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THE DEMAND FOR MONEY IN BRAZIL REVISITED

José W. Rossi*

1 – INTRODUCTION

Money demand specifications based on the Baumol-Tobin inventory-theoretic approach have been widely used in applied studies. The good estimates obtained by Goldfeld (1973) for the USA, in particular, contributed much to the popularity of this type of specification. In fact, the notion of a stable demand for money was quite undisputable in the early 1970s. Views on such a matter were soon to be changed, however, for a subsequent work by Goldfeld (1976) indicated that his previously estimated equation was systematically over-predicting real money balances in the USA after 1973. Much of the post-1976 research efforts in this subject-area in the USA were thus aimed at accounting for the "missing money".

The importance of a stable monetary aggregate could not be over-emphasized, for the success of a given monetary policy depends essentially on such a matter. Thus, the search for a stable money demand has become an important and challenging topic in applied macroeconomics.

According to theories advanced by Gurley and Shaw (1960), the proliferation of money substitutes has increased the interest-elasticity of money balances over time, affecting then the ability of the central bank to change economic conditions through open market operations. In fact, suggestions have been

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* Economic Research Institute (IPEA) and Universidade Federal do Rio de Janeiro. I would like to thank Flavia de Campos Mello for preparing the data and Marcia Pimentel Pinto Azeredo Bigarel for the computing work.

made that money demand instability in the USA and elsewhere is due to financial innovations of recent years. Accordingly, the substitutability between M1 (narrowly defined monetary aggregate) and non-M1 financial assets included in M2 (broad money) has weakened the link of the former with economic activity. As a consequence some researchers have suggested that M2 should perhaps replace M1 as a proper monetary aggregate. However, even if the level of economic activity were more closely related to M2, there still remains the fact that M2 is more difficult to control. Another problem with the use of M2 is that it involves components as different as currency and time deposits. In any case, recent evidence for Brazil (see Guilhoto (1985)) indicates that it makes little difference which of these aggregates is used in the country's demand for money. Thus, this analysis uses only narrowly defined money.

This paper should be seen as an extension of the work by Cardoso (1983) whose estimates for Brazil are relative to the period 1966(i)–1979(iv). Since incentives for financial innovations have presumably become more conspicuous in the 1980s (see Cysne (1985)), we thought it would be appropriate to extend that analysis to include the recent past, namely period 1966(i)–1985(iv), and testing along for structural change in the money demand of the 1980s. Some of the model specifications considered here are, however, new as far as application to Brazil goes.

The organization of the paper is as follows. In the next section we discuss the question of money demand specification. In section 3 the data are described and the estimates analysed. Final remarks are in section 4.

2 — MODEL SPECIFICATION

A first specification for the demand for money is usually obtained from the Baumol-Tobin inventory-theoretic approach. More precisely, from the total nominal inventory cost of nominal money balance, given by

$$C_t = \frac{r_t M_t}{2} + \frac{b_t T_t}{M_t} \qquad (1)$$

(where M is the nominal money balance held, T is the nominal value of transactions, r is the nominal interest rate or opportunity cost of holding money, and b is the cost of converting between money and interest bearing assets; index t stands for time period) one obtains, after the minimization of the equation with respect to real balance:

$$\frac{M}{P} = \left[2b(T/P)/Pr\right]^{1/2}, \qquad (2)$$

where P stands for the price level; subindex t has been omitted. This is essentially a transactionary demand for money. An estimable form of equation (2), which takes into account speculative balances as well, is

$$\log \frac{M}{P} = \alpha + \beta_1 \log \frac{T}{P} + \beta_2 \log r + \mu, \qquad (3)$$

where the real transactions term b/P has been subsumed in the intercept due to the lack of reliable transactions cost index; thus this specifications assumes implicitly that b/P has remained unchanged over time. 1/

1/ Swofford and Whitney (1985) argue that this is somewhat arbitrary, for one could as well assume that the nominal transactions cost had remained constant over time; this requires that "time-saving innovations in transactions must offset any rise in broker fees and the value of time". In such a case, variable Pr should replace variable r in equation (3). The authors found that this alternative specification gives a more stable money demand equation for the USA. This was not the case for Brazil, however, as we could verify from our data.

Many variants of the basic specification given in (3) have in practice been used over the years and across countries. These generally involve either a) more than one interest rate variable, in order to take into account the possibility of substitution between money and other non-monetary financial assets with various degrees of liquidity; b) inclusion of the inflation rate among the explanatory variables, in case commodities are viewed by asset-holders as an alternative to holding money balances; c) use of either actual income, permanent income or wealth level in the place of the transactions variable, T; d) alternative monetary aggregates (i.e., M1, M2, etc.); e) use of either a lagged dependent variable among the explanatory variables to reflect a partial adjustment process of money balances, or more flexible adjustment structures in line with the Almon distributed-lag model; or f) use of some variable for the expectation of an exchange rate devaluation, in order to allow for the possibility of substitution between domestic and foreign assets. [2/]

Some of the above mentioned aspects are taken into account in the specifications that follow. In addition of using most of Cardoso's (1983) specifications we also consider here some new ones, such as the inclusion of a variable for the expectation of an exchange rate devaluation (or measure of economic uncertainty, as we shall argue below), or the use of a dummy variable to allow for a possible downward shift of the demand for money in the 1980s. Furthermore, in order to distinguish between short- and long-run elasticities we use both Almon-lag technique and a new technique proposed by Mitchell and Speaker (1986) called the polynomial inverse lag, as well as a partial adjustment model. As for the latter, if the long-run or desired real money holdings is given, for example, by

$$\log m_t^* = \alpha + \beta_1 \log y_t + \beta_2 \log r_t + \beta_3 \log \dot{p}_t \qquad (4)$$

(where $m^* = \frac{M^*}{P}$ is the desired real money balance, y is the real

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[2/] On some of these questions see, for example, Laidler (1977).

income, r is the nominal interest rate and $\dot{p}$ is the inflation rate) whereas the adjustment to the desired level of real money holdings is given by

$$\frac{m_t}{m_{t-1}} = \left(\frac{m_t^*}{m_{t-1}}\right)^{\delta} \qquad (5)$$

(where δ is the factor of adjustment) then the short-run demand for money is

$$\log m_t = \delta\alpha + \delta\beta_1 \log y_t + \delta\beta_2 \log r_t + \delta\beta_3 \log \dot{p}_t + (1-\delta) \log m_{t-1}. \qquad (6)$$

Thus, once the short-run elasticities are divided by the adjustment factor, δ, one obtains the long-run elasticities of (4). Equation (6) implies an identical geometric distributed lag for all explanatory variables (except the lagged dependent variable); see note 10. The Almon-lag technique allows a more flexible and independent lag structure for the various explanatory variables. But a finite lag length has to be set prior to the estimation, as well as the degree of the polynomial. The polynomial inverse lag technique is an attempt to eliminate the first of these restrictions, for it uses an infinite lag structure. We give further details of the technique in the next section.

3 — DATA AND RESULTS

Quarterly data were used in the estimation, the period analysed being 1966(i)—1985(iv). Data up to 1979(iv) are from Cardoso (1983), except those for the exchange rate (both official and black market) [3]. The updating of Cardoso's series was done using whenever possible her same sources.

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[3] The official exchange rate is from Bulletin do Banco Central (various issues) and the black market exchange rate up to 1983 is from Pechman (1983), and after that it was obtained from the periodicals Exame and Bolsa (various issues).

The estimates of the basic specifications are in Table 1. A set containing six equations is shown for each specification from A through C. The first, third and fifth equations of each set were estimated by Ordinary Least Square and refer to periods 1966(i)–1979(iv), 1980(i)–1985(iv) and 1966(i)–1985(iv), respectively. The second, fourth and sixth equations, on the other hand, were estimated after making correction for first-order autocorrelation in the residuals (Cochrane-Orcutt correction method - CORC) and refer to the same periods as in the preceding cases. This partition of the data was used in order to test for structural change of the model in the 1980s, a period characterized by both higher rates of inflation and lower output growth and also presumably with much financial innovation . [4/]

A casual look at the results for equations of set A, in Table 1, indicates much fluctuation in the values of the parameters both across periods and across methods of estimation within the same period. The latter result, in particular, is probably due to model misspecification. A point that should be noted, in any case, is that the inflation variable (we are in fact using Cardoso's variable, namely the rate of inflation plus unity) turns out to be statistically significant in the equation for the extended period 1966(i)–1985(iv). This is of some interest here for Cardoso (1983) found that such a varibale did not belong into the money demand equation for period 1966(i)–1979(iv) a finding that, in fact, motivated a paper by Darrat (1985) in which it is argued that Cardoso's results were merely due to model misspecification. After using Almon distributed-lag technique, Darrat concluded that the inflation variable was indeed statistically significant in the money demand equation. Darrat's variable is the rate of inflation itself, which is not the same variable as Cardoso's. By using

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4/ The inflation rate per quarter increased from the 6.7 per cent average of period 1966(i)–1979(iv) to 25.2 per cent for period 1980(i)–1985(iv); the rate of growth per quarter fell from the 2.1 per cent average to 0.7 per cent in the same period. As far as financial innovations go two examples can be given, namely the reduction (from three months to one month) in the required time for receiving interest earnings on savings account, and a rapid increase on the demand for government bonds, which implied increasing liquidity; on these points see Cysne (1985).

TABLE 1

ESTIMATES OF MONEY DEMAND FOR BRAZIL WITH ALTERNATIVE SPECIFICATIONS

Equation-Estimation Technique		Period	Const.	Ly	Lr	$L\dot{p}$	Lm_{-1}	Le	D	$\bar{R}^2$	DW	Durbin-h	ρ	Chow's Test
	1. OLS	1966(i) – 1979(iv)	1.430(9.7)	0.946(46.2)	-0.322(- 7.8)	-0.273(-0.9)				0.978	0.71			
	2. CORC	1966(i) – 1979(iv)	3.363(5.1)	0.452(4.2)	-0.207(- 2.1)	-0.382(-1.6)				0.989	1.83		0.97	
A	3. OLS	1980(i) – 1985(iv)	7.062(7.7)	-0.104(- 0.6)	-0.485(- 9.6)	-0.776(-1.5)				0.942	1.63			
	4. CORC	1980(i) – 1985(iv)	7.071(7.1)	-0.114(- 0.6)	-0.477(- 8.2)	-0.769(-1.4)				0.935	1.67		0.10	
	5. OLS	1966(i) – 1985(iv)	1.826(9.8)	0.961(27.5)	-0.438(-11.1)	-1.201(-3.2)				0.935	0.87			
	6. CORC	1966(i) – 1985(iv)	4.530(6.0)	0.123(1.0)	-0.171(- 2.6)	-0.667(-2.5)				0.975	1.71		0.97	25.8 3.8
	1. OLS	1966(i) – 1979(iv)	0.436(3.1)	0.354(5.5)	-0.102(- 3.0)	-0.722(-3.8)	0.646(9.4)			0.992	1.73	1.18		
	2. CORC	1966(i) – 1979(iv)	0.643(3.7)	0.500(7.1)	-0.148(- 3.4)	-0.647(-2.8)	0.489(6.6)			0.992	2.12	-0.31	0.37	
B	3. OLS	1980(i) – 1985(iv)	0.969(0.6)	0.263(1.6)	-0.101(- 1.0)	-1.145(-2.9)	0.627(4.1)			0.967	2.17	-0.64		
	4. CORC	1980(i) – 1985(iv)	0.711(0.5)	0.285(2.0)	-0.094(- 1.0)	-1.117(-3.5)	0.654(4.7)			0.966	1.81	0.63	-0.32	
	5. OLS	1966(i) – 1985(iv)	0.365(3.1)	0.310(7:6)	-0.084(- 3.1)	-1.048(-6:2)	0.695(17.4)			0.987	2.15	-0.69		
	6. CORC	1966(i) – 1985(iv)	0.346(3.3)	0.301(8.1)	-0.080(- 3.3)	-1.034(-6.5)	0.706(19.7)			0.987	1.80	0.92	-0.17	0.9 1.5
	1. OLS	1966(i) – 1979(iv)	0.460(3.2)	0.347(5.3)	-0.104(- 3.0)	-0.705(-3.7)	0.647(9.4)	0.043(0.6)		0.992	1.74	1.15		
	2. CORC	1966(i) – 1979(iv)	0.647(3.6)	0.486(6.7)	-0.147(- 3.4)	-0.637(-2.7)	0.500(6.7)	0.030(0.4)		0.992	2.12	-0.54	0.35	
C	3. OLS	1980(i) – 1985(iv)	0.788(0.5)	0.342(2.0)	-0.124(- 1.2)	-1.148(-3.0)	0.599(3.9)	0.117(1.3)		0.967	2.49	-1.81		
	4. CORC	1980(i) – 1985(iv)	0.707(0.5)	0.369(2.9)	-0.137(- 1.7)	-1.085(-4.0)	0.599(4.8)	0.130(2.0)		0.970	2.09	-0.28	-0.48	
	5. OLS	1966(i) – 1985(iv)	0.478(3.6)	0.327(8.0)	-0.107(- 3.6)	-1.006(-6.0)	0.668(15.9)	0.086(1.8)		0.987	2.20	-1.13		
	6. CORC	1966(i) – 1985(iv)	0.459(3.9)	0.320(8:5)	-0.104(- 3.9)	-0.994(-6.4)	0:677(17.8)	0.082(1.9)		0.987	1.81	0.92	-0.19	0.9 2.1
D	CORC	1966(i) – 1985(iv)	0.418(3.5)	0.323(8.7)	-0.096(- 3.6)	-0.930(-5.9)	0.677(18.0)	0.085(2.1)	-0.030(-1.6)	0.988	1.82	0.85	-0.20	
E	CORC	1966(i) – 1985(iv)	4.39 (5.9)	0.152(1.3)	-0.158(- 2.4)	-0.686(-2.6)			-0.097(-1.7)	0.976	1.64		0.97	

The numbers in parenthesis are t-values and ρ is the estimated first-order serial correlation coefficient used in the CORC estimation; y, r, $\dot{p}$ and e are real income, nominal interest rate, inflation rate and the premium on the exchange rate, respectively. L stands for natural logarithm, D is a dummy variable for the 1980s. The dependent variable is the logarithm of the real money demand (i.e., Lm).

Darrat's variable in Cardoso's equation and making correction for first order autocorrelation in the residuals one obtains the following fit for period 1966(i)–1979(iv):

$$Lm = \underset{(5.05)}{3.47} + \underset{(3.89)}{0.423}\, Ly \underset{(-2.19)}{-0.214}\, Lr \underset{(-2.01)}{-0.032}\, L\dot{p}, \; \bar{R}^2 = 0.989;$$ t-values

are in parenthesis. That is, the inflation rate turns out to be statistically significant thus weakening the argument of both Cardoso and Darrat. It is troublesome that such an important matter should depend on how the inflation rate is defined. Most probably this change in results is due to model misspecification.

Difficulties of model misspecification aside, it is clear from the equations in set A that due to the high inflation rates of the 1980s commodities became more viable alternatives to holding money balances. In support of this, notice that the inflation variable is statistically more significant than the real income variable during the period 1980(i)–1985(iv), a result which is the opposite of that for period 1966(i)–1979(iv).[5/] Also, the coefficient of such a variable is much larger in the 1980s than it was in the previous period. These appear to be sensible results. Ideally, one would use here the expected rate of change in the price level. In such a case, the expected change in prices would affect the expected future real value of money balances and would then be an important determinant of the expected rate of return on money itself. By using actual prices change rather than expected prices change in our equation we are in fact assuming perfect foresight [6/].

5/ Due to the lack of quarterly data the updating of Cardoso's constructed GDP series was done by using the same rate of growth as that of the quarterly Industrial Product. In any case, the results did not change much when Cardoso's entire series was replaced by that of the Industrial Product. Also due to the lack of data information the updating of Cardoso's interest rate series was done with the annualised rate of the six-month bill of exchange. Cardoso uses the interest rate on the six-month bill of exchange up to 1970, and starting in 1971 she uses the rates on the one-year bill of exchangé; the source of the interest rates after 1979 is the periodical Exame (various issues).

6/ Alternatively one could assume that, like Cagan (1956), the expected rate of inflation is formed according to the adaptive expectation hypothesis, that is where the expected inflation is measured as a distributed lag function of present and past inflation rates.

At any rate, during times of rapid and highly variable inflation, expectations of the rate of return on money are bound to change most quickly. As a result, at such times the inflation rate will probably have an important direct effect on the demand for money which is over and above its indirect influence via nominal interest rates, as it has been demonstrated by studies on European hyperinflations (see Thomas (1985)).

As the low Durbin-Watson statistics indicate, misspecification is a problem in group A for equations of both period 1966(i)–1979(iv) and the extended period 1966(i)–1985(iv). In fact, parameters changed noticeably after correction for first-order autocorrelation was used; autocorrelation is not a problem, however, for the equation of period 1980(i)–1985(iv). A point also to be noted is that parameter instability, as indicated by Chow's test, is greatly reduced after using correction for autocorrelation.

Equation E is an attempt to capture a possible downward shift in the preceding specified demand for money starting in 1980(i); that is, a dummy variable equal to one is included for period 1980(i)–1985(iv). As the results indicate the shift is statistically significant at the 10% level, having also a sign consistent with the economizing of money balances assumption due to financial innovations. Now the real income variable is no longer statistically significant in the equation. Also to be noted is that the inclusion of the dummy variable apparently did not solve the misspecification problem entirely, for first-order autocorrelation in the residuals remained high (i.e., $\rho = 0{,}965$); the estimates in equation E were thus obtained after correcting for autocorrelation.

The estimates for the money demand based on the partial adjustment model are in group B (and C) of Table 1. Notice that the inclusion of the lagged dependent variable among the explanatory variables contributed appreciably to the stability of the money demand. Also, the Durbin-Watson statistics are now at more acceptable levels. Furthermore, all the coefficients for both period 1966(i)–1979(iv) and period 1966(i)–1985(iv) are statistically

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significant and have the appropriate sign. Once again, the results indicate an increase in the coefficient of the inflation variable over time, the opposite taking place for the coefficient of the real income variable. Interest rate elasticities, however, changed little over time, thus not supporting the theories advanced by Gurley and Shaw (1960) of an increasing interest rate elasticity due to financial innovations which presumably were a prominent feature in Brazil during the first half of the 1980s (see Cysne (1985)).

The estimates in group B give only the short-run elasticities. Since the factor of adjustment (δ) of actual to desired level of money balances is here around one third per quarter, long-run elasticities are then about three times as large as the short-run elasticities[7/]. For ease of comparison both short- and long-run elasticities are shown side by in Table 2. We shall returns to these elasticities below.

The next specification in Table 1 adds a variable for the expectation of an exchange rate devaluation which is here taken as the logarithm of the (premium) ratio of the black market exchange rate to the official exchange rate, both measured as cruzeiros per dollar. A variable for the expectation of an exchange rate devaluation has been used in studies of money demand for other countries mainly in connection with questions of currency substitution (i.e., substitution of the American dollar for domestic currency); references for Canada, for example, can be found in Morothia and Phillips (1982), and estimates for Argentina, Mexico and Uruguay are given in Ramirez-Rojas (1985). We may say that due to rigid exchange controls no firm ground exists for the inclusion of such a variable in the case of Brazil. At any rate, since the so-called premium on the exchange rate is usually taken in this country as an indicator of economic uncertainty we use it in such

7/ This value for δ is similar to that found by Goldfeld (1976) with USA data for period 1952(ii)–1973(iv).

TABLE 2

A COMPARISON OF ESTIMATES OF MONEY DEMAND ELASTICITIES BASED ON EQUATIONS OF TABLE 1.

	EQUATION	PERIOD	Income Elasticity		Interest Rate Elasticity		Inflation Rate Elasticity		Premium of the Exchange Rate Elasticity	
			SR*	LR*	SR	LR	SR	LR	SR	LR
B	1. OLS	1966(i) – 1979(iv)	0.354	1.000	-0.102	-0.288	-0.722	-2.039		
	2. CORC	1966(i) – 1979(iv)	0.500	0.978	-0.148	-0.290	-0.647	-1.266		
	3. OLS	1980(i) – 1985(iv)	0.263	0.705	-0.101	-0.271	-1.145	-3.070		
	4. CORC	1980(i) – 1985(iv)	0.285	0.824	-0.094	-0.272	-1.117	-3.228		
	5. OLS	1966(i) – 1985(iv)	0.310	1.016	-0.084	-0.275	-1.048	-3.436		
	6. CORC	1966(i) – 1985(iv)	0.301	1.024	-0.080	-0.272	-1.034	-3.517		
C	1. OLS	1966(i) – 1979(iv)	0.347	0.983	-0.104	-0.295	-0.705	-1.997	0.043	0.122
	2. CORC	1966(i) – 1979(iv)	0.486	0.972	-0.147	-0.294	-0.637	-1.274	0.030	0.060
	3. OLS	1980(i) – 1985(iv)	0.342	0.853	-0.124	-0.309	-1.148	-2.863	0.117	0.292
	4. CORC	1989(i) – 1985(iv)	0.369	0.920	-0.137	-0.342	-1.085	-2.706	0.130	0.324
	5. OLS	1966(i) – 1985(iv)	0.327	0.985	-0.107	-0.322	-1.006	-3.030	0.086	0.259
	6. CORC	1966(i) – 1985(iv)	0.320	0.991	-0.104	-0.322	-0.994	-3.077	0.082	0.253
D	CORC	1966(i) – 1985(iv)	0.323	1.000	-0.096	-0.297	-0.930	-2.879	0.085	0.263

* SR – Short-run,
* LR – Long-run.

a context [8/]. Thus, a positive sign is expected here for the coefficient of the premium variable; that is, money-holders will increase their money balances as uncertainty increases. The premium variable has in fact the appropriate sign in all the equations, although it is not statistically significant for period 1966(i)–1979(iv).

Equation D of Table 1 merely involves the inclusion in the preceding specification of a dummy variable for period 1980(i)–1985(iv). Notice that a downward shift in the function is once again detected although its statistical significance is now slightly below the 10 per cent level.

Table 2 shows the long-run elasticities obtained from the corresponding estimated short-run demand equations of Table 1; also reproduced from Table 1 are the short-run elasticities. Long-run income elasticities are generally close to unity for both period 1966(i)–1979(iv) and the extend period 1966(i)–1985(iv), but falls to the range from 0.70 to 0.80 for period 1980(i)–1985(iv); thus, economies of scale exist only for the latter period. As for the long-run interest rate elasticities, their values are mostly close to 0.30. The long-run elasticity of the demand for money with respect to the inflation rate, on the other hand, increases from a value of around 2.0, for period 1966(i)–1979(iv), to a value close to 3.0 in the 1980s; this is due to more rapid and highly variable inflation rates of the 1980s, as we have argued.

Additional evidence for a downward shift of the money demand function in the 1980s is in Table 3. Columms 1 and 2 show the error involved when one uses the estimated money demand of period 1966(i)–1979(iv) for making predictions through out the first half of the 1980s. Notice, in particular, that the prediction errors (defined here as predicted logarithm of real money balances minus actual logarithm of real money balances) are increasingly

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[8/] We have benefited here from conversations with Fernando de Hol-landa Barbosa.

TABLE 3

PREDICTION ERRORS BASED ON VARIOUS ESTIMATED MONEY DEMAND EQUATIONS OF TABLE 1

Year-quarter	EQUATION A-2 (out of sample) 1	EQUATION B-2 (out of sample) 2	EQUATION D (within the sample) 3	EQUATION E (within the sample) 4
1980- I	0.146	0.199	0.209	-0.240
II	0.170	0.088	0.168	-0.241
III	0.255	0.156	0.211	-0.166
IV	0.167	0.031	0.145	-0.200
1981- I	0.258	0.135	0.267	-0.080
II	0.321	0.125	0.236	-0.018
III	0.348	0.125	0.260	0.026
IV	0.189	-0.040	0.105	-0.099
1982- I	0.270	0.098	0.252	0.055
II	0.347	0.150	0.281	-0.002
III	0.317	0.101	0.263	0.002
IV	0.095	-0.044	0.168	-0.070
1983- I	0.301	0.086	0.281	0.004
II	0.406	0.139	0.292	0.084
III	0.508	0.167	0.303	0.176
IV	0.521	0.105	0.221	0.219
1984- I	0.671	0.249	0.350	0.363
II	0.710	0.234	0.298	0.385
III	0.786	0.301	0.345	0.430
IV	0.661	0.167	0.226	0.313
1985- I	0.713	0.241	0.328	0.389
II	0.743	0.224	0.288	0.420
III	0.785	0.271	0.278	0.386
IV	0.571	0.116	0.163	0.173

Prediction error = predicted logarithm of real money demand minus actual logarithm of real money demand; the logarithmic prediction error of 0.785 in 1985(iii) is in fact equivalent to an overprediction of the real money balances around 120 per cent.

positive for equation A-2.[9] Equations B-2 and C-2 produced results which were close to each other; thus we present results for the former only. Once again, the estimated function over-predicts the money balances through out the first half of the 1980s; the exceptions here are the slight understatements for 1981(iv) and 1982(iv).

Results in columns 1 and 2 of Table 3 are out of sample prediction errors. Predictions errors within the sample period were obtained by using equations D and E; the results are in columns 3 and 4, respectively. Notice that while column 3 shows over-predictions for the money demand through out the period 1980(i)–1985(iv), column 4 shows under-predictions in the first three years of that period, and over-predicting the money demand in the remaining years. The former results are in fact consistent with a gentle rotation (rather than the sudden shift imposed by our model specification) of the demand for money starting in 1980(i).

Thus the inclusion of the lagged dependent variable and/or the premium on the exchange rate among the explanatory variables, in spite of providing some parameter stability (at least as indicated by Chow's test), did not prevent the occurence of a "missing money" case for Brazil in the 1980s.

As pointed out by Darrat (1985) the Koyck-lag process obtained from the partial adjustment model is higly restrictive for it assumes "an identical lag for all independent variables with weights following a geometrically declining path" [10]. Thus Darrat (1985) used instead, as mentioned, Almon distributed-lag technique

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[9] Similar underpredictions were obtained by Cysne (1985) whose estimates are based on annual data starting in 1949. That is, his estimated demand for money equation (which does not include the interest rate among the explanatory variables) systematically understates the actual money balances from 1979 to 1983.

[10] In order to see this, it suffices to undertake successive substitution for $(M/P)_{-1}$ in equation 6.

in his estimation of Cardoso's (1983) demand for money. The same lag structure proposed by Darrat is applied here to the extended period 1966(i)–1985(iv), but a second degree polynomial (rather than Darrat's third degree polynomial) is employed 11/. The results are in Table 4. Notice that the long-run elasticities are statistically quite significant and their values do no differ much from those obtained with the more restrictive Koyck-lag mechanism shown in Table 2. That is, income elasticity is close to unity, interest rate elasticity is about one third and the elasticity of the money demand with respect to the inflation variable is about 3.0. It should be noted that these estimates are not strictly comparable with those obtained by Darrat and this is so due to the use, as we mentioned, of different variables for the inflation rate in the two studies. In fact, by using Darrat's variable in the regression we obtained the following long-run elasticities: income (1.2), interest rate (-0.39) and inflation rate (-0.29). That is, our estimated income elasticity for the extended period is slightly higher (i.e., 1.2 against 1.01) than that of Darrat for period 1966(i)–1979(iv), but interest rate elasticity remained unchanged, while the elasticity of the money demand with respect to the inflation rate increase appreciably (i.e., from -0.17 to -0.29) 12/ Notice that the direction of these results is similar to the one found by using the Koyck-lag technique.

As the coefficients of Table 4 indicate, the effects of the real income variable are larger and statistically more significant for the few first lags, including the current effect. A similar picture emerges in the case of the interest rate variable. For the inflation rate, on the other hand, all the

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11/ A third degree polynomial was also tried here but the data matrix turned out to be ill-conditioned. Also, correction for first-order autocorrelation in the residuals was used.

12/ It should be emphisized that we are using here a second order polynomial rather than Darrat's third order polynomial. This is so due to data matrix being once again ill-condicioned in the latter case. Once more, correction for first-order autocorrelation in the residuals was used.

TABLE 4

$$\log m_t = \alpha + \sum_{i=0}^{10} \beta_i \, \text{Log } y_{t-i} + \sum_{i=0}^{8} \gamma_i \, \text{Log } r_{t-i} + \sum_{i=0}^{4} \delta_i \, \text{Log } \dot{p}_{t-i}$$

Variable	Estimates ($\hat{\beta}_i$)	t-values	Variable	Estimates (γ_i)	t-values	Variable	Estimates (δ_i)	t-values
Ly	0.235	2.863	Lr	-0.114	-2.365	L$\dot{p}$	-0.982	-4.849
Ly(- 1)	0.179	3.454	Lr(-1)	-0.104	-3.913	L$\dot{p}$(-1)	-0.661	-4.390
Ly(- 2)	0.132	3.805	Lr(-2)	-0.089	-3.970	L$\dot{p}$(-2)	-0.482	-2.930
Ly(- 3)	0.095	2.922	Lr(-3)	-0.070	-2.647	L$\dot{p}$(-3)	-0.445	-3.020
Ly(- 4)	0.068	1.856	Lr(-4)	-0.046	-1.719	L$\dot{p}$(-4)	-0.550	-2.655
Ly(- 5)	0.051	1.302	Lr(-5)	-0.018	-0.830	$\Sigma\ \delta_i$	-3.120	-5.315
Ly(- 6)	0.043	1.163	Lr(-6)	0.015	0.910	Const.	0.935	2.437
Ly(- 7)	0.044	1.397	Lr(-7)	0.053	1.747	ρ	0.634	6.599
Ly(- 8)	0.055	1.756	Lr(-8)	0.095	1.575	$\bar{R}^2$	0.987	
Ly(- 9)	0.076	1.631	$\Sigma\ \gamma_i$	-0.280	-4.516	DW	2.143	
Ly(-10)	0.107	1.405						
$\sum \beta_i$	1.086	16.209						

Note: For the definition of the variables see Table 1 coefficients of the lagged variable are statistically significant, including the current effect which is the most significant one. In all three variables the current effect was the largest.

A difficulty with the use of the Almon-lag technique is that prior to the model estimation one has to set both a fixed lag length and the degree of the polynomial along which the coefficients of the lagged variables are suppose to fall. Mitchell and Speaker (1986) proposed a modification of the Almon-lag technique in which an infinite lag structure is used (that is, no lag length need to be specified) and the degree of the polynomial is choosen by using a series of nested Ordinary Least Square regressions. This is the so-called polynomial inverse lag (PIL) technique. More precisely, in a model with only one explanatory variable the specification would be

$$Y_t = b + \sum_{i=0}^{\infty} w_i X_{t-i} + e_t,$$

where

$$w_i = \sum_{j=2}^{n} \frac{a_j}{(i+1)^j} , \quad i = 0,1,\ldots, \infty$$

and n is the degree of the polynomial. After substituting this into the preceding equation and rearranging one gets

$$Y_t = b + \sum_{j=2}^{n} a_j Z_{jt} + R_t + e_t \quad ,$$

where

$$Z_{jt} = \sum_{i=0}^{t-1} \frac{X_{t-i}}{(i+1)^j} , \quad j = 2,3,\ldots, n$$

and R_t is the remainder term which is generally negligible and can be dropped when estimating the model.

The use of the PIL technique with our data produced the results of Table 5. Due to data matrix being ill-condicioned for polynomial degree greater than four the choice of polynomials was somewhat limited here. More precisely, polynomials of second, third and fourth degree were employed for all three variables simultaneously with the latter producing the best fit (i.e., highest adjusted coefficient of determination, $\bar{R}^2 = 0.988$). As in the Almon-lag case, correction for first-order autocorrelation in the residuals was applied here. Only the first twenty distributed lag weights are shown in Table 5. A point to be noted is that the long-run elasticities (given by the sum of the twenty weights) do not differ appreciably from those obtained by using the Almon-lag technique. However, a comparison with the Almon-lag results shows some differences in the patterns of the weights. For example, unlike the Almon-lag case, the interest rate has its strongest effect on the money demand one period latter; its current effect is virtually null. Notice that the Almon-lag estimates show strong response of the money demand both in the current period and one period later. Also to be noted is that the effect of the interest rate is virtually null after the seventh lag. This indicates that the choice of eight lags in the Almon-lag case in indeed appropriate for this variable. In fact, the long-run elasticity is identical by using either technique. Also a change in sign for the last several lag coefficients is detected with either technique.

The pattern for the lag effect of the inflation variable is similar in the two cases up to the third lag. The fact that only four lags are used in the Almon-lag case partly explains its somewhat lower total effect (i.e., -3.12 against -3.30). As for the total effect of the income variable it is lower in the PIL case than in the Almon-lag one (i.e., 0.79 against 1.09). Since the weights beyond lag twenty are not null in Table 5 these differences would certainly be reduced if more lags were calculated. In any case the pattern similarities for the few first lag effects in the two techniques is quite apparent.

Finally, a point to be stressed is that for all three variables the Almon-lag technique tends to give more weight to the

TABLE 5

ESTIMATION BY PIL TECHNIQUE OF THE MODEL – $\log m_t = b + \sum_{i=0}^{\infty} w_{1i} \log y_{t-i} + \sum_{i=0}^{\infty} w_{2i} \log r_{t-i} + \sum_{i=0}^{\infty} w_{3i} \log \dot{p}_{t-i}$

LAG (i)	w_{1i}	w_{2i}	w_{3i}
0	0.2750	0.0160	- 1.0860
1	0.2094	- 0.1808	- 0.5982
2	0.0987	- 0.0641	- 0.3959
3	0.0555	- 0.0268	- 0.2679
4	0.0352	- 0.0126	- 0.1906
5	0.0240	- 0.0064	- 0.1417
6	0.0176	- 0.0034	- 0.1090
7	0.0134	- 0.0018	- 0.0866
8	0.0105	- 0.0009	- 0.0703
9	0.0084	- 0.0004	- 0.0582
10	0.0069	- 0.0001	- 0.0489
11	0.0058	0.0001	- 0.0417
12	0.0049	0.0002	- 0.0360
13	0.0042	0.0003	- 0.0313
14	0.0037	0.0003	- 0.0276
15	0.0032	0.0003	- 0.0244
16	0.0028	0.0003	- 0.0200
17	0.0025	0.0003	- 0.0180
18	0.0023	0.0003	- 0.0160
19	0.0020	0.0003	- 0.0150
20	0.0018	0.0003	- 0.0130
$\sum$	0.7882	- 0.2783	- 3.2963

The weights were in general statistically significant (at 10 per cent or lower), the exceptions here were w_{20} and the weights w_{2i} for i larger than 3 and w_{3i} for i larger than 12; for the definition of the variables see Table 1.

last few lag effects than it is actually warranted by the facts, for the less restrictive PIL technique clearly indicates this not to be the case.

4 — FINAL REMARKS

A number of issues can be raised when estimating money demand functions of the type given in Table 1. For instance, interest rate might not be an exogenous variable in the equation, for it is generally directly linked to the money supply, in which case there would be a simultaneaty problem. Fortunately, exogeneity is approximately obtained here, for according to Cardoso (1983) " In Brazil unlike in the US there is no direct reaction function link of money supply to the interest rate. Money supply is rather dominated by the budgetary process".

Similar concern applies to the income variable. Thus, some might suggest that permanent income rather than measured income be used in the regression. If one is willing to measure permanent income according to the adaptive expectations hypothesis (i.e., $y_t^p = \lambda y_t + (1-\lambda)y_{t-1}^p$) it can be shown (e.g., Thomas (1985)) that actual income would then replace permanent income in the money demand equation. Such an equation would also include among its explanatory variables the other variables both in their current value and with one lag period; the dependent variable with one lag period would be an explanatory variable in the regression too. Thus if one problem is solved by this procedure, most probably a new one will be created, for the current value of an explanatory variable is bound to be highly correlated with its value one period earlier. Also one would rather use here the expected inflation rate, not the actual inflation rate. As these two rates in general differ one might use the rational expectation hypothesis about prices change, in which case the use of instrumental variables estimation is required. The choice of the instruments are not a trivial problem, however. Cardoso (1983) used as instruments the explanatory variables with one lag period without much change in results. Thus, we decided not to pursue such a line in this study.

As it was emphasized in the "Introduction", a stable money demand is vital for a successful monetary policy. Also relevant for monetary policy is the size of the interest rate elasticity, for the smaller it is the greater the size of monetary multipliers relative to fiscal multipliers. Now a stable money demand is a required condition for stable monetary multipliers, which would make it easier to predict the effect of a given money supply on the aggregate money income. Naturally a stable relationship between the interest rate and aggregate expenditure is also essential for stable monetary multipliers. In any case, a shifting money demand, as it seems to be the case for Brazil starting in 1980, makes it more difficult to predict the effect on the interest rate of an increase in the money supply. But it should be pointed out, once again, that parameter changes in the 1980s relative to the previous period are due more to changes in the elasticities of the income and inflation variables than to changes in the interest elasticity. In this sense the effect on economic activity of a given money supply might not have changed much over time.

Since the recently introduced (February, 1986) economic reforms of the so-called Cruzado Plan suddenly reduced the country's explosive inflation rate (namely, from monthly rates around 15 per cent to rates close to nill) one may wonder whether such a dramatic break with the past would have caused a new shift (now upwards) on the money demand function. As the inflation and nominal interest rates are important arguments of that function certainly a large increase in the demand for money would consequently be expected. But in order to characterize an upward shift of the money demand the increases on money balances would obviously have to be significantly above that predicted by the function estimated with data of the period immediately before the reforms were introduced. Thus we use here the estimated regressions of period 1980(i)–1985(iv) for predicting the money demand of 1986(i) and 1986(ii), and compare the results so obtained with those actually observed. These were the findings:

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Year	Logarithm of observed and predicted real money demand with equations of Table 1			
		Eq.A-4	Eq.B-4	Eq.C-4
1986(i)	Observed	3.90	3.90	3.90
1986(i)	Predicted	3.75	3.69	3.85
1986(ii)	Observed	4.57	4.57	4.57
1986(ii)	Predicted	5.26	4.64	4.75

That is, the observed logarithm of real money demand in 1986(i) is above the actual logarithm of real money demand for all three equations. A reverse situation takes places in 1986(ii). Thus by June individuals were once again behaving as before, that is, with a demand for real money balances below that predicted by the various model specifications used here. In this sense, there is no evidence of any upward shift of the demand for money due to the recent economic reforms.[13/]

As a final point, after completing this analysis we became aware of the fact that quarterly estimates of the PIB were recently obtained for Brazil (see Boletim Mensal Macrométrica, Junho/1986, nº 18); recall that according to note 5 the updating of Cardoso's constructed series of the quarterly PIB was done by using the same growth rate as that of the quarterly Industrial Product. The insertion, starting in 1980(i), of this new data on our regressions changed the estimates only marginally [14/]. Thus we decided to maintain our previous estimates.

13/ The large difference between observed and predicted values for equation A-4 in 1986(ii) is due to its very high interest rate elasticity. Thus the dramatic reduction of the nominal interest rate in the period analysed had an overwhelming effect on the demand for money balances. A result like this did not take place in 1986(i) simply because the data used there also contained information from the two months preceding the date of the economic reforms. Notice that our data are in fact based on averages of the three months of each quarter.

14/ An exception here was the coefficient of the premium on the exchange rate which became smaller and statistically non-significant; for instance, it changed to -0.042 (with a t-value of -0.89) in equation C-6 of Table 1.

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