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**Price Expectations and the Demand for Money:  
A Comment**

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Working Paper 1984-007A  
<http://research.stlouisfed.org/wp/1984/1984-007.pdf>

1984

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Price Expectations and the Demand for Money:  
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84-007

We would like to thank Stu Allen, Sandy Batten, Alec Chrystal, Scott Hein and Ross Milbourne for useful suggestions on an earlier version of this paper. Jane Mack and John Schulte provided research assistance. The views expressed are the authors' and may not represent those of the Federal Reserve Bank or the Federal Reserve System.

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## I. Introduction

In a recent article in this Review, Ross Milbourne (1983) purports to have resolved an apparent paradox between theory and empirical results. Milbourne notes that, while inflationary expectations play no role in the Tobin-Baumol transactions model of money demand, numerous empirical studies find a statistically significant effect. He argues that these findings are invalid, because the commonly used specification that includes a lagged dependent variable is not the preferred specification. When the preferred adjustment mechanism is used--one that permits individuals to adjust money balances partially to price level changes--the inflation rate "is redundant and not significant."

In this comment we demonstrate that Milbourne overlooked an important, testable restriction. Because of this oversight, he mistakenly interprets his results as evidence that the rate of inflation is not significant in the preferred specification. We also examine the robustness of his empirical results by altering the estimated equation to account for recent well-documented money demand shifts. Our evidence indicates that the paradox remains unsolved.

## II. Real and Nominal Adjustment Models and Expectations

The long-run demand for money is given by

$$\ln(M_t^*/P_t) = \alpha_0 + \alpha_1 \ln y_t + \alpha_2 \ln R_t + \epsilon_t, \quad (1)$$

where  $M^*$  denotes the desired stock of nominal money,  $P$  is the aggregate price level,  $y$  is real income, and  $R$  is "the" nominal interest rate. Assume that individuals adjust their actual money holdings to their desired level via two alternative partial adjustment mechanisms. One is the real-adjustment mechanism

$$\ln(M_t/P_t) - \ln(M_{t-1}/P_{t-1}) = \theta [\ln(M_t^*/P_t) - \ln(M_{t-1}/P_{t-1})] \quad (0 \leq \theta \leq 1) \quad (2)$$

where  $\theta$  represents the speed of adjustment, that is, the rate at which actual balances adjust to their desired levels. Combined with equation (1), individuals are assumed to adjust their nominal money holdings instantaneously with respect to prices but with a lag with respect to real income and the interest rate.

The alternative nominal-adjustment mechanism allows individuals to adjust their money holdings to price level changes with a lag. This form is

$$\ln M_t - \ln M_{t-1} = \lambda (\ln M_t^* - \ln M_{t-1}) \quad (0 \leq \lambda \leq 1) \quad (3)$$

where  $\lambda$  represents the adjustment coefficient. Combining equations (1) and (2) and equations (1) and (3), two specifications of the short-run money demand function can be derived. They are

$$\ln(M_t/P_t) = \beta_0 + \beta_1 \ln y_t + \beta_2 \ln R_t + \beta_3 \ln(M_{t-1}/P_{t-1}) + \epsilon_t \quad (4)$$

and

$$\ln(M_t/P_t) = \gamma_0 + \gamma_1 \ln y_t + \gamma_2 \ln R_t + \gamma_3 \ln(M_{t-1}/P_t) + \epsilon_t. \quad (5)$$

Equation (4) represents the commonly estimated real-adjustment version, equation (5) the nominal-adjustment specification.

The parameters of the reduced-form equations are related to the structural parameters in equations (1)-(3). Thus  $\beta_0 = \alpha_0 \theta$ ,  $\beta_1 = \alpha_1 \theta$ ,  $\beta_2 = \alpha_2 \theta$  and  $\beta_3 = 1 - \theta$  for equation (4) and, for equation (5),  $\gamma_0 = \alpha_0 \lambda$ ,  $\gamma_1 = \alpha_1 \lambda$ ,  $\gamma_2 = \alpha_2 \lambda$  and  $\gamma_3 = 1 - \lambda$ .

Milbourne notes that tests of whether the rate of inflation enters as a separate explanatory variable in equation (1) usually are accomplished by adding the actual (or expected) inflation rate to equation (4). This results in

$$\ln(M_t/P_t) = \beta_0 + \beta_1 \ln y_t + \beta_2 \ln R_t + \beta_3 \ln(M_{t-1}/P_{t-1}) + \beta_4 \pi_t + \epsilon_t, \quad (6)$$

where  $\pi$  represents the actual or expected inflation rate, and the estimated parameter  $\beta_4 = \alpha_3 \theta$ , where  $\alpha_3$  is the additional parameter that results from including  $\pi$  in equation (1).

Milbourne notes that, since  $\ln(M_{t-1}/P_{t-1}) = \ln(M_{t-1}/P_t) + \ln(P_t/P_{t-1})$ , the nominal-adjustment specification (5) can be rewritten as

$$\begin{aligned} \ln(M_t/P_t) = & \gamma_0 + \gamma_1 \ln y_t + \gamma_2 \ln R_t + \gamma_3 \ln(M_{t-1}/P_{t-1}) \\ (7) & + \gamma_4 \ln(P_t/P_{t-1}) + \epsilon_t, \end{aligned}$$

where  $\gamma_4 = 1 - \lambda$  and with the implicit restriction that  $\gamma_3 = -\gamma_4$ . Equation (6) and the unrestricted form of

(7) are observationally equivalent if the actual rate of inflation [i.e.,  $\pi = \ln(P_t/P_{t-1})$ ] is used.

It also is clear that equations (4) and (5) are simply equation (6) subject to the restrictions  $\beta_4=0$  and  $\beta_3=-\beta_4$ , respectively. Thus, both equations (4) and (5) are nested within (6). Milbourne argues correctly that if the latter restriction cannot be rejected, previous studies estimating equation (6) are subject to an alternative interpretation, i.e., the nominal adjustment specification.

Milbourne concludes that if the restrictions  $\beta_4=0$  and  $\beta_3=-\beta_4$  hold, "the rate of inflation is not significant in the preferred [nominal adjustment] specification." (p. 635). It can be demonstrated, however, that these restrictions are not sufficient to test the hypothesis that inflation has no independent influence on money demand. To see this, add the inflation rate to equation (1) and, using equation (3), rewrite equation (5) as

$$\begin{aligned} \ln(M_t/P_t) = & \gamma_0 + \gamma_1 \ln y_t + \gamma_2 \ln R_t + \gamma_3 \ln(M_{t-1}/P_t) \\ & + \gamma_4 \ln(P_t/P_{t-1}) + \epsilon_t, \end{aligned} \quad (8)$$

where  $\gamma_4 = \alpha_3 \lambda$ . Using the definition of  $\ln(M_{t-1}/P_{t-1})$ , equation (8) becomes

$$\begin{aligned} \ln(M_t/P_t) = & \gamma_0 + \gamma_1 \ln Y_t + \gamma_2 \ln R_t + \gamma_3 \ln(M_{t-1}/P_{t-1}) \\ & + \gamma_4' \ln(P_t/P_{t-1}) + \epsilon_t, \end{aligned} \quad (8')$$

with  $\gamma_4' = \alpha_3 \lambda - (1-\lambda)$ . Note that the restriction  $\gamma_3 = -\gamma_4'$  implies that  $-\alpha_3 \lambda = 0$ . The condition that  $\gamma_3 = -\gamma_4'$  obviously can hold if  $\alpha_3 = 0$ ,

$\lambda=0$  or both.<sup>1/</sup> Our point is that the conclusion that the inflation rate does not exert a separate influence in equation (5) requires testing the additional restriction that  $\alpha_3=0$ .<sup>2/</sup> It is precisely this point that Milbourne overlooks. Because this restriction is not tested, and given that his estimates of  $\lambda$  are negative, Milbourne's empirical results cannot reject the possible independent effect of inflation in the nominal money demand specification.

### III. Empirical Results

In this section, we examine the robustness of Milbourne's empirical results. Numerous recent studies have found estimated money demand equations to be unstable when estimated through the mid-1970s. Because Milbourne's model is not specified to account for these instabilities, his estimates may be biased. Thus, the money demand equation estimated here incorporates a growth rate shift term (D1) to capture the mid-1970s shift, and separate dummy variables (D2) and (D3) to account for the special credit control period of 1980(2) and 1980(3).<sup>3/</sup> The credit control period is assumed to have affected the demand for money via a buffer-stock model; see Carr and Darby (1981).

The money demand equations are estimated using seasonally adjusted data for the United States for the period 1952(1) to 1981(2).<sup>4/</sup> The money stock is M1, income is measured as real GNP (\$1972), price is the GNP price deflator (1972=100) and the

interest rate is the 4-6 month commercial paper rate. To make our results comparable with Milbourne's, the equations were estimated with ordinary least squares (OLS).<sup>5/</sup>

The results using the actual rate of inflation are presented in table 1, where the first three equations essentially replicate Milbourne's work. Equation A is the real-adjustment specification, and equation B is the real-adjustment equation including the actual rate of inflation. Equation C is equation (6) with the constraint  $\beta_3 = -\beta_4$  imposed. A likelihood ratio test of equation B and C indicates the restriction cannot be rejected at the 5 percent level ( $\chi^2(1) = 0.08$ ). Note, however, that the estimate of  $\lambda$  is outside of its theoretical bound, suggesting a misspecification of the dynamic adjustment process. This finding, unfortunately, precludes statistical testing for a separate inflation rate effect in equation (5).

Equation D incorporates the dummy variable D1 to account for the mid-1970s money demand shift, and equation E incorporates D1 and the credit control dummies. All dummy variables are significant at the 5 percent level.<sup>6/</sup> The importance of including these terms also is revealed by the reduction in the estimated coefficient on lagged money.

When the hypothesis  $\beta_3 = -\beta_4$  is tested using the dummied equations, it is not rejected in equation D, but is rejected in equation E. (The likelihood ratio statistics are  $\chi^2(1) = 1.68$  and  $\chi^2(1) = 3.82$ , respectively).<sup>7/</sup>

Thus, Milbourne's finding that the nominal specification represents an alternative interpretation of previous empirical results is questionable when the credit control period is considered. Also, because the point estimates of  $\lambda$  fall within the theoretical bound when the dummy variables are included, a direct test of the significance of the inflation rate can be made. This test is tenuous, however, because the hypothesis that  $\lambda=0$  cannot be rejected for either equation. Nevertheless, the estimates of  $\alpha_4$  (and approximate t-ratios) are -43.03 (1.93) and -35.03 (2.38) for equation D and E, respectively.<sup>8/</sup> While limited, the evidence does not reject the possibility of a separate inflation rate effect in the nominal money demand specification. This possibility finds its strongest support in equation E, where the hypothesis  $\beta_3 = -\beta_4$  is rejected.

#### IV. Conclusion

This note examines Milbourne's claim that inflation plays no independent role in influencing the short-run demand for money in the United States when the nominal partial adjustment specification is used. We have shown that he misinterprets his results and mistakenly concludes that there is no significant, separate effect of the rate of inflation on the demand for money in the nominal-adjustment model. We also have shown that if certain shifts in the demand for money are accounted for, there is a significant, separate effect of the inflation rate

in the nominal money demand specification. Moreover, if the credit control experience is accounted for, the nominal specification is not preferred to the real specification with a separate inflation rate effect. While the evidence is not conclusive, it appears that Milbourne's findings are not robust and, hence, the paradox remains unresolved.

## FOOTNOTES

1/It would be sufficient to show that  $\lambda \neq 0$ . Milbourne's estimate of  $\lambda$ , however, falls outside of the theoretical range. Nevertheless, since it appears that estimates of  $\lambda$  are not different from zero, his result that  $\alpha_3 \lambda$  is not different from zero implies nothing about  $\alpha_3$ .

2/Equation (6) and the unrestricted forms of (7) and (8') are observationally equivalent, though they stem from different behavioral assumptions. Because of the identity, noted by Milbourne, it is impossible to distinguish equation (8') from (6) if  $\alpha_3 \neq 0$ . Moreover, composite of equations (6) and (8) suffers from exact multicollinearity. Thus, conventional hypothesis tests will not work. Tests of non-nested models also will not be useful; see Pesaran (1982).

3/The term D1 is defined as  $D1 = 1$  for 1974(2)-1981(2) and zero elsewhere. Previous studies employing such a shift term are Brayton, Farr and Porter (1983), Hafer (1982), Radecki and Wenninger (1983) and Wenninger, Radecki and Hammond (1981).

The credit control shift terms are defined as  $D2 = 1$  for 1980(2), zero elsewhere, and  $D3 = 1$  for 1980(3), zero elsewhere. These are used to capture the effects on the money supply brought on by the implementation and removal of the credit controls. Although the linkage by which the credit controls influenced the money supply are not fully agreed upon, it is generally acknowledged that the large, offsetting money demand forecast errors found in 1980(2) and 1980(3) are products of the large, temporary swings in the nominal money supply. For a discussion of this period as it relates to money demand estimates, see Hein (1982), Judd and Scadding (1981) and Weintraub (1980).

4/Milbourne also examines the inflation effect using Australian data.

5/The equations also were estimated adjusting for first-order autocorrelation. These results do not alter our conclusions.

Milbourne also tests the hypothesis using an expected inflation series derived from an autoregressive model of expectations. We, too, investigated the issue using such a series and found that the expected rate of inflation was not significant in either the nominal- or real-adjustment equation when the dummy variables are included. For the sake of brevity, we do not include these results. They are, however, available upon request.

6/ It is interesting to note the large shift in the Durbin h-statistic when the dummy variables are included. This finding, along with the parameter estimates in table 1, reveals the importance of capturing the 1980 experience with credit controls and the mid-1970s shift in money demand.

7/ The critical value of the  $\chi^2$ -statistic is 3.84 at the 5 percent level. If a standard t-test is used the hypothesis is rejected at the 5 percent level ( $t=1.90$ ) using a one-tailed test. This is because the test that  $\gamma_3 = -\gamma'_4$  is equivalent to  $-\alpha_3 = 0$ . Since it usually is hypothesized that  $\alpha_3 < 0$ , this is a one-tailed test where the alternative is  $\gamma_3 + \gamma'_4 > 0$ .

8/ The variance of  $\alpha_3$  was approximated with a Taylor series expansion.

Table 1: Real and Nominal Specifications: 1952(1) - 1981(2)

<u>Equation</u>	<u>Constant</u>	<u>lny</u>	<u>lnRCP</u>	<u>ln(M/P)<sub>-1</sub></u>	<u>ln(P/P<sub>-1</sub>)</u>	<u>D<sub>1</sub></u>	<u>D<sub>2</sub></u>	<u>D<sub>3</sub></u>	<u>h</u>	<u><math>\bar{R}^2/SE \times 10^{-2}</math></u>
A	-0.137 (4.70)	0.027 (4.67)	-0.016 (6.17)	0.976 (45.73)					2.22	.981/.70
B	-0.196 (7.80)	0.032 (6.74)	-0.010 (4.61)	1.006 (56.07)	-.971 (7.54)				1.14	.988/.57
C	-0.199 (8.39)	0.032 (7.01)	-0.010 (4.79)	1.007 (56.54)	-1.007 (56.54)				1.16	.988/.57
D	-0.229 (7.66)	0.040 (6.37)	-0.012 (5.06)	0.978 (42.83)	-0.793 (5.08)	-0.005 (1.96)			0.95	.988/.56
E	-0.219 (8.81)	0.038 (7.16)	-0.012 (5.91)	.983 (50.12)	-.748 (5.63)	-0.004 (2.24)	-0.027 (5.55)	0.021 (4.27)	3.44	.992/.47

Absolute value of the t-statistics in parentheses.

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Table A: The Effect of Expected Inflation

NOT FOR PUBLICATION

Constant	lny	lnRCP	ln(M/P) <sub>-1</sub>	ln(M <sub>-1</sub> /P)	$\hat{\pi}$	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	h	$\hat{\rho}$	$\bar{R}^2/SE \times 10^{-2}$
-0.175 (5.94)	0.032 (5.74)	-0.012 (4.40)	0.976 (48.28)		-0.731 (3.74)				.34		.983/.66
-0.231 (8.19)	0.046 (7.72)	-0.016 (6.30)	0.934 (45.23)		-0.221 (1.04)	-0.009 (3.80)	-0.032 (5.84)	0.018 (3.22)	2.39		.989/.53
-0.217 (8.49)	0.036 (6.57)	-0.010 (4.58)		0.998 (50.53)	0.032 (0.17)	-0.003 (1.19)	-0.025 (5.23)	0.022 (4.36)	3.82		.991/.48
-0.239 (6.94)	0.050 (6.85)	-0.016 (6.01)	0.910 <sup>a</sup> (34.61)		-0.000 (0.20)	-0.011 (3.96)	-0.033 (6.52)	0.015 (2.88)		0.28 (2.97)	.990/.495

Absolute value of the t-statistics in parentheses. The expected rate of inflation is derived from the regression equation:

a)  $\alpha_4 = -78.18$ ,  $t = 2.70$ .

$$\hat{\pi}_t = 0.001 + 0.443 \pi_{t-1} + 0.191 \pi_{t-2} + 0.336 \pi_{t-3} - 0.060 \pi_{t-4}$$

(1.64)      (4.61)      (1.99)      (3.48)      (0.72)

$$\bar{R}^2 = 0.696$$

$$SE = 0.004$$

Table B: Addition Results for the Effect of the Inflation Rate

NOT FOR PUBLICATION

Constant	y	CRP	(M/P) <sub>-1</sub>	(P/P) <sub>-1</sub>	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	$\hat{\rho}$	$\bar{R}^2/SE \times 10^{-2}$
-0.229 (7.66)	0.040 (6.37)	-0.012 (5.06)	0.978 (42.83)	-0.793 (5.08)	-0.005 (1.96)				.988/.563
-0.188 (8.95)	0.030 (7.53)	-0.010 (5.38)	1.011 (65.22)	0.921 (8.39)		-0.026 (5.36)	0.022 (4.39)		.991/.476
-0.236 (7.18)	0.043 (6.11)	-0.012 (5.23)	0.963 <sup>a</sup> (35.29)	-0.772 <sup>b</sup> (6.46)	-0.005 (2.02)	-0.029 (6.81)	0.016 (3.66)	0.38 (4.10)	.993/.426
-0.201 (7.09)	0.035 (6.23)	-0.012 (4.84)	0.989 (42.27)	-0.871 <sup>c</sup> (7.96)		-0.029 (6.70)	0.016 (3.69)	.39 (4.30)	.992/.433

a)  $\alpha_4 = -19.86$ ,  $t = 3.01$ .

b)  $t = 1.73$  for test of  $\beta_3 = -\beta_4$ .

c)  $t = 1.11$  for test of  $\beta_3 = -\beta_4$ .