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The Demand for Money During High Inflation Episodes: Some Latin American Evidence on the Cagan Model

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Abstract

This paper examines the demand for money under conditions of very high inflation in Argentina, Bolivia, Brazil, Chile and Peru during the 1970s and 1980s. We test whether the monetary and inflationary experiences of these countries can be adequately characterized by the Cagan (1956) model, using an econometric procedure which is not reliant on any particular assumption concerning expectations formation except that forecasting errors are stationary. We also examine the importance of foreign asset substitution in domestic portfolios.

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Summary

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The basic testing of the model employs an econometric procedure that is nonspecific with respect to the method used by agents to form expectations of inflation. The Cagan model is also tested against a more general alternative in which the expected return to foreign asset holding is an additional determinant of real money holdings. The paper examines as well the applicability of the rational expectations hypothesis.

Although it has hitherto proved notoriously difficult to find stable money demand functions for the countries included in this study, the results suggest that the simple Cagan model of money demand under hyperinflation does indeed provide an adequate characterization of the salient features of the inflationary and monetary experiences of these countries during the 1970s and 1980s. Although the study finds some evidence to support the view that the expected return to holding foreign assets to some extend determined real money holdings, tests suggest that the dominant factor was expectations of inflation. On the basis of the present evidence, however, it appears that the Cagan model cannot be coupled with the rational expectations hypothesis for these countries and this period.

I. Introduction

In this paper we consider the demand for and supply of money under conditions of very high inflation in several Latin American countries during the 1970s and 1980s, using Cagan's (1956) hyperinflation model of money demand. Although none of the countries examined have consistently experienced hyperinflation according to Cagan's strict definition (a monthly rate of inflation in excess of 50 percent), they have each experienced very high rates of inflation over sustained periods of time. If the Cagan model is applicable to these countries and periods, then its very simplicity suggests that it will be a powerful tool of analysis in understanding the salient features of the monetary experiences of these countries. 1/ We also test the Cagan model against a more general alternative in which the expected return to foreign asset holding is also a major determinant of real money holdings as well as examining the applicability of the rational expectations hypothesis in this context.

II. The Cagan Model

Cagan (1956) postulates that under conditions of very high inflation, the overwhelming determinant of desired real money holdings will be expected inflation. Denoting the logarithm of nominal money balances and prices by m and p respectively, the model can be written, ignoring the constant term:

$$(m-p)_t = \alpha \Delta p^e_{t+1} + \psi_t \qquad (1)$$

where superscript e denotes expectations formed at time t and ψ_t denotes elements of money demand not captured by the model. If these elements are stationary and admit a Wold representation, then ψ_t will be a stationary but possibly serially-correlated series. Cagan's insight is that under extreme inflationary conditions, real money holdings will be largely determined by inflationary expectations, with the components of ψ_t playing a relatively minor role in their determination. Replacing expected with actual inflation in (1):

$$(m-p)_t = \alpha \Delta p_{t+1} + \epsilon_{t+1}. \qquad (2)$$

where $\epsilon_{t+1} = [\psi_t - \alpha(\Delta p_{t+1} - \Delta p^e_{t+1})]$. Now, suppose that, under conditions of very high and accelerating inflation such as was experienced during the 1970s and 1980s in the five Latin American countries under consideration (see below), the growth rate in real money balances and the rate of change

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1/ More sophisticated analyses (e.g., Montiel, 1989; Calomiris and Domowitz, 1989) are clearly important in understanding the macroeconomics of these countries in greater detail. Our objective, however, is to capture the main features of the data with a very simple model and carefully applied econometrics.

of inflation are each stationary processes (this assumption will later be tested). This would imply that $(m-p)_t$ and Δp_t are each first-difference stationary or, in the terminology of Engle and Granger (1987), integrated of order one, I(1). Subtracting $\alpha\Delta p_t$ from both sides of (2) we have

$$(m-p)_t - \alpha\Delta p = \alpha\Delta p_{t+1} + \epsilon_{t+1}. \qquad (3)$$

If we assume that expectational errors are stationary, regardless of the particular method used to form expectations, 1/2/ then since $\alpha\Delta^2 p_{t+1}$ and ϵ_{t+1} are both stationary, equation (3) implies that the linear combination $[(m-p)_t - \alpha\Delta p_t]$ must also be stationary, even though $(m-p)_t$ and Δp_t are individually non-stationary. 3/ Hence, real money balances and inflation are cointegrated (Engle and Granger, 1987) with a cointegrating parameter (after normalization on real balances) just equal to the parameter of interest in the Cagan model (i.e., the semi-elasticity of real money demand with respect to expected inflation). 4/ Thus, a simple test of the applicability of the hyperinflation model lies in testing whether or not real money balances and inflation are cointegrated. If they are, then a 'super consistent' estimate of α can be obtained by applying ordinary least

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1/ Taylor (1991) investigates the plausibility of the assumption of stationary forecasting errors [when the variable being forecast is I(1)] for a range of alternative assumptions concerning expectations formation.

2/ The following analysis can allow forecasting errors to be serially correlated and heteroskedastic. This would be the case if, for example, expectations were adaptive, which would imply moving average errors whose conditional variance was also serially correlated (Engle, 1982). Phillips (1987) suggests that the Johansen maximum likelihood technique, which is applied below, is applicable in the presence of heterogeneously distributed error processes. Thus, the properties required of the errors are very weak (see the conditions imposed on the error processes in the analysis in Phillips, 1987).

3/ Note that we only require ϵ_t to be non-stationary, not serially uncorrelated. ϵ_t may be serially correlated because of omitted variables (ψ_t) and/or because expectational errors are serially correlated.

4/ Under the additional assumption of rational expectations, this implication of the hyperinflation model is a particular case of a general result for present value models discussed by Campbell and Shiller (1987). A main purpose of the present analysis, however, is to derive a test of the hyperinflation model which is nonspecific with respect to expectations formation. The importance of considering alternative forms of expectations formation in the context of testing present value models is demonstrated by Chow (1989). Rather than use least squares, however, in the empirical work reported below, we apply a maximum likelihood technique for estimating α due to Johansen (1988), since this technique has the added advantage of allowing tests of linear restrictions on the cointegrating parameters to be easily constructed.

squares to equation (2) (Stock, 1987). If they are not cointegrated, then the applicability of the Cagan model is challenged since the omission of determining variables of first or higher order is indicated. 1/

III. Inflation in Argentina, Bolivia, Brazil, Chile, and Peru

The historical development of inflation in the five Latin American countries under examination during the 1970s and 1980s contains both similarities and contrasts across the geographical sample. 2/

In Argentina, the monthly rate of inflation during the period 1971-1985 averaged a little over 10 percent (Table 1), 3/ notwithstanding peaks of 35 to 40 percent per month during the end of the Peronist administration in mid-1975 and again in early 1985. Argentina attempted an 'orthodox' stabilization in the 1976-1978 period, comprising a drastic tightening of the fiscal stance, exchange rate devaluation and the imposition of wage controls (Solimano, 1990). Notwithstanding a fall in the annual inflation rate of some 270 percent, the rate prevailing at the end of 1978 (some 175 percent) was still indicative of substantial price instability. Although unemployment fell during the period, the real costs of the stabilization can be measured by the substantial shift in the distribution of income away from labor over the same period (Foxley, 1983; Ramos, 1986; Solimano, 1990). Attempts to stabilize the economy via exchange rate stabilization, through a policy of preannounced but diminishing devaluations, resulted in further improvements in inflation and real macroeconomic variables over the 1978-1980 period but only at the cost of massive external disequilibrium concomitant to a real exchange rate appreciation of some 50 percent. In the face of adverse external shocks, severe foreign debt problems and strong currency overvaluation, Argentina abandoned its exchange rate-based stabilization plan in the early 1980s and shifted to a crawling peg devaluation policy based on inflation differentials. The recent acceleration in inflation in Argentina began in mid-1982. The Alfonsin government assumed power in January 1984 and initially attempted to reduce inflation, under repeated IMF programs, but without significant success. In June 1985 the government, faced with steadily accelerating inflation and the prospect of an autumn election, adopted the Austral plan. This 'heterodox' (Taylor, 1987) plan struck a balance between the fundamentals--

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1/ Melnick (1990) estimates a real money demand function for Argentina, 1978-1985, with inflation and output as explanatory variables. Melnick finds, however, that the I(1) hypothesis can only be marginally rejected (a Dickey-Fuller statistic of -2.83 against a 5 percent critical value of -2.89 (Fuller, 1976)). Note, however, that Melnick erroneously quotes the critical values from Engle and Granger (1987) rather than Fuller (1976).

2/ International Monetary Fund, 1984; Edwards, 1986; Dornbusch and Simonsen, 1987; Thorp, 1987 a,b; Bruno, et al., 1988; Kiguel and Liviatan, 1988; Helpman and Leiderman, 1988; Solimano, 1989, 1990.

3/ See section IV for a data sources and sample periods.

monetary and fiscal austerity--and pragmatism, residing in the adoption of wage, price, exchange rate and tariff freezes as a central feature of the disinflation program (Frenkel, Fanelli, and Winograd 1986; Machinea and Finelli 1988) and introduced a new currency--the austral. The plan, which was perceived as a radical change of regime, was endorsed by the IMF and Argentina received additional foreign financing. The program quickly had the desired effect: inflation fell from a monthly average rate of 26 percent per month in the first half of 1985 to an average of some 3 percent in the following nine months. As price controls were removed, in April 1986, however, inflation began to rise once more, reaching an annual rate approaching 180 percent in 1987.

In Chile the average monthly inflation rate over the period 1971-1976 was about 11 percent with an exceptional rise to 86 percent in October 1973. The acceleration of inflation in 1973 was largely the result of the monetization of a large fiscal deficit amounting to almost 25 percent of GDP. The first phase of attempted Chilean stabilization, during the 1973-1976 period, involved a drastic reduction in the fiscal deficit to around 2.5 percent of GDP, the introduction of wage controls and an exchange rate devaluation. These measures impacted heavily on the real side of the economy and on the distribution of income, but were unsuccessful in curbing inflation: unemployment rose from 4.6 percent to 19.4 percent and real wages fell by 18 percent over these three years, but the annual rate of inflation in 1976 was still in excess of 200 percent (Foxley, 1983; Solimano, 1989, 1990). Towards the end of the 1970s, Chile moved towards an anti-inflationary strategy based on exchange rate management (Solimano, 1990), and the official exchange rate was fixed from June 1979 until June 1982. This led to an improvement in many of the macroeconomic aggregates including unemployment and real wages, and inflation declined. Unfortunately, concomitant with these domestic improvements came a worsening of the external position: Measured in wage units, the real exchange rate appreciated by more than 50 percent over the 1976-1981 period, generating a massive balance of payments deficit and hence a need for foreign borrowing on a scale which eventually led to severe financial crises (Diaz-Alejandro, 1985). Thus, in similar fashion to Argentina, Chile was forced to abandon its firm exchange rate stabilization plan in the early 1980s and it too adopted a crawling peg devaluation policy. Dornbusch (1990) argues that Chilean exchange rate policy post- 1983, by greatly improving the competitiveness of the traded goods sector, was ultimately responsible for improvements in external debt management and the domestic budget. Chile did not, moreover, experience a similar resurgence of inflation as Argentina eventually did: over the period 1977-1985 the monthly inflation rate averaged some 2 percent.

In Brazil the monthly inflation rate rose from about 1 percent in 1971 to more than 12 percent in 1973. Apart from a sharp rise in 1974, apparently due to an expansionary monetary policy, the annual inflation rate remained stable in the 35-40 percent range until the end of 1978. In 1979, the government apparently shifted to a policy of interest rate targeting and

an accommodative monetary policy. In the same year, new legislation was also enacted which reduced the minimum interval for nominal wage indexation from twelve to six months. Inflation accelerated further in 1983 as a result of a 30 percent real exchange rate devaluation in an attempt to redress the worsening balance of payments due to the foreign debt situation. In February 1986, the authorities adopted a set of policy measures that formed the Cruzado plan--a heterodox plan much in the mold of the earlier Argentinean Austral plan, featuring a combination of a standstill on all indexation, a freeze on wages, prices, the exchange rate and tariffs for public services and a currency reform, replacing old currency units with cruzados. The result was a sudden reduction in inflation to around 1 percent per month, with industrial output rising by some 40 percent between February and October 1986 (Solimano, 1990). By the last quarter of 1986, however, the trade surplus had fallen to around $500 million--approximately half its level at the beginning of the Cruzado plan--and turned into a deficit by the year end. Over the same period, February to October 1986, Brazil lost some $3.5 billion in international foreign exchange reserves. When price controls were abandoned in late 1986, inflation quickly accelerated to a monthly rate of around 15 percent in the first quarter of 1987 and to around 25 percent per month by the end of the second quarter, thereby instigating another stabilization program--the Bresser plan. 1/ This new plan, which sought to improve upon the Cruzado plan by adjusting the exchange rate and tariffs at the beginning of the price freeze and reintroducing partial wage indexation, ultimately failed: in 1988 the annual inflation rate was approaching 1000 percent.

In Bolivia the average monthly rate of inflation during the 1971-1987 period was some 6.5 percent (Table 1). Over the period 1982-1985, however, the inflation rate was much more severe, reaching a monthly rate in excess of 100 percent in February 1985. In fact, during the first half of 1985, Bolivia experienced an annual inflation rate of more than 10,000 percent. The acceleration of Bolivian inflation in 1982 was primarily the result of the monetization of the budget deficit following the sudden reduction in foreign credit by the international banking community. During the period 1975-1980, government expenditure became increasingly financed by foreign borrowing. As the level of international debt built up, international lenders began to lose confidence in the government's ability to honor its liabilities and reduced or halted loans to Bolivia. At the same time, the budget deficit was reaching enormous proportions and was some 30 percent of GDP at a time when explicit tax revenue amounted to less than 5 percent of GDP. In general, the economy was experiencing serious economic and financial crises with widespread shortages, negative real growth rates, a large underground economy, dwindling international reserves and mounting internal and external payments arrears. Between November 1982 and February 1985, six attempts were made to introduce stabilization programs in Bolivia. Each one, however, was overthrown by political unrest, emanating either from

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1/ Named for the Finance Minister, Luis Bresser Pereira, who replaced the originator of the Cruzado plan, Dilson Funaro.

public or governmental political opposition. In 1985, Paz Estenssoro resumed his fourth term of office since 1952, and embarked in August of the same year on Bolivia's most radical reorientation of economic policy in more than 30 years. The seriousness of the economic crisis finally convinced the major political factions to agree to a major overhaul of economic policies. The objectives of the New Economic Policy were to reduce inflation to single digit level, to restore external balance, and to lay the basis for sustained growth. The policy entailed a dismantling of controls on prices, interest rates, international capital flows and exchange rates; the imposition of strict controls over public finances aimed at sharply reducing the budget deficit; and the adoption of several structural and institutional measures, such as a process of rationalization of state enterprises and of reducing the size of the public sector. 1/ Because wages, domestic and imported input prices and most contracts were de facto pegged to the exchange rate, stabilization of the exchange rate was a key factor in regaining control over inflation; and when this was eventually achieved, in August 1985, prices stabilized abruptly (Sachs, 1987). In fact, prices dropped by 2 percent in October 1985. Inflation rose for the next three months, but by the end of 1986 the stabilization had been consolidated (Solimano, 1990). Unlike the Argentinean Austral Plan or the Brazilian Cruzado Plan, the Bolivia program did not include price controls. On the contrary, the stabilization plan dismantled previously existing controls, and proceeded to liberalize markets (Helpman and Leiderman, 1988). At the same time, the plan did not include a currency reform.

In contrast to the Latin American countries considered above, Peru has not implemented a drastic stabilization program in an attempt to stabilize its price level. In 1975, the average monthly inflation rate was some 2 percent, while in 1987 it rose to about 8 percent. The monthly rate has, however, occasionally been as high as 14 percent, giving an annual rate of some 380 percent. The steady acceleration of Peruvian inflation over the period largely reflects the monetization of the government budget deficit following the general reluctance by the international banks to lend to Latin America in the early 1980s. Peru, since the early 1970s, resorted to foreign borrowing to finance its ambitious development plans, the result of which was a massive increase in its external debt. By 1974, Peru was the fourth largest borrower in the Eurodollar market (Thorp, 1987a, p. 368). The budget deficit, which was only 1 percent of GDP in 1979, grew to 12 percent in 1983. As the IMF 1984 report states:

> "The major cause of the internal and external imbalances experienced by Peru during the past two years has been the maintenance of a public sector deficit at a level averaging 9 percent of GDP. Public financial requirements of this magnitude led to an unsustainably high level of net

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1/ See IMF Survey, January 26, 1987.

> foreign financing, a serious crowding out of the private sector in financial markets, and the maintenance of inflationary pressures." 1/

During the period 1980-1985, several unsuccessful attempts were made to correct the balance of payments deficit and the growing level of inflation. These measures were imposed by the IMF and the international financial community. In April 1985, following a massive electoral swing away from the Right, Peru made another attempt to stabilize the economy by freezing all prices and wages. No measures were taken with regard to the fiscal deficit. Although this led to a marked and sudden reduction in inflation, the effect was short-lived (Thorp, 1987b).

As our opening remarks in this section suggested and as the above discussion makes clear, the inflationary experiences of these countries contain significant differences as well as similarities to one another over the 1970s and 1980s. A central aim of this paper is to examine whether or not, notwithstanding these differences, the Cagan model holds up as a simple description of the determination of money demand during such high inflation episodes; if so, it will have passed a stringent test. In addition, we also examine whether, in some average sense, the various economic policies adopted in these countries were, in fact, tantamount to maximization of the inflation tax revenue as a result of printing money. For at least some of the countries considered, there seems to be anecdotal evidence that this was indeed the case during some of this period (see, e.g., Fischer and Easterly, 1990, p. 133). Moreover, it is well-known that as inflation rises, the efficiency of the tax system declines so that there is a natural increased reliance on the printing press as a means of financing the budget deficit in high inflation countries--the so-called Keynes-Olivera-Tanzi effect (Tanzi, 1977).

IV. Empirical Tests of the Cagan Model

Monthly data was obtained, from the International Monetary Fund's International Financial Statistics data tape, on narrow money and consumer prices for each of the five countries discussed above. 2/ In each case, the sample begins in January 1971 and for Argentina and Peru extends through December 1989. For the other three countries, however, data was not available on both series for the whole of this period. Thus, the sample period ends in December 1987 for Bolivia, in February 1986 for Brazil, and in June 1985 for Chile.

Table 2 lists the results of tests for one or more unit roots in the real money balance and inflation rate series. Following the suggestion of Dickey and Pantula (1987), we tested sequentially for two, one and zero

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1/ See IMF, 1984, p. 12.

2/ Exact sources are: money--IFS, line 34, prices--IFS, line 64.

unit roots, using the augmented Dickey-Fuller test (Fuller, 1976). Our conjecture that real money balances and inflation are each I(1) series during this period, for each of the countries under examination, appears to be borne out: the I(1) hypothesis can only be rejected at the 5 percent level when the inflation and real money series are first or second differenced. 1/

The results reported in Table 3 reveal strong evidence of cointegration of current inflation and real money balances for each of the countries. Applying the likelihood ratio test for cointegration due to Johansen (1988), the hypothesis of at most one cointegrating vector (H_0:r≤1) is in no case rejected, whilst the hypothesis of zero cointegrating vectors (H_0:r=o) is easily rejected in every case. 2/ This constitutes evidence in favor of the Cagan model as applied to these Latin American countries, subject only to the caveat that agents' forecasting errors are I(0). Table 3 also lists point estimates of α--the estimated coefficients are in every case correctly signed and of a plausible magnitude.

V. Testing the Rational Expectations Hypothesis

From (1), it can be seen that the Cagan model implies, in effect, that the current level of real money balances can be viewed as proportional to agents' prediction of next period's inflation rate. If expectations are formed according to the rational expectations hypothesis, and if following Sargent (1977), we assume $E(\psi_t|I_t)=0$, then the prediction errors:

$$\zeta_{t+1} = \Delta p_{t+1} - \alpha^{-1}(m-p)_t \qquad (4)$$

1/ As a check on the robustness of these results, we performed the same unit root tests with the sample period in each case truncated at December 1980 (results not reported). In nearly every case, the results were qualitatively identical to those reported above--i.e., both inflation and real balances appear to be I(1). The sole exception is for Bolivian inflation 1971:1-1980:12, for which the I(1) hypothesis is rejected at the 5 percent level. In the remainder of the paper, however, we continue to assume that Bolivian inflation was generated according to an I(1) process over the whole sample on two grounds. First, it is possible that although a unit root is present in the data up to 1980, there is insufficient variability in the 1970s data to detect its presence. Secondly, if we consider the testing process as a whole--we examine two series for five countries for both full and sub-samples--the probability of committing at least one type I error (in this case rejection of the I(1) hypothesis when it is in fact correct for the Bolivian sub-sample) will be high. In any case, using the Bolivian data from January 1981 onwards yielded results qualitatively identical to those reported in the remainder of the paper.

2/ MacDonald and Taylor (1990) provide a discussion of the Johansen technique.

should be orthogonal to information available at time t, I_t say (see, e.g., Cuthbertson and Taylor, 1987):

$$E(\zeta_{t+1}|I_t) = 0 \tag{5}$$

A simple way of testing (5) is to test for zero coefficients in a least squares projection of ζ_{t+1} onto lagged values of itself. 1/2/

Table 4 lists results of regression-based tests of the Cagan model under rational expectations of the kind suggested above. Two sets of prediction errors, ζ_t, were constructed for each country as defined in (4)--one set using the cointegration estimate of α as reported in Table 3 and one set constructed assuming inflation tax revenue maximization, i.e., with $\alpha=-100\pi^{-1}$. In either case, the results indicate a strong rejection of the null hypothesis--the F-statistics are highly significant. Note, however, that these results are highly dependent on the assumption that $E(\psi_t|I_t)=0$. Although this assumption has a high degree of precedent in the hyperinflation literature (see, e.g., Sargent, 1977), it is, in fact, quite arbitrary. If, as we suggested above, ψ_t is interpreted as the Wold representation of omitted variables, then its serial correlation will seriously confound orthogonality tests of this kind (although this will not affect the validity of the any of the other results reported in this paper).

VI. Allowing for Substitution Between Domestic and Foreign Assets

Abel et al. (1979) and Blejer (1978) suggest that, under conditions of very high inflation there will be strong incentives for agents to substitute foreign for domestic assets in their portfolios. Abel et al. (1979) and Taylor (1990) test for this in the context of the German interwar hyperinflation by including the expected rate of exchange rate depreciation in the money demand schedule. In doing so, Abel et al. (1979) use the forward exchange premium as a proxy for the expected rate of depreciation, whilst Taylor (1990) uses the actual rate of depreciation as a proxy for the expected rate. Following Blejer (1978), we assume that, under the relatively lower levels of inflation experienced in Latin America, the expected rate of foreign inflation will also be a significant determinant of the expected return to holding foreign real and nominal assets. If we denote the return, in domestic terms, to holding foreign real and nominal assets as f_{t+1}, then, to a close approximation we have:

$$f_{t+1} = \Delta s_{t+1} + \Delta p^*_{t+1} \tag{6}$$

1/ The parameter α can be estimated by cointegration analysis and, because of the super-consistency of such an estimate when the variables are cointegrated (Stock, 1987), treated as known in testing (5).

2/ Taylor (1990) demonstrates that this is equivalent to testing a set of cross-equation rational expectations restrictions on the vector autoregressive representation of $[\Delta^2 p_t, (m-p)_t - \alpha\Delta p_t)]'$.

where an asterisk denotes a foreign variable and, because of the important degree of exchange control exercised by these countries during much of the sample period, s denotes the (natural logarithm of the) black market exchange rate (domestic price of foreign currency). Including the expected return to foreign asset holding as an additional explanatory variable of the domestic demand for real money balances in (1), we have:

$$(m-p)_t = \alpha\Delta p^e_{t+1} + \vartheta f^e_{t+1} \tag{7}$$

which can be written in the form

$$(m-p)_t - \alpha\Delta p_t - \vartheta f_t = \alpha\Delta^2 p_{t+1} + \vartheta\Delta f_{t+1} + \lambda_{t+1} \tag{8}$$

where λ_{t+1} is a linear combination of the errors made by agents in forecasting inflation and the return to holding foreign assets:

$$\lambda_{t+1} = -\alpha(\Delta p_{t+1} - \Delta p^e_{t+1}) - \vartheta(f_{t+1} - f^e_{t+1}) \tag{9}$$

From (8) and (9) it is clear that, if f is an I(1) process and, as before, forecasting errors are assumed to be stationary, then cointegration would be expected between current real money balances, current inflation and the current rate of return to holding foreign assets if (7) does indeed closely explain the data. Furthermore, this would be expected to hold if substitution between domestic money and foreign assets is significant, regardless of the method used to form expectations, again subject only to the weak assumption that forecasting errors are stationary. A test of this model against the simpler Cagan model analyzed above can be made by testing for the significance of Δf_t in this cointegrating relationship (i.e., testing the hypothesis $\vartheta=0$).

Table 5 contains results of unit root tests applied to the return to holding foreign assets, constructed according to (6), using the U.S. inflation rate and the black market exchange rate against the U.S. dollar. 1/ The time series for this variable does indeed appear to contain a single unit root in its autoregressive representation for each of the countries. Table 6 contains cointegration tests and estimates of relation (7). In each case the point estimate of the semi-elasticity with respect to the foreign rate of return (i.e., ϑ) is of a plausible magnitude and of the correct sign, suggesting that substitution between domestic money and foreign real and nominal assets does to some extent explain the behavior of real money balances. However, the likelihood ratio statistic for the inclusion of the foreign return is in each case insignificant at any standard level of

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1/ Data for the U.S. consumer price index was taken from the International Financial statistics data tape (IFS, line 64) and for the black market exchange rates from Pick's World Currency Yearbook, various issues, with missing values kindly supplied by the IMF desk economists for the relevant countries.

significance. Thus, although there is some evidence of the influence of the return to foreign asset holding on the level of real money balances, this effect appears to be dominated by the influence of the domestic rate of inflation as the prime determinant of real money holdings. 1/

VII. Concluding Remarks and Implications for Further Research

The results of this paper suggest that Cagan's (1956) model of money demand under hyperinflation does indeed provide an adequate characterization of the salient features of the inflationary and monetary experiences of Argentina, Bolivia, Brazil, Chile, and Peru during the 1970s and 1980s. Although we find some evidence to support the view that the expected return to holding foreign assets to some extent determined real money holdings, our tests suggest that the *dominant* factor was expectations of inflation. On the basis of the present evidence, however it appears that the Cagan model cannot be coupled with the rational expectations hypothesis for these countries and this period, although we suggested that caution be exercised in interpreting this result given that serial correlation may also be induced by other variables which may have a secondary influence on real money holdings. Further work might explore the nature and importance of such secondary variables and test for alternative expectations schemes (see, e.g., Chow, 1989) and perhaps also for the presence of rational bubbles (see, e.g., Cassella, 1990). We leave this on the agenda for future research.

1/ It should be noted, however, that statistical inference may be confounded to some extent in this context because of collinearity between inflation and exchange rate depreciation.

Table 1. Inflation and Money Creation in Five Latin American Countries During the 1970s and 1980s

Country	Average Monthly Inflation Rate (%) π	Average Monthly Increase in the Money Supply (%) m	π/m
Argentina	10.30	9.64	1.07
Bolivia	6.58	6.44	1.06
Brazil	4.67	4.51	1.04
Chile	5.44	5.54	0.98
Peru	6.30	5.61	1.12

Note: π and m are such that $P_T=P_1(1+\pi/100)^T$ and $M_T=M_1(1+m/100)$, where P_i and M_i are the price level and nominal money stock in period i and T is the sample size. Sample periods are: Argentina, 1971:1-1989:12; Bolivia, 1971:1-1987:12; Brazil, 1971:1-1986:2; Chile, 1971:1-1985:6; Peru, 1971:1-1989:12.

Table 2. Unit Root Tests

Country	$\Delta^2(m-p)_t$	$\Delta(m-p)_t$	$(m-p)_t$	$\Delta^3 p_t$	$\Delta^2 p_t$	Δp_t
Argentina	-9.81	-5.70	-0.78	-9.92	-8.76	-2.02
Bolivia	-6.66	-5.14	-1.26	-10.39	-6.14	-1.86
Brazil	-8.78	-3.60	-0.45	-10.22	-7.36	0.27
Chile	-7.46	-4.49	-1.47	-8.41	-7.00	-1.96
Peru	-7.50	-3.46	-0.65	-11.55	-6.02	-0.85

Note: The null hypothesis is that the series in question contains a unit root in its univariate autoregressive representation. ADF is the regression 't-ratio' for the autoregressive coefficients to sum to unity--the augmented Dickey-Fuller statistic. Seasonal dummies were included in the auxiliary regressions. The rejection region, for a nominal test size of 5 percent, is {ADFϵ |ADF<-2.89} (Fuller, 1976). Sample periods are: Argentina, 1971:1-1989:12; Bolivia, 1971:1-1987:12; Brazil, 1971:1-1986:2; Chile, 1971:1-1985:6; Peru, 1971:-1989:12.

Table 3. Cointegration Tests and Estimates

Country	Johansen Statistics $H_0: r \leq 1$	Johansen Statistics $H_0: r = 0$	$\hat{\alpha}$
Argentina	0.392	34.032	-12.678
Bolivia	5.150	28.982	-7.390
Brazil	0.028	20.368	-11.249
Chile	2.817	28.860	-16.868
Peru	0.036	34.489	-11.769

Note: If r denote the number of significant cointegrating vectors, then the Johansen statistics test the hypotheses of at most one and zero cointegrating vectors respectively. The 5 percent critical value for $H_0: r \leq 1$ is 9.094 and for $H_0: r = 0$ it is 20.168 (Johansen and Juselius, 1989). Figures in parentheses denote marginal significance levels. Sample periods are: Argentina, 1971:1-1989:12; Bolivia, 1971:1-1987:12; Brazil, 1971:1-1986:2; Chile, 1971:1-1985:6; Peru, 1971:1-1989:12.

Table 4: Tests of the Hyperinflation Model under Rational Expectations

Country	α = cointegration estimate
Argentina	2205.827
Bolivia	511.26
Brazil	967.00
Chile	640.587
Peru	2823.420

Note: Test statistics are distributed as F(4,k) under the null hypothesis of rational expectations, with k=217 for Argentina and Peru, k=193 for Bolivia, k=171, for Brazil, and k=103 for Chile. Marginal significance levels are close to zero in every case. Sample periods are: Argentina, 1971:1-1989:12; Bolivia, 1971:1-1987:12; Brazil, 1971:1-1986:2; Chile, 1971:1-1985:6; Peru, 1971:1-1989:12.

Table 5. Unit Root Tests for the Return to Holding Foreign Assets

Country	Stat.	$\Delta^2 f_t$	Δf_t	f_t
Argentina	ADF:	-12.59	-5.35	-1.07
Brazil	ADF:	-12.67	-6.75	-0.61
Chile	ADF:	-13.37	-7.81	-1.35

Note: Sample periods are: Argentina, 1971:1-1989:12; Bolivia, 1971:1-1987:12; Brazil, 1971:1-1986:2; Chile, 1971:1-1985:6; Peru, 1971:1-1989:12. See note to Table 2.

Table 6. Cointegration Tests and Estimates Including the Return to Holding Foreign Assets

Country	Johansen Statistics H_0:r≤2	H_0:r≤1	H_0:r=0	$\hat{\alpha}$	$\hat{\vartheta}$	LR(ϑ=0)
Argentina	0.043	4.114	38.221	-13.104	-1.227	1.342(0.247)
Brazil	0.314	3.331	39.548	-11.843	-1.824	1.184(0.277)
Chile	0.224	2.947	37.394	-10.594	-0.396	1.926(0.165)

Note: If r denote the number of significant cointegrating vectors, then the Johansen statistics test the hypotheses of at most two, at most one and zero cointegrating vectors, respectively. The 5 percent critical value for H_0:r≤2 is 9.094, for H_0:r≤1 it is 20.168 and for H_0:r=0 it is 35.068 (Johansen and Juselius, 1989). The likelihood ratio statistics for H_0:ϑ=0 were constructed as in Johansen 1988 and are chi-square with one degree of freedom under the null hypothesis. Figures in parentheses denote marginal significance levels. Sample periods are: Argentina, 1971:1-1989:12; Bolivia, 1971:1-1987:12; Brazil, 1971:1-1986:2; Chile, 1971:1-1985:6; Peru, 1971:1-1989:12.

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