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Exchange Rates, Energy Prices, Unemployment, Money, and Inflation: A Further Test

Robert A. Black and Cindy Benzing*

INTRODUCTION

Jerome Stein (1978, 1982) contended that the growth of real money balances is the most important determinant of the rate of inflation over what he calls the short-run period of one to three years. He also stated that nonmonetary factors are not at all important over this period of time. He concluded that the U.S. rate of inflation can be explained in terms of a simple monetarist equation without "... the innumerable exogenous *ad hoc* disturbances to the price level (1982, p. 146)."

Allen Sinai (this *Journal,* 1985), however, has presented evidence from a nonmonetarist model of exchange-rate effects on inflation of the implicit GNP deflator (and other price indexes) for the U.S. His conclusion was that:

> The [value of the] dollar as one of the two or three major determinants of U.S. inflation is here to stay, especially in an economy that has been increasingly integrated into the rest of the world and must function in a regime of flexible exchange rates. (1985, p. 211)

Stein, though, had been critical of the type of inflation model used by Sinai, especially of the use of "... contemporaneous variables ... on both sides of the inflation equation (1982, p. 138)." In view of Stein's criticisms, his own real-balance inflation equation (Stein 1978, 1982; also Keith Carlson 1978) would seem to provide an interesting framework for a test of the exchange-rate hypothesis.[1] If the exchange-rate hypothesis is correct, Stein's real-balance inflation equation is misspecified for the period of flexible exchange rates.

This paper reports tests for whether Stein's inflation equation is misspecified for the period 1967 to 1987.[2] Since the period 1967 to 1987 has also been characterized by volatile energy prices, results of a relative-energy-price hypothesis are also reported here.[3] Furthermore, some time has elapsed since Stein tested for and rejected the effects of unemployment on inflation with his model so we retested an unemployment hypothesis with the more recent data. Finally, since the Fed has recently been targeting M2 rather than M1 (the monetary aggregate used by Stein), we fit the real-balance inflation equation with both aggregates.[4] To avoid Stein's criticism regarding the use of contemporaneous explanatory variables, exchange-rate and energy-price effects are estimated using *lagged* percentage changes in the variables.

Stein has already explained the potential for unemployment effects on inflation in the context of his macrodynamic model. We also use his model to develop exchange-rate and energy-price effects on inflation. Estimates of the resulting inflation equation are presented to show that, over the period of flexible rates and volatile energy prices, the real-balance inflation equation is misspecified without these nonmonetary effects. What is most curious is that the results do not support the hypothesis that money

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causes inflation for the 1967–1987 sample period *unless* the effects of exchange rates, unemployment, and energy prices are included.

STEIN'S REAL-BALANCE INFLATION EQUATION

Stein reduced his macrodynamic model of 11 equations to several key equations, including this one for the rate of inflation (1982, p. 87, eq. 3.45b):

$$\pi_t = \pi_t^* + P_1 u_{t-1} + P_2 \ln m_t + P_3 \pi_t^* + P_4 g_t + P_5 d_t \tag{1}$$

π_t = inflation
u_t = unemployment rate as deviation from its equilibrium value
g_t = real government purchases of goods per capita
π_t^* = anticipated inflation
m_t = real money balances per capita
d_t = ratio of government debt to money

Stein explained why P_3, P_4, and P_5 can be considered zero under a monetarist hypothesis (1982, p. 87–94). He also suggested that P_1 will be zero and then tested this monetarist hypothesis against the Keynesian hypothesis $P_1 < 0$. The resulting monetarist inflation equation, after some transformations,[5] is Stein's real-balance equation (see Stein 1978, equations 3 and 16; and Stein 1982, equations 4.30, 4.33, and 4.34):[6]

$$\pi_t - \pi_{t-1} = a_1(\mu_{t-1} - \pi_{t-1}) \tag{2}$$

π_t = rate of change of GNP deflator
μ_t = rate of change of M1

In estimating equation 2 using post-war U.S. data, both Stein (1982) and Carlson (1978) found that real-balances growth was significant.[7] This equation is based on Stein's assumption that other exogenous factors are unimportant in the inflation process. However, the period since the late 1960s and early 1970s has been one of flexible exchange rates and of volatile energy prices. Furthermore, during the mid-1980s the U.S. experienced high monetary growth with little apparent impact on inflation. While this has been explained as a shift in money velocity, it is also consistent with unemployment effects on inflation since unemployment fell slowly from its high levels in 1982 and early 1983.

If exchange-rate, unemployment, and relative-energy-price effects on the measured rate of inflation are significant, then Stein's inflation equation is misspecified for the period when exchange rates and energy prices have experienced wide swings. The theoretical effect of correcting such a misspecification can be to reduce the bias in the estimated money-growth coefficient and also to reduce its standard error.

EXCHANGE-RATE AND ENERGY-PRICE EFFECTS IN STEIN'S INFLATION EQUATION

As noted above, Stein (1982) has already developed a macrodynamic model with the potential for unemployment effects, though he empirically rejects the significance of unemployment. But he does not explain the potential for exchange-rate effects or for relative-energy-price effects. His model does, however, lend itself to explaining the impact of such factors on inflation.

Exchange-rate effects on inflation have generally not been included in monetarist reduced-form models (see, for example, M. Beenstock and J.A. Longbottom 1982,[8] who specifically refuse to consider exchange rates because of their endogeneity[9]). Dallas Batten and R.W. Hafer (1985) tested for exchange-rate effects in a monetarist inflation model; but their test of McKinnon's (1984) currency-substitution hypothesis rejected the importance of exchange rates. Daniel Himarios (1989) replication and extension of the Batten and Hafer (1985) study found significant exchange rate effects, though Batten and Hafer (1989) rejected these results as spurious.

Nevertheless, the theoretical effects of currency appreciations or depreciations on domestic prices have been recognized for specific industries and for the aggregate economy (see, for example, Rudiger

Dornbusch 1987; Sinai 1985; Arthur Okun 1981; and Lawrence Klein 1978). The various exchange-rate hypotheses are based on underlying assumptions about the elasticity of the demand for imports and about the market structures of the various import-competing industries.

For a particular industry, the theoretical effect of an exogenous depreciation in the dollar, for example, would be to raise the dollar price of imports. Given a non-zero elasticity of demand for imports, the demand for domestic goods would increase, allowing domestic producers to also raise prices. Dornbusch (1987), in looking at the role of market structure in these exchange-rate effects, showed that these effects depend on the degree of homogeneity of imported and domestic goods and thus on the level of competition. Similarly, Okun (1982, pp. 331–32) noted that exchange-rate effects on prices and inflation would be stronger in auction markets than in price-tag markets.[10] Thus, the exchange-rate hypothesis asserts that a significant depreciation (or appreciation) would raise (or lower) market prices of imported goods and import-competing products. These price increases would be reflected in the aggregate price level and in a temporary rise in the measured rate of inflation.

In Stein's model, these exchange-rate effects can work through several channels to affect π in equation 1 above. A depreciation or appreciation could be expected to have effects on Keynesian excess demand[11] and employment (through substitutions between imports and domestic goods), and on anticipations (through, for example, changes in the CPI due to changing import prices). Under the assumptions given above regarding import demand elasticities and import-competing market structures and assuming $P_4 = P_5 = 0$, the partial derivative of inflation with respect to the exchange rate would be:

(3) $$\partial\pi/\partial ex = P_1(\partial u/\partial ex) + P_6(\partial J/\partial ex) + (1 + P_3)(\partial\pi^*/\partial ex)$$

where: $P_1 \leq 0$ $\quad P_6 > 0$ $\quad 1 + P_3 > 0$

$(\partial u/\partial ex) > 0$ $\quad (\partial J/\partial ex) < 0$ $\quad (\partial\pi^*/\partial ex) < 0$

ex = percentage change in the trade-weighted U.S. exchange rate

J = Stein's Keynesian excess demand (see endnote 7)

The exchange-rate hypothesis of Sinai (1985) [and also Okun (1981) and Klein (1978)] is that the overall effect of a depreciation would be to raise inflation temporarily and the expectation is that $\partial\pi/\partial ex < 0$.

Unlike exchange rates, energy prices have regularly been included in reduced-form inflation models [though Beenstock and Longbottom (1982) could not confirm any effect for the U.K.]. John Tatom (1981) included a relative-energy-price variable in his quarterly inflation model for the U.S., explaining that energy-price shocks have a temporary effect on measured inflation due to one-time, general-price-level changes.

In Stein's model, higher energy prices can work through their effects on Keynesian excess demand and unemployment, and on inflation anticipations. The lack of detail regarding the role of non-labor costs in Stein's model means that inflation anticipations must carry the burden of the direct, aggregate-supply effects on inflation of an energy-price change: an exogenous rise in energy prices will cause both producers and consumers/laborers to expect higher inflation. It is also important to note that the aggregate-demand effects on inflation of an energy-price change work against the aggregate-supply effects: a rise in energy prices will depress aggregate demand and increase unemployment, other things equal. These potentially offsetting effects are captured in the following expression for the partial derivative of inflation with respect to percentage changes in relative energy prices:

(4) $$\partial\pi/\partial p^e = P_1(\partial u/\partial p^e) + P_6(\partial J/\partial p^e) + (1 + P_e)(\partial\pi^*/\partial p^e)$$

where:

$P_1 \leq 0$ $\quad P_6 > 0$ $\quad 1 + P_3 > 0$

$(\partial u/\partial p^e) < 0$ $\quad (\partial J/\partial p^e) < 0$ $\quad (\partial\pi^*/\partial p^e) > 0$

p^e = percentage rate of change of price of energy less π

The crucial assumptions are that $\partial\pi^*/\partial p^e$ is positive and that its effects predominate in equation 4 so that $\partial\pi/\partial p^e > 0$.

In view of these theoretical comments regarding exchange-rate and energy-price effects and in view of the potential for unemployment effects, equation 2 above can be amended to reflect a more general specification of the real-balance inflation equation:

$$\pi_t - \pi_{t-1} = a_0 + a_1(\mu_{t-1} - \pi_{t-1}) + a_2u_{t-1} + a_3ex_{t-1} + a_4p^e_{t-1} \quad (5)$$

The monetarist hypothesis is that $a_2 = a_3 = a_4 = 0$. The unemployment hypothesis is that $a_2 < 0$, the exchange-rate hypothesis is that $a_3 < 0$, and the relative-energy-price hypothesis is that $a_4 > 0$. Estimates of equation 5 are reported below.

EMPIRICAL RESULTS

Stein's real-balance inflation equation was estimated for the period 1967 to 1987. A benchmark equation was estimated with the lagged real-balance variable as the only explanatory variable (following Stein), using both M1 and M2. Then various combinations of lagged unemployment, lagged percentage changes in exchange rates, and lagged percentage changes in relative energy prices were added. Annual U.S. data for the GNP deflator, trade-weighted nominal U.S. exchange rate, and price index of fuels, related products, and power were taken from the *Economic Report of the President.* The relative price of energy was calculated as the ratio of the price index of fuels, related products, and power to the index of the GNP deflator. Data on percentage changes in yearly values of M1 and M2 were also taken from the *Economic Report of the President.*

With yearly time-series data such as that used here, multicollinearity is a potential problem. As a result, we applied the Belsley, Kuh, and Welsch (1980) test for multicollinearity among the explanatory variables. The test indicated that collinearity was not a problem, giving added confidence in the results reported below.

Table 1 summarizes estimates of the real-balance inflation equation using M1. Equation 5.1a shows the results of estimating Stein's real-balance inflation equation without unemployment, exchange-rate, or energy-price effects. It is clear that, for the period 1967 to 1987, the equation no longer confirms the monetarist hypothesis. The coefficient on growth in real balances is not significant; furthermore the Durbin Watson statistic indicates the presence of autocorrelation.[12]

The other estimates in Table 1 show four important results. First, allowing for lagged unemployment, lagged exchange rates, and lagged relative energy prices in the real-balance inflation equation *increases* the significance of money-growth effects for the 1967–1987 sample. Second, the serial-correlation problem which occurs without the nonmonetary effects is eliminated by their addition. This is apparent by comparing the Durbin-Watson statistics of equations 5.1a and 5.1h. Third, unemployment, exchange-rate, and relative-energy-price coefficients all have the correct signs and are significant, or nearly so, at the 10 percent level (two-tailed test); all three would be included based on maximum adjusted R^2 or on an approximately similar test of using 1.0 as the critical value of the t statistic.[13] Finally, unemployment is the only variable significant at the 5% level in equation 5.1h; this is dramatically different from Stein's (1982) rejection of unemployment using U.S. data till 1979.

Table 2 summarizes estimates of the real-balance inflation equation using M2. Once again, the benchmark equation does not confirm the monetarist hypothesis. M2 clearly does not perform as well as M1, indicating that, while M2 may be preferred for targeting nominal GNP during the 1980's, it is not superior in explaining inflation for the entire period 1967–1987. Yet, while M2 does not perform as well as M1, both unemployment and exchange rates are significant determinants of inflation; including them also improves the significance of real money balances again.

Using both M1 or M2, the highest adjusted R^2 is attained by including unemployment, exchange rates, and energy prices and the estimated coefficients are not very sensitive to the choice of monetary aggregates. Since, in both Table 1 and Table 2, the coefficients on money growth increase in value and in significance as exchange-rate and energy-price effects are allowed, equations 2, 5.1a, and 5.2a would

TABLE 1

Estimates of a Real-M1-Balance Inflation Equation with Unemployment, Exchange Rates, and Energy Prices

$$\pi_t - \pi_{t-1} = a_0 + a_1(\mu_{t-1} - \pi_{t-1}) + a_2 u_{t-1} + a_3 ex_{t-1} + a_4 p^e_{t-1}$$

π = rate of change of GNP deflator
μ = rate of change of M1
ex = percentage rate of change of trade-weighted U.S. exchange rate
p^e = percentage rate of change: price index of fuels, power, and related products divided by GNP deflator
u = rate of unemployment

Sample: U.S. 1967–1987 (annual)

Equation	Intercept	$(\mu_{t-1} - \pi_{t-1})$	u_{t-1}	ex_{t-1}	p^e_{t-1}	R^2_{adj}	DW
5.1a	−0.186	0.077	—	—	—	−.001	1.46
	(0.50)	(0.98)					
5.1b	3.402**	0.113	−0.553**	—	—	.338	1.70
	(2.86)	(1.75)	(3.12)				
5.1c	−0.097	0.011	—	−0.102**	—	.280	2.21
	(0.30)	(0.16)		(2.77)			
5.1d	−0.401	0.174	—	—	0.082	.059	1.29
	(1.02)	(1.72)			(1.44)		
5.1e	2.446*	0.062	−0.397*	−0.063	—	.400	2.07
	(1.91)	(0.90)	(2.04)	(1.62)			
5.1f	3.262**	0.219**	−0.567**	—	0.089*	.446	1.75
	(2.99)	(2.78)	(3.49)		(2.03)		
5.1g	−0.295	0.100	—	−0.098**	0.073	.336	1.88
	(0.88)	(1.12)		(2.77)	(1.53)		
5.1h	2.425*	0.165*	−0.428**	−0.056	0.082*	.495	1.91
	(2.07)	(2.01)	(2.39)	(1.56)	(1.96)		

T values are reported in parentheses below each coefficient.
R^2_{adj} refers to the R^2 adjusted for degrees of freedom.
*Significant at 10% level (two-tailed test).
**Significant at 5% level (two-tailed test).

appear to be misspecified for the sample period considered. Under a monetarist hypothesis, the expected result is that adding exchange-rate effects to equation 7 would decrease the significance of money-growth as the two variables competed for explanatory power which supposedly belongs solely to money growth (the endogeneity of exchange rates is in view here). Instead, adding exchange-rate growth has strengthened the monetarist case for money while also confirming the role of exchange rates in the inflation process when those rates are flexible. Similarly, adding energy prices further strengthens the monetarist case for inflationary effects of money growth, though the influence of energy prices is not as significant in this yearly model as in Tatom's (1981) quarterly monetarist model. And the real-balance equation no longer rejects unemployment as irrelevant to yearly changes in inflation of the GNP deflator.

It is also notable that the magnitudes of exchange-rate effects estimated in this study are comparable to those estimated by Sinai (1985, pp. 218–19). He found that a 10 percent depreciation in the dollar (without full structural-model feedback) would lead to a 1.4 percent increase in inflation of the implicit GNP deflator over three years. Equation 5.1h in Table 1 suggests that a 10 percent depreciation would cause a 0.56 percent increase in the implicit GNP deflator after one year. This corresponds very closely to Sinai's result since, allowing for cumulative effects due to feedbacks between inflation and real balances, the impact on inflation after three years would be 1.42 percent.[14]

TABLE 2

Estimates of a Real-M2-Balance Inflation Equation with Unemployment, Exchange Rates, and Energy Prices

$$\pi_t - \pi_{t-1} = a_0 + a_1(\mu_{t-1} - \pi_{t-1}) + a_2 u_{t-1} + a_3 ex_{t-1} + a_4 p^e_{t-1}$$

π = rate of change of GNP deflator
μ = rate of change of M2
ex = percentage rate of change of trade-weighted U.S. exchange rate
p^e = percentage rate of change: price index of fuels, power, and related products divided by GNP deflator
u = rate of unemployment

Sample: U.S. 1967–1987 (annual)

Equation	Intercept	$(\mu_{t-1} - \pi_{t-1})$	u_{t-1}	ex_{t-1}	p^e_{t-1}	R^2_{adj}	DW
5.2a	−0.074	−0.005	—	—	—	−.059	1.56
	(0.15)	(0.04)					
5.2b	3.390**	0.099	−0.574**	—	—	.261	1.85
	(2.68)	(1.03)	(2.89)				
5.2c	−0.002	−0.027	—	−0.105**	—	.283	2.25
	(0.01)	(0.31)		(3.02)			
5.2d	−0.214	0.032	—	—	0.026	−.111	1.52
	(0.36)	(0.24)			(0.44)		
5.2e	2.285*	0.049	−0.383*	−0.073*	—	.379	2.22
	(1.78)	(0.53)	(1.87)	(2.01)			
5.2f	3.360**	0.186	−0.619**	—	0.055	.274	1.89
	(2.68)	(1.52)	(3.08)		(1.13)		
5.2g	−0.269	0.044	—	−0.111**	0.050	.288	2.12
	(0.57)	(0.39)		(3.16)	(1.05)		
5.2h	2.189*	0.145	−0.423*	−0.077**	0.062	.421	2.17
	(1.76)	(1.31)	(2.11)	(2.19)	(1.44)		

T values are reported in parentheses below each coefficient.
R^2_{adj} refers to the R^2 adjusted for degrees of freedom.
*Significant at 10% level (two-tailed test).
**Significant at 5% level (two-tailed test).

CONCLUSIONS

Using U.S. data for 1967 to 1987, we have shown that the real-balance inflation equations estimated by Stein (1978, 1982) and Carlson (1978) are misspecified for the period of flexible exchange rates and volatile energy prices. Furthermore, contrary to their findings, unemployment is more significant than money growth in explaining inflation when U.S. data for the 1980s are included. Without unemployment, exchange rates, and relative energy prices, Stein's real-balance inflation equation does not yield a significant coefficient for the effect of real-balances growth on the change in the rate of inflation. Switching from M1 growth to M2 growth does not solve the problem. But when lagged unemployment and lagged percentage changes in relative energy prices and exchange rates are added, the real-balance equation again confirms the importance of money growth for inflation.

This study points out difficulties in overemphasizing money growth in the year-to-year inflation process, to the exclusion of other factors. While one can amend monetarist inflation equations in the 1980's with "shift parameters" to explain the changes in velocity, it seems preferable to include possible *causes* of velocity changes such as unemployment along with other factors relevant to the inflation process.[15] It may be true as monetarists contend that, in the very long run and during certain periods, money seems to be crucial to the inflation process. However, during other periods and in the one-to-three year period, non-monetary factors also seem to be crucial in the inflation process, even to the point of upsetting any usual link between money and prices. Ignoring these factors leads to misspecification of monetarist inflation equations.

The late 1960s and the decade of the 1970s were difficult periods for nonmonetarist forecasters (see, for instance, Meltzer 1969) while monetarist inflation equations were quite satisfactory up to 1979. The 1980s, however, became the difficult period for monetarist inflation forecasters. This is what we have demonstrated here. Our results also suggest that a balanced approach to inflation forecasting is preferred to either of the ideological extremes of ultra-monetarism or rigid nonmonetarism. The days should be put behind us when Okun (1981) can write about inflation without mentioning money (except to say that during a hyperinflation we lose our taste for money) or when Stein (1978, 1982) can attempt to explain short-run inflation without nonmonetary factors.

NOTES

1. We chose to re-estimate Stein's yearly model for several reasons. First, Stein's model is such a strong statement about the monetarist approach to inflation. Unlike other monetarists such as Tatom (1981), Stein discredits completely the role of all non-monetary factors such as unemployment, whose effects are said to be transitory or fleeting. Even the rational expectations approach to explaining inflation has evolved into a more general model such as we are suggesting here. The explanation is that rational agents do not simply focus on anticipated money growth, as in Robert Barro's (1978) approach, but focus instead on all available information when a forecast is made. In contrast, Stein's approach to inflation appears less balanced than he claims (1982) and it also deserves empirical review in light of the new data from the 1980s.

   Second, Stein's (1978, 1982) conclusions have to do with causes of price inflation over the period of one to three years. One could estimate a quarterly model (as Dallas Batten and R.W. Hafer 1985, and Daniel Himarios 1989 have done) but the yearly model is preferred if one is interested in testing *Stein's* propositions about time periods longer than a year. Yearly data have fewer transitory fluctuations than quarterly data; so proving that nonmonetarist factors are important should be more difficult in a yearly model than in a quarterly model. In essence, our criticism of Stein's conclusions gives him the benefit of doubt by *not* using a quarterly model. Our sense is that his model should be criticized on its own terms.

   Finally, his real-balance inflation equation is derived from an explicit dynamic macro model (see the comment along these lines by Meghnad Desai and David Blake 1982). This allows for an explicit theoretical derivation of non-monetary causes of inflation. Other so-called "reduced-form" monetarist models—especially those of the St. Louis variety—have been criticized as "pseudo-reduced form's" because they do not stem from any particular structural model (see James Tobin 1969, p. 23).
2. While the fixed-exchange-rate system was still in place until the suspension of gold payments in 1971 and the subsequent official breakdown of the system in 1973, the trade-weighted U.S. exchange rate begins to fluctuate in 1968 after the devaluation of the British pound. The results reported below for this sample period are quite similar to the results obtained by using the shorter period 1971 to 1986.

   An additional benefit of using the period 1967 to 1987 is that the data begin and end at about the same point in the business cycle—in the later stages of an extended boom. As an anonymous referee pointed out, the stage of the cycle is related to the accuracy of the assumption that the coefficient on unemployment in equation 1 below is zero, particularly in a short-run model. However, any short-run unemployment effects on inflation should theoretically cancel each other over the course of the several complete business cycles covered by the sample.
3. Stein prefers to ignore energy prices but other monetarists have included energy-price variables in their quarterly reduced-form inflation models (see, for example, John Tatom 1981).
4. The switch from M1 to M2 was caused by the decrease in M1 velocity after 1982; see, for example, Robert Hetzel (1987). Paul Anderson (1969) explained some time ago the effects that velocity changes could have on the "St. Louis Equation" for nominal GNP. That the velocity change between 1982 and 1983 had a detrimental effect on monetarist inflation models was apparent from the mistaken forecasts of high inflation in 1983 and 1984; see for example, R.W. Hafer (1984) who reports forecast errors of 3 to 4 percent over actual inflation. See also David Stockton and James Glassman (1987). "Shift parameters" can be introduced into monetarist inflation models to account for the velocity change, but the approach here is to investigate the potential effects of omitted variables which may have been influential in the inflation process. M2 is used along with M1 because M2 velocity was not as volatile as M1 velocity.
5. These transformations are developed differently in Stein (1978) and Stein (1982) but the results are the same.
6. Equation 2 explains accelerations in inflation by accelerations in the growth of real money balances. Subtracting lagged inflation from both sides of equation 2 yields a more instructive form of the model: $\pi_t = a_1\mu_{t-1} + (1 - a_1)\pi_{t-1}$. Now it can be seen that the model is consistent with Milton Friedman's (1961) hypothesis that monetary policy works with a long lag, represented here by a Koyck lag. Alternatively, including lagged inflation could be consistent with a nonmonetarist hypothesis of sluggish price adjustment (Robert J. Gordon 1981, 1990). This

specification can be seen as reflecting adaptive expectations, as Friedman assumed. But this is not the only possible assumption; it can also represent gradual price adjustment, based on long-term contracts or catalog and menu pricing in fixed-price markets rather than on the fooling of workers.

7. Stein's study reported results for the period 1958 to 1979 (Stein 1982, p. 140) while Carlson's study was for the period 1954 to 1976.
8. Beenstock and Longbottom (1982) begin with a model of the log of the price level. However, when they apply the error-correction specification, it becomes a model of inflation or a model of the rate of change of inflation.
9. Several points need to be made here. First, the endogeneity of exchange rates does not prevent them from being entered *with a lag* into a reduced form equation. Second, the presumed effect of exchange rates on inflation is based on the occurrence of a "speculative wave" (Klein 1978) or "a purely exogenous appreciation [or depreciation] of the dollar" (1981) which overwhelms endogenous movements in the exchange rate and, as a result, temporarily alters the measured rate of inflation.
10. However, Okun (1982) also noted that mark-ups and profit margins in the price-tag sector tend to be more responsive to weak demand due to import competition than to weak demand due to domestic competition.
11. Econometrics texts regularly suggest that first-order autocorrelation be corrected using one of the two-step procedures commonly available as part of most time-series regression packages. However, this is especially inappropriate to do with equations 5.1a or 5.2a. The hypothesis under study is that important variables have been omitted from equation 2 and equation 5.1. Since most economic variables (including those under study here) exhibit some first-order autocorrelation, leaving an important variable out of the regression will cause the error term to exhibit first-order autocorrelation. In this case, the appropriate procedure is to test for omitted variables first to see if that resolves the autocorrelation problem. As the other equations in Tables 1 and 2 show, this approach does resolve the problem. No *ad hoc* correction appears to be necessary once the mis-specification is addressed.
12. In Stein's (1982) model, Keynesian excess demand is defined as:

$$J = c + i + g - y$$

where c, i, and g are real per-capita components of current aggregate demand (planned consumption, planned investment, and government expenditure respectively) and y is real per-capita current output. It is no matter that his model does not include net exports as long as it is assumed that his domestic consumption and investment, c and i, are inversely related to exogenous changes in the exchange rate. The Keynesian excess demand 'J' does not appear in equation 1 above because Stein assumed, under a monetarist hypothesis, that the log of per-capita real money balances ($\ln m_t$) is the only crucial determinant of J with an impact on inflation. In the more general inflation equation, $J = J(y, m, b, g, \ldots)$ rather than simply ln m appears as the aggregate-demand term (Stein 1982, p. 20, eq. 2.7).

13. Including a variable if the t statistic of its coefficient is greater than one is also similar to several other recently developed statistical criteria for model selection. See George G. Judge, *et al.* (1980), pp. 420–22.
14. To calculate the cumulative effect of an exchange-rate depreciation on inflation, first note that the real balance equation (equation 2) can be rewritten as follows:

$$\pi_t = a_1\mu_{t-1} + (1 - a_1)\pi_{t-1}$$

This form of the equation makes clear that any initial impact of exchange-rate changes on inflation will then have further effects because current inflation is correlated with the previous year's inflation. Since a_1 is estimated as 0.165 in equation 5.1h, $(1 - a_1) = 0.835$. As a result, the cumulative impact of a 10 percent depreciation of the dollar after three years would be equal to $(-0.056)\ (1 + 0.835 + 0.835^2)\ (-10) = 1.42$.

15. Two facts suggest that velocity may not be the only difficulty with the real-balance inflation equation. First, M2 does not perform better than M1 even though the velocity of M2 is more stable. Second, fitting the real balance equation from 1962 to 1979 (several years before velocity turned down) shows that, while unemployment is not important, energy prices and exchange rates are.

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