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INTERNATIONAL EVIDENCE ON THE DEMAND FOR MONEY

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Abstract—One of the current questions in the literature on the demand for money is whether the adjustment of actual to desired money holdings is in nominal or real terms. This paper describes a simple procedure that can be used to test the nominal against the real hypothesis. The test is carried out for 27 countries. The paper also tests the structural stability of the demand for money equations and the correctness of the dynamic specification.

The results are strongly in favor of the nominal adjustment hypothesis. There is, however, some evidence of moderate structural instability before and after 1973. The instability does not affect the conclusion that the nominal adjustment hypothesis dominates the real adjustment hypothesis.

I. Introduction

ONE of the current questions in the literature on the demand for money is whether the adjustment of actual to desired money holdings is in nominal or real terms.[1] This paper describes a simple procedure that can be used to test the nominal against the real hypothesis. The test is carried out for 27 countries. The paper also tests the structural stability of the demand for money equations and the correctness of the dynamic specification.

II. The Model and Test

The typical demand for money model begins by postulating that the long-run desired level of real money balances (M_t^*/P_t) is a function of real income (y_t) and a short-term interest rate (r_t). The equation is usually specified in log form. The functional form used here is

$$\log(M_t^*/P_t) = \alpha + \beta \log y_t + \gamma r_t. \tag{1}$$

The log form has been used except for the interest rate. Interest rates can at times be quite low, and it may not be sensible to take the interest rate variable to be in log form. If, for example, the interest rate rises from 0.02 to 0.03, the log of the interest rate rises from -3.91 to -3.51, which is a change of 0.40. If, on the other hand, the interest rate rises from 0.10 to 0.11, the log of the rate rises from -2.30 to -2.21, which is only a change of 0.09. One does not necessarily expect a one percentage point rise in the interest rate to have four times the effect on the log of desired money holdings when the change is from a base of 0.02 than when it is from a base of 0.10. It may be a better approximation simply to use the level of the interest rate in an equation like (1) instead of the log of the rate, and this has been done here. Results are, however, presented below for both the level and log specifications.

If the adjustment of actual to desired money holdings is in real terms, the adjustment equation is

$$\begin{aligned}&\log(M_t/P_t) - \log(M_{t-1}/P_{t-1})\\ &= \lambda[\log(M_t^*/P_t) - \log(M_{t-1}/P_{t-1})] + \epsilon_t.\end{aligned} \tag{2}$$

If the adjustment is in nominal terms, the adjustment equation is

$$\log M_t - \log M_{t-1} = \lambda(\log M_t^* - \log M_{t-1}) + \mu_t. \tag{3}$$

Combining (1) and (2) yields

$$\begin{aligned}\log(M_t/P_t) &= \lambda\alpha + \lambda\beta \log y_t + \lambda\gamma r_t\\ &\quad + (1-\lambda)\log(M_{t-1}/P_{t-1}) + \epsilon_t.\end{aligned} \tag{4}$$

Combining (1) and (3) yields

$$\begin{aligned}\log(M_t/P_t) &= \lambda\alpha + \lambda\beta \log y_t + \lambda\gamma r_t\\ &\quad + (1-\lambda)\log(M_{t-1}/P_t) + \mu_t.\end{aligned} \tag{5}$$

Equations (4) and (5) differ in the lagged money term. In (4), which is the real adjustment specification, M_{t-1} is divided by P_{t-1}, whereas in (5),

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[1] The seminal paper by Chow (1966) used the real adjustment process. Goldfeld (1973, 1976) used both, but ended up focusing on the nominal process. Recent papers include Hafer (1985), Hafer and Hein (1980), Hwang (1985), Milbourne (1983), Spencer (1985), and Thornton (1985, 1986). A recent survey of demand for money equations is in Judd and Scadding (1982).

which is the nominal adjustment specification, M_{t-1} is divided by P_t.

A test of the two hypotheses is simply to put both lagged money variables in the equation and see which one dominates. If the real adjustment specification is correct, $\log(M_{t-1}/P_{t-1})$ should be significant and $\log(M_{t-1}/P_t)$ should not, and vice versa if the nominal adjustment specification is correct. This test may, of course, be inconclusive in that both terms may be significant or insignificant. In the present case, however, as will be seen, the test is rarely inconclusive.

One must be concerned in the estimation of (4) and (5) about the possible endogeneity of y_t, r_t, and P_t. Because of this, the equations have been estimated by two stage least squares (2SLS). The first stage regressors that were used are mentioned in the next section. This estimation work is based on the assumption that M_t is an endogenous variable. If M_t were set exogenously by the monetary authority, then the demand for money equation should not be estimated by 2SLS with M_t on the left hand side. In this case r_t should be on the left hand side, with only y_t and P_t as endogenous explanatory variables.

It may also be the case that the error terms are serially correlated, and, as discussed in the next section, this has been taken into account in the estimation. The equations have been estimated in per capita terms, which means that M_t has been divided by POP_t and M_{t-1} has been divided by POP_{t-1}, where POP is the population of the country.

III. The Data and Results

The data that have been used are part of my multicountry model (Fair (1984)). The data are quarterly. Money demand equations have been estimated for 27 countries. The non U.S. data are from the International Financial Statistics of the IMF except for the data on GNP for the OECD countries, which are data from the OECD. For each country except the United States the variables are as follows. M is the money supply, seasonally adjusted when available. r is a short-term interest rate. The interest rate that seemed to correspond most closely to short-run money market conditions was chosen for each country. In a few cases the only short-term interest rate available was the discount rate, and so this rate had to be used. y is real GNP, and P is the GNP deflator. In some cases quarterly GNP data were not available, and in these cases quarterly data were constructed by interpolation. The industrial production index was typically used as the quarterly interpolation variable. POP is the population of each country. The data on population are annual, and quarterly data were constructed by assuming that the change in population in each of the four quarters of the year is the same.[2]

The money demand equations for the United States are part of my U.S. model (also in Fair (1984)). There are three relevant equations: an equation explaining the demand for money by households, an equation explaining the demand for money by firms, and an equation explaining the demand for currency. (Money includes demand deposits and currency.) The data on demand deposits and currency are from the Flow of Funds Accounts. They are *end-of-quarter* data. y for the household equation is real disposable income, and y for the firm and currency equations is the real level of sales. r for the equations is the after-tax three-month Treasury bill rate.

All equations include a constant term. The non U.S. equations also include three seasonal dummy variables. Most of the GNP data are not seasonally adjusted for countries other than the United States, and some of the money data are also not seasonally adjusted. The seasonal dummy variables are meant to pick up unaccounted for seasonal effects.

The first set of results is presented in table 1. Except for four countries, the equations have been estimated by 2SLS.[3] The first stage regressors used for each country are the main predetermined variables in my multicountry model for that country. About 18 first stage regressors per country were used. Each equation was first estimated under the

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[2] See Fair (1984), appendix B, for a complete description of the data. The data have been updated for purposes of this paper. The sample period listed in table 1 below for each country shows the period over which the data were collected for that country. The sample periods begin four quarters after the quarter for which data on all relevant variables are available. They end at the latest available data. In Fair (1984) all the GNP data were taken from the IMF. For this paper, as noted above, the GNP data for the OECD countries have been taken from the OECD.

[3] The four countries are Turkey, Colombia, India, and Pakistan. The sample periods seemed too short for these countries for the use of 2SLS to make much sense. The equations for these countries were estimated by ordinary least squares.

TABLE 1.—ESTIMATES OF THE MONEY DEMAND EQUATIONS WITH BOTH LAGGED MONEY VARIABLES
DEPENDENT VARIABLE IS $\log(M_t/(POP_t P_t))$

	First $\hat{\rho}$	Second $\hat{\rho}$	$\log(y_t/POP_t)$	r_t	Real Adj.	Nominal Adj.	DW	SE	R^2	Sample	$\log r_t$	SE
Canada	−0.157	0	0.071	−0.0038	−0.72	1.66	2.26	.0282	.957	621–854	−0.036	.0281
	(1.52)		(2.88)	(2.37)	(1.45)	(3.31)					(2.77)	
Japan	0.000	0	0.084	−0.0050	1.19	−0.29	1.93	.0230	.993	661–854	−0.040	.0230
	(0.03)		(1.32)	(3.25)	(2.76)	(0.61)					(3.34)	
Austria[b]	0.237	0	−0.007	0.004	−0.29	1.26	1.60	.0223	.956	651–861	0.022	.0224
	(1.91)		(0.29)	(1.55)	(1.15)	(4.78)					(1.52)	
Belgium	−0.266	−0.226	0.057	−0.0048	0.54	0.33	2.05	.0187	.904	611–844	−0.030	.0186
	(2.62)	(2.62)	(3.84)	(5.09)	(2.01)	(1.17)					(5.07)	
Denmark	−0.274	0	0.270	−0.0031	0.33	0.52	2.34	.0376	.874	691–844	−0.029	.0375
	(1.97)		(2.30)	(1.71)	(0.55)	(0.90)					(1.69)	
France	−0.164	0	0.094	−0.0022	0.24	0.49	2.20	.0215	.868	641–854	−0.027	.0212
	(1.36)		(3.51)	(1.71)	(0.55)	(1.08)					(2.29)	
Germany	0.114	0	0.343	−0.0053	−0.03	0.74	1.77	.0129	.992	691–854	−0.036	.0127
	(0.81)		(4.76)	(5.96)	(0.10)	(2.40)					(6.12)	
Italy	0.008	0	0.130	−0.0035	0.13	0.79	1.99	.0185	.934	711–853	−0.030	.0195
	(0.06)		(1.81)	(2.59)	(0.46)	(2.43)					(1.82)	
Netherlands	−0.063	0	0.392	−0.0083	−0.34	0.79	2.03	.0176	.978	611–844	−0.028	.0193
	(0.53)		(6.99)	(5.65)	(1.56)	(3.24)					(3.60)	
Norway	−0.727	−0.727	0.087	−0.0024	0.19	0.76	1.97	.0347	.962	611–844	−0.018	.0349
	(10.13)	(10.13)	(2.13)	(1.52)	(0.60)	(2.36)					(1.37)	
Sweden	0.527	0.527	1.213	0.0076	−1.29	1.05	2.13	.0227	.943	711–824	0.019	.0238
	(3.58)	(3.58)	(5.00)	(2.35)	(4.29)	(2.89)					(1.66)	
Switzerland	−0.116	0	0.050	−0.0097	1.45	−0.57	2.16	.0312	.881	611–843	−0.039	.0304
	(1.07)		(1.18)	(2.57)	(1.68)	(0.65)					(2.32)	
U.K.	−0.377	−0.377	0.118	−0.0048	0.25	0.69	1.87	.0225	.927	581–861	−0.043	.0220
	(4.31)	(4.31)	(7.00)	(4.93)	(1.49)	(4.22)					(5.49)	
Finland	−0.108	0	0.651	−0.0082	0.26	0.26	2.09	.0415	.912	711–854	−0.090	.0414
	(0.66)		(3.79)	(1.77)	(0.69)	(0.68)					(1.56)	
Greece[b]	−0.490	−0.490	0.169	−0.0011	−0.12	0.99	2.00	.0391	.988	611–844	−0.017	.0389
	(5.26)	(5.26)	(2.77)	(1.15)	(0.33)	(2.70)					(1.16)	
Ireland	−0.280	−0.280	0.068	−0.0045	0.15	0.80	1.97	.0307	.927	611–844	−0.049	.0311
	(2.77)	(2.77)	(2.74)	(3.83)	(0.62)	(3.20)					(3.88)	
Portugal[b]	−0.080	0	0.194	−0.0061	0.26	0.51	1.98	.0332	.960	611–834	−0.034	.0334
	(0.60)		(3.14)	(2.60)	(0.77)	(1.32)					(1.87)	
Turkey[a, b]	−0.426	−0.426	0.184	−0.0026	0.10	0.77	2.09	.0503	.941	701–844	−0.095	.0494
	(3.36)	(3.36)	(2.91)	(2.58)	(0.78)	(7.13)					(0.74)	
Australia	0.163	0	0.104	−0.0058	0.21	0.69	1.74	.0226	.938	703–854	−0.061	.0221
	(1.08)		(1.17)	(2.92)	(0.61)	(1.97)					(3.26)	
New Zealand[b]	0.013	0	0.041	−0.0078	−0.030	1.19	1.97	.0339	.977	611–851	−0.076	.0343
	(0.11)		(0.71)	(3.80)	(0.79)	(3.08)					(3.59)	
South Africa	0.077	0	0.070	0.0022	−0.26	1.17	1.82	.0353	.923	621–853	0.011	.0359
	(0.69)		(1.35)	(1.95)	(0.93)	(4.27)					(1.10)	

TABLE 1.—(*Continued*)

	First $\hat{\rho}$	Second $\hat{\rho}$	$\log(y_t/POP_t)$	r_t	Real Adj.	Nominal Adj.	DW	SE	R^2	Sample	$\log r_t$	SE
Colombia[a, b]	−0.244	0	0.034	−0.0009	0.22	0.55	2.24	.0372	.720	711–844	−0.024	.0372
	(1.64)		(0.21)	(0.37)	(0.78)	(1.95)					(0.41)	
Peru[b]	0.008	0	0.120	−0.0016	0.21	0.64	1.90	.0462	.986	711–844	−0.079	.0452
	(0.05)		(0.78)	(1.04)	(0.97)	(3.05)					(2.03)	
India[a]	−0.078	0	0.125	0.0008	0.23	0.58	2.10	.0369	.828	611–811	0.007	.0369
	(0.59)		(1.71)	(0.50)	(1.35)	(3.33)					(0.58)	
Pakistan[a]	−0.136	0	0.036	−0.0019	−0.34	1.28	2.19	.0268	.968	731–842	−0.019	.0267
	(0.91)		(0.47)	(0.51)	(1.48)	(5.22)					(0.59)	
Philippines[b]	0.198	0	0.057	0.0014	0.07	0.80	1.71	.0294	.821	581–802	0.007	.0295
	(1.05)		(2.34)	(0.68)	(0.28)	(2.96)					(0.53)	
U.S. households	−0.121	0	0.051	−0.0026	−0.18	1.13	2.19	.0140	.976	541–862	−0.015	.0139
	(1.02)		(3.58)	(2.22)	(0.70)	(4.19)					(2.67)	
U.S. firms	−0.105	0	0.042	−0.0061	0.27	0.68	2.19	.0237	.940	541–862	−0.020	.0238
	(0.67)		(3.11)	(2.71)	(0.56)	(1.36)					(2.27)	
U.S. currency	−0.366	−0.366	0.057	−0.0015	0.17	0.79	2.08	.0091	.948	541–862	−0.009	.0092
	(4.38)	(4.38)	(8.14)	(3.00)	(1.37)	(6.34)					(2.88)	

Notes: Real adjustment explanatory variable is $\log(M_{t-1}/(POP_{t-1}P_{t-1}))$. Nominal adjustment explanatory variable is $\log(M_{t-1}/(POP_{t-1}P_t))$. t-statistics in absolute value are in parentheses.

[a] Estimation technique is ordinary least squares.

[b] Only discount rate data available for r_t.

assumption of a first order autoregressive error term. If the t-statistic of the estimate of the autoregressive coefficient was less than two in absolute value, the equation was reestimated under the assumption of no autoregressive error term.[4] The column in table 1 labelled "First $\hat{\rho}$" contains the estimate of the autoregressive coefficient from the first regression.[5] The first and second estimates are, of course, the same if the t-statistic of the estimate is greater than two in absolute value.

The center section of table 1 contains the main results. The explanatory variables in each equation include real per capita GNP, the interest rate, the two lagged money variables, a constant, and three seasonal dummy variables. The estimates of the constant and the coefficients of the three dummy variables are not presented in the table to save space. The sample periods are presented in the third-to-last column. The sample period chosen for each country is the longest sample period that could be chosen given the availability of the data.

The last two columns of table 1 present partial results from another regression. This regression is the same as the main regression except that the level of the interest rate has been replaced by the

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[4] This is one way of testing for the presence of an autoregressive error. Provided that one has a consistent estimate of the autoregressive coefficient and its standard error, the t-test is valid asymptotically even if there are endogenous and lagged endogenous variables among the explanatory variables, which is the case in this paper. The equations in the serial correlation case were estimated using the method in Fair (1970).

Even though the Durbin-Watson statistic is biased towards two when there is a lagged dependent variable in the equation, it is still a useful summary statistic. If the DW statistic is not close to two when there is a lagged dependent variable in the equation, there are likely to be serious serial correlation problems with respect to the error term. The DW statistic has thus been presented in tables 1 and 2. For the equations that are estimated under the assumption of a first order autoregressive error term, the summary statistics (including the DW statistic) are for the error term that exists after transformation to eliminate the autoregressive error component.

[5] Note that "First $\hat{\rho}$" does not mean the value of ρ after the first iteration of the iterative process that is used to estimate the equation. It is the value of ρ after convergence for the first regression that was run.

log of the interest rate. The estimate of the coefficient of the log of the interest rate is presented in the penultimate column, and the standard error of the regression is presented in the last column. These results allow one to see the effects of using the log of the interest rate instead of the level.

It should be noted that no "searching" was done for these results. Each equation has the same eight explanatory variables, and the sample periods have not been fiddled with to try to produce some desired result. In what follows a variable will be said to be "significant" if the t-statistic of its coefficient estimate is greater than 2.0 in absolute value.

The results in table 1 provide strong support for the nominal adjustment hypothesis. In 25 of the 29 cases, the nominal lagged adjustment variable dominates the real lagged adjustment variable in the sense of having a higher t-statistic. In 3 cases —Japan, Belgium, and Switzerland—the real variable dominates. In one case—Finland—there is essentially a tie.

There are no cases in table 1 where the coefficient estimates of both lagged money variables are significant and positive. (Both estimates are significant for Sweden, but the real lagged adjustment coefficient is negative.) There are eight equations where both lagged money variables are insignificant: Denmark, France, Switzerland, Finland, Portugal, Australia, Colombia, and the U.S. firm equation. This insignificance is due to the collinearity between the two lagged money variables. When only one variable is included, as in table 2 below, the variable is significant. In all but one of the eight insignificant cases, there is an obvious winner in the sense of one variable having a larger coefficient estimate and t-statistic than the other. (The exception is the tie for Finland.) In some of the cases in table 1 one lagged money coefficient is negative and the other is greater than one. Again, this problem goes away in table 2 when only one variable is included in the equation. The negative coefficients in table 1 all have smaller t-statistics in absolute value than the corresponding t-statistics for the positive coefficients. In summary, then, the test seems to work well. The test discriminates nicely between the two lagged money variables.

Regarding the income and interest rate variables, only the equation for Austria has the wrong sign for both income and the interest rate. None of the other equations have the wrong sign for income; four other equations have the wrong sign for the interest rate, those for Sweden, South Africa, India, and the Philippines. Eight of the twenty-nine equations have significant estimates of the autoregressive coefficient of the error term. All the significant estimates are negative.

The results using the log of the interest rate are in general fairly close to the results using the level. There are four countries, France, Italy, Portugal, and Peru, where one form is significant and the other is not. The log form is significant for France and Peru, and the level form is significant for Italy and Portugal. Although not shown in table 1, the use of the log form resulted in only one switch regarding the dominant lagged money variable, which was for Finland. For Finland the results using the log form favored the nominal adjustment variable over the real adjustment variable, whereas the results using the linear form showed a tie.

A second set of results is presented in table 2. For this set the lagged money variable that was dominated was dropped from the regression and the equation was reestimated.[6] In addition, for the five cases where wrong signs for the interest rate were obtained, the interest rate was dropped.[7]

The results in table 2 are in one sense rather remarkable for macro results, especially given the low quality data for many countries. Of the 29 estimates of the income coefficient, 20 have t-statistics greater than two. Of the 24 estimates of the interest rate coefficient, 16 have t-statistics greater than two in absolute value. All the coefficient estimates of the lagged money variables are significant and less than one.

In another sense, however, the results in table 2 are not that strong. Where the sample period seemed long enough for a given country, a test of the hypothesis that the coefficients are the same before and after the first quarter of 1973 was made. Many of the results in the literature for the United States show an instability of the coeffi-

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[6] The nominal adjustment specification was chosen for Finland because there was slight evidence in favor of it when the log form of the interest rate was used. In this case, however, the data really do not support one hypothesis over the other.

[7] When the interest rate was dropped from the equation for Austria, the coefficient estimate of the income variable became positive (although highly insignificant), and so the income variable was left in the Austrian equation.

TABLE 2.—ESTIMATES OF THE MONEY DEMAND EQUATIONS WITH BETTER LAGGED MONEY VARIABLE
DEPENDENT VARIABLE IS $\log(M_t/(POP_tP_t))$

	$\hat{\rho}$	$\log(y_t/POP_t)$	r_t	Real Adj.	Nominal Adj.	DW	SE	R^2	df	χ^2_A	Real Adj.	Nominal Adj.	Sample	χ^2_B
Canada	0	0.059	−0.0044	—	0.94	2.15	.0282	.957	7	19.06[e]	1.00	−0.14	731–854	1.42
		(2.55)	(2.86)		(26.76)						(0.82)	(0.11)		
Japan	0	0.053	−0.0044	0.93	—	1.97	.0228	.993	7	59.36[e]	0.87	−0.27	731–854	7.33[d]
		(1.37)	(3.60)	(27.21)							(2.85)	(0.77)		
Austria[b]	0	0.002	—	—	0.96	1.60	.0225	.955	6	15.98[d]	−0.46	1.26	731–861	0.15
		(0.08)			(20.11)						(1.27)	(3.51)		
Belgium	−0.240	0.057	−0.0050	0.86	—	2.06	.0193	.898	8	24.51[e]	−0.54	1.38	731–844	0.40
	(2.33)	(3.65)	(5.14)	(22.73)							(1.53)	(4.19)		
Denmark	0	0.267	−0.0030	—	0.84	2.36	.0370	.878	—	—	—	—	—	4.97
		(2.32)	(1.70)		(11.25)									
France	0	0.096	−0.0019	—	0.73	2.16	.0215	.868	7	45.31[e]	−0.86	1.33	731–854	3.17
		(3.58)	(1.64)		(10.52)						(2.11)	(3.23)		
Germany	0	0.345	−0.0053	—	0.71	1.76	.0128	.992	7	5.83[c]	—	—	—	3.50
		(5.10)	(6.71)		(13.92)									
Italy	0	0.113	−0.0031	—	0.94	1.93	.0188	.932	—	—	—	—	—	2.86
		(1.83)	(2.97)		(19.93)									
Netherlands	0	0.407	−0.0086	—	0.43	2.01	.0183	.977	7	16.26[d]	0.16	0.31	731–844	1.59
		(7.15)	(5.77)		(5.45)						(0.31)	(0.60)		
Norway	−0.730	0.087	−0.0023	—	0.95	1.97	.0347	.962	8	23.66[e]	−0.67	1.46	731–844	0.08
	(10.27)	(2.15)	(1.47)		(22.96)						(1.41)	(3.29)		
Sweden	−0.468	0.49	—	—	0.65	1.54	.0238	.937	—	—	—	—	—	2.44
	(3.48)	(3.21)			(5.68)									
Switzerland	0	0.040	−0.0079	0.89	—	2.21	.0299	.891	7	16.89[d]	1.60	−0.78	731–843	1.31
		(1.06)	(3.22)	(19.39)							(1.88)	(0.92)		
U.K.	−0.344	0.119	−0.0043	—	0.93	1.85	.0223	.927	8	16.98[d]	0.44	0.49	731–861	2.59
	(3.89)	(6.97)	(4.62)		(40.42)						(2.12)	(2.37)		
Finland	0	0.642	−0.0077	—	0.51	2.14	.0413	.912	—	—	—	—	—	0.94
		(3.76)	(1.70)		(4.66)									
Greece[b]	−0.495	0.163	−0.0013	—	0.87	2.00	.0389	.988	8	5.93	—	—	—	5.26
	(5.34)	(2.80)	(1.45)		(18.11)									
Ireland	−0.250	0.074	−0.0045	—	0.95	1.96	.0310	.926	8	11.66	—	—	—	0.97
	(2.50)	(3.15)	(3.72)		(37.31)									
Portugal[b]	0	0.181	−0.0051	—	0.81	2.05	.0322	.962	7	23.98[e]	−0.15	0.62	731–834	2.97
		(3.14)	(2.70)		(11.65)						(0.52)	(2.04)		
Turkey[a,b]	−0.412	0.211	−0.0029	—	0.85	2.07	.0505	.941	—	—	—	—	—	11.88[e]
	(3.28)	(4.04)	(3.22)		(16.81)									
Australia	0	0.094	−0.0055	—	0.90	1.75	.0227	.937	—	—	—	—	—	0.63
		(1.07)	(2.84)		(18.52)									
New Zealand[b]	0	0.018	−0.0083	—	0.88	2.03	.0337	.977	7	21.83[e]	0.08	0.75	731–851	1.20
		(0.36)	(4.27)		(29.61)						(0.17)	(1.42)		
South Africa	0	0.095	—	—	0.96	1.79	.0357	.922	6	22.54[e]	0.15	0.85	731–853	0.06
		(2.44)			(33.00)						(0.55)	(3.20)		

TABLE 2.—(*Continued*)

	$\hat{\rho}$	$\log(y_t/POP_t)$	r_t	Real Adj.	Nominal Adj.	DW	SE	R^2	df	χ^2_A	Real Adj.	Nominal Adj.	Sample	χ^2_B
Colombia[a, b]	0	0.036	−0.0008	—	0.75	2.22	.0374	.718	—	—	—	—	—	4.10
		(0.22)	(0.34)		(8.30)									
Peru[b]	0	0.156	−0.0013	—	0.83	1.86	.0463	.986	—	—	—	—	—	1.13
		(1.04)	(0.89)		(12.12)									
India[a]	0	0.146	—	—	0.80	2.01	.0374	.823	6	13.11[d]	0.16	0.57	731–811	2.35
		(2.10)			(11.10)						(0.56)	(1.94)		
Pakistan[a]	0	0.077	−0.0011	—	0.92	1.94	.0274	.967	—	—	—	—	—	0.18
		(1.05)	(0.28)		(16.69)									
Phillipines[b]	0	0.067	—	—	0.85	1.69	.0298	.817	6	5.19	—	—	—	0.48
		(3.02)			(13.16)									
U.S. households	0	0.048	−0.0030	—	0.94	2.16	.0140	.976	4	6.04	—	—	—	8.30[d]
		(3.51)	(3.03)		(36.60)									
U.S. firms	0	0.042	−0.0055	—	0.96	2.19	.0237	.940	4	8.53	—	—	—	0.57
		(3.09)	(2.85)		(39.83)									
U.S. currency	−0.348	0.059	−0.0012	—	0.95	2.06	.0091	.948	5	9.35	—	—	—	3.80
	(4.15)	(8.44)	(2.65)		(59.25)									

Notes: Real adjustment explanatory variable is $\log(M_{t-1}/(POP_{t-1}P_{t-1}))$. Nominal adjustment explanatory variable is $\log(M_{t-1}/(POP_{t-1}P_t))$. *t*-statistics in absolute values are in parentheses.

χ^2_A: Test of hypothesis that coefficients before and after 1972IV are the same.

χ^2_B: Test of hypothesis that coefficients of $\log(y_{t-1}/POP_{t-1})$ and r_{t-1} are zero. Degrees of freedom equal two except for the five countries where r_t is not in the equation. For these five countries there is one degree of freedom.

Critical χ^2 values for 1, 2, and 4–8 degrees of freedom are, respectively, 3.84, 5.99, 9.49, 11.07, 12.59, 14.07, and 15.51 at the 5% confidence level and 6.63, 9.21, 13.28, 15.09, 16.81, 18.48, and 20.09 at the 1% level.

[a] Estimation technique is ordinary least squares.

[b] Only discount rate data available for r_t.

[c] Possible structural break point taken to be 1975IV rather than 1972IV.

[d] Hypothesis rejected at the 5% level.

[e] Hypothesis rejected at the 1% level.

cients before and after 1973, and so it is of interest to test for this. A chi-squared test was used.[8]

Twenty tests were performed in table 2. The hypothesis of structural stability was rejected at the 1% level in 8 cases and at the 5% level in 5 cases. It was not rejected in 7 cases. Interestingly enough, the hypothesis was not rejected for any of the 3 U.S. equations. These results thus indicate some lack of structural stability. In only 2 of the rejected cases, however, were the chi-squared values extremely large—Japan and France. In a loose sense one might say that the lack of stability seems moderate.

When the hypothesis of structural stability was rejected for a country, the equation was estimated for the second subperiod (1973I to the end of the data) with both lagged money variables included. In other words, the test of the real versus nominal adjustment hypotheses was made for the second subperiod. Partial results from these regressions are presented in table 2. In only two cases, Canada and Belgium, were the results reversed from those in table 1 for the whole sample period. For Canada

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[8] The chi-squared test is as follows. The 2SLS objective function is $u'Z(Z'Z)^{-1}Z'u = S$, where u is a $T \times 1$ vector of error terms and Z is a $T \times K$ vector of first stage regressors. u is a function of the coefficients and the endogenous and predetermined variables in the equation. In general u is a nonlinear function of both coefficients and variables. If u is taken to be the error term after transformation to eliminate first order serial correlation, then u is a nonlinear function of the coefficients *inclusive of* the serial correlation coefficient. In this setup the serial correlation coefficient is treated as a structural coefficient. This is the procedure followed here.

Now, consider some set of restrictions on the coefficients. Assume that there are k restrictions. Let S^* be the value of S when the restrictions are not imposed, and let S^{**} be the value of S when the restrictions are imposed. Let $\hat{\sigma}^2$ be the estimate of the variance of the error term in the unrestricted case. Then $(S^{**} - S^*)/\hat{\sigma}^2$ is asymptotically distributed as chi-squared with k degrees of freedom. (See Andrews and Fair (1987) for a general proof.)

For the test in table 2 the restricted case is where the coefficients before and after 1973I are the same. The unrestricted case is where the coefficients differ in the two subperiods.

the results switched from the nominal to the real hypothesis, and for Belgium they switched from the real to the nominal hypothesis. The support for the nominal adjustment hypothesis is thus not changed by restricting the analysis to the period after 1973.

A final test of the money demand equations was made, which is a test of the dynamic specification. Consider a model in which a variable y_t is postulated to be a function of a vector of variables z_t. Hendry, Pagan, and Sargan (1984) show that the model

$$y_t = \beta_1 z_t + \beta_2 z_{t-1} + \beta_3 y_{t-1} + \epsilon_t$$

is quite general in that it encompasses many different types of dynamic specifications. The present demand for money equations are based on the implicit assumption that β_2 is zero. This specification can thus be tested against the more general Hendry et al. specification by including the variables in z_{t-1} in the equation and testing whether they are significant. The two variables in this case are $\log(y_{t-1}/POP_{t-1})$ and r_{t-1}. These two variables were added to the equations in table 2, and a chi-squared test of the hypothesis that the coefficients of the two variables are zero was performed. The chi-squared values are presented in table 2. The test has two degrees of freedom except for the five countries where the interest rate is excluded, where it has one degree of freedom. (For countries where the interest rate is excluded, r_{t-1} was not added to the equation.)

The equations did much better on this test than they did on the first test. The hypothesis was rejected at the 1% level in only one case—Turkey—and it was rejected at the 5% level in only two cases—Japan and the U.S. equation for households. The dynamic specification of the money demand equations thus seems reasonable.

IV. Conclusion

The results of estimating money demand equations for 27 countries in this paper are strongly in favor of the nominal adjustment hypothesis. The equations themselves are quite good in terms of the number of coefficient estimates that are of the right sign and that are significant. Also, the equations stand up well when tested against a more general dynamic specification. There is, however, some evidence of structural instability before and after 1973, although the instability is generally moderate. The instability does not affect the conclusion that the nominal adjustment hypothesis dominates the real adjustment hypothesis.

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