Equilibrium Relationships Between Money and Other Economic Variables

By JAMES R. LOTHIAN*

Central to the quantity theory of money are a number of important propositions about the long-run equilibrium effects of changes in the nominal stock of money on other economic variables. A standard way of testing these propositions is to use quarterly or annual data, explicitly model the lag structure and then derive the long-run solution of the model from the empirical estimates. An alternative is to use some type of smoothing procedure to approximate positions of equilibrium and then to use these transformed data directly in testing hypotheses. The National Bureau technique of averaging data over reference cycle phases is one such method; Robert Lucas's application of Fourier transforms in "Two Illustrations of the Quantity Theory of Money" (1980) is another; and John Geweke's method (1982) of frequency decomposition is a third.

An entirely different way of approaching the problem is to use cross-country-average rather than time-series data as the basic units of observation. The advantage, according to Lucas, is that, "Since the two quantity-theoretic laws [that he examines] are obtained as characteristics of steady states, or limiting distributions, of theoretical models, the ideal experiment for testing them would be a comparison of long-term average behavior across economies with different monetary policies but similar in other respects" (p. 1006).

In this paper I conduct such an experiment. The data that I use are for 20 OECD countries over the period 1956–80. The specific relationships that I examine are those between money and the price level, money and real income, money and interest rates, and money and exchange rates. In the main the data accord well with the quantity-theoretic model. Classical neutrality holds. There is evidence of a Fisher effect, albeit a less than complete effect, on interest rates. Finally, the data are consistent with long-run purchasing power parity and, hence, correspondingly with a long-run monetary approach to exchange rate determination.

I. Theory and Data

The theory underlying the empirical investigation summarized in the next section of the paper is the quantity theory of money and its corollary in a multicountry context, the monetary approach to exchange rate determination. For an extended treatment of the basic quantity theory, the interested reader can refer to Milton Friedman (1969); for a statement of the monetary approach to exchange rates, to Jacob Frenkel (1976). Given the purpose of this paper, I merely illustrate the implications of the two by considering a simple example in which I assume an initial steady-state equilibrium that is interrupted by an unanticipated one-time increase in the rate of growth of the domestic money supply. I then trace the short-term and long-term implications of that change for other domestic economic variables and for the exchange rate.

To proceed with the example, suppose that the money supply had been increasing for an extended period of time at a rate of 5 percent per year and that it then undergoes a sudden, one-time acceleration to a rate of growth of 10 percent per year. Suppose further that when money had been growing at that 5 percent rate, inflation had averaged 2 percent, real growth 3 percent and the yield on long-term government bonds 5 percent.

The initial effect is to create a disparity between the rate at which individuals wish to

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accumulate money balances and the rate at which they are actually doing so. The amount of money individuals actually hold relative to their nominal incomes, therefore, becomes greater than the amount they desire to hold. Correspondingly, the implicit yield on those money balances on the margin falls below the yields on bonds and on other alternative assets. To correct these imbalances, individuals increase their spending. In the process, yields on other assets fall, output grows more rapidly, and the rate of inflation gradually begins to increase.

Within the context of the quantity theory, the downward effect on rates of interest and upward effect on the growth of real output are temporary phenomena. In the final equilibrium position, the rate of inflation will have risen to 7 percent, increasing by the same amount as the rate of monetary growth, and bond yields will have risen to 10 percent, reflecting the now higher actual (and anticipated) rates of inflation. The rate of growth of real output will be unaffected.[1]

With regard to exchange rates there is an immediate analogue. The initial effect of a sudden and unanticipated monetary acceleration in lowering domestic real rates of interest will, everything being equal, lead to an incipient capital outflow. To offset that outflow, the exchange rate must depreciate enough to produce anticipation of a subsequent appreciation. That, in turn, will lessen, or eliminate, the potentially widened differential between the yields on domestic and foreign assets. In the final equilibrium position, overshooting of this sort will be eliminated and the rate at which the exchange rate is changing will bear a one-to-one relationship to the change in the rate of growth of the domestic money supply.

So, to build on the example given above, again assume that the rate of growth of the domestic money supply increased by five percentage points. Assume further that the rate of growth of foreign-country money supply remained unchanged. In the new equilibrium, the exchange rate, the domestic currency price of a unit of foreign-country currency, would now increase at a five percentage points per annum faster pace.[2]

These, of course, are highly simplified examples. For my purposes, however, simplicity of this sort is a virtue. If the data do actually support these simple formulations, one can have greater confidence in the underlying theory as a useful tool.

To test the various hypotheses just outlined, I assembled annual data for 20 OECD countries for the period 1956–80 for an $M1$-type definition of money, consumer prices, real income (*GNP* or *GDP*, depending upon availability), U.S. dollar exchange rates, and, for a 14-country subset, long-term bond yields. The source of most of these data was the International Monetary Funds's (IMF) *International Financial Statistics* and companion tapes. The remainder came from the NBER data base described in the appendix to Michael Darby, myself et al. (1983).

To minimize the effects of shorter-term fluctuations, I computed the average rates of growth of each variable for each country for the two subperiods 1956–73 and 1974–80 (see Table 1). I then computed the changes in these average rates of growth from the one period to the next and, with the one exception noted below, used them as my basic units of observation. For $M1$, real income, the price level, and the exchange rate, these were shifts in average annual logarithmic rates of change; for the interest rate variables used in the examination of exchange rate relationships, they were shifts in average annual arithmetic rates of change. In each of these instances, therefore, the end result was a measure of longer-term acceleration, a "growth shift." The exception to this rule was the interest rate variable used in the Fisher equation, which for theoretical rea-

[1] The transition to equilibrium following these initial effects is harder to specify. Overshooting of inflation, a one-time shift in the desired ratio of money to income, and a decline in the rate of growth of real income are all features of the process.

[2] Implicity assumed is no permanent alteration in the growth rates of the quantities of real cash balances demanded in the two countries. A one-time decline in the level of real cash balances demanded in the domestic country, and hence, temporarily lower growth rate, will characterize the transition process period.

TABLE 1—AVERAGE ANNUAL RATES OF CHANGE AND STANDARD DEVIATIONS: 20 OECD COUNTRIES, 1956–80

	Means[b]		Standard Deviations[b]	
Variable[a]	1956–73	1974–80	1956–73	1974–80
$M1$	9.11	11.51	6.51	8.52
Consumer Price Index	4.30	11.68	3.06	8.62
Real Income	5.10	2.61	2.54	2.63

Sources: IMF and Darby, myself et al.

[a]Percentage rates of change were computed as first differences of the natural logarithms of the variables multipled by 100.

[b]Shown in percent.

sons I constructed as the between-period shift in the average *level* of interest rates.[3]

The first subperiod is the era of Bretton Woods, 1973 marking the point of its final demise. The second is the era of managed floating. In addition to facilitating the study of exchange rate movements per se, this division offers a rather unique opportunity of another sort. After the breakdown of the Bretton woods system, the monetary policies of the various countries included in this study became more divergent. The result is, therefore, a much richer body of data from which to make inferences than the period of fixed exchange rates alone affords.

II. Empirical Evidence

In discussing the empirical findings, I divide the four relationships into three categories, lumping the money-price and money-real output relationships under the common heading of "classical neutrality," and then going on to consider the relationship between interest rates and inflation rates, the Fisher equation. Exchange rate relationships make up the final subsection. Throughout, the emphasis is on graphical evidence in which the theoretical and the hypothesized relationships are compared. Related regression results and formal statistical tests of hypotheses are presented in Table 2.

A. *Classical Neutrality*

Some preliminary evidence with respect to neutrality is contained in Table 1. The first two columns in the table present the averages of the annual rates of growth of real income, consumer prices, and $M1$ for the 20 countries for the separate subperiods 1956–73 and 1974–80. The second two columns show the corresponding standard deviations.

Consider the averages first. For the 20 countries taken together, we see an increase in both monetary growth and inflation from one period to the next, but a decrease in the rate of real income growth. That's one small bit of evidence in favor of the quantity-theoretic positive correlation between monetary growth and inflation. But, except for contradicting the naive Phillips curve, it tells us little about neutrality. More important on that score is the pattern of variability between periods.

With the final breakdown of the Bretton Woods system of fixed exchange rates in 1973, foreign countries gained greater policy independence. Monetary growth, not surprisingly, became more variable. So too did inflation. The variability of real income growth, in contrast, remained the same. The implications, therefore, are entirely consistent with the neutrality proposition: longer-term changes in monetary growth apparently affect the rate of inflation, but not the rate of real income growth.

[3]Differentiating the standard Fisher equation with respect to time results in an equation linking the increase in the interest rate and the increase in the anticipated rate of inflation. The empirical analogue here is a relationship between the shift in the average level of interest rates and the shift in the average rate of growth of the price level.

TABLE 2—REGRESSIONS FOR CROSS-COUNTRY GROWTH SHIFTS: 20 OECD COUNTRIES, 1956–80

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2$$

Variables[a] Dependent	Independent (X_1, X_2)	DF No. of Observations	Coefficients[b] β_0	β_1	β_2	$\bar{R}^2$/ SEE	Test Constraint	F-Ratio	Significance Level
P = Cost of Living Index	$M1$ = Narrowly Defined Money	18	.052	.891		.665	$\beta_1 = 1$	.053	.480
			(.008)	(.149)		.033			
y = Real Income	$M1$	18	−.027	.097		.121	$\beta_1 = 0$	3.606	.071
			(.003)	(.051)		.011			
i = Long-Term Bond Yield	P	14	.008	.541		.634	$\beta_0 = 0$; $\beta_1 = 1$	23.412	0.000
			(.007)	(.112)		.012			
e = Spot Dollar Exchange Rate	DP	17	−.004	.898		.871	$\beta_0 = 0$; $\beta_1 = 1$	1.457	.260
			(.005)	(.084)		.020			
e	$DM1$; Dy	16	−.048	.914	−1.397	.625	$\beta_0 = 0$; $\beta_1 = 1$	2.038	.162
			(.031)	(.178)	(.769)	.035			
e	$D(M1 - y)$	17	−.006	.889		.591	$\beta_0 = 0$; $\beta_1 = 1$	.687	.521
			(.008)	(.171)		.171			
e	$D(M1 - y)$; Di	10	.002	.403	.053	.588			
			(.007)	(.186)	(.014)	.022			

Sources: See Table 1.

[a] D denotes a variable constructed as the difference between the relevant foreign and U.S. variables. With the exception of interest rates, all variables are differences between the average annual logarithmic changes in the period 1974–80 and 1956–73. The interest rate term in the last regression is the difference between the average annual arithmetic changes in interest rates in the two periods for the foreign country less the similar difference for the United States. The interest rate term in the third regression is the difference in the average levels of interest rates in the two periods.

[b] Standard errors are shown in parentheses.

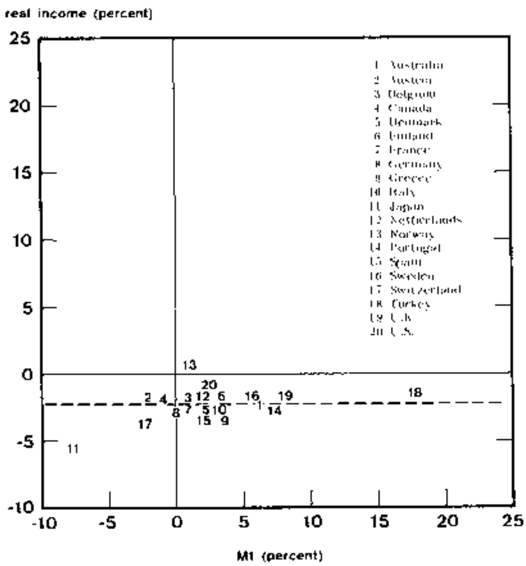

FIGURE 1. GROWTH SHIFTS: REAL INCOME VS. $M1$

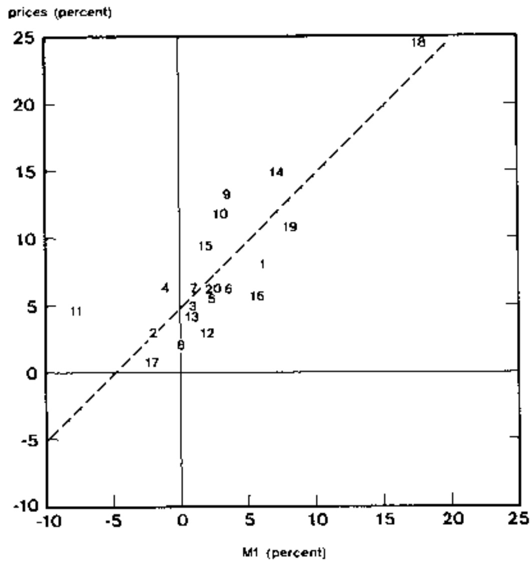

FIGURE 2. GROWTH SHIFTS: PRICES VS. $M1$

These relationships, moreover, are not just a statistical quirk caused by combining the data for all 20 countries. This becomes apparent when Figures 1 and 2 and the corresponding regressions are considered. Figure 1 plots the growth shift in money in each country, the change from one period to the next in the average annual rate of monetary growth, against the similar growth shift in real income. Figure 2 plots the growth shift in money against the growth shift in the price level.

The money-real income points are scattered about a horizontal line drawn through the means of the observations. All countries experienced roughly the same decrease in real growth despite huge differences in the change in the average rate of monetary growth. The money-inflation points, however, are scattered about a 45° line, again drawn through the means. If monetary growth in one country accelerated by, say, five percentage points more than in another, there was a similar difference in the amount by which inflation accelerated.

The regressions add to the story told by the two figures. Growth shifts in real income are statistically unrelated to those in $M1$: we cannot reject the quantity theory hypothesis that the intercept and slope coefficients jointly are zero. Growth shifts in prices and $M1$, however, are closely matched: we cannot reject the hypothesis that the slope coefficient in this equation is unity. The data, therefore, clearly support the classical neutrality proposition of the quantity theory.[4]

B. *The Fisher Equation*

Figure 3 plots the shift in the average level of the long-term bond rate against the growth shift in prices (the shift in the average rate of inflation) for the 14 out of 20 countries for which there are interest rate data. If the Fisher relation held exactly and the average rate of inflation was an accurate proxy for the anticipated rate, the points would all fall on a 45° line through the origin. A permanent increase in the anticipated rate of inflation of, say, five percentage points would, as in the example outlined in the previous section, increase the nominal bond yield by five percentage points.[5]

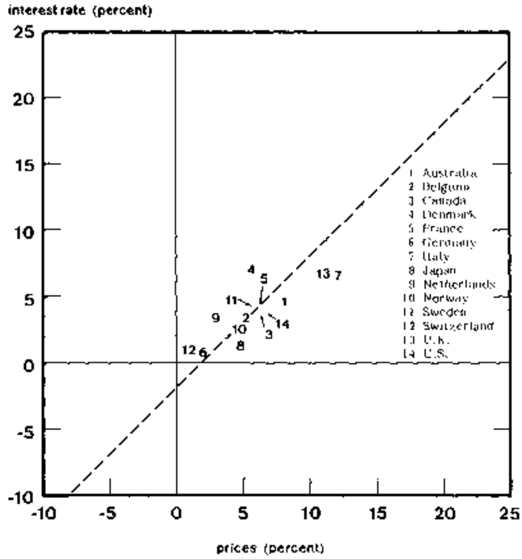

FIGURE 3. GROWTH SHIFTS: INTEREST RATE LEVEL VS. PRICE GROWTH

In fact, most of the points do cluster about a 45° line, but the relationship is far from perfect and the line itself does not intersect the vertical axis at the origin. Hence, even relative to the substantial average increases in both rates of inflation and rates of interest (over five and roughly four percentage points, respectively), there is a considerable dispersion of the observations about the line. This, in turn, suggests that real rates of interest, measured as they implicitly are here as the difference between the average nominal bond yield and the average actual rate of inflation, were by no means constant among countries. Nor were they constant over time within countries. In most of the countries in the sample, the increase in inflation exceeded the increase in bond yields by one percentage point or more. In the estimated regression equation, this variability in real rates over both time and space leads to a rejection of the joint hypothesis of a zero intercept and a unit slope coefficient.[6]

[4] There is the possibility of a more complex relationship. Friedman (1977) has associated the decline in real income growth in many of these countries with an increase in the variability of inflation and ultimately, therefore, in monetary policy.

[5] The discussion ignores both the positive tax effect on interest rates described by Darby (1975) and the negative Mundell effect.

[6] See Frederic Mishkin (1982, 1984) for evidence drawn from multicountry data on the nonconstancy of real rates across countries and over time within countries, respectively.

One factor that may be important here is a decline in the *ex ante* real rate. The average rate of real growth declined in almost all of the countries between the first period and the second period. Using the real rate of growth as a proxy for the real return on real assets (Friedman and Anna Schwartz, 1982, ch. 10), we might, therefore, infer that the *ex ante* real yield on bonds has also declined.

That, however, cannot be the full explanation since there is little correlation among countries between the degree of movement in our measure of *ex post* real bond yields and real rates of growth. An alternative explanation is that in most of the countries in the sample, there was simply a lag in the adjustment of expectations to changes in rates of inflation. On the surface, this hypothesis seems implausible: the time periods involved appear too long for rational market participants not to have adjusted their expectations fully. The objection to that line of reasoning, though, is that it implies a knowledge of the inflation process on the part of individual market participants that they may not have had. Predicting longer-term rates of inflation is essentially a problem of predicting the longer-term rate of monetary growth. The latter, in turn, is a question of the monetary policy regime. Given inertia in the political process, formation of expectations in a regressive and seemingly myopic fashion may, therefore, be entirely rational. In the absence of an obvious and dramatic political change, market participants may view policy over the next decade as differing little from policy in the last.[7]

To sum up, I find support for the Fisher equation as a general proposition. Conversely, the data provide no support for the popular notion that easy money and low

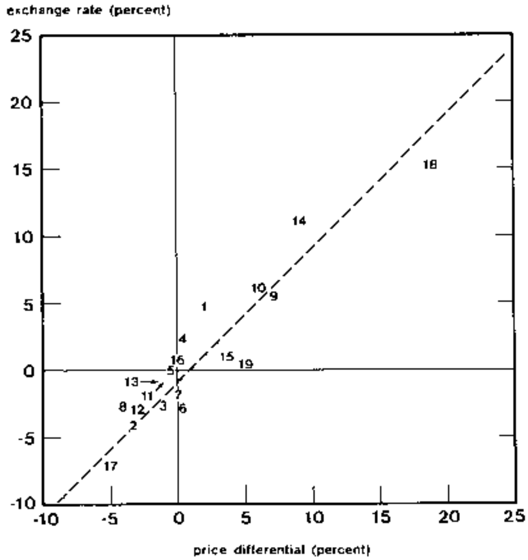

FIGURE 4. GROWTH SHIFTS: EXCHANGE RATE VS. PRICE DIFFERENTIAL

interest rates go hand in hand. Real rates of interest, as measured here, were far from constant either temporally or geographically, however.

C. *The Monetary Approach to Exchange Rates*

Figure 4 plots the shift in the rate of change of the foreign currency versus dollar exchange rate against the shift in the inflation differential, where the latter is defined as the shift in the difference between the average rates of foreign and U.S. inflation. Figure 5 plots a similar relationship except that the shift in the differential excess rate of monetary growth replaces the shift in the inflation differential as a variable. It, in turn, is defined as the shift in the difference between the average rates of foreign and U.S. $M1$ growth less the shift in the difference between the corresponding rates of real income growth. The first component of this latter algebraic total indicates the degree to which the differential growth rates of the money supplies in the foreign country and the United States has changed; the second proxies the extent to which the differential growth rates of the real quantities of money

[7]See Friedman and Schwartz (p. 556) for a similar discussion of bond yields in the United States in the latter part of the nineteenth century. They attribute the substantial difference between bond yields and the (negative) rate of inflation at that time to investors' fears that agitation for free silver would lead to an abandonment of gold and renewal of inflation. This example, coupled with the results obtained here as well as with recent U.K. and U.S. experience, raises the dual questions of what can be considered rational behavior a priori and how one can ascertain empirically whether behavior is or is not rational.

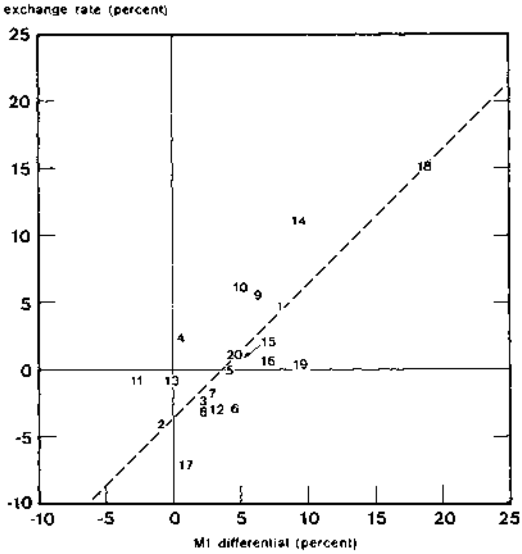

FIGURE 5. GROWTH SHIFTS: EXCHANGE RATE VS. $M1$ DIFFERENTIAL

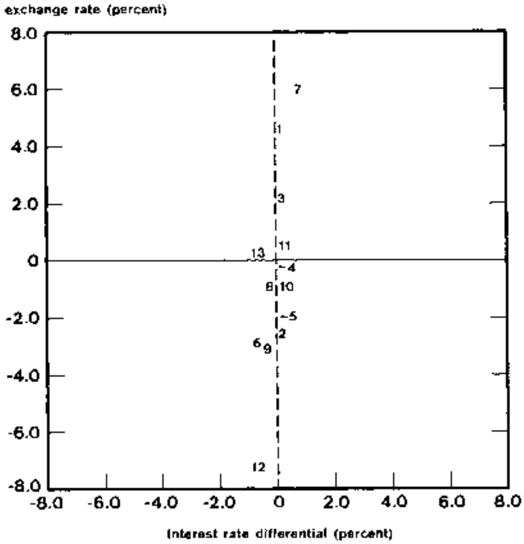

FIGURE 6. GROWTH SHIFTS: EXCHANGE RATE VS. INTEREST RATE DIFFERENTIAL

demanded in the two countries has changed. Combined, the two therefore provide a measure of the shift in the relative excess supplies of monies (or demands if the total is negative).[8]

Figure 4 is, of course, a direct transformation of Figure 5, provided that the money-to-inflation link holds. It is just the purchasing-power-parity relationship stated in terms of accelerations in prices rather than in levels of prices.

As the figures show, both longer-term relationships hold tolerably well. In each instance, the points are clustered about 45° lines drawn through the means of the observations, indicating the existence of one-to-one relationships between shifts in the rates of change of exchange rates and shifts in the rates of change of the other variables.

The regressions corresponding to the charts buttress this conclusion. In all instances, the percentage of variation of the exchange rate variable accounted for is substantial (.87 with the inflation differential; .63 and .59 with the unconstrained and constrained differential monetary growth variables, respectively). In all instances, however, I am unable to reject the joint hypothesis that the intercept term in the regression is zero and the slope term is unity.

An additional implication of the monetary approach is also confirmed by the data. That model posits a positive relation between the exchange rate, defined as it is here as the foreign-currency price of a dollar, and the difference between the foreign and the U.S. interest rate. The rationale is that an increase in the foreign interest rate reduces the real amount of foreign money that foreigners want to hold, and hence for a given money supply produces an excess supply of money. This, in turn, results in upward pressure on the exchange rate or weakening of the foreign currency relative to the dollar.

The common view to the contrary is that an increase in a country's interest rate neces-

[8]It is only a proxy since other arguments of the demand for money functions are omitted and the income elasticities of demand implicitly are assumed to be unity. The regression results reported in Table 2 are broadly consistent with this second assumption. The income elasticity estimates derived from the sixth equation are not significantly different from unity. Additional results for the smaller sample indicate, however, that interest rates also clearly matter. The interest rate term in the seventh regression has the correct sign and is significantly different from zero.

sarily strengthens its currency via its effects on capital inflows. The data do not support this second proposition as a long-term hypothesis. As Figure 6 indicates, there is no relation between the growth shift in the exchange rate and the shift in the differential rate of change of nominal bond yields. Conversely, when the interest rate variable is included in a regression equation representative of the monetary approach, it is statistically significant and has the expected positive sign. An increase in the own-country interest rate, other things being equal, weakens rather than strengthens its currency.

III. Conclusions

In this paper I have examined three sets of hypotheses associated with the quantity theory of money: the classical neutrality proposition, the monetary approach to exchange rates, and the Fisher equation. The data are completely consistent with the first two and moderately supportive of the last. Given the nature of the data, the fact that they are generated by, to use Lucas's term, an "ideal experiment," and given the simplicity of the tests, I view the results as a strong confirmation of the theory.[9] Looked at from the opposite perspective, they provide little or no support to the corresponding alternative hypotheses, the naive Phillips curve, the interest rate theories of exchange rate determination and the liquidity preference theory of interest rate determination.

[9] For corroborative cross-country evidence for the money-price relationship see Schwartz (1973) for a sample of 40 developed and less developed countries, and William Norton and Robin McDonald (1981) for a sample of 10 developed countries. Lucas, as an introduction to his U.S. analysis, presents similar evidence for 16 Latin American countries.

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