The demand for money in developing countries: Assessing the role of financial innovation

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The Demand for Money in Developing Countries: Assessing the Role of Financial Innovation

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Abstract

Traditional specifications of money demand have been commonly plagued by persistent overprediction, implausible parameter estimates, and highly autocorrelated errors. This paper argues that some of those problems stem from the failure to account for the impact of financial innovation. We estimate money demand for ten developing countries employing various proxies for the innovation process and provide an assessment of the relative importance of this variable. We find that financial innovation plays an important role in determining money demand and its fluctuations, and that the importance of this role increases with the rate of inflation.

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Summary

Traditional specifications of money demand have been commonly plagued by persistent overprediction, implausible parameter estimates, and highly autocorrelated errors. This paper argues that some of those problems stem from failure to account for the impact of financial innovation. The empirical part of the paper finds that financial innovation is an important determinant of money demand and its fluctuations and that this importance increases with the rate of inflation.

The theoretical part of the paper has two contributions. First, by examining models of the demand for money by firms as well as households, the paper shows that the scale variables are different in the two sectors. Second, observed shifts, or movements over time, in money holdings, which are often difficult to account for satisfactorily, may be attributable to changes in the transactions technology. This refers to firms and households finding ways or being offered means to economize on money holdings, a process usually referred to as "financial innovation."

The empirical section of the paper examines the time series properties of data and finds that the key variables are generally not stationary. Having established this, the analysis proceeds to test for cointegration, which, if established, determines that the variables have a well-determined relationship to one another. Despite the use of a variety of specifications, cointegration was established in a minority of cases, and, where cointegration did not obtain, the parameter estimates suggested continuing misspecification.

In the sample of developing countries chosen, the role of financial innovation (however modeled) was quantitatively important in determining money demand. Although the sample was relatively small, the importance of financial innovation was positively related to the average rate of inflation.

The findings of the paper suggest that while it may be difficult to forecast the path of financial innovation, modeling the process in some way may help recover better estimates of the deeper parameters in the money demand function. Failure to do so may lead to misreading the path and speed of policy transmission, financial programming errors, and incorrect estimates (with fiscal implications) of seigniorage yields.

I. Introduction

From standard IS-LM models and their extension to open economies in the Mundell-Fleming manner to international monetary models and "new" classical models, money plays a central role. The demand for money serves as a conduit in the transmission mechanism for both monetary and fiscal policy in these types of models, so that the stability of the money demand function is critical if monetary and fiscal policy are to have predictable effects over time on real output and the price level. As well as being at the heart of the issue of monetary policy effectiveness, the demand for money is important in assessing the welfare implications of policy changes and for determining the role of seignorage in an economy.

In criticisms of the various analytical approaches commonly used in policy assessments, it is frequently questioned whether the demand for money is indeed stable and predictable, particularly in developing countries. This questioning resulted from findings that traditional specifications of the demand for money function in a number of industrial countries displayed temporal instability in the 1970s. 1/ And it intensified as empirical work on developing countries found that standard specifications encountered similar problems. There have been difficulties with: persistent overprediction of money demand, resulting in so-called "missing money" episodes; parameter estimates that are often not plausible; and highly autocorrelated errors.

To deal with serial correlation in the residuals, a standard econometric procedure is to assume that the error term in the structural equation is a first order autoregressive process (AR(1)) and to re-estimate the equation using the Cochrane-Orcutt method; however, the validity of the implied non-linear restriction is seldom tested. 2/ Another response to the problems with residuals is to include short-run dynamics in the specification; thus, a common procedure is to invoke some form of partial adjustment scheme (generally first-order) to justify inclusion of a lagged dependent variable in the hope that the residuals become white noise. Nevertheless, the other types of problems tend to remain; in particular, parameter values tend to vary with the sample period and often remain in a range that suggests misspecification is still present.

These problems suggesting misspecification appear to be most severe in developing countries experiencing relatively high inflation rates or inflationary episodes. Often, inspection of raw data indicate shifts or even continuing movements in holdings of money balances that are unrelated to the behavior of the explanatory variables chosen. And the shifts are nearly always in the direction of firms and households finding ways or being offered means to economize on their holdings of money balances, lending them the appearance of being irreversible in nature. For these reasons, the process is usually dubbed "financial innovation".

1/ See, for example, Goldfeld (1976).
2/ See, for example, the critique in Hendry and Mizon (1978).

The purpose of the present paper is to revisit traditional money demand specifications. First, we consider issues relating to the appropriate choice of scale and opportunity cost variables that should be included in the money demand function. As well as analyzing the demand for money by households, the paper puts forward a new transaction-cost model of firm's or business money demand. An implication of considering specific models of household and firm's demand for money is that the transaction variables are likely to be different between the two sectors; in other words, the choice of the appropriate scale variable will be sector dependent. This implication suggests that in modeling aggregate money demand, the relative size of money holdings between the two sectors is likely to be an important factor in determining which scale variable performs better empirically. The models also suggest that failure to specify the opportunity cost variable in a particular form may result in making incorrect inferences about the associated elasticity of money demand. Second, we consider how the process of financial innovation can be expected to affect the demand for money by households and firms. And we explore ways in which such a process can be modeled, in particular whether a deterministic trend or a stochastic trend in the form of a random walk can be useful. Section II presents the theoretical framework while Section III examines the time series properties of data drawn from a sample of developing countries and provides evidence indicating misspecification of money demand functions. Section IV looks at alternative approaches to modeling financial innovation and assesses the relative importance of this variable, while Section V considers the policy implications of the findings.

II. Theoretical Framework

The aggregate demand for money is the result of money demanded by different sectors: households, firms, and government. The assumptions commonly employed in the literature are that this aggregate demand for money balances depends positively on a scale variable, most frequently GDP, negatively on one or more opportunity cost variables, usually some nominal interest rate and/or the inflation rate, and that all parameters that characterize money demand (intercept and slope coefficients) are time-invariant. In the remainder of this section, the aggregate demand for money is derived from the optimizing behavior of households and firms under certainty. The model considered also expands on the usual assumptions by allowing for the impact of financial innovation on money holdings. The section concludes with a discussion of the relative merits of the alternative measures of the opportunity cost and scale variables implied by theory and considers some of the aggregation problems that may arise. The different specifications presented provide the basis for the empirical part of the paper.

1. Households' demand for money

Households are characterized by an infinitely-lived representative consumer who faces transaction costs. 1/ The consumer maximizes the utility function:

$$\sum_{t=s}^{\infty} \beta^{t-s} u(c_t), \tag{1}$$

where the subscript s denotes time, c is consumption of the only perishable good, β the discount factor and u(•) is a concave utility function. For every unit of the consumption good bought by the consumer, he/she must spend "h" units of the consumption good, which we represent below by the function $h(m^h/c, \theta)$. Transactions costs decrease as the ratio m^h/c rises, which explains the existence of the non-interest bearing asset called money. This function can be interpreted as the resources spent in shopping activities associated with transactions. The more units of consumption held in the form of money per unit of consumption bought, the lower the cost of per unit transactions. The transactions technology must be convex in its first term in order to obtain a well-defined demand for money. Finally, the term θ_t represents the state of the art of the transactions technology. 2/ We assume the cost function to be increasing in θ_t; therefore, a reduction in this parameter reduces the cost of transactions and is associated with (positive) financial innovation.

The household can save by acquiring interest-bearing bonds, b_t, which pay a nominal return between end-of-period t and end-of-period (t+1) equal to i_t. With these assumptions and measuring all flows and stocks at the end of each period, the budget constraint in real terms can be expressed as:

$$b_t + m_t^h + c_t + h\left(\frac{m_t^h}{c_t}, \theta_t\right) c_t = b_{t-1}\left(1 + r_{t-1}\right) + \frac{m_{t-1}^h}{\left(1 + \pi_{t-1}\right)} + y_t^h, \tag{2}$$

where π_t is the inflation rate between end-of-period t and end-of-period (t+1), r_t is the real interest rate $([1+i_t]/[1+\pi_t] - 1)$ and y^h is household income from wages and dividends. 3/

1/ This section is based on Arrau and De Gregorio (1991), where the model is described in greater detail.

2/ See De Gregorio (1991) for a discussion of financial innovation as shifts in the transactions technology.

3/ Dividends will be defined later when we discuss the firm's problem. Now we only need to note that dividends are not a decision variable for households.

Let λ_t be the lagrange multiplier for (2); maximization with respect to b_t leads to $\lambda_t/\lambda_{t+1} = (1 + r_t)$. Using this result and maximizing with respect to $m^h{}_t$ we obtain:

$$h_1\left[\frac{m_t^h}{c_t}, \theta_t\right] = -\frac{i_t}{1+i_t}. \tag{3}$$

Equation (3) is a relation between money held by households, the opportunity cost of holding money, and consumption. This first order condition states that the consumer allocates resources to money until the marginal cost of the last unit of money (interest lost as money is not an interest bearing asset) is equal to the marginal benefit associated with the reduction of the cost of transactions today. The relevant cost of holding money is the nominal interest rate, as holding money not only implies losing the real return on the interest bearing asset but also its erosion of value through inflation. In this formulation, the interest rate i_t is discounted by $(1+i_t)$, an issue we will return to later.

The next step is to define the functional form h(.). In particular, we are interested in the formulation which leads to the Cagan specification.

$$\log(m_t^h) = \log(\theta_t) + \log(c_t) - \alpha \frac{i_t}{1+i_t}, \tag{4}$$

where $-\alpha$ is the semi-elasticity of the interest rate and the elasticity of consumption is unity. 1/

2. Firms' demand for money: A transactions cost model

We now extend the household transaction cost model to the firm. The joint behavior of households and firms will be analogous to that of Stockman (1981). 2/

The firms' managers maximize the present value of the cash dividends to the shareholders (households). This objective function can be expressed as:

1/ A suitable functional form is,

$$h\left(\frac{m^h}{c}, \theta\right) = K\theta + \frac{1}{\alpha}\left[\frac{m^h}{c}\log\left(\frac{m^h}{c\theta}\right) - \frac{m^h}{c}\right],$$

where the K denotes a constant large enough to make $h(.) > 0$ and $h_2(.) > 0$. It is also possible to obtain a scale elasticity less than 1 when the transactions technology exhibits increasing returns to scale.

2/ Stockman's cash-in-advance model has the usual inconvenience of a demand for money with fixed velocity and hence, no role for the interest rate. Our approach is more general and allows for an interest-sensitive demand for money.

$$V_t = \max \sum_{s=1}^{\infty} R_{t-2+s}\, d_{t-1+s}, \tag{5}$$

where,

$$R_t = \frac{1}{\prod_{s=1}^{t} (1+r_s)}, \tag{6}$$

$$d_t = f(k_t) - w_t - I_t\left[1 + g(\frac{m_t^f}{I_t}, \theta_t)\right] - m_t^f + \frac{m_{t-1}^f}{1+\pi_{t-1}}, \tag{7}$$

and

$$k_t = I_t + (1-\delta)k_{t-1}. \tag{8}$$

To insure its consistency with the treatment of households, the flows at period t in (5) are discounted with the discount factor subscripted (t-1). Implicitly, we also assume that the firm can issue bonds at the same yield. Equations (6) and (7) define the discount factor and cash dividends respectively. The firm produces and sells $f(k_t)$ units of goods given the capital stock k_t, pays a wage bill equal to w_t, invests I_t units of goods, spends g(.) in transactions costs (shopping resources) for every unit invested, and finally must devote $m^f_t - m^f_{t-1}/(1+\pi_{t-1})$ units of today's profits to increase the stock held in the form of money. Equation (8) determines the evolution of firm's capital stock, k. The capital stock at period t is equal to last periods' stock (net of depreciation) incremented by gross investment, I. Dividends are not equal to the firm's profit because of the need to add to money balances. Profits would typically be defined before this cash addition, and the latter would show up as a reserve increase on the liabilities side and as a cash increase on the assets side of the balance sheet. Finally, the term y^h_t, which appeared in the household's budget constraint (equation (2)), can be explicitly defined now as the sum of wages and dividends, $(w_t + d_t)$.

As with households, firms demand money because it reduces transaction costs. Consequently, the unitary cost function g(.) satisfies the same properties as that of the households, h(.). 1/ Substituting (6)-(8) into (5) and maximizing, leads to a first order condition for m^f_t that can be expressed as:

1/ For greater simplicity we make the transaction cost to the firm and household dependent on a common financial innovation parameter, θ.

$$g_1(\frac{m_t^f}{I_t}, \theta_t) = -\frac{i_t}{1+i_t}, \quad (9)$$

which is analogous to the household's demand for money, equation (3). The only difference is that the scale or transaction variable is investment and not private consumption. Depending on the functional form g(.), we could obtain, as before, a Cagan formulation,

$$\log(m_t^f) = \log(\theta_t) + \log(I_t) - \alpha \frac{i_t}{1+i_t}. \quad (10)$$

3. Aggregation issues

Equations (4) and (10) represent the demand for money by households and firms respectively, aggregation of these leads to:

$$\log(m_t) = \log(\theta) + \log(I_t + c_t) - \alpha \frac{i_t}{1+i_t}. \quad (11)$$

To obtain (4) and (10), however, we used the simplifying assumption of a common scale elasticity equal to unity. However, the model can yield money demand functions where the scale elasticities are less than one. Aggregation in the more general case is discussed in Appendix A.

In our empirical implementation we will estimate the following equation:

$$\log(m_t) = \eta_t + \beta_1 i_t + \beta_2 \log(Q_t) + \nu_t. \quad (12)$$

where i_t represents some measurement of the opportunity cost (whether it is i or i/(1+i) will be discussed later), Q_t some measurement of the scale variable, $\log(\theta_t) = \eta_t$, and ν_t is the error term introduced into (12) to have the equation in a regression form. This error may have different sources, some of which are discussed in Appendix A.

4. The opportunity cost of money

While the specifications yield i/(1+i) as the relevant opportunity cost measure, most of the empirical literature on money demand employs i. The difference is not trivial from the empirical point of view, as the variable i has higher variability than i/(1+i). Further, in the case of high inflation countries (which constitute half of our sample), the difference between these two measures can be considerable.

In what follows, we explain why i/(1+i) is the relevant opportunity cost variable: At the end of period t, the household must decide how much to hold in the form of money and how much to spend on consumption. The last unit allocated to money represents a loss of the interest rate i_t, a cash flow which would be realized at the end of period (t+1). The benefit of the last unit allocated to money, however, reduces the unitary cost of consumption transactions by $h_1(.)$ at the end of period t. Consequently, to make benefits and costs comparable at a point in time, the nominal flow i_t must be discounted by the factor $(1+i_t)$.

The model presented here can, with some alterations, also produce i as the opportunity cost of holding money. The key difference in the results rests directly on the timing of the services associated to the current money decision. If current money decisions yield services next period (m_{t+1} is decided at t), i is the relevant opportunity cost variable. To illustrate this in the case of the consumer, we modify the budget constraint, (2), in the following way:

$$b_{t+1} + (1+\pi_t)m^h_{t+1} + c_t + h\left[\frac{m^h_t}{c_t}, \theta_t\right] c_t = b_t(1+r_t) + m^h_t + y^h_t, \qquad (13)$$

where stocks and flows are now better understood as occurring at the beginning of period. Now $m^h{}_t$ is a state variable and the consumer chooses c_t and $m^h{}_{t+1}$ at the beginning of period t. Money, therefore, must be chosen one period before it yields transaction services. Analogous maximization to section 2 would yield the relation,

$$h_1\left[\frac{m^h_{t+1}}{c_{t+1}}, \theta_{t+1}\right] = -i_t. \qquad (14)$$

In what follows, we argue that the assumption that produces a specification such as equation (13) does not lend itself well to application using quarterly or lower frequency data. The beginning-of-period measurement introduces a wedge between the time when the money decision is made (since $m^h{}_{t+1}$ is chosen at time t) and the transaction services that decision produces, which occur at t+1. Perhaps such time interval is less arbitrary when the data in question are available at a frequency similar to the actual transactions period (say one month or higher), but with quarterly data or annual data it appears more plausible to think that decisions to consume and hold money are made simultaneously. In the end, we conduct broad specification searches that consider, in turn, both measures of opportunity cost and allow the data to determine the choice.

The theoretical framework assigns a well-defined role to "financial innovation" in the determination of money demand, indicating that its omission would result in a misspecified relationship. In the section that follows we illustrate the failure of approaches that ignore the role of financial innovation. In Section IV we consider a variety of alternatives in modeling financial innovation.

III. Failure of Traditional Approaches

Empirical studies of money demand typically rely on a specification such as (12) as a starting point. However, empirical applications of this basic model have been commonly plagued by a variety of problems, among which the more serious have been: persistent overprediction, frequently referred to as "missing money" episodes; implausible parameter estimates, commonly in the form of income elasticities well in excess of unity; and, highly autocorrelated errors. To deal with the problem of serially correlated errors and incorporate "short-run" dynamics, most commonly under the assumption of some form of partial adjustment scheme, specifications such as (12) are frequently extended to include a lagged dependent variable. Even then, the basic problems tend to persist, particularly if the sample considered covers a broad time period, thus suggesting that the traditional model may be misspecified. As the previous section illustrates, misspecification could arise because of failure to account explicitly for financial innovation or, in the case of the countries where only industrial production is available, the use of an inappropriate scale variable.

In addition to basic misspecification problems, the estimation of money demand may be further complicated by the time series properties of the variables themselves. The theoretical relationship among real money balances, a scale variable, and an opportunity cost variable is most commonly specified in terms of levels. As a consequence, empirical studies of money demand have most often involved the estimation of a linear or log-linear versions of (12). However, it has been commonly found that income, interest rates, and real money balances are non-stationary processes. 1/ If these variables are all individually I(1), inferences about the income and interest elasticities of money demand can only be made if a linear combination of these variables exists that is I(0), namely, if cointegration has been established (see, for instance, Engle and Granger (1987)). If a cointegrating vector is found, then the error term associated with that vector is a stationary well-defined process and ordinary least squares (OLS) provides consistent estimates of the true parameters and inference-making can proceed as usual. 2/ Alternatively, absence of cointegration in a traditional money demand specification would indicate that while a scale variable and interest rates may still be necessary for "pinning down" the steady state demand for money--they are not sufficient. As Section II highlights, the missing variable could be financial innovation.

1/ The most common variety of nonstationarity found in economic time series is integration of order one (i.e., I(1)), which implies that the differenced variable is stationary (i.e., I(0)) and therefore has a well-defined, finite variance.

2/ The small-sample properties of the OLS estimator when all variables are I(1) and cointegration obtains are examined via Monte Carlo simulations in Banerjee, et. al. (1986).

1. Data and specification issues

The empirical work outlined in subsequent sections employs quarterly data for ten diverse developing countries. The sample period varies across countries and was dictated by data availability; Table A.1 in Appendix B details the period of coverage for each country. Real money balances are defined as the narrow monetary aggregate, M1, deflated by consumer prices. When possible, quarterly time series on household consumption and GDP were employed as scale variables. In the absence of large external imbalances, we can expect GDP to be a good proxy for the scale variable when both firms and households have similar transactions technology, and the government behaves as a household when consuming and as a firm when investing. In the other extreme, when firms are more efficient than households in making transactions (see equation A.1 in Appendix A), we expect consumption to be a better proxy for the scale variable. In the absence of quarterly consumption and GDP data, industrial production was used as a proxy. 1/

Real balances as well as the scale variables are expressed in per capita terms. The quarterly population series was constructed from the annual observations under the assumption that population growth is evenly distributed throughout the year. Nominal interest rates on deposits were used, when possible, as a measure of opportunity cost. For countries where such rates were regulated and virtually constant over the sample period, however inflation, as measured by consumer prices, was the preferred choice. 2/ The theoretical model outlined in the previous section indicates that i/(1+i) is perhaps a more appropriate measurement of opportunity cost. Consequently, for the five high-inflation countries in our sample, where this distinction acquires importance, all subsequent estimation uses i/(1+i). For the relatively low inflation countries the more conventional measure is retained, as it generally provided superior results. Seasonal dummies were included when appropriate.

2. Empirical results

To assess the time series properties of the variables of interest the Dickey-Fuller test (D.F.) outlined in Dickey and Fuller (1981), and the augmented Dickey-Fuller (A.D.F.) were employed. As is commonly the case, the null hypothesis of a unit root in money, income, and the opportunity cost variables could not be rejected. 3/ Having thus established that the

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1/ The countries where industrial production was the only available scale variable (at a quarterly frequency) are: India, Malaysia, Morocco, and Nigeria.

2/ Inflation was used as a more relevant measure of opportunity cost in Morocco, and Nigeria.

3/ The tests performed tested both the null hypothesis of a simple random walk as well a random walk with a constant drift. While the results of these tests are not reported in the paper, to economize on space, these are available upon request.

variables in question are I(1) (unit root tests were also performed on the differenced variables), traditional money demand specifications were estimated by applying OLS to a variety of specifications that included alternative sets of scale and opportunity cost variables. To test for cointegration, the residuals of these equations were subjected to the D.F. and A.D.F. tests making the appropriate adjustments in the critical values (see Engle and Yoo (1987)).

The results summarized in Table 1 have a number of common characteristics worth noting. With the exception of Israel, the scale and opportunity cost variables have the anticipated signs. However, the magnitudes of several elasticity estimates lack economic meaning (for instance, Mexico and Argentina). 1/ The Durbin-Watson (D.W.) statistics are uniformly low. In many previous studies of money demand the low D.W. statistics were taken as evidence that portfolio changes occurred gradually, and a partial adjustment scheme was warranted (for surveys see Goldfeld and Sichel (1990) and Judd and Scadding (1982)). More recently, the D.W. statistic has been reinterpreted as yet another way of assessing whether individual variables are stationary (Bhargava (1986)) or whether a cointegrating vector has been found (Engle and Granger (1987)). Thus, the low D.W. of these traditional money demand equations are consistent with the D.F. and A.D.F. test results on the residuals which indicate that with the exception of India and Korea, the null hypothesis of no cointegration cannot be rejected. 2/ The lack of cointegration in the remaining eight countries, irrespective of which scale variable or opportunity cost variable was used, may be a product of the low power of these tests when the autocorrelation coefficient is close to one. 3/ An equally plausible and perhaps more probable explanation is that traditional specifications routinely fail to account for the ongoing process of financial innovation. To the extent that the financial innovation process has any <u>permanent</u> effects on desired money holdings, specifications such as those presented in Table 1 would be misspecified and not expected to cointegrate.

IV. The Extended Model: Alternative Approaches to Modeling Financial Innovation

The arguments in favor of incorporating a role for financial innovation or technological change in the demand for money have long been considered in the money demand literature. Gurley and Shaw (1955 and 1960), argued that the creation and growth of money substitutes made the demand for money more

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1/ This is a different result from that of Melnick (1989), who finds cointegration in the case of Argentina during the 1978-85 period.

2/ In the case of Korea the test results are mixed. The D.W. and D.F. tests indicate cointegration but the A.D.F. does not.

3/ If the error terms are stationary but highly autocorrelated and the number of observations are small these tests would <u>not</u> reject nonstationarity a high proportion of the time.

TABLE 1: TRADITIONAL MONEY DEMAND SPECIFICATIONS[1/]

COUNTRY	CONSTANT	OPPORTUNITY COST MEASURE			SCALE VARIABLE			D.W.	R^2	IS IT A COINTEGRATING EQUATION?
		i	p	i/(1+i)	c	gdp	ip			
ARGENTINA	-4.86			-0.73	0.84			0.41	0.14	NO
	(-1.78)			(-1.75)	(1.76)					
	-18.83			-0.51		2.57		0.62	0.65	NO
	(-8.15)			(-1.92)		(8.13)				
BRAZIL	2.69			-4.86	0.64			1.42	0.92	NO
	(36.79)			(-20.54)	(2.47)					
	2.63			-4.98		0.35		1.43	0.91	NO
	(31.55)			(-20.44)		(1.39)				
CHILE	-5.13			-1.07	0.96			1.04	0.60	NO
	(-15.52)			(-3.38)	(5.09)					
	-6.22			-0.77		1.33		0.83	0.65	NO
	(-13.73)			(-2.48)		(6.11)				
INDIA	-4.03	-2.53					0.59	1.04	0.63	YES
	(-29.80)	(-1.54)					(10.69)			
ISRAEL	24.64			-4.33		-2.98		0.37	0.75	NO
	(4.00)			(-11.51)		(-3.65)				
KOREA	-6.56	-0.51			1.27			0.43	0.73	YES[2/]
	(-7.78)	(-0.23)			(8.40)					
	-7.49	-1.09				0.94		0.92	0.77	YES[2/]
	(-8.74)	(-0.56)				(9.65)				
MALAYSIA	1.91	-2.43					0.07	0.80	0.35	NO
	(11.16)	(-1.97)					(1.93)			
MEXICO	-2.18			-2.76	4.84			0.42	0.72	NO
	(-6.72)			(-2.24)	(6.28)					
MOROCCO	2.56		-1.32				0.27	0.54	0.26	NO
	(9.53)		(-2.42)				(1.58)			
NIGERIA	0.69		-0.89				0.19	0.63	0.17	NO
	(12.69)		(-1.50)				(1.15)			

1/ T-statistics are in parentheses.
2/ Cointegration obtains using the Dickey-Fuller and Durbin Watson tests, not the Augmented Dickey-Fuller.

Notes

i: nominal interest rate
p: inflation rate
c: consumption
gdp: gross domestic product
ip: industrial production

interest elastic. Lieberman (1977), argues that increased use of credit, better synchronization of receipts and expenditures, reduced mail float, more intensive use of money substitutes, and more efficient payments mechanisms will tend to permanently decrease the transaction demand for money over time. Estimating the demand for narrow money in the United States, Lieberman incorporates a time trend in the money demand equation as a proxy for the unobservable variable--technological change. More recently, Ochs and Rush (1983), focusing on the demand for currency, argue that once innovations that economize on the use of currency have taken place, the impact on the demand for currency is likely to be permanent since these innovations require long-lived capital investments with very substantial sunk costs but low operating costs. In similar spirit Moore, Porter and Small (1988), include a time trend in the "long-run" demand for M1 in the United States.

Despite empirical evidence from the industrial countries supporting inclusion of a financial innovation proxy in the demand for money, most of the literature does not rely on such a specification for developing countries where there is also evidence of money demand instability. Evidence of instability is to be found in the work of Darrat (1986), who tests the stability of money demand for four Latin American countries; in Sundararajan and Baliño (1990), who test for and find shifts in money demand in several developing countries during periods of banking crises; and in Rossi (1989), who identifies a downward shift in the demand for money during the 1980s for Brazil. Exceptions to this neglect of the impact of financial innovation on money demand are Darrat and Webb (1986), who test the Gurley-Shaw thesis for India, and Arrau and De Gregorio (1991), who model financial innovation via a time-varying intercept for Chile and Mexico: this approach is used later. In the sections that follow the demand for money is reestimated by considering a variety of proxies for financial innovation.

1. Is a deterministic trend a good proxy for financial innovation?

To the extent that financial innovation can be characterized by fairly smooth improvements in cash management techniques, a negative time trend would appear to be a reasonable proxy. Equation (12), with the relevant variations in scale and opportunity cost variables was estimated for all the countries in the sample and the results are summarized in Table 2, where the choice of variables is also detailed.

$$\log(m_t) = \eta_1 + \eta_2\, t + \beta_1\, i_t + \beta_2 \log(Q_t) + \nu_t. \qquad (15)$$

As expected, the coefficient on the time trend is negative in eight of the ten countries and significant in six out of those eight. For Morocco, the coefficient is positive, but not significantly different from zero, while for Malaysia the time trend is highly collinear with industrial production, and as such, it is excluded from Table 2. The inclusion of the trend also has the effect of moving the estimates of the income and interest elasticities closer to economically meaningful values. When GDP or

TABLE 2: A DETERMINISTIC TREND AS A PROXY FOR FINANCIAL INNOVATION 1/

COUNTRY	CONSTANT	OPPORTUNITY COST MEASURE i	p	i/(1+i)	c	SCALE VARIABLE gdp	ip	TIME	D.W.	R^2	SEASON	IS IT A COINTEGRATING EQUATION?
ARGENTINA	-9.02			-0.47		1.31		-0.01	1.00	0.77	NO	YES
	(-3.07)			(-2.14)		(3.35)		(-4.38)				
BRAZIL	2.90			-1.44	1.48			-0.02	1.45	0.98	YES	NO
	(35.91)			(-2.49)	(5.73)			(-6.23)				
	2.83			-2.17		1.04		-0.02	1.01	0.97	YES	YES
	(29.53)			(-3.50)		(4.04)		(-4.77)				
CHILE	-5.51			-0.95	1.28			-0.00	0.42	0.74	YES	NO
	(-18.53)			(-2.47)	(7.55)			(-0.47)				
	-6.48			-1.45		1.60		-0.00	0.74	0.74	YES	NO
	(-14.90)			(-3.93)		(7.33)		(-2.97)				
INDIA	-2.98	-2.83					1.00	-0.00	1.30	0.75	YES	YES
	(-9.52)	(-1.98)					(8.19)	(-3.42)				
ISRAEL	-25.64			-2.97		3.80		-0.03	1.09	0.94	YES	YES 2/
	(-5.05)			(-13.70)		(5.63)		(-12.85)				
KOREA	-11.74	-2.97			2.38			-0.01	0.63	0.75	YES	YES 2/
	(-3.64)	(-1.14)			(3.49)			(-1.66)				
	-5.74	-1.84				1.09		-0.00	1.11	0.78	YES	NO
	(-4.74)	(-0.81)				(4.35)		(-0.65)				
MALAYSIA	----------------------											
MEXICO	-1.02			-0.27	1.88			-0.03	1.24	0.98	YES	NO
	(-8.79)			(-0.67)	(6.41)			(-19.09)				
MOROCCO	2.54		-1.23				0.28	0.00	0.52	0.27	NO	NO
	(9.29)		(-2.01)				(1.59)	(0.46)				
NIGERIA	0.72		-0.89				0.29	-0.00	0.68	0.22	NO	NO
	(12.42)		(-1.52)				(1.62)	(-1.42)				

1/ T-statistics are in parentheses.
2/ Cointegration obtains using the Dickey-Fuller and Durbin Watson tests, not the Augmented Dickey-Fuller.

Notes

See Table 1 for the definitions of the variables.

consumption is used the average income elasticity is about 1.2. 1/ It is interesting to note that in two of the countries where cointegration obtains, Argentina and Brazil, the point estimates for the scale variable elasticity are not significantly different from unity, which is consistent with our theoretical priors. When industrial production is employed as a scale variable, the average elasticity is about 0.52. The consistently lower coefficients of industrial production are largely due to the greater variability of production vis-à-vis GDP or consumption. 2/ Some measure of opportunity cost appears to be significant in seven of the ten countries (see Table 1 for Malaysia).

The cointegration tests were once again performed on the residuals of the equations reported in Table 2. In the case of Argentina and Brazil, the inclusion of the time trend had the effect of making the residuals stationary--that is, cointegration was achieved. In the case of India, cointegration obtains with and without a time trend, while in the case of Korea, where a traditional money demand equation did not appear to be misspecified, the inclusion of the time trend increased the serial correlation in the errors. In the remaining six countries, with no cointegrating vector, it would appear the financial innovation process cannot be adequately proxied by a deterministic trend.

The log of the ratio of M2 to M1 was also used as a proxy for financial innovation. The rationale is that the greater the array of money substitutes (reflected in the quasi-money component of M2) the lower the demand for narrow money. The results, presented in Table A-2 in Appendix B, indicate that in eight of the ten countries M2/M1 had the anticipated sign. In the case of Korea and Israel, the inclusion of M2/M1 produced a cointegrating vector.3/ However in most instances, M2/M1 was found to be collinear with the opportunity cost variable, as such, less weight is given to these results. In the section that follows financial innovation is modelled as a stochastic trend.

1/ Note that the previously negative coefficient on GDP for Israel now has the correct sign, although the magnitude, significantly above unity, remains difficult to interpret. The latter is also true for Mexico and Chile (in the case of GDP).

2/ These results are similar to those in Wilbratte (1977), who compares the demand for money of households and firms for the United States. When gross product of nonfinancial business is used as a scale variable (a proxy for the firm's scale variable) coefficients are well below those obtained when GNP or "permanent" income is used.

3/ In the case of Israel, this specification also yielded plausible values for the income (and consumption) elasticities.

2. Is a stochastic trend a good proxy for financial innovation?

This section presents an alternative approach to deal with financial innovation. We assume that technological changes in transactions (financial innovation) can be described by a stochastic trend process, and therefore they are permanent shocks to money demand. As in Arrau and De Gregorio (1991), the assumption is that the technological parameter evolves as the simplest stochastic trend process, a random walk. It is also assumed that the permanent shocks are orthogonal to the stationary shocks affecting money demand.

These assumptions can be written as:

$$\eta_t = \eta_{t-1} + \epsilon_t \tag{16}$$

where,

$$\epsilon_t \sim N(0, \sigma_\epsilon^2), \qquad and \qquad cov(\epsilon_t, \nu_t) = 0. \tag{17}$$

We also define $\sigma_\epsilon^2 = \gamma\sigma^2$ and $\sigma_\nu^2 = (1-\gamma)\sigma^2$, where the parameter γ represents the relative importance of the permanent shocks (financial innovation) to money demand vis-à-vis the transitory shocks.

Therefore, the demand for money becomes:

$$\log(m_t) = \eta_t + \beta_1 i_t + \beta_2 \log(Q_t) + \nu_t, \tag{18}$$

which is a standard regression equation except that the intercept evolves as a random walk.

Note that this definition for financial innovation is "everything that affects permanently the demand for money other than the scale and opportunity cost variables." Therefore, it may include other permanent changes besides pure technology. For example, permanent changes in regulatory policy that affect the banking system's ability to provide the medium of exchange would be included in our estimation of financial innovation. This would explain why periods of "negative innovations" can be observed. Other sources of permanent shocks could also be included, as for example, people's expectations about policies that affect the costs of holding money. It is beyond the scope of this paper to disentangle the different explanations for permanent shifts in money demand, so we associate all such effects in our broad concept of financial innovation.

The estimation technique employed here was first applied by Cooley and Prescott (1973a,b, 1976) and a brief outline of it appears in Appendix B. This three-step procedure, which allows for a time-varying intercept, provides estimates for: the time-invariant parameters, here the elasticities of the scale and opportunity cost variables as well as the seasonal factors; the relative importance of the permanent shocks (financial innovation) to money demand (i.e., γ); the sequence $\{\eta_t\}$, which traces the whole path of financial innovation and; the variance-covariance matrix of the residuals.

When $\gamma = 1$, only permanent shocks appear in the money demand equation. In this case, all changes in money demand are due to financial innovation. The estimation of this case is equivalent to estimating equation (12) in first differences. On the other extreme, $\gamma = 0$ implies that η_t is a constant and OLS applied to equation (12) in levels would be the appropriate method.

The preferred specifications for each country are shown in Table 3. Two equations are reported by country, the first one is for the maximum likelihood estimator of γ while the second uses a value for γ which is 30 percent smaller than the maximum likelihood estimate. This alternative is presented because, as shown in Arrau and De Gregorio (1991) with Monte Carlo simulations, misspecification of the true process followed by η_t and υ_t may produce an upward bias in the estimation of γ.

India is the only country where the assumption of a time-varying intercept did not produce reasonable results. This, however, is not surprising since the cointegration results of the traditional specifications indicate that there was no nonstationary variable omitted.

The method used in this section provides quite a good fit. The reason for this is that it allows maximum flexibility (through the choice of η_t) in explaining the behavior of the dependent variable. In the extreme case that γ=1, the R^2 is equal to 1, since all the residual is identified with financial innovation. In the regressions reported in Table 3 the R^2 are, in general, above 0.98. Under a correct specification of this model we also obtain unbiased estimates of the elasticities of the scale and opportunity cost variables. The tight fit, however, does not imply that money demand can be forecast with precision, since the change in η_t can not be forecast, and these changes can have a large variance.

There is no clear cut criteria to evaluate whether or not a time-varying intercept is a reasonable assumption, as in the case where a time trend or M2/M1 is used as a proxy for financial innovation, there the first test is to establish whether the inclusion produces cointegration. In any event, the estimations presented in Table 3 show that except for Malaysia and Nigeria, where the income elasticities are not significant, the parameter estimates fall in line with economic priors. As discussed previously, the problem with Malaysia and Nigeria may be the use of industrial production as a "proxy" of the true scale variable. Income elasticities fluctuate between 0.2 and 1, which are consistent not only in sign but also in magnitude with our theoretical presumptions. Thus, one of the traditional anomalies of money demand estimations, income elasticities larger than one, is not present in these estimations. Except for Argentina, consumption performs better than GDP as a scale variable when both variables where available. Interest rate elasticities range from -0.2 to -3.1, which

TABLE 3: A STOCHASTIC PROCESS AS A PROXY FOR FINANCIAL INNOVATION 1/

COUNTRY	OPPORTUNITY COST MEASURE			SCALE VARIABLE			GAMMA	SIGMA²	SEASON
	i	p	i/(1+i)	c	gdp	ip			
ARGENTINA		-0.29			0.76		1.00	0.0078	YES
		(-1.52)			(1.93)				
		-0.44			1.00		0.70	0.0062	YES
		(-2.14)			(2.39)				
BRAZIL		-3.11		0.47			0.83	0.0027	YES
		(-3.36)		(2.02)					
		-3.26		0.60			0.58	0.0025	YES
		(-4.07)		(2.60)					
CHILE		-0.50		1.04			0.75	0.0035	YES
		(-1.45)		(5.46)					
		-0.51		1.06			0.53	0.0033	YES
		(-1.47)		(5.79)					
INDIA	-------------------								
ISRAEL		-0.16		0.76			1.00	0.1255	YES
		(-0.58)		(2.15)					
		-0.15		0.89			0.70	0.0112	YES
		(-0.54)		(2.36)					
KOREA	-1.00			0.27			0.86	0.0058	NO
	(-1.71)			(2.05)					
	-0.94			0.31			0.60	0.0053	NO
	(-1.52)			(2.17)					
MALAYSIA	-1.69					0.01	0.84	0.0004	YES
	(-0.97)					(0.09)			
	-2.25					0.03	0.59	0.0003	YES
	(-1.43)					(0.49)			
MEXICO		-0.54		1.02			1.00	0.0025	YES
		(-1.09)		(2.39)					
		-0.83		1.46			0.70	0.0026	YES
		(-1.56)		(3.41)					
MOROCCO	-0.53					0.19	0.68	0.0200	NO
	(-1.90)					(2.62)			
	-0.51					0.20	0.48	0.0006	NO
	(-1.75)					(2.52)			
NIGERIA	-0.67					0.12	0.79	0.0790	NO
	(-1.84)					(0.63)			
	-0.59					0.10	0.55	0.0057	NO
	(-1.56)					(0.55)			

1/ T-statistics are in parentheses.

Notes

See Table 1 for the definitions of the variables.

are also in the feasible range. Although, for some countries, the value of the interest rate elasticity is statistically insignificant.

Comparing the estimations with those that are analogous when a deterministic trend is used, it is observed that in most cases the elasticities are smaller, in absolute value, under the assumption that the intercept is stochastic. Another important result is that whenever the deterministic time trend was included with a time varying intercept, the former never appears to be significant. 1/ This suggests that one, but not both, can be used to approximate financial innovation. This, in turn, suggests that when financial innovation is modeled as a random walk, the process does not have a drift. Table 4 summarizes the choice of variables and estimation technique that gave the best results.

3. Is the role of financial innovation large or small?

After using several alternatives to estimate financial innovation, it is useful to discuss quantitatively how important its effects on the demand for money are. We present two basic approaches. The first one consists of looking at the value of γ. This measure tells us how much of the (unexplained) shocks to money demand are due to financial innovation. The second one is to look at the role of financial innovation in the explained variation of money demand. For this purpose some variance decompositions are performed.

The maximum likelihood estimations of γ show that its value is quite large in all the countries. For the cases of Argentina, Israel and Mexico the maximum likelihood estimation of γ was at the extreme value of 1. For the rest of the countries, the value of γ is higher than 0.66. This implies that more than 2/3 of the variance of the total residual in the money demand equation is accounted for by financial innovation. In other words, most of the shocks to money demand have permanent effects.

It is interesting to note that in the high inflation countries, the value of γ is larger than in low-to-moderate inflation countries. Figure 1 illustrates in a scatterplot between γ and average inflation this positive correlation. In fact, the three countries where γ is one have been characterized by high inflation during the sample period. This would seem to indicate that the shocks to money demand have a larger permanent component in high inflation countries. This result, is in part due to our broad definition of financial innovation, which is also capturing the secular "dollarization" that has taken place in most of the high inflation

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1/ This is consistent with the results of Monte Carlo simulations presented in Cooley and Prescott (1973b), which indicate it is observationally difficult to distinguish a time trend and a time varying intercept with OLS. Using a time varying intercept, however, is more successful in identifying the presence of time trends.

TABLE 4: MOST "PLAUSIBLE" SPECIFICATION

COUNTRY	OPPORTUNITY COST			SCALE VARIABLE			TIME	METHOD OF ESTIMATION			
	i	p	i/(1+i)	c	gdp	ip		OLS	TVI	BOTH	NEITHER
ARGENTINA			X		X		X			X	
BRAZIL			X	X	X		X			X	
CHILE			X	X					X		
INDIA	X					X		X			
ISRAEL 1/			X	X	X					X	
KOREA 1/	X			X	X			X			
MALAYSIA	X					X					X
MEXICO			X	X					X		
MOROCCO		X				X					X
NIGERIA		X				X					X

1/ If M2/M1 is used as a proxy for financial innovation, cointegration obtains

<u>Notes</u>

See Table 1 for the definitions of the variables.
TVI: Time-varying intercept

countries in our sample. 1/ However, this is not the only way to quantify the importance of financial innovation on changes in money demand. We should also compare its explanatory power with respect to the other regressors, an issue that is addressed in what follows.

The next way of evaluating the importance of financial innovation in money demand is to determine how much of the explained variation in money demand is due to financial innovation vis-à-vis its traditional determinants. Although it was found that a time trend does not wholly capture the financial innovation process in the majority of the countries, it is still useful to investigate what share of the explained variation in money demand is traced to this proxy of technological change. Let us consider the case where a time trend is included in the demand for money and define m^* as the fitted value of m. The sample variance of m^* can be decomposed as follows:

$$Var(m^*_t) = \hat{\beta}_1^2 Var(i_t) + \hat{\beta}_2^2 Var(\log(Q_t)) + \hat{\beta}_3^2 Var(t) + Covs, \qquad (19)$$

where Covs represents the sum of the three covariances (appropriately weighed by the β_i's). Equation (12) can be used to approximate a variance decomposition. We consider that the relative explanatory power of each term in the total variance is the share of the variance in the total variance discounted by the covariance terms. This is equivalent to assuming that the covariances are proportionately distributed according to these shares.

Three remarks are worth emphasizing with respect to this procedure. First, this decomposition is conditional on a given sample, since variables with unit roots, as is the case with the variables in our data set, have infinite unconditional variance. For this same reason the sample variance of time is considered. Although the trend is a deterministic variable, it has variation in the sample and contributes to the variance of m^*. Finally, as most variance decompositions, the estimates of β's are treated as the true values of the parameters, without considering their own variance.

Table 5 presents this variance decomposition. Two striking results emerge. First, the time trend accounts for an average of 68 percent of the explained variation in the high inflation countries (Argentina, Brazil, Israel, and Mexico) while accounting for only 14 percent in the remaining six moderate-to-low inflation countries. Second, in three of the four high inflation countries (Brazil, Israel, and Mexico), the opportunity cost variable accounts for a higher percentage of the explained variance than the scale variable--the opposite being true in the low-to-moderate inflation countries (see Figure 2). The first of these observations lends support to

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1/ To isolate the effects of currency substitution from financial innovation a money demand function, such as the one derived in Guidotti (1989), would have to be estimated. There, a foreign interest rate affects the demand for money in addition to the domestic rate, the scale variable, and the financial technology parameter.

Figure 1: GAMMA

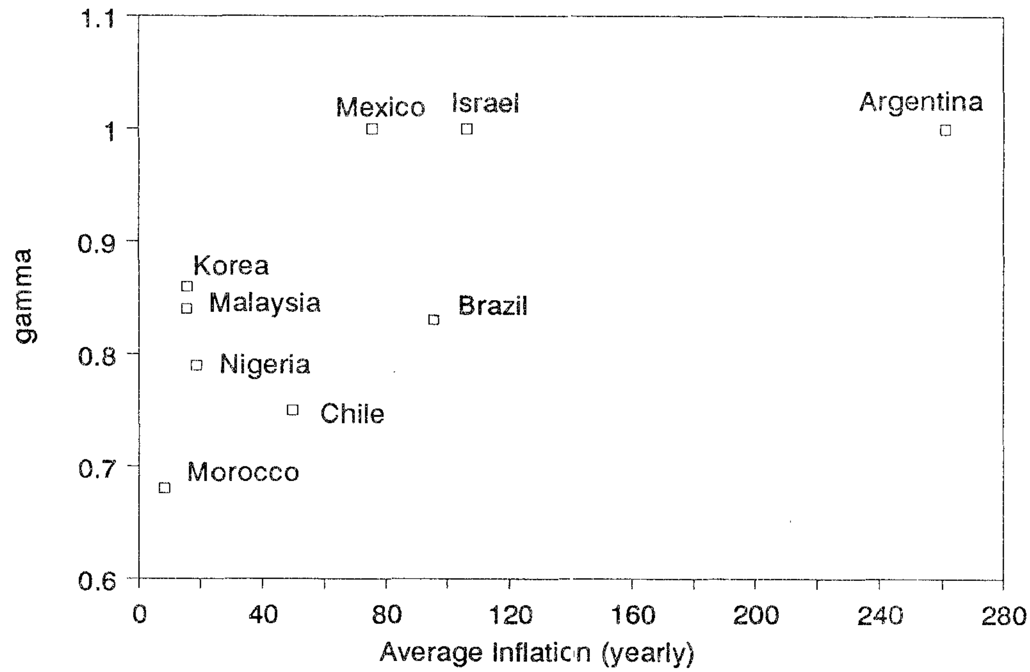
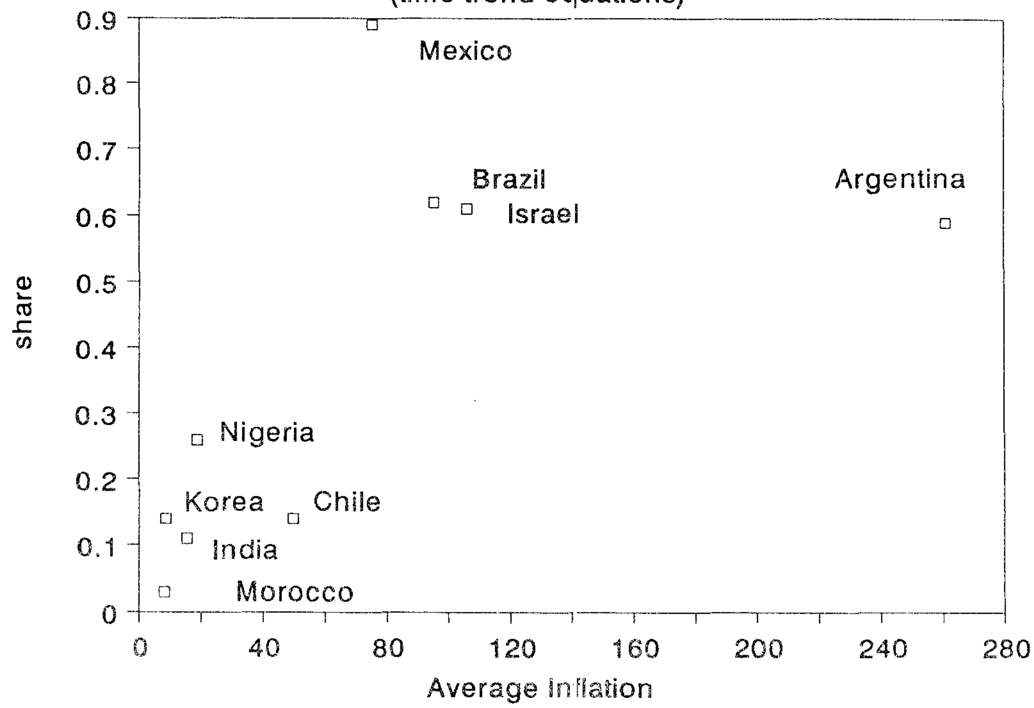


Figure 2: Share of Financial Innovation
(time trend equations)



the view that high inflation speeds the process of financial innovation, as ways to economize on the use of cash balances are more intensively sought.

In the case that financial innovation is modeled as a stochastic process, the last remark made for the time trend case is quite relevant. The estimated path of η_t has two sources of variability, first the variance of the true η's and second the variance of the estimators. Because we assume that the estimates of the β's are nonstochastic and equal to their true value, we should discount the first component in the variance decomposition. Hence, when computing m^* at t we should consider η_{t-1} as known and non random, therefore the variability explained by financial innovation is the variability explained by the shock ϵ_t. Thus, the counterpart to equation (20) for the case of stochastic financial innovation is:

$$Var(m^*_t) = \hat{\beta}_1^2 Var(i_t) + \hat{\beta}_2^2 Var(\log(Q_t)) + \hat{\gamma}\hat{\sigma}^2 + Covs, \qquad (20)$$

The rest of the procedure is analogous to the one used for the deterministic time trend case. Columns (5) to (7) of Table 5 present the results of the variance decompositions exercise in the case of the stochastic trend. The results show that, except for Brazil, financial innovation is a very important component of the variability of the fitted value of m. The results are, however, not as striking as those of the previous three columns, in fact, there is no observed clear correlation between the explanatory power of financial innovation and inflation (see Figure 3). The difference with column (1) is that although the estimate of γ is larger in inflationary countries, the estimate of σ is larger in low inflation countries. Therefore, since as was already pointed out, this method tends to produce an almost perfect fit, the variance decomposition will assign a larger share for financial innovation in countries that started with a very poor fit. These include, for example, the cases of Malaysia, Morocco and Nigeria, in which R^2 in the equations without proxying financial innovation (Table 1) are on average 0.26, due in large part to a bad proxy for the scale variable. In contrast, in Argentina, Brazil, Israel, and Mexico the average (for the relevant equations) is 0.78.

The results of this section highlight that in all countries, irrespective of how it is modelled, financial innovation plays a quantitatively important role in determining money demand and its fluctuations. Although the evidence is less definite, among other reasons, because the number of countries examined is too small to obtain strong patterns, it can also be concluded that the importance of financial innovation in explaining shocks to money demand as well as its variability is increasing with the rate of inflation.

TABLE 5: HOW MUCH OF THE EXPLAINED VARIATION IS ACCOUNTED BY FINANCIAL INNOVATION?
(Shares)

COUNTRY	GAMMA	----------OLS WITH TREND----------			-----TIME-VARYING INTERCEPT-----			AVERAGE INFLATION
		Opportunity Cost Variable	Scale Variable	Financial Innovation	Opportunity Cost Variable	Scale Variable	Financial Innovation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ARGENTINA	1.00	0.06	0.34	0.59	0.06	0.30	0.64	261.1
BRAZIL	0.83	0.31	0.07	0.62	0.94	0.02	0.04	95.3
CHILE	0.75	0.26	0.60	0.14	0.06	0.76	0.18	49.8
INDIA	----	0.01	0.85	0.14	----------	----------	----------	8.7
ISRAEL	1.00	0.29	0.10	0.61	0.01	0.37	0.61	106.2
KOREA	0.86	0.04	0.81	0.15	0.10	0.24	0.66	15.6
MALAYSIA	0.84	----------	----------	----------	0.22	0.00	0.78	15.4
MEXICO	1.00	0.11	0.00	0.89	0.06	0.51	0.43	75.3
MOROCCO	0.68	0.33	0.64	0.03	0.11	0.14	0.75	8.2
NIGERIA	0.79	0.31	0.42	0.26	0.10	0.04	0.85	18.6

V. Concluding Remarks

This paper has revisited the question of the appropriate specification of money demand functions, with a primary focus on developing countries. It was pointed out that the transmission mechanism for monetary and fiscal policy in a variety of economic models depends on the stability and predictability of the demand for money. Nevertheless, empirical work done by others, as well as that presented herein, indicate that traditional approaches tend to suffer from a number of problems which suggest misspecification.

We see two principal contributions in the present paper. First, by examining theoretical models of the demand for money by firms as well as households we find that the scale variable is likely to be different between the two sectors. Thus, in estimating the aggregate demand for money the appropriate scale variable may well depend on the relative size of each sector's holdings of money balances, which in turn can depend on the transactions "technology" and possible differences between the sectors in efficiently utilizing the technology. Second, observed shifts, or movements over time, in money holdings which are often difficult to account for satisfactorily may be attributable to shifts or movements in the transactions technology. By this, we mean firms and households finding ways and/or being offered means to economize on money holdings, a process usually referred to as "financial innovation".

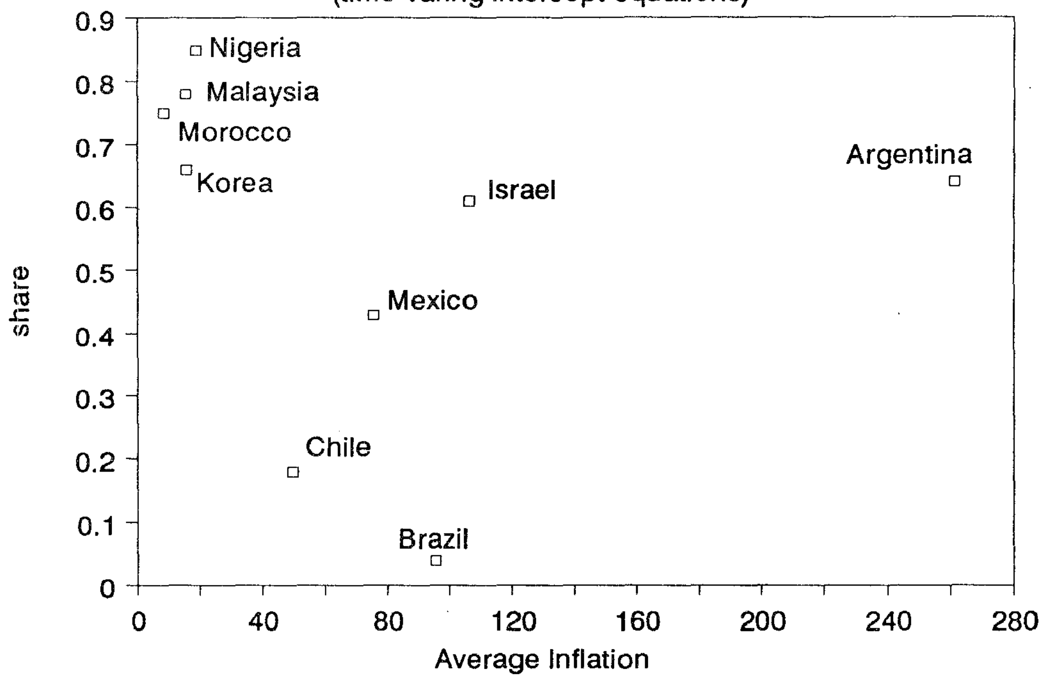
In the empirical section of the paper, we examined the time series properties of data drawn from a sample of developing countries and found that the key variables are generally not stationary, or more precisely, they are not integrated of order zero. Having established this fact, the analysis proceeded to test for cointegration which, if established, determines that the variables have a well-determined relationship to one another. Despite the use of a variety of specifications, cointegration was established in a minority of cases, and, where cointegration did not obtain, the parameter estimates suggested continuing misspecification.

As it was posited that the above results could be the result of ignoring the role of financial innovation, the paper then examined how such a process could be introduced into estimation procedures. Considered first was the possibility of modeling financial innovation as a deterministic drift process, or in other words, incorporating a time trend into regressions. In general the results of incorporating a time trend were favorable in terms of a significant parameter for the trend itself. However, despite obtaining more plausible parameter estimates for the other explanatory variables, in six of the ten countries examined the continued lack of a cointegrating vector suggested that a time trend was not an adequate proxy for financial innovation. An alternative proxy variable, the ratio of M1 to M2, was also considered, but the results were even less clearcut. We then considered whether financial innovation could be modeled as permanent shocks to money demand by assuming that the technological or innovation process follows a random walk. In general, the results were again an improvement in terms of deriving time-invariant parameters of the money demand function, and indeed better than modeling innovation as a time trend.

Consideration was then given to ascertaining how important financial innovation is in determining the demand for money. We found that, in the sample of developing countries chosen, the role of financial innovation (however modeled) was quantitatively important in determining money demand. It was also established that, although the sample was relatively small, there seems to be a positive relationship between the importance of financial innovation and the average rate of inflation that a country is experiencing. This finding is consistent with the prior that the costs of failing to innovate will be higher as the inflation rate rises.

The findings of the paper suggest that while it may be difficult to forecast the path of financial innovation, it may well be beneficial to model the process in some way, so as to recover better estimates of the deeper parameters in the money demand function. Failure to do so may lead to such policy difficulties as misreading the path and speed of policy transmission, financial programming errors, and incorrect estimates (with fiscal implications) as to seigniorage yields.

Figure 3: Share of Financial Innovation
(time-varing intercept equations)



Discussion on Aggregation and the Regression Error

This Appendix discusses the aggregation of households' and firms' demand for money when both sectors have a common interest semi-elasticity, $-\alpha$, but when the scale elasticity differs across sectors and is less than 1. Let ϕ^h and ϕ^f denote the scale elasticities of households and firms, respectively. In this case aggregation of the general form of (4) and (10) in the text, is,

$$\log(m_t) = \log\left(\theta_t^f I_t^{\phi^f} + \theta_t^h c_t^{\phi^h}\right) - \alpha \frac{i_t}{1+i_t}, \tag{A.1}$$

In this Appendix we explore under which conditions the above equation can be expressed as:

$$\log(m_t) = \log(\theta_t) + \phi\log(I_t + c_t) - \alpha \frac{i_t}{1+i_t}. \tag{A.2}$$

and assess how to recover the underlying parameters from the aggregate elasticities.

To focus on the case where the scale elasticities are different and less than 1, we continue to assume that the technological parameters θ^h and θ^f are equal. Consequently (A.1) can be expressed as:

$$\log(m_t) = \log(\theta_t) + \log(I_t^{\phi f} + c_t^{\phi h}) - \alpha \frac{i_t}{1+i_t} \tag{A.3}$$

Matching the different terms from (A.2) and (A.3) we can define the aggregate scale elasticity, ϕ, as 1/:

$$\phi = \frac{\log(I^{\phi^f} + c^{\phi^h})}{\log(E)}; \qquad E = I + c, \tag{A.4}$$

where E is expenditures in both consumption and investment.

For the case where both scale elasticities are equal, say ϕ^*, (A.4) can be expressed as:

$$\phi = \frac{\log\left[\left(\frac{I}{E}\right)^{\phi^*} + \left(\frac{c}{E}\right)^{\phi^*}\right]}{\log(E)} + \phi^*. \tag{A.5}$$

1/ Henceforth we neglect the time subscript.

Substituting in (A.2) we have,

$$\log(m_t) = \log(\theta_t) + \phi^*\log(I_t + c_t) - \alpha \frac{i_t}{1+i_t} + \log\left[\left(\frac{I_t}{E_t}\right)^{\phi^*} + \left(\frac{c_t}{E_t}\right)^{\phi^*}\right], \quad \text{(A.6)}$$

Except for the last term, (A.6) is the regression form we are looking for. The last term, however, is non-negative (the argument in log is ≥ 1 while $\phi^* \leq 1$). Without more structure about the way I and c are related, this term will part of the regression error and is assumed to be homoscedastic and uncorrelated. The mean of this term will affect the level of the intercept ($\log(\theta_0)$ for a sample from $t = 0,..,T$, if the intercept is time-varying), but not the other elasticities.

When the elasticities are not equal, however, we cannot express the term $\phi\log(E)$ as homogenous of degree 1 in log(E) for the case of proportional increases in consumption and investment (unlike A.5 above). This means that the aggregate elasticity is not invariant with respect to the level of E (for proportional increase in consumption and investment) and therefore (A.2) is not a suitable regression equation. The intuition behind this result is that with different scale elasticities, that is with different scale economies associated to the transaction technologies from households and firms, proportional increases in both scale variables have different proportional increases in their respective money demands, so that we cannot make the aggregate elasticity independent of the individual levels.

In short, we conclude that to obtain a regression equation like (A.2) we need to make both transaction functions g(.) and h(.) identical. If the scale elasticities are equal to unity, the regression error is not due to aggregation problems but stem from other sources (e.g. measurement errors). However, in the case where scale elasticities are equal but less than 1, a regression error, which stems from aggregation, appears.

TABLE A-1: DATA SET

COUNTRY	SAMPLE PERIOD	NUMBER OF OBSERVATIONS
ARGENTINA	1977:1 TO 1987:2	42
BRAZIL	1975:1 TO 1985:4	44
CHILE	1975:1 TO 1989:3	59
INDIA	1971:1 TO 1988:3	71
ISRAEL	1974:2 TO 1988:3	58
KOREA	1974:1 TO 1984:4	44
MALAYSIA	1980:1 TO 1988:2	34
MEXICO	1980:1 TO 1989:2	38
MOROCCO	1978:3 TO 1988:2	40
NIGERIA	1975:1 TO 1983:4	36

TABLE A-2: M2/M1 AS A PROXY FOR FINANCIAL INNOVATION[1/]

COUNTRY	CONSTANT	OPPORTUNITY COST MEASURE			SCALE VARIABLE			M2/M1	D.W.	R^2	SEASON	IS IT A COINTEGRATING EQUATION?
		i	p	i/(1+i)	c	gdp	ip					
ARGENTINA	-12.35			-0.26		1.77		-0.62	0.62	0.87	NO	NO
	(-7.57)			(-1.55)		(8.11)		(-8.06)				
BRAZIL	2.60			-5.52	0.37			0.19	0.62	0.95	YES	NO
	(29.02)			(-9.23)	(1.41)			(1.00)				
	2.54			-5.52		0.16		0.16	0.60	0.95	YES	NO
	(27.57)			(-8.99)		(0.69)		(0.84)				
CHILE	-6.05			-0.24	1.51			23.50	0.55	0.76	YES	NO
	(-16.18)			(-0.64)	(7.60)			(2.03)				
	-6.21			-0.83		1.37		-2.89	0.54	0.69	YES	NO
	(-11.92)			(-2.06)		(5.73)		(-0.24)				
INDIA	-3.08	-4.38					0.93	-0.26	0.70	0.79	YES	YES
	(-14.71)	(-3.27)					(12.14)	(-4.98)				
ISRAEL	-1.04			0.77	0.60			-0.79	0.78	0.98	NO	YES[2/]
	(-0.89)			(0.30)	(3.48)			(-18.92)				
	-5.37			-0.29		1.13		-0.74	0.91	0.98	NO	YES[2/]
	(-2.82)			(-1.69)		(4.42)		(-28.06)				
KOREA	-9.95	-2.48			2.17			-1.17	0.83	0.92	YES	NO
	(-16.83)	(-2.02)			(16.99)			(-9.33)				
	-6.09	-3.17				1.29		-0.73	1.96	0.87	YES	YES[2/]
	(-12.72)	(-2.09)				(13.15)		(-5.40)				
MALAYSIA	2.07	-2.39					0.14	-0.10	0.81	0.35	NO	NO
	(20.17)	(-1.89)					(1.83)	(-1.01)				
MEXICO	-2.74			-4.11	5.32			0.51	0.55	0.79	YES	NO
	(-7.04)			(-3.06)	(6.65)			(2.66)				
MOROCCO	2.65		-1.47				0.26	-0.10	0.57	0.28	NO	NO
	(9.54)		(-2.60)				(1.50)	(-0.97)				
NIGERIA	1.17		-0.74				0.30	-1.15	0.55	0.53	NO	NO
	(11.14)		(-1.64)				(2.38)	(-4.97)				

1/ T-statistics are in parentheses.
2/ Cointegration obtains using the Dickey-Fuller and Durbin Watson tests, not the Augmented Dickey-Fuller.

Notes

See Table 1 for the definitions of the variables.

Estimation with a Time-varying Intercept

For sample size T and by recursive substitution, θ_t in equation (13) can be replaced by θ_T in (13) to obtain:

$$\log(m_t) = \theta_T + \beta_1 \hat{i}_t + \beta_2 \log(Q_t) + \mu_t, \tag{A.7}$$

here,

$$\mu_t = \nu_t - \sum_{\tau=t+1}^{T} \epsilon_\tau . \tag{A.8}$$

All parameters in equation (6) are time-invariant and therefore can be estimated by traditional least square methods. The only correction is that the residuals have a non-spherical distribution, so GLS should be used. Define $\sigma_\epsilon^2 = \gamma\sigma^2$ and $\sigma_\nu^2 = (1-\gamma)\sigma^2$, it is easy to verify that the elements of the variance-covariance matrix are of the form:

$$cov(\mu_{t_1},\mu_{t_2}) = \sigma^2[(1-\gamma)1_{(t_1=t_2)} + \gamma \min\{T-t_1,T-t_2\}], \tag{A.9}$$

where $1_{(\cdot)}$ is an indicator function that takes a value of one when the condition in parenthesis holds and zero otherwise.

If γ were known, the application of GLS would be straightforward. However, γ is unknown, but can be estimated by maximum likelihood methods. Given a value of γ, the concentrated likelihood function (after replacing the estimators of the other parameters in the regression) is:

$$\mathcal{L}^*(\gamma) = -\frac{T}{2}\left[1+\ln(2\pi)+\ln(s^2)\right]-\frac{\ln(|\Omega(\gamma)|)}{2}, \tag{A.10}$$

where s^2 is the estimated variance of the regression residuals and $\Omega(\gamma)$ is the variance-covariance matrix of the residuals. A grid search for γ between 0 and 1 yields the maximum likelihood estimator.

To estimate the whole path of θ_t, the procedure is similar to the one used to estimate θ_T. To estimate θ_τ $(1 \le \tau \le T)$, all θ_t can be substituted by θ_τ and the resulting residuals used to construct the variance-covariance matrix, which is then used to estimate the parameters by GLS. It can be shown that the point estimates of the time invariant parameters (here income and interest elasticities, and seasonal parameters when included) are the same for all values of τ, only the intercept changes.

Summarizing, the procedure to estimate the time varying intercept, which corresponds to financial innovation, and the rest of the parameters of the money demand function consists of the following steps:

(i) Estimation of equation (6) by GLS for all γ in [0,1].

(ii) Choice of the γ that maximizes the concentrated likelihood. 1/ This stage also provides the estimators of the time invariant parameters.

(iii) Recovering the whole path of θ_t by estimating, with GLS, an equation similar (6) with θ_τ as intercept for all τ.

1/ Note that the estimation of γ is for the equation with θ_T as the intercept. This could be done for other values of the intercept, but the results do not change significantly.

References

Arrau, Patricio and José De Gregorio, "Financial Innovation and Money Demand: Theory and Empirical Implementation," Working Paper No. 585, World Bank, (1991).

Bhargava, A., "On the Theory of Testing for Unit Roots in Observed Time Series," Review of Economic Studies, (1986), pp. 369-384.

Cagan, P., "The Dynamics of Hyper-Inflation", in M. Friedman (ed.) Studies of the Quantity Theory of Money, Chicago: Chicago University Press, (1956).

Cooley, T.F. and E. Prescott, "An Adaptive Regression Model," International Economic Review, (1973a), pp. 364-371.

______, "Test of an Adaptive Regression Model," Review of Economics and Statistics, (1973b), pp. 248-256.

______, "Estimation in the Presence of Stochastic Parameter Variation," Econometrica, (1976), pp. 167-184.

Darrat, Ali F., "Monetization and Stability of Money Demand in Developing Countries: The Latin American Case," Savings and Development, (1986), pp. 59-72.

Darrat, Ali F. and Michael A. Webb, "Financial Changes and Interest Elasticity of Money Demand: Further Tests of the Gurley Shaw Thesis," Journal of Development Studies, (1986), pp. 724-730.

De Gregorio, José, "Welfare Costs of Inflation, Seignorage, and Financial Innovation," IMF Working Paper Number WP/91/1, (1991).

Dickey D.A. and W.A. Fuller, "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root," Econometrica, (1981), pp. 1057-1072.

Engle, Robert F. and C.W.J. Granger, "Co-integration and Error Correction: Representation, Estimation, and Testing," Econometrica, (1987), pp. 251-276.

Engle, Robert F. and B.S. Yoo, "Forecasting and Testing Co-integrated Systems," Journal of Econometrics, (1987), pp. 143-159.

Goldfeld, Stephen M., "The Case of Missing Money," Brookings Papers on Economic Activity, (1976), pp. 683-730.

Goldfeld, Stephen M. and Daniel E. Sichel, "The Demand for Money," in B. Friedman and F. Hanhn, (eds.) Handbook of Monetary Economics, Vol. I, (1990).

Guidotti, P.E., "Currency Substitution and Financial Innovation," IMF Working Paper WP/89/39, (1989).

Hendry, D.F. and G.E. Mizon, "Serial Correlation as a Convenient Simplification, Not a Nuisance: A Comment on a Study of the Demand for Money by the Bank of England," Economic Journal, (1978), pp. 549-563.

Judd, John P. and John L. Scadding, "The Search for a Stable Money Demand Function," Journal of Economic Literature, (1982), pp. 993-1023.

Lieberman, Charles, "The Transaction Demand for Money and Technological Change," Review of Economics and Statistics, (1977), pp. 307-317.

Melnick, Rafi, "The Demand for Money in Argentina 1978-87: Before and after the Austral Program," mimeo, (1989).

Moore, George R., Richard Porter, and David H. Small, "Modelling the Disaggregated Demand for M2 and M1: The U.S. Experience in the 1980s," in Board of Governors of the Federal Reserve System, Financial Sectors in Open Economies: Empirical Analysis and Policy Issues, (Washington: Board of Governors), (1990).

Ochs, Jack and Mark Rush, "The Persistence of Interest-Rate Effects on the Demand for Currency," Journal of Money Credit and Banking, (1983), pp.499-505.

Rossi, Jose W., "The Demand for Money in Brazil: What Happened in the 1980s," Journal of Development Economics, (1989), pp. 357-367.

Stockman, A. C., "Anticipated Inflation and the Capital Stock in a Cash-in-Advance Economy", Journal of Monetary Economics 8, (1981), pp. 387-393.

Sundararajan, V. and Tomás J.T. Baliño, "Issues in Recent Banking Crises in Developing Countries," IMF Working Paper Number WP/90/19, (1990).

Wilbratte, Barry J., "Some Essential Differences in the Demand for Money by Households and by Firms," Journal of Finance, (1977), pp. 1091-1099.