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The behavior of money and other economic variables: Two natural experiments

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A B S T R A C T

The object of this paper is to test the performance of the quantity-theory model and the related proposition of monetary neutrality in a context in which, to use Bernanke's phraseology, "money move[d] for reasons that [were] plausibly unrelated to the current state of the economy." We investigate this question using data from two recent episodes of monetary-policy regime change – the move to floating exchange rates throughout the industrialized world following the breakdown of Bretton Woods in the early 1970s and the shift toward less expansive monetary policy that to varying degrees took place in these countries a decade or so later. The results of this exercise are highly positive. The money–price relationship that we observe is fully consistent with theory – growth shifts in the nominal stock of money and in the price level are highly correlated and bear a one-to-one relation to one another. Growth shifts in exchange rates are significantly related both to growth shifts in relative price levels and to growth shifts in relative excess supplies of money. The classical neutrality proposition – in this context superneutrality – in general, receives strong, though not totally unambiguous, support.

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1. Introduction

Every once in a great while history provides us with a natural experiment, an episode in which a major change in a key economic variable occurs that has no direct relation to the contemporaneous movements in the variables that theory suggests it ought to affect.[2]

A classic example was the currency reform during the U.S. Civil War by the Confederacy in spring 1864. A second was provided by the massive inflow of specie from the New World to Spain in the sixteenth century. In the first example, a rapidly growing money stock suddenly fell and a decline in the price level followed. In the second, a century-long upward movement in price levels occurred throughout most of Europe. The question that researchers addressed in both instances had to do with the links between the monetary changes and the price behavior that followed (Lerner, 1956; Hamilton, 1934).

In this paper we investigate the same question using data from two more recent episodes of monetary-policy regime change – the move to floating exchange rates throughout the industrialized world following the breakdown of Bretton Woods in the early 1970s and the shift toward less expansive monetary policy that to varying degrees took place in these countries a decade or so later.[3] Both quite arguably were natural experiments in their own right. Both, moreover, were followed by similar sea changes in price behavior – the Great Inflation of the 1970s and early 80s in the first instance and the two decades of relative price stability thereafter in the latter case.

Our object here is twofold: to test the performance of the quantity-theory model and the related proposition of monetary neutrality in an ideal context, one in which, to use Bernanke's (2002) phraseology, "money move[d] for reasons that [were] plausibly unrelated to the current state of the economy;" and to reexamine this unique period of macroeconomic behavior from a vantage point in which the dust has, so to speak, settled.

The association between broad movements in money supply growth and inflation in these three episodes is one small but nevertheless telling bit of evidence in favor of what Nelson (2003) has termed the "AEMP proposition," the proposition that, as Friedman (1963) had earlier put it, "substantial inflation is always and everywhere a monetary phenomenon." In effect, however, when this association is examined for any one country or pooled data for several countries the evidence from these episodes provides only three observations.

Fortunately, these regime changes also had a cross-country dimension to them. Underlying the breakdown in Bretton Woods was a desire on the part of many countries to pursue monetary policies independent to that of the United States. Floating exchange rates provided the leeway to do so. Differences among countries in long-term rates of money-supply growth and inflation increased dramatically as a result. Some counties, like Italy and the United Kingdom, saw substantial increases in their inflation rates following the move to floating exchange rates; others, like Germany and Switzerland, only small increases. On the downside, similar cross-country differences emerged as all countries in the sample during the course of the 1980s and 90s returned to the same moderate rates of inflation but from quite different starting points.

In our empirical analysis, we exploit these differences. We use panel data for 20 OECD countries over the period 1960–1998 to investigate the relations between money and prices, real incomes and exchange rates. We focus in particular on the cross-country and cross-regime movements in these data using as our basic units of observation growth shifts, cross-regime changes in the within-regime country average annual rates of growth of the variables.[4] We go on to compare our findings for the 20 OECD countries with findings for a control group of 13 additional countries in which monetary policies followed time paths different to those of the OECD countries in these three periods. As a further check on our results, we estimate a series of money–price regressions using the disaggregated yearly data.

[2] See Bernanke (2002) for a discussion of the important role that such experiments have played in empirical monetary economics and Friedman (2005) for a recent application to U.S. experience.

[3] See Barro (1982) and Darby et al. (1983) for discussions of this first episode and King and Goodfriend (2005) for a recent retrospective on the second.

[4] Earlier studies employing a similar methodology include Schwartz (1973), Lothian (1985), Duck (1993), McCandless and Weber (1995), and Dwyer and Hafer (1999).

The results of this exercise are highly positive. The money–price relationship that we observe is fully consistent with theory – growth shifts in the nominal stock of money and in the price level are highly correlated and bear a one-to-one relation to one another. Growth shifts in exchange rates are significantly related both to growth shifts in relative price levels and to growth shifts in relative excess supplies of money. The classical neutrality proposition – in this context superneutrality – in general, receives strong, though not totally unambiguous, support.

These findings, moreover, do not appear to be a statistical fluke, the result of some omitted variable like oil prices or commodity prices. One bit of evidence here is timing. Both changes in monetary regime antedate the inflation changes. A second is the cross-country disparity in the magnitudes of the inflation changes. Given the substantial differences in the conditions affecting the supply of money in the various countries, it is difficult to argue that money was purely passive. Third, and perhaps most important, in the 13-country control group we observe a money–price relationship that is virtually identical to that of the OECD countries, which is not what one would expect to find if some factor other than money had been responsible for the change in inflation in the OECD countries. The results obtained with the panel of disaggregated data, lend further support to these findings. There is a positive but less than one-to-one relationship between inflation and excess money growth and an improvement in the relationship between the first differences of these two variables (i.e. logarithmic second differences of the levels of excess money and the price level) as the degree of temporal aggregation is increased. The latter, as we argue below, is what one would expect, given errors in the two variables.

These findings are important in two regards. On the general level of macroeconomic theory, they provide strong support for the quantity-theory model. On the more specific level of price behavior during the course of the Great Inflation and the disinflation that followed, they show that the quantity theory is capable of explaining an overwhelming share of the long-term movements in inflation in these two episodes. The other factors widely considered to have affected the money–price relationship – oil and commodity prices in the first instance and financial innovation in the second – evidently have mattered very little over the long run.

2. Industrial-country inflation in the post-world war II period

In the early post-WWII years, the Bretton Woods Agreement for fixed exchange rates exerted a powerful force on inflation behavior in the countries making up that system. Under the Bretton Woods regime, cross-country inflation differences were non-zero but generally quite small. In the absence of revaluation or devaluation, inflation rates and monetary policies could not wander too far from inflation and monetary policy in the United States, the reserve-currency country. The United States for its part retained a residual link to gold and thus provided a nominal anchor of sorts to the system.

Bretton Woods, however, finally broke down after considerable stress in August 1971 when the United States closed the gold window and unilaterally floated. The European countries, after futile attempts to maintain some exchange-rate fixity, gave up the ghost a little over a year and a half later and a new period in the behavior of monetary policy and inflation both within and across countries got fully underway. Then as the 1970s drew to a close, a series of shifts in the monetary policies began to change again, this time in the direction of less expansiveness. By the mid 1980s, these shifts both intensified and became very nearly ubiquitous. Inflation followed suit falling back to the relatively low levels of the early Bretton-Woods years throughout the industrialized world.

Taylor (2002), in reviewing the history of the post-WWII era, described it quite aptly as "the Great Inflation flanked by two periods of relative price stability." Fig. 1 provides an overview of monetary and inflation behavior that is fully consistent with this description. Shown there is a plot of yearly values of the twenty-country average rate of inflation over the period 1958–1998 against a similar average of the rate of growth of the excess supply of money, proxied here by the ratio of the nominal stock of money to real GDP.[5] What immediately strikes the eye are the sharp contrast between the 1970–1982 period

[5] The list of countries is as follows: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States. The source of these data was the *IFS* on CD-ROM. We describe these data below.

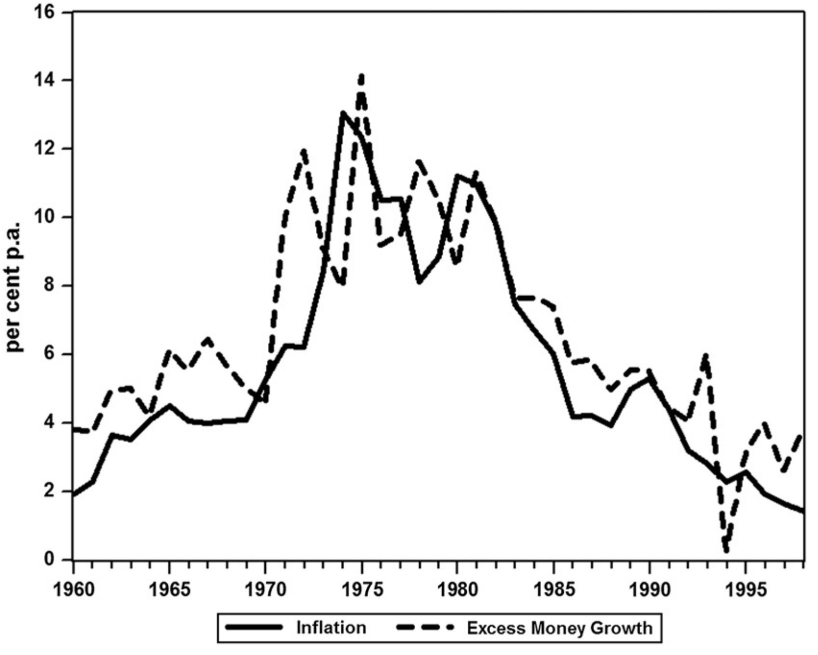

Fig. 1. Inflation vs. excess money growth. Averages for 20 OECD countries.

and the periods preceding and following it and the close correspondence between the movements in the two series. We see both moderate rates of inflation and moderate rates of excess money growth under Bretton Woods, substantial step-like increases in both following the advent of floating exchange rates at the start of the 1970s, and then abrupt reversals roughly a decade later, with average rates of excess money growth and inflation both falling sharply and then remaining low and relatively stable for the remainder of the period.

At this level of abstraction, therefore, the quantity theory is clearly supported. In the simplest open-economy quantity-theory model, these two sea changes in inflation correspond in one-to-one fashion with the two changes in the monetary regime that occurred over this period – the natural experiments which are the focus of this paper. As the chart indicates, however, most of the movement in the data is due to differences in means across the three periods. In effect, we have many fewer independent observations than 40 years' worth of data would seem to indicate.

The quantity-theory explanation, however, has been subject to dispute on several scores. From the very outset, many economists questioned the assertion that the increased rate of inflation post-1973 was primarily the result of shifts in monetary policy goals. The then-reigning and still popular alternative explanation – the special factors theory of inflation – attributed the increase in inflation to the first oil-price shock, the continued high inflation for the decade thereafter to its lagged effects coupled with those of the second such shock in 1979, and the subsequently lower inflation to the absence of any similar shocks.

A second area of contention is the behavior of the demand for money following the waves of financial innovations that began around the start of 1980s. Indeed, this behavior has seemed so problematic, that articles have appeared in Federal Reserve publications with titles like "Are Money Growth and Inflation Still Related?" (Dwyer and Hafer, 1999), and "What Remains of Monetarism?" (Hafer, 2001). Equally indicative in this regard are the actual practices of monetary policy makers. Most industrial-country central banks focus exclusively on one or the other short-term interest rate in conducting policy, with little seeming attention to the various monetary aggregates (Borio, 1997). Indeed, the well-known "Taylor rule" for the conduct of monetary policy is couched in terms of a short-term interest rate rather than money supply or some narrower aggregate such as bank reserves or high-powered money. The New Keynesian models that have gained ascendancy over the past decade and use Taylor rule as a building block have thrust money farther into the background.

Objection also has been raised to the monetary model of exchange rates and balance of payments that is one of the theoretical underpinnings of the quantity-theory explanation of changes in international inflation behavior over this period. In what has become a classic article on the subject, Meese and Rogoff (1983) demonstrated the poor predictive power of the model relative to a naive random-walk forecast. Flood and Rose (1995), comparing the volatilities of nominal exchange rates and the variables that appear as arguments in standard exchange-rate equations, reached similar conclusions. Based on the disparity between the two, they concluded, "the most critical determinants of exchange-rate volatility are not macroeconomic."[6]

3. The basic open-economy, quantity-theory model

To formalize the quantity-theory argument and illustrate potential differences in economic behavior under regimes of fixed and floating exchange rates, let us consider a long-run, two-country model.[7] This two-country world is made up of a small open domestic economy and large reserve-currency country. In the case of the domestic economy, the model takes the form of a demand for money function, a monetary equilibrium condition, and a real-exchange-rate relation.

We write the demand for money function as:

$$\mathrm{d}m^d = L(\mathrm{d}y, \mathrm{d}i, u) + \mathrm{d}p, \qquad (1)$$

where $\mathrm{d}m^{\mathrm{d}}$ is the percentage rate of growth of the desired quantity of nominal cash balances demanded, $\mathrm{d}y$ is the percentage rate of growth of real income, $\mathrm{d}i$ is the change in the nominal rate of interest, $\mathrm{d}p$ is the rate of inflation and u is a portmanteau variable included to represent other factors such as the degree of financial sophistication and the quality of money. Real income in the long-run context of the model is assumed to be exogenous, determined outside the model in the Walrasian system of equations that describe the myriad individual markets making up the economy – the real business cycle core. It is assumed to be unaffected by changes in monetary growth: money is "neutral."

The equation for the real exchange rate written in terms of rates of change takes the form:

$$\mathrm{d}p = \mathrm{d}p' + \mathrm{d}e - \mathrm{d}q, \qquad (2)$$

where a prime signifies the reserve-currency country, $\mathrm{d}e$ is the percentage change in the nominal exchange rate, defined as the price in domestic currency of a unit of the reserve currency, and $\mathrm{d}q$ is the percentage change in the (equilibrium) real exchange rate. Inclusion of the last term, therefore, allows for the effects of real variables, such as continued differences in productivity growth in the two countries, on the exchange rate. In the fixed exchange rate case, $\mathrm{d}e$ is zero and if $\mathrm{d}q$ is also zero, as it is assumed to be in the strict version of the purchasing-power-parity hypothesis, $\mathrm{d}p$ equals $\mathrm{d}p'$.

In equilibrium, the growth rate of the nominal quantity of money supplied and the growth rate of the nominal quantity of money demanded also are equal:

$$\mathrm{d}m = \mathrm{d}m^d. \qquad (3)$$

Combining (3) with (1) and assuming purchasing power parity, we get:

$$\mathrm{d}m = L(\mathrm{d}y, \mathrm{d}i, u) + \mathrm{d}p'. \qquad (4)$$

[6] Another body of literature questions the related proposition of monetary insulation under floating exchange rates. See, for example, Lastrapes and Koray (1990), Joyce and Kamas (1994) and Wheeler and Pozo (1997).

[7] An open-economy model of this sort underlies much empirical literature in monetary economics beginning with Fisher (1935), and continuing with Friedman and Schwartz (1963), and Darby et al. (1983). It is also the basis of the monetary approach to the balance of payments advanced by Johnson (1969) and others at the end of the 1960s and in the early 1970s.

The upshot here is that with dp' given, the nominal stock of money in the domestic economy is proximately determined by the quantity of real cash balances demanded. Monetary growth and inflation in the case of this assumed small domestic economy are jointly determined. For the reserve-currency country, in contrast, monetary growth is determined by domestic policy considerations. Given the behavior of the real quantity of money demanded, it in turn determines the rate of inflation both in the reserve-currency country and in line with the discussion above in the domestic economy too.

Interest rates in this world of long-run equilibrium and fixed exchange rates are assumed to change by the same absolute amount in the domestic economy and in the reserve-currency country. By definition, exchange rates are fixed. If they are expected to remain so, then via uncovered interest-parity, the levels of nominal interest rates in the two countries will be equal. Since actual and anticipated rates of inflation within each country are equal by the assumptions of the model, real interest rates via the Fisher equation also will be equal.

In a floating exchange rate world, equations (1)–(3) and the reserve-currency-country analogues of (1) and (3) are combined into a three-equation system in which the rate of change of the exchange rate is determined by the difference in the growth rates of the excess supplies of money (d$m - L$) in the two countries and each country's inflation rate is determined by growth in its excess supply of money alone.

We can write these equations as:

$$\mathrm{d}e = \mathrm{d}m - L(\mathrm{d}y, \mathrm{d}i, u) - \mathrm{d}m' + L'\left(\mathrm{d}y', \mathrm{d}i', u'\right), \tag{5}$$

$$\mathrm{d}p = \mathrm{d}m - L(\mathrm{d}y, \mathrm{d}i, u), \tag{6}$$

$$\mathrm{d}p' = \mathrm{d}m' - L'(\mathrm{d}y, \mathrm{d}i, u). \tag{7}$$

Again these are to be viewed as long-run equilibrium equations.

Unlike the fixed-rate case, there is no necessary connection between growth rates of the supply of and the demand for money in the domestic economy. Money supply growth in both countries will be determined by domestic considerations. An increase in the growth rate of the demand for money with no change in the growth of supply would result in a decrease in the rate of inflation. Variations in the nominal quantity of money demanded will impinge on domestic money-supply growth only if policymakers choose to stabilize inflation.

In further contrast to the situation under fixed exchange rates, nominal interest rates are free to vary among countries. Here uncovered interest parity is consistent with differences in the levels of interest rates equal to the percentage rate of increase of the exchange rate. This independence of nominal interest rates need not correspond to similar independence of real interest rates if capital controls imposed under fixed exchange rates have been removed, which as Goldberg et al. (2003) show, appears to be the case.

The implications of the model are, therefore, straightforward. In the long-run equilibrium world that it describes, growth in the excess supply of money should bear a one-to-one relationship to inflation and no relationship to real income growth. Qualitatively, the same thing should be true for relative inflation rates and hence by extension relative excess money growth vis-à-vis exchange rates growth: one-to-one relationships between both nominal variables and the rate of change in the nominal exchange rate and no relationship between either nominal variable and the rate of change of the real exchange rate.

4. Empirical results

The data we use to test these propositions are for the same twenty OECD countries and the same period as the data shown in Fig. 1. For all 20 OECD countries, we have collected annual figures for the period 1957–1998 for a broad definition of money, which we label M2 (generally the sum of what the IMF terms "money" and what it terms "quasi-money"), the consumer price index, real and nominal GDP, and foreign vs. U.S. dollar exchange rates. We stop in 1998 because of the introduction of the Euro in 1999 and resultant change in the Euro-area monetary data. The source of most of these data again

Table 1
Means and standard deviations of cross-country data by periods.

	1960–70	1971–82	1983–98
Means			
dP	3.76	9.70	3.94
dM2	10.18	13.15	7.48
dM2 − dy	5.00	10.33	4.91
dy	5.24	2.82	2.57
dE	0.59	0.84	0.15
dQ	−0.63	−1.39	−0.56
Relative dP	1.22	2.23	0.70
Relative dM2 − dy	2.15	3.47	2.23
Standard deviations			
dP	1.73	3.82	2.45
dM2	4.92	5.83	4.81
dM2 − dy	4.93	5.64	4.78
dy	2.89	2.01	1.85
dE	1.92	6.26	5.90
dQ	2.70	5.28	5.48
Relative dP	1.73	3.84	2.50
Relative dM2 − dy	5.00	5.68	4.83

Note: Data are in the form of average annual rates of growth. The symbols dP, dM2, dy, dE and dQ represent the growth rates of the price level, money defined broadly as the sum of *IFS* "money" plus "quasi-money", real GDP, the nominal foreign vs. US dollar exchange rate and the real foreign vs. U.S. dollar exchange rate, respectively; dM2 − dy is a proxy for the growth rate of the excess supply of money; relative dP and relative dM2−dy are the differences between the respective foreign and U.S. variables.

was the International Monetary Fund's International Financial Statistics, both on CDROM and in the companion print publications.[8]

We focus on behavior across the three regimes that we identified above. For each of the variables of interest we computed average rates of growth for each country for each of the three regimes separately. We then took the first differences of these averages and used the resultant figures – the "growth shifts"– as the basic units of observation in our analysis.

The first change in monetary regime is the easier of the two to date. The Bretton Woods agreement for all practical purposes broke down in August 1971 when the United States, the reserve-currency country, severed its remaining links to gold and unilaterally floated. A little over a year and a half later, floating became the norm as the European countries, after futile attempts to maintain some exchange-rate fixity, finally gave up the ghost. A dividing line somewhere in the 1970–1972 range can, therefore, be quite easily justified.

The second change in regime is harder to pin down since no key event like the move to floating exchange rates can be pointed to as heralding its start. One solution is to choose a date at which policymakers in major countries began to shift toward less-inflationary policy. This would argue for a starting date somewhere around 1980, perhaps a year earlier. Margaret Thatcher, who had pledged to reduce inflation in the United Kingdom had been elected in spring 1979, the Federal Reserve had changed its operating procedure and begun to focus more heavily on inflation in fall 1979, and then following Ronald Reagan's election in November 1980 became much more resolute in its anti-inflation fight.[9]

The monetary data plotted in Fig. 1 point to the same 1970 breakpoint for the end of the first regime, but suggest a later – 1982 as opposed to 1980 – breakpoint for the end of the second. After averaging slightly below 5.0 per cent per annum from 1960 through 1970, excess money growth which we proxy as the difference between nominal money growth and real GDP, increased in step-like fashion to over

[8] In a number of instances we encountered breaks in these data and in several cases missing observations. Breaks were corrected by interpolation. Publications of the OECD provided most of the missing data.

[9] German and Japanese policy also began to shift at roughly the same time. See the discussions by Helmet Schlesinger of the Deutsche Bundesbank and Reiichi Shimamoto of the Bank of Japan in Paul Meek, ed. (1983).

10 per cent per annum in 1971. It then remained in or near double-digit rates in every year save one from 1971 to 1982, after which it began a marked decline. From an average rate of 10.3 per cent per annum for the period 1971–1982 it fell to 7.6 per cent per annum in 1983–1985, and then to an average rate of 4.2 per cent per annum over the remaining years of our sample period. We use these 1970 and 1982 endpoints in defining the three policy regimes and in computing the cross-regime growth shifts.[10]

We focus on the cross-regime shifts for several reasons. First, and most important, is that both shifts in policy preceded the changes in the rate of inflation and hence appear to be natural experiments in the true sense of the term. A second has to do with the magnitude of these movements. The differences in average inflation rates across the three regimes account for the lion's share of the temporal movement in inflation over this forty-year period.[11] As such, they have been and still are of considerable interest not only to researchers but also to policy makers and the general public. Third, averaging the data by regimes and taking differences in these averages provides an approximation to the changes in the long-term equilibrium growth rates that are the focal points of the basic monetary model we have outlined.[12] Finally, averaging helps solve the errors-in-variable and resultant signal-extraction problems that plague many empirical investigations of macroeconomic data.[13]

Before turning to the analysis of the relationships linking the growth shifts in the variables, we present a general overview of the data on a regime-by-regime basis. The summary statistics that we report provide a further important bit of evidence in support of the quantity-theory model.

4.1. Summary statistics for the OECD sample

Table 1 lists cross-country averages and cross-country standard deviations of the rates of growth of the key variables and of four additional variables used in our analysis: the difference between M2 growth and real GDP growth, the rate of growth of the real exchange rate, the inflation differential relative to The United States; and the rate of growth of the relative excess supply of M2 relative to the United States.

The figures presented in Table 1 are both fully consistent with the picture painted in Fig. 1 and, with the partial exception of exchange rates, are consistent with the neutrality proposition. Average rates of growth of M2 and excess M2 increase and then decrease across the three periods. The same is true for the growth rates of the other two nominal variables, nominal GDP and the price level. The average rate of growth of real GDP, in contrast, follows an entirely different pattern. In general, the same things hold true for the standard deviations for these variables. The cross-country standard deviations of the nominal variables increase and then decrease, while the standard deviation of real GDP declines steadily across the three periods.

[10] To try to gain greater precision in dating the endpoint of the second regime, we ran a series of first-order autoregressions for excess money using dummy variables for the second regime that spanned gradually increasing periods. These pointed to an endpoint somewhere between 1982 and 1986, but since the standard errors of these regressions in the main differed only slightly from one another the results of this exercise were of little help in distinguishing the exact date.

[11] The dominance of the cross-regime variation is highlighted further by regressions of the two series on a dummy variable for the second (high-inflation) regime. In both instances, it accounted for roughly 70 per cent of the variation in the dependent variable.

[12] Fisher and Seater (1993) point out further that a necessary condition for tests of the superneutrality of money is that the rate of growth of money supply and the rate of inflation both be $I(1)$. While this condition generally is not met for developed country data, it appears to be approximated in the neighborhood of the two regime changes studied here (see Evans and Wachtel, 1993).

[13] Estrella and Mishkin (1997) and Friedman and Schwartz (1991) contain discussions of these problems in the context of studies of monetary behavior. Estrella and Mishkin point out that one possible reason for their largely negative results may simply be a low signal-to-noise ratio in their sample, since it is a period of generally low variability in the growth rates of money and the other nominal variables of interest. In such an environment, shocks to velocity, the "noise" in the system, can more easily obscure the monetary effects, the "signals." Dwyer and Fisher (2009) show that averaging the data mitigates this problem. Friedman and Schwartz (1991, pp.43–45) argue for an errors-in-variables approach to the problem with the errors "interpreted to include all stochastic disturbances affecting the variables under study," disturbances stemming both from the use of imprecise empirical proxies for the variables suggested by theory and errors of measurement in the proxy variables themselves.

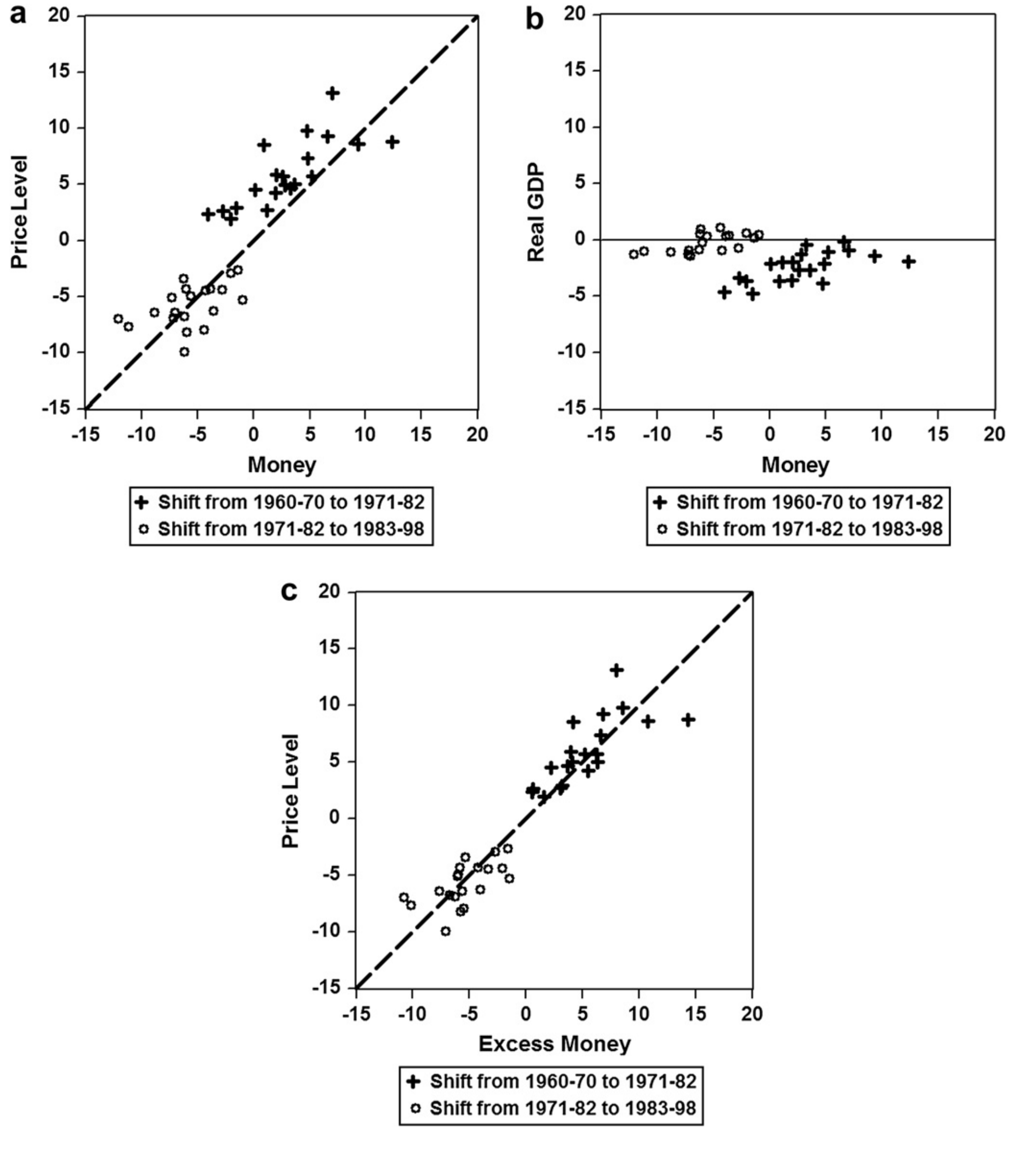

Fig. 2. Growth shifts in consumer prices, real GDP and monetary variables across 20 OECD countries. Figures plotted in the charts are shifts in the rates of growth of the variables between the periods 1960–70 and 1971–82 and 1971–82 and 1983–98 for each of the twenty countries. All data are in per cent terms.

For the average growth rates of nominal exchange rates, there is a parallel with movements in the relative average rates of inflation and a lesser but still positive association with relative average rates of growth of excess M2. In both cases, and in contrast to the standard result with higher frequency data, the changes in the growth rate of the nominal exchange rate are actually *less* in absolute value than the changes in the growth rates of these other two nominal variables. In broad outline, therefore, nominal exchange rates did behave over the long run as theory would suggest. There is, however, a negative association between inflation and real-exchange-rate growth across the three periods. This is the one departure from neutrality to which we referred earlier. It is mirrored further in the behavior of the standard deviations. Growth rates of both nominal and real exchange rates are more variable across

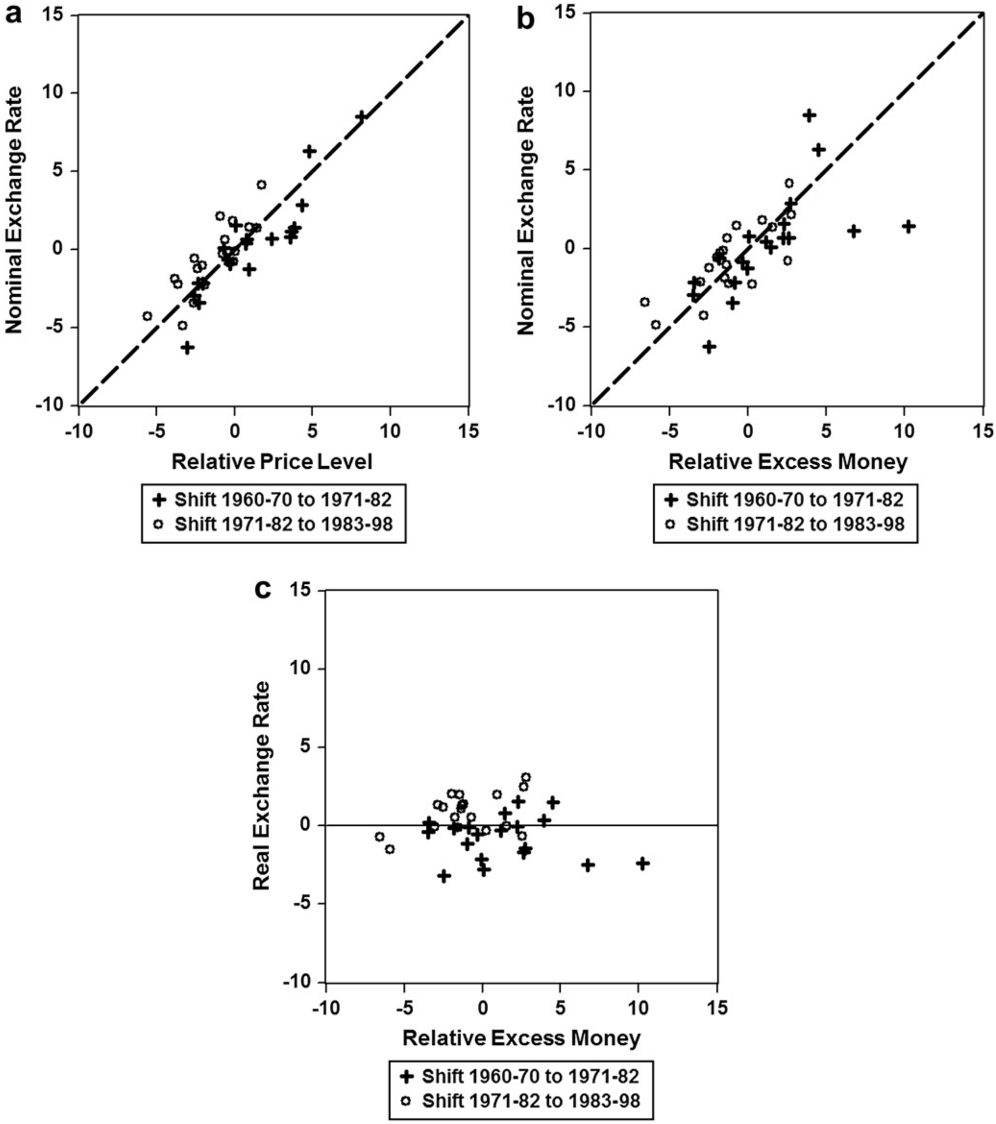

Fig. 3. Growth shifts in nominal and real U.S. Dollar exchange rates vs. relative consumer prices and relative excess money across 19 OECD countries. Figures plotted in the charts are shifts in the rates of growth of the variables between the periods 1960–70 and 1971–82 and 1971–82 and 1983–98 for each of the nineteen countries relative to the United States. All data are in per cent terms.

countries under both post-1973 regimes and, although the variability in both instances decreases somewhat during the third regime, the decreases are considerably less than the decreases in the cross-country variability of inflation. The match is somewhat closer with relative M2 growth.

4.2. Analysis of growth-shift relations in the OECD sample

We turn now to the analysis of the cross-regime growth shifts. Figs. 2 and 3 contain graphs of these data. Tables 2 and 3 report the corresponding regression results. Plotted in the first two panels of Fig. 2 are growth shifts in inflation and real GDP in the 20 OECD countries against growth shifts in nominal

Table 2
Results of cross-country regressions for consumer prices and real GDP, 20 OECD countries.

Dependent variable	Constant	ΔdM2	Δ (dM2 − dy)	R^2/SEE
ΔdP	1.500	1.016		0.775
	3.022	11.636 (0.179)		3.044
Δdy	−1.436	−0.075		0.049
	−5.837	−1.732		1.509
ΔdP	0.159		0.978	0.880
	0.453		16.941 (.389)	2.223

Note: The symbol Δ represents a first difference operator; thus Δd*x* is the change in the regime-average rate of growth of *x* – the growth shift in x from Period 1 to Period 2 and from Period 2 to Period 3, where Period 1 is 1960–1970, Period 2 is 1971–1982 and Period 3 is 1983–1998. All variables are defined as in Table 1. Conventional *t* statistics are given directly beneath the coefficient estimates; *t* statistics to test the hypothesis that the coefficient is unity are given in parentheses beneath the coefficients, The R^2 is adjusted for degrees of freedom.

M2. Plotted in the third panel is the growth shift in inflation against the growth shift in excess M2. Plotted in the two panels of Fig. 3 are growth shifts in nominal U.S. dollar exchange rates against growth shifts in relative consumer prices and in relative excess supplies of M2, respectively. Plotted in the third panel are growth shifts in real U.S. dollar exchange rates against growth shifts in relative consumer prices. In each instance, the crosses indicate shifts from regime one to regime two; the circles, growth shifts from regime two to regime three.

Taken as a group, the forty points in the chart for prices vs. actual M2 appear fairly evenly dispersed about the forty-five-degree line through the origin. Over the broad range of experience, therefore, the one-to-one relationship between inflation and money growth suggested by theory approximately holds. The other noticeable feature of these data, is the difference in behavior in the two episodes. Most of the observations for the first growth shift lie to the northeast and tend to be somewhat above the forty-five-degree; while most of the observations for the second growth shift lie to the southwest and are scattered about the line. For real GDP, the picture is quite different. There clearly is no positive relationship between real GDP and money, and if anything, only a rather weak negative relationship. This, in turn, appears to be largely the result of a difference in the means of the two real GDP growth shifts rather than any systematic monetary effects. When we take this difference into account and focus on the relationship between prices and excess M2, we see very much the same thing as for prices versus actual M2 except that the points are now much more tightly distributed about the forty-five-degree line than in the earlier chart. Taking account of the shift in real income growth and its effects on the quantity of real money balances demanded, therefore, improves the relationship.

The regression results reported at the top of Table 2 are completely consistent with these impressions. The slope coefficients in the regressions of prices on money and excess money are almost identically equal to and insignificantly different from unity and the intercept in the nominal GDP regression is close to and insignificantly different from zero. Both regressions, moreover, account for

Table 3
Results of cross-country regressions for exchange rates, 20 OECD countries.

Dependent variable	Constant	Relative dP	Relative Δ (dM2 − dy)	R^2/SEE
ΔdE	0.004	0.864		0.724
	0.016	9.911 (1.565)		1.501
ΔdE	−0.254		0.605	0.461
	−0.745		5.712 (3.730)	2.099
ΔdQ	0.042		−0.047	−0.017
	0.167		−.609	1.544

Note: The underlying variables are as defined in Table 1. The symbol Δ represents a first difference operator; thus Δd*x* is the change in the regime-average rate of growth of *x* – the growth shift in *x* from Period 1 to Period 2 and from Period 2 to Period 3 where Period 1 is 1960–1970, Period 2 is 1971–1982 and Period 3 is 1983–1998. Relative ΔdP and Relative Δ (dM2 − dy) are defined with the US as the numeraire. For example, Relative ΔdP for country *i*, equals $\Delta dP_i - \Delta dP_{US}$. Conventional *t* statistics are given directly beneath the coefficient estimates; *t* statistics to test the hypothesis that the coefficient is unity are given in parentheses beneath the coefficients. The R^2 is adjusted for degrees of freedom.

a high proportion of the variance of the independent variable – 78 per cent when actual money is the independent variable and 88 per cent when excess money is the independent variable. In the real GDP regression, in contrast, the explanatory power of the growth shift in money is low and its estimated slope coefficient is small in absolute value and statistically insignificant at conventional levels, findings that again are consistent with theory.

The exchange-rate plots in the three panels of Fig. 3 bear more than a family resemblance to those for prices and real income, showing a close positive association between the nominal variables – nominal exchange rates and relative price levels in Fig. 3a and nominal exchange rates and relative excess supplies of M2 in Fig. 3b – and no association between real and nominal variables – real exchange rates and relative excess supplies of M2 in Fig. 3c.

Table 3 reports the corresponding regression results. In the first two regressions, the shift in nominal U.S. dollar exchange rate growth is the dependent variable while the differentials in inflation shifts and in excess M2 growth alternate as the independent variables. In the third regression, the shift in real-exchange-rate growth is the dependent variable and the shift in relative excess M2 growth is the independent variable. The coefficients of both the inflation differential and the excess M2 growth differential are significantly different from zero, and in the case of relative price levels, tolerably close to and not statistically different from unity. Purchasing power parity in growth rate form, therefore, approximately holds and the monetary model of exchange rates also receives empirical support. Excess M2 growth, in contrast, has no effect on the real exchange rate.

4.3. *Results for the control group*

A key element of laboratory experiments is the presence of a control group incorporated before the fact in the experimental design. This is clearly impossible with macroeconomic data. It is, however, possible to mimic some of the features of a control group, given the right circumstances. To that end,

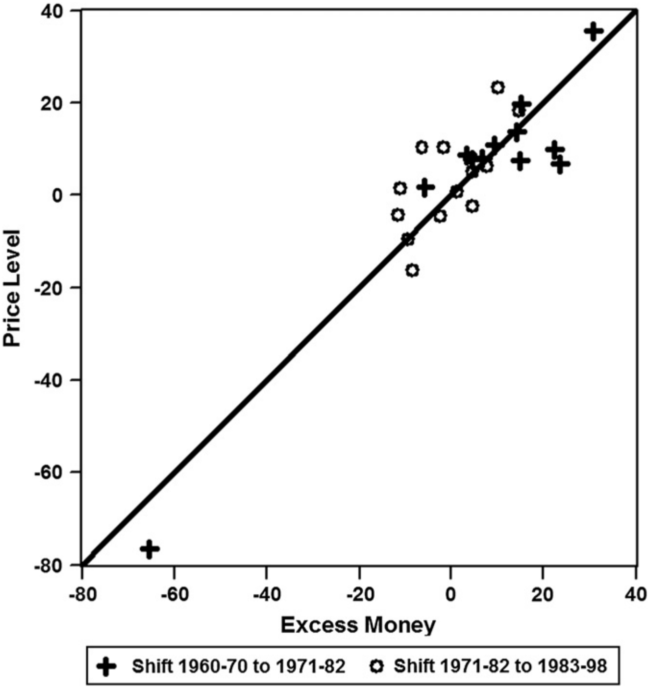

Fig. 4. Growth shifts in consumer prices vs. growth shifts in excess money across 13 other countries. Figures plotted in the charts are shifts in the rates of growth of the variables between the periods 1960–70 and 1971–82 and 1971–82 and 1983–98 for each of the thirteen countries. All data are in per cent terms.

we have put together data for a sample of non-OECD countries for the same time period as for the OECD countries. The criteria that we used to choose this other-country sample were data availability and differences in monetary behavior relative to that of the 20 OECD countries across the three subperiods.

The sample is made up of the following thirteen countries: Iceland, Indonesia, Israel, Jamaica, Korea, Mexico, Nigeria, Paraguay, Philippines, South Africa, Uruguay, Venezuela, and Zimbabwe. Of this group, one country, Indonesia, experienced a substantial decline in excess money growth from period one to period two, in contrast to the increase experienced in all 20 of the OECD countries; two others, Iceland and Israel, experienced increases well above that of any of the OECD countries; and a fourth, Korea experienced rather similar low double-digit rates of excess money growth in both periods. Seven of the remaining eight countries experienced increases between periods two and three, and the eighth, South Africa, an almost imperceptible decrease, in contrast to the substantial decreases experienced throughout most of the OECD sample.

Fig. 4 contains a plot of the growth shifts in the CPIs for these countries against the growth shifts in excess M2. Table 4 reports related regression results. Two things stand out in the chart. The first and most noticeable is the strong positive relationship between the two variables; the second is the greater dispersion of the points about the forty-five degree line than in the comparable chart for the OECD sample. The corresponding regression results are reported in the first regression in Table 4. The estimated coefficient of the excess money variable, like that reported in Table 2, is close to and not significantly different from unity; the estimated intercept is close to and not significantly different from zero. The coefficient of determination is almost the same as that for the regression in Table 2, .82 versus .78; the standard error of the regression is, however, almost four times as large, 8.527 versus 2.223. Reported in the second regression are the results for the two samples combined. To allow for variations in both the intercept and the slope across the two samples we constructed a dummy variable (D13) that took the value of unity for the 13 countries and zero otherwise, entering it both separately and multiplied by the excess money variable, thus allowing both the intercept and the excess money coefficients to vary across the samples. Viewed alone or together, the coefficients associated with the dummy variables are not even close to statistically significant at conventional levels.

4.4. Results with disaggregated data

It was clear from Fig. 1 that at the level of the country-average data plotted in that chart the quantity theory was entirely capable of explaining inflation behavior over our sample period. What was equally clear, however, was that the time-series variation in the data provided very limited information.[14]

Our solution to the problem has been to focus on the two big movements in the time series, the two episodes of regime change that we have termed "natural experiments," and to exploit the cross-section properties of the data to investigate the money–price relationships further. The alternative is to focus directly on the full panel itself. As a check on the results presented above, we ran a series of regressions on the annual data for all 20 countries combined. We summarize this evidence in Table 5.

Shown there are the results of two regressions, one a simple OLS regression of prices on excess money; the other a similar regression but including fixed effects for countries. In both regressions, we used data in the form of logarithmic first differences and included both the contemporaneous value of the excess money variable and three lagged values as regressors. To allow for heteroskedasticity we used White's estimates of the covariance matrix. The excess money coefficients were all statistically different from zero and in both instances summed to roughly 0.70. In broad outline, therefore, these results agree with those presented earlier. Unlike those earlier results, however, these results do not support neutrality.

What accounts for the difference between our earlier findings on the one hand and those reported both in Table 5 and in studies such as Estrella and Mishkin (1997) that obtain out and out negative results? The answer, we suggested earlier, is errors in variables, in the broader sense in which both Estrella and Mishkin and Friedman and Schwartz (1991) use the term.

[14] An additional, problem with the time-series data is simultaneity. Under Bretton Woods, money supplies of non-reserve countries over the long-run, though not the short run (see Darby et al., 1983), were endogenously determined.

Table 4
Results of cross-country regressions for consumer prices, 13-country control group, separately and pooled with the 20 OECD countries.

Dependent variable	Constant	$\Delta(dM2 - dy)$	DC	$DC \times \Delta\ (dM2 - dy)$	Wald test	R^2/SEE
13 countries						
ΔdP	1.100	.991				0.815
	.638	10.319 (0.086)				8.527
Pooled						
ΔdP	0.159	.978	0.941	0.013	0.111	0.826
	0.448	12.579 (0.002)	0.524	0.083		5.522

Note: The symbol Δ represents a first difference operator; thus Δdx is the change in the regime-average rate of growth of x – the growth shift in x from Period 1 to Period 2 and from Period 2 to Period 3 where Period 1 is 1960–1970, Period 2 is 1971–1982 and Period 3 is 1983–1998. DC is a dummy variable that takes the value 1 for the 13 countries and 0 otherwise. All other variables are as defined for Table 1. Conventional t statistics are given directly beneath the coefficient estimates; test statistics for the hypothesis that the coefficient is unity are given in parentheses beneath the coefficient. Standard errors in the pooled regression are based on White's heteroskedasticity-consistent variance matrix. The Wald test for the pooled data is a test of the hypothesis that the coefficients of DC and the product of DC and $\Delta(dM2 - dy)$ are both zero. Critical values at the .10 and .05 levels are 4.61 and 5.99, respectively. The R^2 is adjusted for degrees of freedom.

Table 5
Regressions of prices on excess M2 for OECD countries using first differences of annual data.

Constant	$(dM2 - dy)_t$	$(dM2 - dy)_{t-1}$	$(dM2 - dy)_{t-2}$	$(dM2 - dy)_{t-3}$	Sum	R^2/SEE
1.144	0.237	0.131	0.174	0.170	0.712	0.505
5.172	8.822	4.970	6.047	6.269		3.164
Fixed	0.227	0.124	0.166	0.163	0.680	0.525
Effects	8.305	4.721	5.734	5.948		3.099

Note: The underlying data are logarithmic first differences of annual data in both regressions. White heteroskedasticity-consistent t statistics are given directly beneath the coefficient estimates. The R^2 is adjusted for degrees of freedom. All variables are as defined as in Table 1.

Evidence consistent with this conjecture is presented in Table 6. Shown there are the results of two additional regressions of prices on excess money. In both, the data have the same dimension of logarithmic second differences as the growth shifts that we examined above. In the first of these regressions, the data are logarithmic second differences of the annual data; in the second, they are differences of non-overlapping four-year averages of logarithmic differences of the annual data. In the regression with the annual data, the estimated coefficient of the excess money variable, although statistically significant, is so close to zero as to be almost economically meaningless. In the regression using differences in four-year averaged data, the relationship is much stronger, but still very much weaker than in the comparable regression in Table 2. The estimated coefficient of the excess money variable in this regression, although much larger than in the regression with the annual data, is nevertheless far removed from the coefficient of unity suggested by theory and reported for the comparable regression in Table 2.

Table 6
Regressions of prices on excess M2 for the 20 OECD countries based on second differences of disaggregated data.

Dependent variable	Nobs	Constant	$\Delta(dM2 - dy)$	R^2/SEE
Annual data				
ΔdP	771	−.008	.040	0.009
		−0.097	3.027	2.248
4-year averages				
ΔdP	180	−.064	0.294	0.195
		−0.316	6.753 (0.376)	2.711

Note: The symbol Δ represents a first difference operator. The underlying data are logarithmic second differences of annual data in the first regression and differences of four-year averages of logarithmic first differences in the second. Conventional t statistics are given directly beneath the coefficient estimates; a t statistic to test the hypothesis that the coefficient is unity is given in parentheses beneath the coefficient in the second regression. The R^2 is adjusted for degrees of freedom. All variables are as defined in Table 1.

Averaging the data is of course a classic method of dealing with errors-in-variables problems and the resultant downward bias in coefficient estimates to which they lead. The progressive improvement in the estimates that we obtain as we go from annual to four-year average to regime-average data is what one would expect to find in the presence of such problems.

5. Conclusions

The experience of the United States and other industrial countries during the past four and a half decades with its two sea changes in inflation behavior and the accompanying differences in such behavior among countries is a fertile ground for testing the key propositions of monetary theory. The move to floating exchange rates provided governments with the degree of freedom to pursue divergent and in some instances substantially more expansive monetary policies than under the pegged, but occasionally changing, nominal exchange rates of Bretton Woods. The subsequent shift to less expansive policies and declines in inflation throughout the industrialized world in the early 1980s added to the richness of this experience.

We use panel data for 20 OECD countries over this period to test two key propositions of monetary theory: that inflation is a monetary phenomenon, traceable in the first instance to excess growth in money supply and that the nominal exchange rate as the price of two monies moves directly with the relative excess supplies of the two monies.

Using extremely simple techniques, we find strong support for both propositions. We explain both the major temporal movements in inflation and nominal exchange rate growth and the bulk of the differences in their time paths among countries. In the main, we also are unable to reject the restrictions placed on the coefficients in these two relationships by the theory. In the process, therefore, we also find support for a key tenet of classical monetary theory, the proposition of monetary neutrality – in our context, superneutrality.

Viewed as a long-run proposition, the quantity theory model performs remarkably well. Any difficulties of the model in explaining behavior in the short run fade as the time horizon is lengthened and the focus shifted to major movements. These results, therefore, have implications for the debate surrounding the now ascendant New Keynesian models of the inflation process.

As Nelson (2008) points out, such models became highly problematic as descriptions of long-run inflation. The Taylor-type equations describing central-bank monetary policy in these New Keynesian models reduce to a steady-state Fisher equation and the Phillips-curve equations governing inflation dynamics to an equilibrium condition between actual and anticipated rates of inflation.

The question, therefore, is what determines the anticipated rate of inflation. It cannot be the nominal interest rate since the only control that the central bank exerts over the nominal interest rate in the steady state is by altering the steady-state rate of inflation. If we want to predict the steady-state inflation we are, therefore, left with two options – either introduce a money-demand equation and, hence, appeal to the quantity theory or simply to identify the steady-state rate of inflation as the central bank's target rate. The latter might be defensible in a world in which central-bank policy is fully credible. It makes very little sense in contexts like ours, however, in which steady-state inflation rates have been altered markedly and in which the degree of central-banks' credibility has been both low on average and variable over both time and space.

Left unanswered is the underlying question of what accounts for the monetary fluctuations that induced the major movements in inflation in these countries. Taylor (2002) in his overview of the period considers various alternatives and concludes that a large part of the initial problem was the intellectual failings of the naive Phillips-curve model.[15] Correspondingly, he attributes the lowering of inflation to changed procedures for conducting monetary policy that are "more rule-like or systematic"

[15] Sargent (1999) makes a similar argument. See Boschen and Weise (2002) for evidence supporting this interpretation. Ireland (1999), among others, presents evidence supporting an alternative time-consistency explanation of policy. Nelson (2004) argues for what he terms the "monetary neglect hypothesis." Meltzer (2006), we believe rightly, also stresses the additional role played by political factors and the changed views of the American electorate vis-à-vis the relative economic harm of unemployment and inflation.

and to a "diffusion of ideas and experience about monetary policy" that spurred and otherwise enabled policymakers to implement less-inflationary monetary policy. To the extent that Taylor's conjectures are correct, the results reported here become all the more important, serving as an additional reminder of the potential harm that can result from ignoring the long-standing implications of classical monetary theory.

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