and the Effects of Fiscal Policy," **Journal of Money, Credit, and Banking** 18, 415-29.

Moore, George R., Richard D. Porter, and David H. Small (1990) "Modeling the Disaggregated Demands for M2 and M1: The U.S. Experience in the 1980s." In **Financial Sectors in Open Economies: Empirical Analysis and Policy Issues**, edited by Peter Hooper, Karen H. Johnson, Donald L. Kohn, David E. Lindsey, Richard D. Porter, and Ralph Tryon, pp. 21-105. Washington, D.C., Board of Governors of the Federal Reserve System.

Triplett, Jack E. (1992) "Economic Theory and BEA's Alternative Quantity and Price Indexes," **Survey of Current Business** 72 (April), 49-52.

Young, Allan H. (1992) "Alternative Measures of Change in Real Output and Prices," **Survey of Current Business** 72 (April), 32-48.

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