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Survey of Literature on Demand for Money: Theoretical and Empirical Work with Special Reference to Error-Correction Models

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Abstract

A stable money demand forms the cornerstone in formulating and conducting monetary policy. Consequently, numerous theoretical and empirical studies have been conducted in both industrial and developing countries to evaluate the determinants and the stability of the money demand function. This paper briefly reviews the theoretical work, tracing the contributions of several researchers beginning from the classical economists, and explains relevant empirical issues in modeling and estimating money demand functions. Notably, it summarizes the salient features of a number of recent studies that applied cointegration/error-correction models in the 1990s, and it features a bibliography to aid in research on demand for money.

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I. Introduction

A stable money demand function forms the core in the conduct of monetary policy as it enables a policy-driven change in monetary aggregates to have predictable influences on output, interest rate, and ultimately price. Because of its importance, a steady stream of theoretical and empirical research has been carried out worldwide over the past several decades. Majority of the work was confined to the industrial countries, especially in the United States and the United Kingdom. Relatively fewer studies were conducted on developing countries, but work has been increasing in recent years. This trend is primarily triggered by the concern among central banks and researchers around the world on the impact of moving toward flexible exchange rate regimes, globalization of capital markets, ongoing financial liberalization and innovation in domestic markets, and the country-specific events on the demand for money.

Most of the research up until the 1980s was carried out by the so-called partial adjustment models in which demand for money is thought to be a function of scale variable and a vector of opportunity cost variables. Furthermore, it was determined that due to adjustment costs, there was a lag involved for the "desired" level of holdings to match the "actual" level. Models built under this framework for the United States using post World War II data indicated that the demand for money, especially narrow money, revealed instability in the 1970s which is commonly known as "the missing money episode." Other industrial countries experienced similar problem as well. The results on developing countries, however, are mixed.

Two sets of explanations were provided for this observed instability. The first one considered the ongoing financial innovation being responsible for this issue, while the second focused on the inadequacy of the partial adjustment modeling framework as an empirical apparatus to analyze the demand for money. In order to find a solution, research on the first group attempted a variety of scale variables and modeled the financial innovation process in various ways. These refinements improved the explanatory power of the model when the past data were used but could not predict the future well. The second strand of research identified a number of theoretical and econometric problems associated with the partial adjustment framework. On the theoretical basis, buffer-stock models were put forward, but they ran into empirical difficulties as well. The econometric problems associated with the partial adjustment models led to error-correction models. The important feature of these models is that they provide significant emphasis on the time series characteristics of data. While the economic theory is allowed to define the long-run equilibrium, the short-term dynamics is determined from the data. Because of their success, they have become the primary tool to analyze the demand for money in the 1990s.

The theory suggests that the demand for money is *demand for real balances* and is a function of scale variable (as a measure of economic activity) and a set of opportunity cost variables (to indicate the foregone earnings by not holding assets which are alternatives to money). This finding has, in general, been confirmed by various theoretical framework such as inventory models, assets theories, and consumer demand theory approach. However, they differ in terms of specification and representation of these variables. Consequently, the empirical research takes this conclusion as the starting point and attempts to model the demand for money by blending the concepts from these theories. In that regard, it employs a variety of formulations, functional relationships, and data series to analyze the determinants and the stability of demand for money. Consequently, the findings also vary from study to study.

Therefore, in order to develop theory-consistent empirical models and provide the economic intuition behind the functional relationships, the paper, first provides a brief account of theoretical developments beginning from the classical economists in the next section. In the following section, it discusses in detail the merits and short-comings of various commonly-used empirical framework and issues concerning the selection of variables and their specification. As error-correction models have proved to be an important modeling framework, this section also highlights the salient features of a number of studies which employed this framework in the 1990s in both industrial and developing countries. The paper also provides a detailed set of references for issues relevant to empirical work to aid the researchers interested in carrying out the money demand research.

II. THEORY

Money is the modern medium of exchange and the standard unit in which prices and debts are expressed. Basically, it serves four major functions–medium of exchange, store of value, unit of account, and source of deferred payment. In general, demand for money is demand for real balances. Money demand theories have evolved over time and this section briefly touches upon the developments beginning from the classical tradition to the recent ones.[2]

A. Classical Economics

Economists beginning from the classical tradition prevailed upon the four major functions as mentioned above to formulate their theories of money. According to the classical theory, all markets for goods continuously clear and relative prices flexibly adjust to ensure that the equilibrium is attained. The economy is always in full employment levels except for the transitory deviations as a result of real disturbances. In such an economy, the role of money is simple: it serves as the numéraire, that is, a commodity whose unit is used in order to express prices and values, but whose own value remains unaffected by this role. It also

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[2]Refer to Schumpeter (1954), Barber (1967), Barro and Fischer (1976), McCallum and Goodfriend (1987), Goodhart (1989), Goldfeld and Sichel (1990), Papademos and Modigliani (1990), Cuthbertson and Barlow (1991), Grossman (1991), and Laidler (1993) for surveys of literature on theoretical developments on money demand.

facilitates the exchange of goods (medium of exchange) as Jevons (1875) pointed out that the use of money satisfied double coincidence of wants.[3] However, it does not influence the determination of relative prices, real interest rates, the equilibrium quantities of commodities, and thus aggregate real income. Money is "neutral" with no consequences for real economic magnitudes. Its role as a store of value is perceived as limited under the classical assumption of perfect information and negligible transaction costs.

The roots of the modern theory of money demand began to implant from the early contributions of Leon Walras whose money demand theory is simply a part of his general theory of economic equilibrium (see Schumpeter (1954), p. 1082).[4] Apart from Walras, there was little emphasis on money demand *per se* in the pre-1900 contributions of classical economists like Mill (1848) and the early 20th century neoclassical economists like Wicksell (1906) despite a clear recognition by these analysts that some particular quantity of real money holdings would be desired by the economic agents under a specified set of circumstances. The concept of money holdings began to take a formal shape in the quantity theory especially through the writings of Pigou (1917). Earlier, Fisher (1911) provided the famous formulation of quantity theory through the so-called equation of exchange.

B. Quantity Theory

The quantity theory brings forth a direct and proportional relationship between the quantity of money and the price level. This relationship was developed in the classical equilibrium framework by two alternative but equivalent expressions. The first version called "equation of exchange" is associated with Irving Fisher of Yale University and the second "Cambridge approach or cash balance approach" is associated with the Cambridge University economists, especially A.C. Pigou. Both versions are primarily concerned with money as a means of exchange, and hence, they yield models of the transaction demand for money. While Fisher (1911) concentrated on institutional details of the payment mechanism in his analysis, Cambridge economists focused on motives for holding money by individuals.

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[3]Refer to Goodhart (1997) for a recent study on historical account of various concepts of money. Ritter (1995) presents the theoretical underpinning on moving from barter to the fiat-money regime. The references contained in the article point out various studies on the evolution of money.

[4]Schumpeter was referring to Walras's 4th edition of the *Elements d'economie politique pure* (1900) in which Walras's pure theory of money was fully developed, although he has been developing his theory over the 1876-99 period.

Fisher's "equation of exchange"

In the classical quantity theory, demand for money was not even mentioned, instead what stressed was a concept called "transactions velocity of circulation of money" which measures the average number of times a unit of money is employed in carrying out transactions in the given period. This approach associated with Fisher (1911), is based upon the "equation of exchange," $M_s V_T = P_T T$, which relates the quantity of money in circulation M_s to the volume of transactions T and the price level of articles traded P_T in a given period through a proportionality factor V_T called the "transactions velocity of circulation." This equation is not an identity rather an equilibrium condition. Money is held simply to facilitate transactions and has no intrinsic utility.

Referring to Fisher's writings, Schumpeter (1954) has pointed out that in the equation of exchange, M_s is normally the most important "active" variable and P_T is the "passive" element. Although, M_s, V_T, and T are only "proximate causes" of P_T, there are scores of other variables which act through M_s, V_T, and T on P_T. The velocity variable incorporates the technological factors and institutional arrangements of the monetary system governed by non-monetary factors and is assumed to be stable in the short run. The quantity of money is assumed to be determined independent of other variables shown in the equation so is the variable T, the volume of transactions. In the classical economics framework of full-employment equilibrium, it is assumed that there exists a stable ratio between the level of transaction and the output. Given these considerations, the equation of exchange can be shown as: $\bar{M}_s \bar{V}_T = P_T \bar{T}$ where bars over M_s, V_T, and T signify that these variables are determined independently of others. It is evident from this framework by treating $\bar{M}_s$ exogenous and holding $\bar{V}_T$ and $\bar{T}$ constant, the equilibrium price level moves in strict proportion to the quantity of money, that is, money is "neutral."

Cambridge approach

An alternative paradigm to the quantity theory relates the quantity of money to nominal income and stresses the role and importance of money demand in determining the effect of money supply on the price level. This so-called Cambridge approach or cash balance approach, is primarily associated with the neoclassical economists Pigou (1917) in particular and Marshall (1923), among others associated with the Cambridge University.

Three issues are different in the cash balance approach compared to the earlier one. First, the emphasis is made on individual choice rather than on market equilibria. The Cambridge economists asked what determines the amount of money an individual agent would wish to hold given that the desire to conduct transactions makes money holding attractive at all in contrast to the earlier approach by Fisher, who raised the question what determines the amount of money an economy needs to carry out a given volume of transactions. That is, the focus has changed from a model where V was determined by the payments mechanism to one where agents have a desired demand for money (Cuthbertson and Barlow (1991), p. 16)). Second, money is held not only as a medium of exchange as in Fisher's case, but also as a store of value that provides satisfaction to its holder by adding convenience and security. And third, the concept of money demand comes across more explicitly as discussed below. In this connection, Cambridge economists pointed out the role of wealth and the interest rate in determining the demand for money.

When formalizing the model, particularly Pigou, chose to simplify it by assuming that for an individual the level of wealth, the volume of transactions, and the level of income–over short periods at least–move in stable proportions to one another. When other things are being equal, the demand for money in nominal terms (M_d) is proportional to the nominal level of income (Py) for each individual and hence for the aggregate economy as a whole, that is, $M_d = kPy$. It was recognized that k might depend on other variables in the consumer allocation problem such as the interest rates and wealth, but the main focus was the level of transactions. Incorporating the money market equilibrium condition of $M_s = M_d$, an equivalent expression of $M_s * (1/k) = M_sV = Py$ can be obtained. Since, $M_s = M_d = M$ in equilibrium, the equivalent expression leads to the familiar quantity theory formulation of $MV=Py$ relating the quantity of money to the nominal income. Unlike in Fisher's formulation, V is termed here as the "income velocity of circulation" determined by technological and institutional factors and is assumed to be stable. Given that the real income y is at the full-employment level and V being fixed, an increase in the quantity of money results in a proportional increase in P–that is, money is "neutral," the familiar quantity theory exposition.

The Cambridge formulation of the quantity theory provides a more satisfactory description of monetary equilibrium within the classical model by focusing on the public's demand for money, especially the demand for real money balances, as the important factor determining the equilibrium price level consistent with a given quantity of money. The emphasis the Cambridge formulation places on the demand for money is notable because it influences both the Keynesian and the Monetarist theories. More importantly, the analytical thinking has been redirected from the institutional factors and the needs of the community at large to the individual behavior of choice.

C. Other Neoclassical Approaches

The neoclassical economists considered the primary role of money as a medium of exchange. It was sought for the command over goods and services that it provided. Money was economically interesting as it was spent and circulated throughout the system. Its store of value function was also emphasized. One shortcoming, however, was that there was no explicit role for interest rates in determining the demand for money in their writings. They attributed rather various other factors affecting the demand for money. For example, Marshall and Pigou suggested that the uncertainty about the future was a factor influencing the demand for money (see Laidler (1993), p. 53). Cannon (1921) postulated a negative relationship between money demand and the anticipated inflation, which was recognized by Marshall (1926) also (see McCallum and Goodfriend (1987)).

Previously, the Cambridge economists implicitly stated the potential importance of the interest rate as a key variable affecting money demand by the term "other things being equal," where, the factor *k* in the Cambridge model as discussed above contained possible influence of the rate of return on alternative assets. Lavington (1921) identified the interest rate as a key determinant of the marginal opportunity cost of holding money, that Fisher (1930) later concurred. Hicks (1935) argued that the money demand theory should be built within a framework of traditional value theory, in which money demand is the outcome of a problem of choice among alternative assets subject to a wealth (balance sheet) constraint, and hence, is influenced mainly by anticipations of yields and risks of these assets as well as by transactions costs. However, it was Keynes who provided a convincing explanation on the importance of the interest rate variable affecting money demand and emphasized the significance for macroeconomic analysis of the interest sensitivity of money demand, "liquidity preference."

D. Keynesian Theory

Keynes provided a more rigorous analysis than his predecessors and looked at the money demand issue in a completely different analytical angle. When the classical and neoclassical economists analyzed the money demand mainly in terms of "money in motion," that is, there is no hoarding possibility as all income is spent, Keynes analyzed money in terms of "held" (as in the Cambridge approach of the quantity theory) and focussed on the motives that lead people to hold money and the money demand arising from these motives.[5] In this respect, Keynes associated himself with the Mercantilist views.

Keynes postulated that the individuals held money with three motives: transactions, precautionary, and speculative. The transactions motive is similar to the emphasis the quantity theories placed on money as a medium of exchange. He theorized that the level of transactions conducted by an individual, and also by the aggregate of individuals, bears a stable relationship to the level of income thereby suggesting that the "transactions demand" for money depends on the level of income. The transactions demand for money arises because of the nonsynchronization of payments and receipts. Individuals are also uncertain about the payments they might want, or have, to make. He hypothesized that this precautionary motive also creates a demand for money. Therefore, the precautionary demand for money provides a contingency plan for unscheduled expenditures during unforseen circumstances. Money serves as a medium of exchange in this motive, and by and large, it depends on the level of income as well. His significant contribution to the money demand theory, however, came from the role the speculative motive plays. The speculative demand for money is what Keynes called as "liquidity preference." Keynes tried to formalize one aspect of the suggestions earlier made by Marshall and Pigou that uncertainty about the future was a factor influencing the demand for

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[5]Keynesian approach to the money demand theory was well developed in Keynes (1930 and 1936).

money. Instead of talking uncertainty in general, Keynes focused on one economic variable, the future level of the interest rate, in specific, the future yield on bonds.

The store-of-value function is emphasized in the speculative motive of the demand for money. Individuals can hold their wealth either in money or in bonds. The price the individuals are willing to pay for bonds depends on the rate of interest as the prospective buyers would wish to earn at least the going rate of interest on their bond portion of their portfolio. Keynes argued that, at any time, there was a value, or perhaps a range of values, of the rate of interest that could be regarded as normal. When the rate is above this normal range there is a tendency for people to expect it to fall, and rise when the rate is below this range.

For an individual agent with given and precise expectations about the future value of the interest rate, the speculative demand for money is a discontinuous function of its current level. However, for the economy as a whole, people may have divergent expectations about the rate of change of the interest rate toward their own precise estimates of its future value. Provided that there is some diversity of opinion about the expected rate of interest at any moment, and the money and bond holdings of each agent are insignificant relative to the total amount in the economy, the aggregate speculative demand for money function becomes a smooth and negative function of the current level of the interest rate.

Thus the interest rate was formally introduced in the money demand function and the function now can be represented as $m^d = f(y,i)$, where the demand for real money balances m^d is a function of real income y and interest rate i. Thus the Keynesian theory of money demand, like his predecessors', is a theory of demand for real money. The major implication of the Keynesian analysis is that when the interest rate is very low, everyone in the economy will expect it to increase in the future, and hence, prefers to hold money whatever is supplied. At this stage, the aggregate demand for money becomes perfectly elastic with respect to the interest rate. The economy gets into a situation called "liquidity trap" in which the interest elasticity of money demand can be infinite at low levels of interest rate.

Upon Keynes's contribution to the theory of money demand, researchers put forward a number of other theories by including both income and interest rates as arguments to examine the nature and the determinants of the money demand functions. These theories implicitly address a broad range of hypotheses by emphasizing the transactions, speculative, precautionary, or utility considerations of holding money. The following subsection discusses briefly major aspects of these theories.

E. Post-Keynes Theories of Money Demand

Two characteristics of money provide the starting point for many of these theories. The medium of exchange function leads to transactions models of which inventory models assume the level of transactions to be known and certain, and the precautionary demand models treat net inflows as uncertain. The store-of-value function gives rise to asset or portfolio models where money is held as part of the portfolio of assets of the individuals. Thus the special characteristics of money leads to formulation of theories that are based on explicit motives for holding it. There are also theories which ignore the motives aspect altogether but instead assume that people do hold money, and analyze the demand for money in a general consumer demand theory framework. The discussion begins with the inventory-theoretic models.

Inventory-theoretic approach

Baumol (1952) and Tobin (1956) used this approach to develop in a deterministic setting a theory of money demand in which money was essentially viewed as an inventory held for transactions purposes. Although liquid financial assets other than money offered higher yields, the transactions costs of going between money and these assets justified holding such inventory. These models assume the presence of two stores of value (money and an interest-bearing alternative asset), a fixed cost of making transfers between money and the alternative asset, and exogenous receipt and expenditure streams. All payments are made with money and all the relevant information is assumed to be known with certainty.

The household's portfolio problem, therefore, involves balancing of two component factors: one is that earning assets pay interest while money does not; and the other is that money, however, is required to make transactions due to lack of synchronization between receipts and expenditures. Brokerage costs may be incurred when earning assets must be sold to finance a transaction. Consequently, higher average holdings of money help minimize such transaction costs, but also mean greater forgone earnings of interest. Therefore, even though the holdings of assets may be for shorter periods, the interest earnings may be worth the cost and inconvenience of financial transactions involved.

The optimal transaction frequency, therefore, involves a balance between the increase in transaction costs and the reduction in interest costs. The agents minimize the sum of brokerage costs and interest income forgone. These models lead to a well-known "square-root formula"— $m^* = \sqrt{(a_o y)/2r}$, which says that optimal demand for real money balances (m^*) is directly proportional to transactions costs (a_o) and real income (y), and inversely proportional to the interest rate (r). A summary of extension of these models can be found in Barro and Fischer (1976) and Cuthbertson and Barlow (1991). Roley (1985) lists the theoretical work done by Clower and Howitt (1978), Akerlof (1979), Akerlof and Milbourne (1980a), and Santomero and Seater (1981), among others, as alternatives to the transactions demand approaches of Baumol (1952) and Tobin (1956). Smith (1986) develops a dynamic version of this framework.

Another class of models that emphasizes the transaction role of money is the "cash-in-advance models." These are equilibrium models which incorporate a specific sort of restriction that purchases in a given period should be paid for by currency brought in from the previous period. This type of limitation is commonly known as "cash-in-advance constraint" (from the fact that the buyers need cash in advance) or "Clower constraint" (bearing the researcher's name who first developed this type of constraint) (see Clower (1967)). It provides an alternative for including money in the utility function and offers an intuitively appealing and simple analytical tool to investigate why rational agents may hold money.[6] Lucas (1980) made seminal contributions in developing the cash-in-advance models to provide microfoundations for money and to extend the theoretical support for transactions demand for money. He incorporated the optimizing behavior of individuals as discussed in Baumol (1952) and Tobin (1956) and the cash-in-advance constraint in a macroeconomic equilibrium setting to study the transactions demand for money.

Although there are many variations exist, in general, the cash-in-advance models have the following five elements: first, there are a large number of identical agents deriving utility over time by consuming goods; second, the agents have certain endowments which are allowed to trade with other agents for money that was brought in from the previous period; third, the total amount of consumption goods acquired should not exceed the total amount of money, thus the available money establishes a ceiling for the goods to be consumed;[7] fourth, the trading is conducted according to some strict rules regarding the time, place, and interval of trading; and fifth, in equilibrium, total amount of production equals consumption and the demand for money is exclusively the transactions demand.[8]

However, there are a number of problems associated with this theoretical apparatus. First of all, it failed to provide a convincing explanation why people use money or what objects circulate as money; in short, it could not provide the microfoundations for money

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[6]The earlier impetus for the cash-in-advance constraint comes from the work of Brunner (1951) who recognized the transaction role of money not in the utility function but from the constraints faced by a transactor when deciding how much to supply and demand of each good (see Howitt (1992)). In money in the utility function approach, agents are assumed to derive utility not only from consuming goods and services but also from holding real balances (see Patinkin (1965)). The agents get utility because holding real balances reduces the probability of running out of cash as a result of the stochastic payment process. In other words, it influences the shopping time involved in taking trips to banks (see Brock (1974)). Feenstra (1992) provides a brief account of the money in the utility function approach.

[7]However, there are models which exist which allow for credit markets with people having no cash at the beginning of the period (see Sargent (1987)) and where one can finance the entire purchases through trade credit rather than by giving cash in advance (see Kohn (1981)).

[8]The transaction demand for money arises from Lucas's (1982) assumption that the agents learn in the beginning of each period the current state of economy after which they trade their assets and money and buy consumption goods. However, by introducing uncertainty (by way of modifying the assumption that the agents must decide on their cash holdings before they know the current state and hence before they know their consumption), one can develop a combined transactions, precautionary, and store-of-value of demand for money (see Svensson (1985)).

which it intended to do. It also put severe restrictions in terms of timing and interval of transactions (see Howitt (1992)). As the cash-in-advance constraint puts a strict upper limit on purchases during a given period, the demand for money tends to be less sensitive to interest-rate changes (see McCallum and Goodfriend (1987)). Since introducing uncertainty in the model brings in not only the transactions demand for money but also the precautionary and demand for money as a store of value, McCallum and Goodfriend (1987) proposes a "shopping-time" model to bring out the medium-of-exchange role of money more explicitly.

Precautionary demand for money approach

As next to the transactions motive, people do hold money for the precautionary motive. The precautionary demand for money arises because people are uncertain about the payments they might want, or have, to make (Whalen (1966)). In this framework, the more money an individual holds, the less likely he or she is to incur the costs of illiquidity. But the more money the person holds, the more interest he or she is giving up. Therefore, the person optimizes the amount of precautionary cash balances to hold by carefully weighing the interest costs against the advantages of not being caught illiquid (Dornbusch and Fischer (1990)).

The precautionary money demand models are developed by relaxing the assumption underlying the inventory models that receipts and payments are known with certainty. However, the probability distribution of receipts and expenditures are assumed to be known. For example, Miller and Orr (1966 and 1968) applied a stochastic framework for the inventory models by assuming a random flow of receipts and expenditures. Patinkin (1965) assumed that an economic unit faces a given amount of net expenditures over a discrete interval, but the timing of cash inflows and outflows during the period is uncertain. The unit holds a precautionary cash balance to guard against the possibility of a string of cash outflows that would otherwise exhaust liquid resources during that period. One implication of the model is that an increase in the overall volume of transactions would lead to a less than proportional increase in money holding.

Barro and Fischer (1976) and Cuthbertson and Barlow (1991) summarize the work done in this area by other researchers. Akerlof and Milbourne (1980b), Milbourne (1983), and Milbourne, Buckholtz, and Wason (1983) present some recent models on precautionary demand for money. These models have implications in the empirical estimation of money demand function in a class of models called "buffer-stock" which is discussed in the next section.

Money as an asset approach

Many theories have been put forth by treating money as an asset by emphasizing its store-of-value function. These so-called asset or portfolio models are often associated with the "Yale School" which view the demand for money in the context of a portfolio choice problem. The demand for money, in this framework, is interpreted more broadly as part of a problem of allocating wealth among a portfolio of assets that includes money with each asset generating some mix of explicit income and implicit (or non-pecuniary) service flows. Major emphasis is placed on risk and expected returns of the assets. In the case of money, the pecuniary yield includes the services such as the ease of making transactions (as the transactions models imply), in addition to rendering liquidity and safety (Judd and Scadding (1982)). These models are being developed to show the relationship between the interest rates and the demand for real money. They also consider the importance of wealth and liquidity as other key variables in determining the money demand.

As an alternative explanation for Keynes's original liquidity preference schedule arising from the differences in expectations of future interest rates, Tobin (1958) demonstrated that the theory of risk-avoiding behavior of individuals provided basis for the liquidity preference and for a negative relationship between the demand for money and the interest rate. Actually, the risk-aversion theory is based on the simple principles of portfolio management. In this framework, the risk/reward characteristics of various assets together with the taste of the individual determine the optimal portfolio structure which is obtained by maximizing the utility consistent with the available opportunities.

Tobin (1958) postulated that an individual would hold a portion of his/her wealth in the form of money in the portfolio because the rate of return on holding money was more certain than the rate of return on holding earning assets. Therefore, it is riskier to hold alternative assets in comparison with holding just money alone. The difference in riskiness may arise because government bonds and equities are subject to market price volatility, while money is not. In spite, the individual is willing to face this risk because the expected rate of return from the alternative assets exceeds that of money. Consequently, the risk-averse economic agents may want to include some money in an optimally structured portfolio. However, Fischer (1975) has shown that the risk-aversion behavior of the economic agents alone does not provide a basis for holding money. It is primarily because money is not completely riskless as Tobin (1958) postulated above since it is subject to the risk of price level changes. There are other assets, such as time deposits, that have preciously the same risk characteristics as money but yield higher returns. The safe asset is, therefore, an indexed bond.

A class of models called "overlapping-generations models" also emphasizes the store-of-value function of money. Originally pioneered by Samuelson (1958), two classical macroeconomists, Thomas Sargent and Neil Wallace, among others brought these models to prominence in the 1980s (see Wallace (1977 and 1988) and Sargent and Wallace (1982)). The overlapping-generations models are dynamic equilibrium models which emphasize the differing perspectives on saving of young and old individuals. For a simple exposition, the agents are assumed to live in two periods (periods 1 and 2) so that at any moment half the economy's population is young and the other half is old, enabling the generations to overlap.

Money is considered purely as an asset in these models with its medium-of-exchange function to facilitate current transaction being completely ignored; money, instead, makes it possible otherwise impossible intergenerational transactions. Each agent receives at birth a certain endowment of consumption goods, which are nondurable that cannot be stored for consumption in the next period. However, the endowment can be exchanged for money which can be stored between periods. In each period, the young exchanges some of its endowment of consumption goods for money from the old generation, thereby facilitating the older generation to smooth out its consumption across periods. Introduction of money in this framework has opened up the possibility of intergenerational trade which brings the benefits to all concerned.

It looks like money is playing the role of medium of exchange in these models, but it is the durability or its capacity to act as a store of value is facilitating the intertemporal shift of consumption possibilities. Thus, these models provide a vehicle to understand the demand for money as an asset rather than as a means of exchange. The major criticism, however, is that they fail to explain the observed tendency for agents to hold money when other assets exist which are devoid of nominal risks but pay positive interest rates (see McCallum (1989)).[9]

Consumer demand theory approach

Alternatively, money is also analyzed under the consumer demand theory approach (Friedman (1956) and Barnett (1980)), where goods are held because the individuals derive utility from them. This approach is often associated with the "Chicago School" which considers the demand for money as a direct extension of the conventional theory of demand for any durable good.[10] This was the case in "restatement of the quantity theory," in which, Friedman (1956) argues that the demand for assets should be based on axioms of consumer choice. He begins with the general demand theory as an explicit starting point by treating money as any other asset yielding a flow of services and using a broad measure of wealth (human and non-human) as the appropriate budget constraint.

Instead of asking what prompts the individuals to hold money as Keynes did, Friedman assumes that people do hold money as in the Cambridge approach of the quantity theory and analyzes how much money people want to hold under various circumstances. One minor difference is that the measure Friedman uses in his analysis corresponds to broad money while the earlier approach refers to narrow money. He went along with the views of the neo-Keynesians' portfolio approach of money demand where money was part and parcel of financial assets, but added further that the real goods should also be included in the portfolio as they yield a stream of services. Consequently, he suggested that significantly broad range of opportunity cost variables including the expected rate of inflation (as a proxy for yield on real

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[9]Apparently theoretical models that combine both the transactions and portfolio approaches of money demand are extremely few. Goldfeld (1987) cites Ando and Shell (1975) for such a study. Spencer and Yahya (1985) refer to a study by Frenkel and Jovanovic (1980) which blends the transactions and the precautionary demand for money.

[10]See Feige and Pearce (1977) for further discussion of this approach.

goods) have theoretical relevance in a money demand function. He also demonstrated wealth as a key determinant of money demand.[11]

In the recent literature, the consumer demand theory approach has been playing a lead role in the area of monetary aggregation theory.[12] The idea is that the calculation of monetary aggregates such as M1, M2, M3, and L as in the case of the United States (which may vary in other countries), use equal weights for their components. This procedure implicitly assumes that the different segments of nonbank public treat each component of the monetary aggregates they hold as perfect substitutes. In reality, however, the economic agents do not consider these components held in their portfolio as perfect substitutes as each component may have different opportunity cost. Hence, an alternative measure to construct the "consistent" aggregates will be applying weights appropriately that reflect the extent to which the assets provide liquidity and transaction services.[13]

The weights are calculated based on the moneyness of assets or the substitutability among them by applying the principles of micro economics. The assets formally enter as inputs into the production function of money services and are consistently aggregated based on their joint contribution to the output of money services. The greater the contribution the larger the weight the particular asset gets. The earlier impetus of this approach was provided by Chetty (1969) who employed a constant elasticity of substitution production function to find the degree of substitution between money and other financial assets. The elasticity estimates are then used to aggregate the money and other financial assets. The recent papers by Anderson, Jones, and Nesmith (1997b and 1997c) show various new formulations and the aggregation techniques used to calculate the monetary aggregates. The aggregates are usually approximated by statistical numbers generated based on the theory of index numbers. One such common monetary aggregate frequently employed in the recent empirical literature is "divisia index."[14]

F. Conclusion

So far we have traced the theoretical developments on money demand beginning from the classical tradition. In the classical school, money served as a numéraire. The quantity

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[11]See Cuthbertson and Barlow (1991) and Kaufman (1992) for further an elaboration on this approach.

[12]See Barnett (1980 and 1990), Barnett, Offenbacher, and Spindt (1984), Barnett, Fisher, and Serletis (1992), and Anderson, Jones, and Nesmith (1997a).

[13]See Barnett (1980) and Janssen (1996).

[14]Fase and Winder (1994) state that F. Divisia (1925 and 1926) first formulated the monetary index concept in a series of articles published in *Revue d'Economie Politique*.

theory provided some important insights into the concept of money demand, especially through the writings of Pigou. The cash balance approach of the Cambridge University economists explicitly stressed the demand for money as public demand for money holdings and laid out the formal relationship between demand for real money and the real income. Keynes built upon the Cambridge approach and developed the money demand theory based on explicit motives that prompt people to hold money and formally introduced the interest rate as an additional explanatory variable in determining the demand for real balances.

The post-Keynes economists developed a number of models to provide alternative explanations to confirm the formulation relating real money balances with real income and interest rates. The medium-of-exchange function of money led to the inventory-theoretic formulation that emphasized the transactions costs under certainty and to the precautionary demand for money models that introduced the concept of uncertainty in otherwise transactions cost models. The cash-in-advance models further exemplified money's medium-of-exchange function. The asset function of money led to asset or portfolio approach which evaluated the demand for money under the optimization of portfolio framework where money was held as part of a portfolio of many assets which inherently differed in the yield and risk characteristics. The overlapping generations models went to an extreme by completely ignoring money's medium-of-exchange role and emphasizing only the asset role does the money play. The consumers demand theory approach retained the characteristics of the portfolio approach but considered money as any other consumer good providing flow of services and analyzed the demand for it under the utility maximization framework. In short, all these models can be broadly lumped into three separate frameworks namely transactions, asset, and consumer demand theories of money.

The interesting point is while all these models analyzed the demand for money in different angles, the resulting implications are almost the same. In all instances, the optimal stock of real money balances is inversely related to the rate of return on earning assets, that is the interest rate, and positively related to real income. The differences, of course, arise in terms of using the proper transaction (scale) variable and the opportunity cost of holding money. The empirical analysis of money demand estimation takes this conclusion as a starting point.

III. Empirical Analysis

A large body of literature is available in estimating money demand functions. The work in the past was confined primarily to industrial countries, especially in the United States and in the United Kingdom. However, lately there has been considerable interest among several industrial and developing countries alike. The central banks in these countries come to realize that the stable money demand function forms the corner stone for the conduct of monetary policy. Researchers from other institutions are also keen in looking at the stability of the these functions in midst of rapidly changing external and internal economic and financial landscape including those mentioned in Section I above and increasing tendency toward liberalization of international transactions. One of the significant contributors of the empirical research on money demand is the major advancements made in time series econometrics in the past ten years or so which have motivated the researchers to revisit the empirical models built previously.

This section provides a brief overview of relevant issues concerning the empirical estimation of money demand functions, which are slightly different from those presented in the theoretical literature of the last section, and discusses broad types of models employed in the empirical work with their relative strengths and weaknesses. The lessons learned from the literature survey will help select the appropriate modeling framework and estimation technique. Additionally, it will yield information regarding the variables to be selected and their preferred specifications.

A. Money Demand Theories and the Empirical Estimation Issues

As seen in the previous section there is a diverse spectrum of money demand theories emphasizing the transactions, speculative, precautionary, or utility considerations. These theories implicitly address a broad range of hypotheses. One significant aspect, however, is that they share common important elements (variables) among almost all of them. In general, they bring forth a relationship between the quantity of money demanded and a set of few important economic variables linking money to the real sector of the economy (Judd and Scadding (1982), p. 993). What sets apart among these theories, however, is that although they consider similar variables to explain the demand for money, they frequently differ in the specific role assigned to each (Boorman (1976), p. 35). Consequently, one consensus that emerges from the literature is that the empirical work on the money demand is motivated by a blend of theories.

In general, the empirical work begins with a conventional textbook formulation of a simple theoretical money demand relationship of the form $m = f(y,r)$ relating demand for real money balances (m) to a measure of transactions or scale variable y and the opportunity cost of holding money r. The formulation also incorporates as a purely empirical matter, the lagged dependent variable to bring forth the short-run dynamics which will be examined later in this section.

The next subsection discusses the choices of variables as suggested by different set of theories. The following subsections lists common types of formulations specified in the empirical estimation over time and provide detailed account of each. To meet this task, they refer to, among several original papers, the information presented in a number of surveys carried out over the past three decades summarizing the current state of affairs up until they were written. A sample list of surveys is as follows: Goldfeld (1973 and 1987), Boorman (1976), Feige and Pearce (1977), Laidler (1977 and 1993), Judd and Scadding (1982), Gordon (1984b), Roley (1985), and Goldfeld and Sichel (1990). Since these surveys have been written almost in steady intervals, they also trace the developments taking place over time and provide an understanding on the type of empirical work carried out in a number of countries to reflect the changing financial and economic conditions as mentioned before and the availability of new econometric techniques.

B. Discussion on Choice of Variables

The possible choices to represent the scale variable and the opportunity cost of holding money vary from study to study and the underlying theories specifically considered. The definition of money employed in the empirical work also differs according to these criteria. In general, the empirical estimations underline the transactions and asset theories. The transaction theories view money functioning as a medium of exchange and is held as an inventory for transaction purposes. Asset theories consider the demand for money in much broader terms as part of a problem of allocating wealth among a portfolio of assets which included money. While the transactions theories bring out the importance of money for transaction purposes, the asset theories emphasize liquidity and safety that money implicitly provides in addition to the explicit income the portfolio generates.

On theoretical grounds, these two sets of theories share differences in their suggestions in representing the following three variables (see Judd and Scadding (1982)): regarding money, the transaction theories emphasize the narrow measure to include only the actual means of payment. The asset theories prefer a broader definition to encompass liquid substitutes like savings deposits which the more general asset theories did not rule out a priori; on the appropriate scale variable, the transactions theories include income while the asset theories employ wealth; and on the opportunity cost of holding money, the former suggests short-term interest rates such as yields on treasury bills, whereas the latter proposes yields on longer-term financial assets. For each of these variables, there are wide range of choices employed in the empirical research as discussed below.

Money stock definition

Although definitions vary across countries due to either institutional characteristics or arbitrary decisions (Boughton (1992)), money stocks are generally classified into two major groups–narrow and broad money. Narrow money consists of those assets readily available and transferable in every day transactions which provide the means-of-exchange function. Broad money comprises of a wide range of assets rendering portfolio opportunity to asset holders. As far as the demand for narrow money is concerned, for individuals holding currency and low- or zero-interest checkable deposits at significant amounts, the asset motives of holding money can be of little relevance. Similarly, the asset holders are more concerned with evaluating the substitutability of each asset which will further enable them decide which type to hold in their portfolio. The correct definition of money to be used, therefore, becomes an empirical matter (Laidler (1993)). Consequently, several definitions of money have been attempted in the empirical analysis.

The narrow money is generally shown by M1 which includes currency plus demand deposits at the commercial banks. There are even more narrowly defined aggregates such as

M0 as in the United Kingdom, for example, consisting of notes and coin in circulation. The broad money, typically represented by M2 containing less liquid assets, comprises of several other assets such as time deposits at the commercial banks, savings and loan associations, money market mutual funds and so on over and above M1. The industrial countries have even broader aggregates like M3 (in a majority of industrial countries and a number of developing countries including Malaysia), M2+ (in Canada), M4 (in the United Kingdom), and L (in the United States). Countries like Argentina have the broadest measure as M5.[15]

Several empirical studies exclusively estimated the demand for M1 with an argument that the broader aggregates might muddy the interest rate effects. The bulk of the analytical work on M1 was conducted in the United States and in Western Europe on the assumption that M1 was more amenable to control by the monetary authorities.[16] Studies on a number of developing countries also indicate that the models using narrow definition of money work better than those employing broad money reflecting the weak banking system and low level of financial sector development (see Moosa (1992) and Hossain (1994)).

Since the boundaries of M1 shift over time to accommodate the new instruments created as a result of the evolving financial system and institutional framework, arguments were raised in favor of using broad money in the empirical estimation. This measure was hypothesized to yield a stable money function (Laidler (1966)) and was considered a preferable measure with which to evaluate the long-run economic impact of the change in monetary policy (Hafer and Jansen (1991)). The interest in estimating the demand for broad money also emanates from the fact as pointed out by Ericsson and Sharma (1996), "although, easier to control narrowly defined aggregates are less useful in policy issues because their relationship with nominal income appears subject to considerable variability. Broader aggregates appear more stable relative to nominal income, but they are less amenable to control." Goldfeld and Sichel (1990) cite the empirical difficulties in using narrow definition of money for estimation purposes coupled with blurring distinctions between transactions and portfolio consideration of money are reasons for the heightened interest among researchers in using a concept like M2. Many studies are found in the literature which exclusively used M2

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[15]See Kumah (1989) for a detailed presentation of money stock definitions in various countries. The central bank bulletins provide useful source for money stock definitions in the respective country.

[16]See Goldfeld (1973), Boorman (1976), Roley (1985), Rasche (1987), Baba, Hendry, and Starr (1992), Mehra (1992), and Hess, Jones, and Porter (1994) among others for studies estimating the demand for M1 in the United States; Hendry and Ericsson (1991b) for the United States and the United Kingdom; Kremers and Lane (1990) for countries participating in the European Monetary System (EMS); Ramos-Francia (1993) for Mexico; and Price and Insukindro (1994) on Indonesia. Feige and Pearce (1977) and Judd and Scadding (1982) present the results of the work done by a number of other researchers using M1 as the money stock variable.

or even broader aggregates to estimate the demand for money.[17] However, it is not uncommon to find studies that evaluate the demand for money using both the narrow and broad money aggregates.[18]

There are also empirical studies which estimated the demand for the individual components of money. The underlying idea is that the disaggregation provides more flexibility in the choice of variables and specification of adjustment patterns. The disaggregation was done in two ways: (i) by the type of assets; and (ii) by type of holders. Goldfeld (1973) disaggregated M1 in the case of the United States into currency and the demand deposits. Moore, Porter, and Small (1990) conducted a similar study in the context of M1 for the United States, Price and Insukindro (1994) for narrow money in Indonesia, and Lim (1993) for broad money in Australia.[19] In terms of by type of holders, Goldfeld (1973) estimated the money demand for households, business, state and local governments, financial sectors, and the rest of the world using the U.S. flow of funds data. Drake and Chrystal (1994) and Janssen (1996) did similar analysis for the United Kingdom. The former estimated the demand for money by the industrial and commercial companies, while the latter, evaluated the demand for personal sector as well.

The argument advanced for disaggregating by type of holders is that the motives of holding money vary across sectors; for example, some sectors hold money primarily for transactions purposes while others for the portfolio reasons. Consequently, analyses based on by holders provide an opportunity to understand the demand arising from various sectors of the economy which will in turn be helpful in formulating the monetary policy.

Researchers also modified the standard aggregates of money to test for their stability. For example, Simpson and Porter (1980) used a number of alternative M1 measures such as M1B (containing demand deposits adjusted plus currency in the hands of public plus other checkable deposits minus foreign deposits); augmented M1B (additionally to contain overnight repos and eurodollar deposits); and augmented M1B plus money market mutual

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[17]See Mehra (1993) for the United States; Arize and Shwiff (1993) for Japan; Deutsche Bundesbank (1995) for several industrial countries; Orden and Fisher (1993) for Australia and New Zealand; and Ericsson and Sharma (1996) for Greece.

[18]See Aghevli and others (1979), Andersen (1985), Habibulla (1990), Hafer and Jansen (1991), Tseng and Corker (1991), Boughton (1992), Teng (1993), Arize (1994), Choudhry (1995a), and Dekle and Pradhan (1997). Boughton (1992) provides references on work done in several developing and industrial countries; also refer to Deutsche Bundesbank (1995) for results involving earlier studies.

[19]See tabular presentation in Feige and Pearce (1977) and Judd and Scadding (1982) for summary results of earlier studies evaluating the demand for currency and/or demand deposits separately.

funds. Judd and Scadding (1982) was also passing on arguments to modify M1 that includes repos to reflect their increased use by corporations as a result of falling transactions costs. They also list the efforts of other researchers who modified M1 in a variety of ways.[20]

More recently, studies have also been using the so-called divisia aggregates. In this context, the central banks of Canada, Germany, Japan, the Netherlands, Spain, Switzerland, the United Kingdom, and the United States have become increasingly active in developing these indices as alternatives for the existing monetary aggregates.[21]

To sum up, monetary aggregates employed in the empirical analysis vary from study to study. They are selected based on the study objective of the researchers and other variables being considered in the estimation.

Scale variable

The scale variable is used as a measure of transaction relating to the economic activity. As mentioned previously, the transactions motive of cash balance holdings places more emphasis on current income while the asset portfolio behavior on wealth. In the empirical estimation, however, the level of income has been widely used to represent the scale variable, mainly because it poses little measurement problem. The most prominent candidate is GNP. A number of other related variables that move together with GNP such as net national product (NNP) and GDP have also been heavily used as substituting one for another does not present any significant differences (see Laidler (1993), pp. 98-99).

However, as Judd and Scadding (1982) have pointed out that there are some problems associated with using GNP like: (i) it does not consider transfers and transactions in financial assets and existing goods; (ii) it includes imputations that may involve no transactions; and (iii) it nets out the intermediate transactions. Therefore, some other measures like bank debits, bank loans, and gross debits to demand deposits are also employed.[22] Bomberger and Makinen (1980) recommend expenditure-based proxies such as gross national income (GNI) which is defined as GNP plus the terms of trade adjustment for an open economy. The reasoning is that in such an economy, the impact on foreign trade on total domestic transaction is best reflected by an expenditure-based indicator like gross national expenditure (GNE) which is implicitly assumed to be equal to GNI. Researchers have used several other measures such as personal

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[20]See also Levantakis and Brissimis (1991) for a list of some other studies using alternative M1 measures.

[21]Refer to the previous section for a discussion on divisia aggregates. For some recent studies using divisia indices, see Yue and Fluri (1991), Fase and Winder (1994), Ford and Morris (1996), Janssen (1996), and Anderson, Jones, and Nesmith (1997b and 1997c).

[22]See Roley (1985) for additional choices.

disposable income, private spending, final sales, and domestic absorption as well (see Mankiw and Summers (1986)).

Recent research has been focussing on developing a few other scale variables based on the transactions measure. The first type involves construction of more comprehensive measures of transactions and the next in disaggregation of transactions into various components reflecting the notion that all transactions are not equally "money intensive" (see Goldfeld and Sichel (1990), pp. 318-20). For example, Mankiw and Summers (1986) argue that the consumption is much more money intensive than other components of GNP. Similarly, there is a view that for an open economy, disaggregation of a scale variable to appropriately reflect the nature of international transactions may be important (see Goldfeld and Sichel (1990)). Radecki and Wenninger (1985) find relevance for this type of breakdown in the context of the United States as well. However, Goldfeld and Sichel (1990) report that there is no firm evidence that the categorization of GNP into components yields a dramatic improvement in the behavior of aggregate money demand.

Wealth is another important choice to represent the scale variable, although it is difficult to measure. Only in a handful of countries like the United Kingdom and the United States data do exist to construct long time series on certain aggregate measures of wealth. Consequently, a number of studies incorporating wealth as a scale variable are also carried out using the U.K. and the U.S data.[23] Alternatively, permanent income has been used as a proxy for wealth as it can be constructed based on current income and expected future income. Friedman sends a strong signal using this variable as stated by Friedman and Schwartz (1982), "income as measured by statisticians may be a defective index of wealth because it is subject to erratic year-to-year fluctuations, and a longer-term concept like the permanent income developed in connection with the theory of consumption, may be more useful." Consumption is also the appropriate scale variable in cash-in-advance models (see Lucas (1988)). Furthermore, Mankiw and Summers (1986) argue that if permanent income is a proxy for wealth, then consumption should be the natural observable proxy for the unobservable permanent income.[24]

Aside from the theoretical emphasis, income is often justified as a proxy for wealth on the grounds of greater data availability and reliability. Ultimately, the selection of an appropriate scale variable becomes an empirical issue (see Gupta and Moazzami (1988)). But, a majority number of studies use GNP as the relevant scale variable mainly because the data,

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[23]See references cited in Feige and Pearce (1977), Judd and Scadding (1982), and Laidler (1993).

[24]See Fujiki and Mulligan (1996) on Japan using consumption as the scale variable.

in general, are readily available; in addition, it satisfies directly or indirectly both the income and wealth criteria that the scale variable should represent.[25]

Opportunity cost of holding money

The opportunity cost of holding money involves two ingredients: the own-rate of money and the rate of return on assets alternative to money. Tobin (1958) and Klein (1974) are in favor of including both of these rates.[26] When the narrow definition of money is used for studies in the United States using data prior to 1980, some researchers treated the own rate as zero because checkable deposits then consisted solely of demand deposits with an explicit yield of zero. After the 1980 deregulation, however, this issue has become somewhat complicated as some components of money carried explicit interest while several others had different nonzero rates of return. This issue is also applicable for other countries where there are financial instruments paying explicit interest which form the part of M1. However, as Laidler (1993) indicates that majority of the empirical studies assume the own-rate of money as zero or the interest rates having an unvarying rate that can be conveniently ignored.

Regarding the return on assets alternative to money, researchers had several choices. Those adopting a transactions view typically used one or more short-term rates like the yields on government securities, commercial paper, or savings deposits with a notion that these instruments are closer substitutes for money and their yields are especially relevant among the alternatives that are forgone by holding cash. Those considering a less narrow view of the demand for money have used correspondingly a broader set of alternatives including the return on equities, yields on long-term government or corporate bonds or on CDS (see Hamburger (1977), Hall, Henry, and Wilcox (1989)).[27] However, Laidler (1993) points out that what is important in the money demand function is to include some sort of variable rather than "which" variable to represent the opportunity cost of holding money since the research

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[25]In some cases the scale variable is altogether omitted when the speed of adjustment of the monetary aggregates is too rapid and when higher frequency such as monthly data are used for which data are simply not available for the chosen scale variable (see Asilis, Honohan, and McNelis (1993)). On the other hand, Adam (1991) and Kole and Meade (1995) employ both income and wealth as the scale variables to study demand for M3 in the United Kingdom and M3 in Germany respectively. For analysis involving high frequency data, index of industrial production is typically used because data are usually available (see McNown and Wallace (1994) and Choudhry (1995b)).

[26]The new research confirms the importance of including both rates. Omission of own-rate of money often leads to break down of the estimated money demand function especially when the financial innovation occurs in the economy (see Ericsson (1998)).

[27]The alternative also includes return on foreign securities especially for open economies as explained later in the subsection.

has shown that the demand for money is not sensitive to the precise measure of the variable chosen. Accordingly, many studies use just one measure of interest rate to represent both the own rate and the return on alternative assets for money.[28]

Friedman (1977) suggested that if holding money was viewed as a part of general portfolio decision process, then the whole spectrum of interest rates be used in the money demand equation. Accordingly, Heller and Khan (1979) applied the entire term structure of interest rates for the United States and found that this measure performed better than the use of any single interest rate in explaining the variation in the demand for money. Alternatively researchers were advancing the idea of using interest rate spreads instead of including interest rates in their levels especially for analyzing demand for broad money because the share of interest-bearing portion in broad money has increased in a number of countries implying that broad money is affected by the relative returns rather than the general level of interest rates (see Samuelson (1947), Tobin (1958), and Friedman (1977) for theoretical arguments; and Klein (1974), Heller and Khan (1979), Tseng and Corker (1991), and Mehra (1993) for empirical work). The role of spreads in money demand does not necessarily refer to maturity or term structure of interest rates, but to the risk, default, and/or liquidity structure of interest rates (see Dialynas and Edington (1992) for a good discussion of yield spreads that Teriba (1997) considers the relevant concept of spreads in the money demand function).[29]

In general, in the portfolio framework, agents consider money as part of the portfolio consisting of domestic financial and real assets, and foreign assets. The closed-economy versions of money demand functions typically address the first two choices. The return on domestic financial assets is already indicated by the variables mentioned above. The return on real assets is usually represented by the expected rate of inflation. The open-economy type models also include the third item in the above list, that is, foreign assets. The returns on foreign assets are usually represented by the foreign interest rates and the expected rate of depreciation of the domestic currency. The subsequent paragraphs address the issues concerning the returns on real assets and on foreign assets in length.

On theoretical grounds, inclusion of the expected rate of inflation follows Friedman (1956 and 1969). The former argues that if money were a way of holding wealth, the demand for money should be viewed as demand for services yielded by this asset. In that respect, since physical goods are alternative forms of holding wealth, the expected rate of change in the price level should be included among the arguments of the money demand function. Friedman

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[28]However, Sriram (1999) shows that both the own rate and the return on alternative assets of money are important in explaining the demand for money in the context of Malaysia. Ericsson (1998) concurs that failure to include the own-rate of money will result in breakdown of the estimated money demand function especially when financial innovation occurs in the economy.

[29]Some studies also apply the difference between interest rate and inflation, which can be interpreted as real interest rate (see Kamin and Ericsson (1993)).

(1969) postulates that the expected rate of inflation can be considered as (the negative of) the own-rate of return on cash balances, since it measures the depreciation cost which the individual can avoid by increasing the consumption at the same rate. The individual by holding one more dollar of cash balances, is foregoing not only the yield on bonds, equities, and other assets, but also one more dollar of consumption (see Cesarano (1991), p. 1650). As a slightly different angle, inflation also measures the cost of buying a good tomorrow rather than today (see Ericsson (1998)). The relationship between expected inflation and the demand for money is well documented by Arestis (1988a, p. 421) who states that "the real value of money falls with inflation whilst that of real assets is maintained, so that there is a strong incentive for economic agents to switch out of money and into real assets when inflationary expectations are strong."

For estimating money demand function in countries where the financial sector is not well developed especially as in the case of developing countries, the expected rate of inflation is the only variable used as the opportunity cost of holding money.[30] The reasons for using this variable over some representative interest rates in estimating money demand are as follows: first, there is limited substitution possibility between money and other financial assets due to the under-developed financial markets outside the banking system; second, the interest rates may show insufficient variation for a long period of time because they may be regulated by the government; third, payment of interest is legally prohibited in some countries; fourth, interest rates may not be observable due to lack of financial system; and fifth, the interest rate data simply may not be available (see Wong (1977), Crockett and Evans (1980), Darrat (1984), and Choudhry (1995a)).

The use of expected rate of inflation is also appropriate in countries which are experiencing high inflation as the rate of return on alternative financial assets is dominated by the rate of inflation (see for example, Cagan (1956), Frenkel (1977), Khan (1977), Ahumada (1992), and Honohan (1994)). A recent study by Choudhry (1995b), however, indicates that in high inflation countries it is important to include an appropriate exchange rate variable in addition to the expected inflation in explaining the demand for money. Domowitz and Elbadawi (1987) show that the failure to do so may overstate the influence of inflation on money demand.

There is a line of argument that the nominal interest rates alone are sufficient in the money demand models especially the Baumol-Tobin type transactions demand models. The justification is that when moderate inflation prevails in an economy, variations in nominal interest rates can capture the variations in the expected rate of inflation. Therefore, the expected rate of inflation should not have any additional explicit impact on demand for money than its implicit influence through the interest rates (see Heller and Khan (1979) and Jusoh

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[30]In some countries where the financial institutions are highly unorganized and fragmented, the degree of credit restraint in the economy is introduced as a proxy for opportunity cost of holding money (see Wong (1977) and Nyong and Raheem (1990)).

(1987)). However, in many studies, it is also included along with the nominal interest rates for reasons explained below.

On the theoretical grounds, Friedman (1956) argues that the physical goods should be considered as the substitutes for money, and hence, higher expected inflation should induce a portfolio shift away from money to physical assets. On the empirical side, Laidler and Parkin (1975) show that in countries where interest rates are not unregulated, although these two variables show some relationship, the level of nominal interest rates might not fully incorporate the expected inflation rate. In this situation, there is room to include both variables in the money demand equation (see Laidler (1985)). As another explanation, in developing countries which do not have alternative financial assets to money, nominal interest rates can be considered as the own-rate of money; and the expected inflation rate is the return on real assets (Arestis and Demetriades (1991)).

The expected rate of inflation is measured in many ways in the literature: for example, calculated using adaptive expectations (see Cagan (1956), Adekunle (1968), Darrat (1986a), Khan and Knight (1982), and Gupta and Moazzami (1988)) or rational expectations (see Arize (1994)); set up as the weighted average from the past values (see Brissimis and Leventakis (1985)) or just using the lagged inflation values (see Asilis, Honohan, and McNelis (1993)); collected from the opinion survey data (Goldfeld (1973)); derived from the forward premium in the foreign exchange market (see Frenkel (1977)); or simply equating the ex-post as the ex-ante value (see Crockett and Evans (1980) and Eken and others (1995)).[31] Honohan (1994) in a study on estimating the demand for money in Ghana used the actual inflation in place of expected inflation with an argument that in a number of earlier studies, the expected inflation was found to be highly correlated with the actual inflation.

In an open economy, choice of assets for portfolio diversification is wider as foreign-currency denominated assets are now available in addition to the domestic financial and real assets. As more and more countries are moving toward the floating-exchange-rate regime, the domestic money demand could also be sensitive to the external monetary and financial factors (see Bahmani-Oskooee (1991)). In that respect, if foreign securities were to form an appropriate investment alternative, then their expected rates of return plus expected exchange rate changes should appear in the money demand function (see McKenzie (1992)).[32] Fortunately, the currency substitution literature lends the necessary support in choosing the appropriate variables that account for the foreign influence.

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[31]See references listed in Laidler (1985) confirming the influence of expected rate of inflation on demand for money in a number of countries and various alternatives used to measure this variable.

[32]The potential importance of exchange rate on money demand has been suggested earlier by Mundell (1963) although the issue did not receive that much attention until the 1980s.

The direct currency substitution literature refers to the portfolio shifts between the domestic and foreign money, which is influenced by the expected exchange rate changes. The indirect currency substitution literature suggests that the foreign interest rate becomes a focus variable especially if the foreign securities provide a relevant investment alternative. The hypothesis is that an increase in rates of return in foreign securities may potentially induce the domestic residents to increase their foreign asset holdings financed by drawing down the domestic money holdings. Similarly, if the domestic currency is expected to depreciate the domestic portfolio holders would be encouraged to readjust their portfolios in favor of foreign assets. Thus while the direct currency substitution literature focuses on exchange rate variable, the capital mobility or indirect currency substitution literature centers its attention on foreign interest rate variable (see McKinnon (1982), Cuddington (1983), Giovannini and Turtelboom (1993), and Leventakis (1993)).

The foreign interest rate is represented, in most cases, by the eurodollar rates (London interbank offered rate (LIBOR)) (see for example, Price and Insukindro (1994) and Chowdhury (1995)). The short-term interest rates prevailing in major industrial countries are also taken either individually (Arize, Spalding, and Umezulike (1991)) or as weighted average of them (see Arango and Nadiri (1981), Darrat (1986b), and Arize (1994)).

The exchange rate influence is represented in a number of ways as follows: being calculated as a simple weighted sum of the past and current exchange rates (Bahmani-Oskooee (1991)); treating the depreciation of the ex-post parallel market exchange rate as ex-ante expected rate of depreciation especially in countries where forward currency markets are not well developed and informal market is prevalent which fully incorporates changes in the exchange rates (Adam (1992)); using the uncovered interest parity (Filosa (1995)); estimating from the forward premiums (Leventakis (1993)); employing the present and lagged values of the exchange rates (see Brissimis and Leventakis (1985)); considering ex-post as ex-ante (Leventakis (1993)); applying the moving average of actual exchange rate changes in the past years (Dekle and Pradhan (1997)); presenting the difference between home and foreign interest rates (McKinnon (1982)); and computing some effective exchange rate indices by giving appropriate weights for the bilateral exchange rates (Arize (1994)). In some cases the nominal effective exchange rates are used such as in McNown and Wallace (1992), Chowdhury (1995), and Ericsson and Sharma (1996); and in some others the real effective exchange rates as in Bahmani-Oskooee (1991).[33] Instead of the effective exchange rate indices, some studies rather used either nominal or real exchange rates in the equation (McGibany and Nourzad (1995)).[34]

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[33]Bahmani-Oskooee (1991) omits the foreign interest rates altogether from the equation with an argument that they move in line with the domestic rates, and hence, introduced the real effective exchange rates instead.

[34]Refer to the following studies in addition to those cited in the text which address the issues (continued...)

To summarize, the opportunity cost of holding money has two ingredients: own-rate of money and returns on alternative assets for money. The return on alternative assets further comprise of return on domestic financial and real assets, and return on foreign assets. In a closed-economy version, in addition to the own-rate of money, returns on domestic assets are the relevant variables. Various choices are available to represent the domestic financial assets as discussed in the subsection. The return on domestic real assets is usually proxied by the expected inflation rate. In an open economy, returns on foreign assets are also important (as represented by foreign interest rate and/or some form of exchange rate variable). Although in theory, all these variables need to be included as the opportunity cost of holding money, in practice various combinations of these variables are attempted in estimating money demand function. The selection of these combinations and measures to represent these variables depend mostly on the macroeconomic development, the status of the domestic financial sector, the extent to which interest rates are liberalized, the openness of the economy, and the availability of data; in short, it is an empirical issue.

C. Functional Forms

Money demand functions are generally specified in real terms on the assumption that the price elasticity of nominal money balances is unity.[35] The implication of this assumption is that the price-level changes alone will not cause changes in the demand for real money balances (the demand for real money balances is homogenous of degree zero in the price level) or, alternatively, that the demand for nominal balances is proportional to the price level. This in turn implies that the public is free of money illusion in its demand for real money balances. Economic theory does not provides any rationale as to the correct mathematical form of the money demand function. In the equation form, sometimes the relationship is specified as linear but more often as exponential (Boorman (1976), p. 323). In general, three major functional forms dominated the empirical literature: linear-additive, log-linear, and linear-nonadditive (see Feige and Pearce (1977)). There is consensus, however, that the log-linear version is the most appropriate functional form (see Zarembka (1968) and Darrat (1986b)).

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[34](...continued)
concerning the specification of an open-economy type money demand function and selection of relevant opportunity cost(s) of holding money: Jonson (1976), Hamburger (1977), Boughton (1979), Arango and Nadiri (1981), McClean (1982), Darrat (1984 and 1986b), Yahya (1984), Arestis (1988b), Arize (1989, 1992a, 1992b, and 1994), Bahmani-Oskooee and Pourheydarian (1990), Djeto and Pourgerami (1990), Domowitz and Hakkio (1990), Metwally and Abdel Rahman (1990), Tseng and Corker (1991), Bårdsen (1992), Simmons (1992), Al-Loughani and Moosa (1993), Arize and Shwiff (1993), Perera (1993), Choudhry (1995b), Bahmani-Oskooee and Shabsigh (1996), Tan (1997), and Teriba (1997).

[35]Some researchers employed the nominal magnitudes instead. However, the specification in real terms is the most common form used in the empirical research and the one suggested by the economic theory (see Goldfeld (1973), p. 624).

D. Specification Issues

One type of log-linear specification extensively used for estimating money demand is the so-called partial adjustment model (PAM), originally introduced by Chow (1966) and later popularized by Goldfeld (1973). The model augments the conventional formulation of money demand by introducing the following two concepts: (i) distinction between "desired" and "actual" money holdings; and (ii) the mechanism by which the actual money holdings adjust to the desired levels. The model faired well when the postwar-1973 data were used. However, it was unable to explain the apparent instability in money demand function experienced since the early-1970s, and hence lost its appeal to alternative approaches like buffer-stock models (BSMs), and more recently, the error-correction mechanism approach. In fact, Boughton and Tavlas (1991) found that the estimates obtained by BSM and ECM for money demand in the five largest industrial countries significantly outperformed those from the various versions of the PAMs. Our discussion, despite, will begin with the PAM as it earlier formed a basis for a large volume of empirical work. Also, the two other competing approaches have been developed learning from the apparent failure of this type of model.

Partial adjustment models

The PAM framework arises from the equilibrium approach of money demand which assumes perfect price and interest rate flexibility with perfect information where economic agents are assumed to be permanently in the process of adjusting their current money holdings to the desired long-run level. The tastes are assumed to be constant and that individuals adjust their holdings of money instantly and costlessly to any change in the vector of variables that determine money holdings (Gordon (1984b)).

According to the conventional textbook formulation of the demand for money, the "long-run" or desired real money balances demanded in period t will be positively related to a transaction variable and negatively related to the opportunity cost variable. A typical conventional money demand function may look as shown in equation (1) below:

$$m_t^* = a_o + a_1 y_t + a_2 i_t \qquad \textbf{(1)}$$

where m_t^* is the "long-run" or desired real money balances demanded in period t, y_t is the real income in period t, and i_t is one or more representative opportunity cost variable(s) in period t. All the variables are shown in natural logarithms.

The money market is assumed to be in equilibrium initially. When the original condition is disturbed, either income or interest rate or both are necessary to adjust to restore the market back to the equilibrium so that the desired money balances equal the actual money stocks as reported in the statistical series (Boorman (1976)). However, the presence of portfolio adjustment costs prevents a full and immediate adjustment of actual money holdings to desired levels (Goldfeld (1973)), and is assumed to take place through a partial scheme as suggested by Chow (1966). In this framework, actual money balances adjust to the gap between the desired or long-run demand for real money balances and the previous period's holdings such that:[36]

$$m_t - m_{t-1} = d\ (m_t^* - m_{t-1}) \tag{2}$$

where m_t is the actual money balances in real terms demanded in period t and d is the partial adjustment coefficient with $0 < d < 1$. Again all the variables are shown in natural logarithms. By combining the equations (1) and (2), one can derive the following equation:

$$m_t = da_o + da_1 y_t + da_2 i_t + (1-d)\ m_{t-1} \tag{3}$$

where the coefficients a_1 and a_2 provide the long-run elasticity of money demand with respect to income and interest rate respectively while da_1 and da_2 give short-run elasticities with $0 < (1\text{-}d) < 1$.

The equation is very similar to the conventional money demand function as shown in (1) above except that the lagged real money balance variable is included on the right hand side (RHS). This sort of equation was, generally, estimated with the ordinary least squares (OLS) using the Cochrane-Orcutt technique to adjust for serial autocorrelation. The lagged adjustments were introduced via a Koyck transformation or Almon lag structure. The introduction of the lagged real money balance variable became a hall mark of the PAM and its important contribution to the empirical work of the money demand function. The coefficient of the lagged money demand variable provided most of the explanatory power of the regression and was positive and highly significant (Goodfriend (1985)). Its value in the empirical estimation was emphasized by Laidler (1984) by saying "the variable happened to be much utilized and badly needed." As will be seen later, the other competing models also incorporated this variable in their specifications. Although interpretations vary according to these models, basically it brings out the short-run dynamics or adjustment in the money demand equation capturing the permanent adjustment of the short-run to the long-run demand for money.

The PAMs were enormously popular in studies that analyzed the demand for money both for the United States and elsewhere. Goldfeld (1973), Boorman (1976), Feige and Pearce (1977), Judd and Scadding (1982), Laidler (1985), and Goldfeld and Sichel (1990), among others have surveyed studies on the United States. Boughton (1979 and 1981) and Fair (1987) have undertaken cross-country studies including the United States. Boughton

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[36]The partial adjustment scheme is derived from minimizing the one-period quadratic costs of adjustment $(m_t - m_{t-1})^2$ and costs of disequilibrium $(m_t - m_t^*)^2$.

(1992) cites a number of papers addressing the work carried out in countries other than the United States (mostly in industrial countries).

Generally two types of adjustment schemes have been employed. In the first type, the adjustment of actual to desired money holdings are in real terms, and hence, these models are called "real partial adjustment models (RPAMs)." Here the lagged money balance variable is in the form of M_{t-1}/P_{t-1} as derived from equations (1) and (2) above, where M and P are nominal money balances and prices respectively. In the second type, the adjustment is assumed to be in nominal terms, and hence called, "nominal partial adjustment models (NPAMs)," in which the lagged money balance variable is in the form of M_{t-1}/P_t (see White (1978), Hafer and Hein (1980), and Fair (1987)). The adjustment scheme will look as follows:

$$\log M_t - \log M_{t-1} = \lambda \ (\log M_t^* - \log M_{t-1}) \qquad \textbf{(4)}$$

where M_t, M_{t-1}, and M_t^* are in nominal instead of in real terms as shown in equation **(2)**.

Incorporating these points, researchers estimating money demand functions using the annual data with a small sample size (15-20 observations) or quarterly data for the postwar period have used a generic or broader version of the partial adjustment specification as shown in Goldfeld and Sichel (1990):

$$\ln m_t = b_o + b_1 \ln y_t + b_2 \ln i_t + b_3 \ln m_{t-1} + b_4 \pi_t + u_t \qquad \textbf{(5)}$$

where m_t is real money balances, y_t is a transactions variable, i_t represents one (or more) interest rates, and $\pi_t = \ln \ (P_t/P_{t-1})$ is the rate of inflation associated with the price index, P_t. The inclusion of π_t in the above equation is meant to encompass the real partial adjustment model framework in which b_4 is zero or the nominal partial adjustment model framework in which $b_4 = -b_3$.

As mentioned before, the PAM worked well using the postwar data for up until 1973; but faired very poorly when the data after 1974 were included.[37] Specifically, it was unable to explain the apparent instability in the money demand experienced since the early-1970s to what is called "missing money episode." The empirical estimates have produced inaccurate predictions of real money balances (Boughton (1991)). In general, all estimates showed very low short-run elasticities for income (about 0.1) and interest rates (around -0.05) and a

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[37]For a detailed survey on the stability issue in the context of the United States, refer to Leventakis and Brissimis (1991).

coefficient close to unity for the lagged dependent variable. Meanwhile, the long-run interest elasticity was considerably higher in the order of -0.3. The bulk of the further research indicated that the PAM failed both on theoretical and empirical grounds.[38]

There are a number of criticisms surrounding this model framework. For instance, the lagged money variable was highly significant and provided most of the explanatory power. Apparently it implied an extremely long lag of adjustment (Boughton (1992)).[39] In addition, having a small interest elasticity coefficient in the short run and a larger one in the long run means, following a change in the money stock, interest overshooting should occur in the short run–a larger change in the interest rate is necessary in the short run to clear the money market and a smaller change in the long run (Milbourne (1988)).[40]

It was also felt that the failure of the PAM was due to the problem associated with measuring monetary aggregates used in the equation. One alternative suggested was using the divisia aggregates. However, introduction of these aggregates did not appear to resolve the missing money problem of the 1980s (see Lindsey and Spindt (1986)). There were also concerns related to scale variable and the impact of financial innovation (see Judd and Scadding (1982), Roley (1985), and Hetzel and Mehra (1989)). To that end, different scale variables such as wealth (for example, Goldfeld (1976), Friedman (1978)) and bank debits (see Lieberman (1977)) were attempted. On issues concerning financial innovation, various models on the impact of deregulation and financial innovation such as ratchet variables, use of interest rates at peak levels (see for example, Enzler, Johnson, and Paulus (1976), and Simpson and Porter (1980)), addition of brokers fees, and so on are tried (see Judd and Scadding (1982)). These refinements improved the model's ability to explain the past performance but shown only limited success in predicting the future money demand.

As another strand of criticism, some of the instabilities and statistical problems were attributed to the limited dynamics presented in the model. The partial-adjustment approach restricts the lag structure excessively at the beginning of the empirical investigation as it assumes that the adjustment costs and expectations could be captured in a very specific,

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[38]See Goodfriend (1985) for theoretical problems; and Laidler (1980), Cooley and LeRoy (1981), Gordon (1984b), Goodfriend (1985), Rose (1985), Yoshida (1990), and Hendry and Doornik (1996) for empirical implications and difficulties. The major econometric problems experienced were serial autocorrelation, simultaneity bias, model misspecification, and spurious regressions due to nonstationarity of data.

[39]However, further research indicated that the estimated coefficient was typically too high to be interpreted as representing a desired speed of adjustment (Goodfriend (1985)); it was rather due to statistical problems.

[40]However, such over-shooting does not seem to be an attribute of money markets in the real world (see Goodhart (1984)).

simple fashion (Cuthbertson and Taylor (1987) and Boughton (1992)).[41] However, this theory-based dynamic specification may result in residual autocorrelation or heteroscedasticity because omission of important lagged variables may result in model misspecification (see Yoshida (1990)). Therefore, the BSM and ECM addressed issues associated with the dynamics in a more rigorous way. In the BSMs, in addition to the lagged money demand variable on the RHS, the difference between the desired and actual money holdings are also introduced. In the ECMs, the short-run dynamics was specially dealt with. In this respect, the error-correction specification can be thought of as a more general, intertemporal version of PAMs (see Tseng and Corker (1991)). The next subsection explores the buffer-stock approach and the following subsection the error-correction approach.

Buffer-stock models

The BSMs came force in the literature during the 1980s as an alternative paradigm for money demand estimation to overcome the two common problems with the partial adjustment specification namely interest overshooting and long implausible lags of adjustment. They derive the theoretical foundation from the precautionary demand for money. As the name "buffer stock" suggests the money holdings in these models are considered as shock absorber to smoothen much of the unexpected day-to-day variations in receipts and expenditures. Since it is costly to make continual portfolio adjustments, an unexpected inflow might remain as excess money holdings for some time. The economic agents, aided by the buffer the money provides, permit temporary deviations of their money holdings from the desired level (Milbourne (1988)), and adjust their current money holdings to some average target level instead. For a survey of literature on this approach, refer to Laidler (1984 and 1988), Cuthbertson and Taylor (1987), Milbourne (1988), and Cuthbertson and Barlow (1991).

These models fall under the broad category of disequilibrium approach of money demand. Two common basic assumptions of this approach are exogenous money stock, that is, money stock is primarily influenced by the supply factors–open market operations and/or loan expansion of the banking system–and a disequilibrium real balance effect.[42] This approach assumes that the money market is in disequilibrium because there is a possibility that at certain times and places and over certain time intervals aggregation over the agents' excess money holdings may not eliminate the difference between the aggregate demand and supply of money (Laidler (1984)). The disequilibrium phase can be long enough to have the exogenous changes in the money supply work their way through the economic system resulting in positive real

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[41]As an alternative to partial adjustment framework, adaptive expectations model was gaining popularity in the 1970s and was considered superior at that time. However, it also faded when the rational expectation approach was increasingly applied in the macroeconomic literature.

[42]In comparison, the partial adjustment models assume that the money stock is demand determined in the short run and the money market is in equilibrium where the endogenous variables y, r, and P adjust to clear the market (see Milbourne (1988)).

balance effects in all markets. This approach, thus, concerns more on the transmission mechanism of monetary policy in the short run and renders an alternative explanation of the short-run dynamic relationships between money, income, prices, and interest rates in comparison with the conventional money demand functions.

There are two major changes in the BSMs over the PAMs. First, money shocks are explicitly modeled as part of the determination of money demand. Second, the lag structure is much more complex. These two novelties have the following three implications (see Boughton and Tavlas (1991)). First, the short-run interest overshooting problem is avoided. According to the buffer-stock proponents, the reason the PAMs did poorly in explaining the missing money episode is that they failed to consider the short-run impact of monetary shocks. In the BSMs, the positive monetary innovations result in an accumulation of cash balances in the short run, and hence, the cash balances rather than the interest rates adjust which help overcoming the interest overshooting problem. Second, the complicated nature of the monetary transmission mechanism is much more realistically dealt with by modeling the effects on short-run money demand directly. Third, the insertion of the money shock variable in the money demand function addresses the specification bias of the PAMs assuming that the BSM is the "true" model.

In the applied work of BSM, the literature identifies three major approaches–single equation disequilibrium money models, complete disequilibrium monetary models, and shock-absorber models. The single equation models start with the notion that if the money stock is exogenous, equation like (3) should be considered as a semi-reduced form, that is, an equation for one of other variables rather than a structural money market equation. Therefore, this approach recommends inverting the money demand function prior to estimation, assuming that the chosen dependent variable (price level, interest rate, or output) adjusts slowly to its long-run value. Artis and Lewis (1976) argued that the equation like (3) is a semi-reduced form for interest rate, while Laidler (1980) interpreted it as one for the price level. Unfortunately, as Cuthbertson and Taylor (1987) have pointed out a major disadvantage of this approach is that only one argument may be chosen as the dependent variable while on *a priori* grounds one might expect all the arguments of the demand function to adjust simultaneously.

The second approach of complete disequilibrium monetary models, therefore, involves large scale econometric models where the disequilibrium money holdings are allowed to influence a wide range of real and nominal variables. The following types of equations appear in this type of approach (see Cuthbertson and Taylor (1987)):

$$\Delta X_t = f(Z_t) + \gamma(L)(M_t^s - M_t^d) \qquad \textbf{(6)}$$

$$M_t^d = \alpha_o P_t + \alpha_1 R_t + \alpha_2 Y_t \tag{7}$$

X_t may be a set of real and nominal variables (for example, output, prices, exchange rate), Z_t is a set of predetermined "equilibrium" variables, M_t^d is the long-run demand for money, and $\gamma(L)$ is a lag polynomial. As the money disequilibrium term appears in more than one equation, the model yields cross-section restrictions on the parameters of the long-run demand for money function. The major problem with this approach is that the estimates of the coefficient of the long-run money demand equation are conditional upon the correct specification of the entire model (See Cuthbertson (1988) and Milbourne (1988)). These types of models did not perform well in the flexible exchange rate regime open economies as they did in the context of closed economies such as the United States (Cuthbertson and Taylor (1987)).

Another strand in the buffer stock approach is modeling the "shocks" affecting the demand for money. This hypothesis is rather loose one and hence the "shocks" analyzed vary from study to study. However, the shock absorber model as developed by Carr and Darby (1981) is the most widely used BSM. This type of model directly estimates the demand-for-money function by incorporating money-supply shocks in an otherwise conventional demand for money function.[43] The model emanated from the inadequacy of the Chow's partial adjustment scheme as shown in equation (2) above to provide an explanation of short-run money demand in quarters in which money supply shocks occur.[44] Carr and Darby (1981) argue that the anticipated changes in money supply will be reflected in the price level expectations leaving no effect on real money balances. However, the unanticipated changes in the money supply will temporarily be displayed in money holdings. The authors, hence, modified the conventional money demand equation to include unanticipated money as an additional explanatory variable.

The original Carr and Darby's model has gone through several modifications to address the econometric problems of the original version. In general, the shock absorber model formulates the money demand as follows:

[43]See also MacKinnon and Milbourne (1984), and Carr, Darby, and Thornton (1985).

[44]Chow's model does well in reference to changes in the determinants of the long-run money demand or expected changes in the nominal money supply. However, apparently, the model does not work well in the case of nominal money supply shocks (see Carr and Darby (1981), pp. 184-86).

$$(m-p)_t = \beta_o + \beta_1 y_t + \beta_2 i_t + b_3(m_{t-1}-p_{t-1}) + \alpha(m_t-m_t^*) + u_t \quad \textbf{(8)}$$

$$m_t^* = \bar{g}Z_t + \varepsilon_t \quad \textbf{(9)}$$

The equation (8) is just a RPAM of demand for money with an additional term of unanticipated money of $m_t-m_t^*$ (where m_t^* is the anticipated component of the money supply). Z_t is a set of variables that agents assume having a systematic influence on the money supply; $\bar{g}$ is a vector of coefficients to be estimated; and ε_t is a white-noise error.

The results of the empirical application of this approach are mixed. While Boughton and Tavlas (1991) obtained good results for a number of industrial countries, other researchers as referred in Cuthbertson and Taylor (1987) including the authors themselves concluded that the BSM of Carr and Darby type was not supported by data. The performance of the model also depends on the underlying partial adjustment scheme used. One major criticism is that m_t appear on both sides of equation (8) causing econometric problems, in specific that m_t and u_t are no longer uncorrelated.

In general, the BSMs have been proposed as improvements over the PAMs, but they are still subject to a number of short comings. Further to the words of Laidler (1984) that the lagged demand for money variable is "badly needed," Goodfriend (1985) argues that the BSMs are a way to justify the lagged dependent variable on the RHS rather than having an economic justification in the first place. The short-run dynamism structure is much more sophisticated in the BSMs in comparison to the PAMs, but still is somewhat restrictive. Another criticism with the BSMs is the assumption of money stock exogeneity. As Laidler (1993) has pointed out the nominal money supply, in real world, does respond to changes in variable underlying the demand for money. Fischer (1993), indeed, shows in the context of Switzerland that money stock is a dependent rather than an exogenous variable.

In the empirical testing as well these models did not fare well. Milbourne (1987) summarized the reservations of the BSMs both in theoretical and in empirical grounds. In fact, Milbourne (1988) concluded from his extensive survey that "the buffer stock notion is an interesting idea, the current models do not lend themselves to empirical testing, and those models which do have performed poorly." Subject to these criticisms, the BSMs lost their appeal while the ECMs have come to the forefront in estimating the money demand function to which we turn in the next subsection.

Error-correction models

The ECMs have proved to be one of the most successful tools in applied money demand research. This type of formulation is a dynamic error-correction representation in which the long-run equilibrium relationship between money and its determinants is embedded in an equation that captures short-run variation and dynamics (see Kole and Meade (1995)). The impetus came from the findings that in modeling the demand for money, due consideration be given not only in selecting appropriate theoretical set up and the empirical make up, but also in specifying the proper dynamic structure of the model. Accordingly, the economic theory should be allowed to specify the long-term equilibrium while short-term dynamics be defined from the data. The new research shows that the dynamic adjustment process is far more complex than as represented in the PAMs and BSMs. In fact, one of the major reasons for the failure of these two types of models is that they severely restricted the lag structure by relying solely on economic theory or naive dynamic theory without thoroughly examining the actual data (and the underlying data generating process).

Work done by researchers like Hendry (1979 and 1985) constantly questioned whether the observed instability in the U.K. and the U.S. money demand functions could be a spurious phenomenon due to incorrect specification.[45] Transformation of variables from levels into first differences to overcome the nonstationarity problem (and hence spurious regression problem) as carried out by Hafer and Hein (1980), Fackler and McMillin (1983), and Gordon (1984a) is not a solution because it loses valuable information on long-term relationship that the levels of economic variables convey. There was also a constant tension in applied money demand work between the long-run equilibrium and short-run dynamics and the difficulty in specifying explicit plausible methods of expectations formations or dynamic adjustment. The cointegration and ECM framework seem to provide answers to these modeling, specification, and estimation issues. The cointegration technique, if carefully applied, allows inferences on the long-run relationship providing a firm basis for the investigation of short-run dynamics.

The ECM is shown to contain information on both the short- and long-run properties of the model with disequilibrium as a process of adjustment to the long-run model. Granger (1983 and 1986) has shown that the concept of stable long-term equilibrium is the statistical equivalence of cointegration. When cointegration holds and if there is any shock that causes disequilibrium, there exists a well defined short-term dynamic adjustment process such as the error-correction mechanism that will push back the system toward the long-run equilibrium. In fact, cointegration does imply the existence of a dynamic error-correction form relating to variables in question (Engle and Granger (1987)).

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[45]Meanwhile researchers like Laidler (1980), Cooley and LeRoy (1981), Goodfriend (1985), and Gordon (1984a and 1984b) were pointing out to the econometric problems associated with the conventional money demand functions and raising concerns regarding the robustness of the past empirical estimation (see Roley (1985), p. 612)).

Since the long-run specification is based on the theory and the short-run behavior is modeled after carefully examining the underlying data generating process, the model formulation is not standard across the board but may differ from case to case. As they have demonstrated their ability to incorporate the difficult empirical issues in modeling and estimating money demand and showed the richness in their implications, the ECMs have attracted significant research interest among the economists from around the world. They also encompass previously discussed models as restrictive cases. Consequently, within the past decade, the estimation of cointegrating relationship together with largely unconstrained dynamic adjustment processes have become a useful generalization of the PAMs and the BSMs that dominated the literature in the 1970s and early-1980s.[46]

Arize and Shwiff (1993) summarize the desirable properties of the ECM as follows: "First, it [ECM] avoids the possibility of spurious correlation among strongly trended variables. Second, the long-run relationships that may be lost by expressing the data in differences to achieve stationarity are captured by including the lagged levels of the variables on the right-hand side. Third, the specification attempts to distinguish between short-run (first-differences) and long-run (lagged-levels) effects. Finally, it provides a more general lag structure, which does not impose too specific a shape on the model (Hendry (1979))."

There is a growing literature on the application of cointegration with or without ECM to examine the demand for various definitions of money in the past ten years. One major contribution of this new procedure is that it allows the researchers handle the question on the appropriate formulation of the dynamic elements of the model independent of the specification of long-run parameters. The major contributions on these techniques and concepts were made by Sargan (1964), Davidson and others (1978), Banerjee and others (1986), Granger (1986), Hendry (1986), Engle and Granger (1987), Johansen (1988), Phillips and Perron (1988), and Johansen and Juselius (1990).

In the money demand literature, these techniques initially were applied to examine the demand for money in the United States and United Kingdom as traditionally these countries dominated the research on money demand. A significant degree of additional effort was directed in these countries to explain the instability of money demand observed in the 1970s.[47]

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[46]Goodhart (1989) points out that there is a close connection between cointegration/ECM and buffer-stock approaches. He states that "like the former, the latter depends on the existence of a stable long-term relationship between money holdings and nominal incomes. Various shocks, then drive actual money balances away from their long-term equilibrium levels, a divergence that people are waiting to tolerate temporarily because money balances are particularly suited to act as a buffer to such shocks." See Lastrapes and Selgin (1994) for a recent paper relating these two approaches.

[47]The earlier papers which estimated the money demand for the United States include Rose

(continued...)

The new techniques were also used, to certain extent as in the case of previous models, for studies dealing with other industrial countries as the central banks in these countries have always been interested in analyzing the demand for money because of its implications in conducting the monetary policy.[48]

The ECM approach received only scant attention to analyze the demand for money in developing countries in the 1980s with some exceptions such as Domowitz and Elbadawi (1987) on Sudan, Arestis (1988a) for a group of small developing economies, and Gupta and Moazzami (1988, 1989, and 1990) for Asia. With the encouraging results from these earlier studies researchers expanded their focus to analyze the demand for money in a wide range of countries. Table A1 summarizes the salient features of selected papers analyzing the demand for money for a number of countries, especially in developing world, using this approach.[49]

The earlier ECMs on money demand tended to be based on bivariate cointegrating relationship between money and the chosen scale variable as developed by Engle and Granger (1987). However, further research suggested that multivariate cointegrating vectors encompassing a broader number of variables provided a fuller characterization of the long-run determinants of demand. The specification of such multiple cointegrating vectors between nonstationary variables primarily employs the procedures developed by Johansen (1988) and Johansen and Juselius (1990) which make the original Engle-Granger framework as a special case.

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[47](...continued)
(1985), Baba, Hendry, and Starr (1988), Cuthbertson and Taylor (1988), Ebrill (1988), Mehra (1989), and Hendry and Ericsson (1990). For the United Kingdom, refer to Hendry (1979, 1985, and 1988), Hendry and Ericsson (1983 and 1990), Hendry and Richard (1983), Patterson (1987), Taylor (1987), Hall, Henry, and Wilcox (1989), and Muscatelli (1989). For a group of industrial countries including the United States and the United Kingdom, see Boughton and Tavlas (1991) and Domowitz and Hakkio (1990).

[48]See Corker (1990) and Yoshida (1990) for Japan; Muscatelli and Papi (1990) for Italy; and Arestis (1988b) for Greece, among others.

[49]Selected references for other papers are Deutsche Bundesbank (1995) and Filosa (1995) for a number of countries in the European Union; Hendry and Ericsson (1991b) for the United States and the United Kingdom; Hoffman and Rasche (1991), Baba, Hendry, and Starr (1992), Boughton (1993), and Hess, Jones, and Porter (1994) for the United States; Adam (1991), Brookes and others (1991), Johansen (1992b), Ericsson, Hendry, and Tran (1993), and Janssen (1996) for the United Kingdom; Bagliano and Favero (1992) for Italy; Chowdhury (1995) for Switzerland; Ahumada (1992) for Argentina; Huang (1994) for China; Arestis and Demetriades (1991) for Cyprus; De Lemos Grandmont (1995) for Mexico; and De Broeck, Krajnyák, and Lorie (1997) for countries of the former Soviet Union.

Table A1 reveals a number of interesting points. In terms of the study objectives, majority of the papers were interested in estimating cointegrating relationships and setting up appropriate short-run dynamic ECMs. Only a very few focused on estimating just the long-run cointegrating relationship (see Hafer and Jansen (1991), Eken and others (1995), Haug and Lucas (1996), for example). With regard to estimation techniques, the two widely used approaches are Engle and Granger (1987); and Johansen (1988) and Johansen and Juselius (1990). Within these two procedures, the latter has become more prominent as it provides an opportunity to evaluate the presence of multiple cointegrating vectors and has shown that it is more efficient than the former.[50] The former approach was used only in a few studies especially during the early part of the 1990s (although, not shown in the table, this technique was very commonly employed in the studies done in the 1980s). In a way, the papers published in the mid- to late-1980s exclusively used the former procedure. The research papers came out in the end-1980s and beginning of the 1990s applied both procedures. The recent papers most often apply multivariate procedures especially of Johansen (1988) and Johansen and Juselius (1990).[51]

The most common unit root test is the augmented Dickey-Fuller (ADF) test although the number of lags to start with varied across studies. The other unit root tests such as Dickey-Fuller (DF), Kwiatkowski, Phillips, Schmidt, and Shin (KPSS), Phillips and Perron, and CRDW also received some attention. In terms of results, majority of the papers did find cointegrating relationship between the monetary aggregates and the arguments of the money demand function. The caveat, however, is that sometimes conflicting results were obtained from different tests being used. One important finding is that generally a stable relationship between money and its arguments is obtained. The Chow test was primarily used for examining the stability.[52]

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[50]The main advantage of the Engle-Granger's two-step procedure is its simplicity. It is a single equation approach and seems to work well when the sample size is sufficiently large. However, in finite samples, this procedure does not work well as usually indicated by a relatively low R^2 from the cointegrating regression; the long-run coefficient estimates also can be badly biased (see Banerjee and others (1986)). Furthermore, the power of the cointegration test is greater in Johansen (1988) and Johansen and Juselius (1990) procedure.

[51]There are few other cointegration techniques such as Phillips and Ouliaris (1990), Johansen (1991c) to estimate I(2) series, and Johansen's reduced rank regression model with a very general deterministic trends (for one study where the data series appeared to contain a unit root possibly about a deterministic trend (see Hoffman and Tahiri (1994)). Additionally, the dynamic OLS and cointegration regression Durbin-Watson (CRDW) test procedures are also used in some studies.

[52]Some other stability tests include CUSUM, CUSUMSQ, Farley and Hinich (1970), Ashley (1984), Hansen (1992), and Hansen and Johansen (1993).

It is interesting and surprising to find stable money demand relationships considering the big debate on monetary instability of the 1970s. A point worth noting is that by applying the new ECM framework some studies have even concluded that the demand for broad money in Japan, the United Kingdom, and the United States remained stable during those years which the overwhelming past research employing the conventional models identified as the period of monetary instability (see Rose (1985), Baba, Hendry, and Starr (1988), Hendry and Ericsson (1991b), and Mehra (1993) for the United States; Corker (1990) and Yoshida (1990) for Japan; and Adam (1991), Hendry and Ericsson (1991b) for the United Kingdom). These observations just confirm that indeed the earlier models did suffer from specification problems and the ECM models provide an appropriate framework to model the money demand.

E. Conclusion

Significant amount of work has been done in estimating money demand functions both in developed and, increasingly, in developing countries as discussed in the section. The empirical work begins with an objective that for a stable money demand function it is imperative to have as fewer arguments as possible linking money with the real sector. The literature review confirms the earlier theoretical assertion that the major determinants of money demand are scale variable and opportunity cost of holding money which are represented by various alternatives.

Since the availability and definitions of monetary aggregates vary among countries, the typically employed aggregates included narrow and broad money. The narrow money usually represented by M1 and the broad money by M2, M3, M4, M5, among others. A number of other aggregates in between these two broad categories are also used. Some studies also estimated the demand for individual components of these monetary aggregates (disaggregated by type of assets and by type of holders), while some others tried the divisia aggregates for the broad categories. The scale variable is represented by two broad choices namely income and wealth. Here again, possible representation for income comprised of GNP, GDP, NNP, national income, industrial output, and so on; and for wealth, permanent income, consumption expenditure, for instance.

For opportunity cost of holding money, the theory called for own rate and the return on alternative assets. However, the empirical work requires inclusion of some representative rate rather than focusing on any specific interest rate. For developing countries characterized by underdeveloped financial sector or those where the interest rates are regulated by government, the expected inflation enters as an additional variable or used as the only variable to represent the opportunity cost of holding money. In hyper-inflation countries, the expected inflation variable is solely used in place of any type of interest rates mainly because the rate of return on alternative financial assets is dominated by the rate of return on real assets.

The recently promising open-market economy models require to include some combination of appropriate exchange rates and foreign interest rates in addition to the variables discussed above. In fact, in the world of international capital and financial market integration, the recent studies indicate that the influence of international monetary developments on domestic money holdings should be explicitly taken into account in specifying the money demand function. This is true for both industrial and many developing countries alike.

The partial adjustment framework was extremely popular in the 1970s. However, it was unable to explain the missing money episode of the 1970s. A number of refinements were made to improve its performance. These changes improved the model's ability to explain the past performance but shown only limited success in predicting the future money demand. Further research indicated that the partial adjustment models suffered from specification problem and highly restrictive dynamics. The solutions suggested were to modify the theoretical base and improve the dynamics structure. The first suggestion led to buffer-stock models which were built upon the theory of precautionary demand for money and the second suggestion resulted in error-correction models.

The buffer-stock approach explicitly incorporated money supply shocks in an otherwise conventional money demand models. However, it also ran into severe criticism especially its relevance in the empirical application. Meanwhile, research that focussed on improving the dynamics in the money demand function specification have become more promising. These new error-correction models have enabled the researchers to find out the existence of long-term linear cointegrating relationship among variables while stressing the short-term dynamics of adjustment toward the long-run equilibrium. These models have shown that the lag structures should be selected based on the data generating process of the economic variables and not on *a priori* based on the economic theory or naive dynamic theory. Therefore, by combining what the theory says with the advancements in time series econometrics, the current state of research seems to be better equipped to analyze the demand for money. The literature also reveals a growing number of papers written in a score of countries in the past few years.

Although different approaches are used, the error-correction models have now become the work horse of the money demand research and have proved to be successful. Hence, they have appeared to be the likely replacement of the partial adjustment specification that had dominated the money demand literature in the past. Another advantage of these models is that the possible endogeneity problem often encountered in the empirical research is avoided because each variable is considered as potentially endogenous. The importance of this technique is underscored by the fact that some researchers have concluded that the instability of money demand as noticed earlier under the partial adjustment scheme has disappeared under the error-correction framework.

Three important points come out of the analyses presented in the section. First both the model specification and the estimation technique are equally important. With a well-specified model and an estimation technique such as cointegration/error-correction model the recent research has shown that it is possible to obtain stable money demand function with meaningful parameter estimates. Second, it is clear from across a wide range of countries that the real money balances are cointegrated with the traditional arguments in the money demand function and the dynamic process can be estimated so as to explain short-run fluctuations as well. Third, recent studies are finding more and more evidence supporting the foreign influence on the domestic money demand function as national financial markets are increasingly integrated with the world economy and a number of countries follow flexible exchange rate regime.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Country/ Author(s)	Sample Period/ Frequency	Monetary Aggregate(s)	Determinants			Unit Root Test(s)	Order of Integration	Cointegration Technique(s)/ Test(s)	Stability Test(s)	Error-Correction Model (ECM)	Findings
			Scale variable(s)	Interest rate(s)	Other(s)						
Industrial countries											
United States											
Hafer and Jansen (1991)	1915:1-1988:4 Quarterly	real M1; real M2 1/	real output in 1972 dollars 1/	CPR; CBR	...	ADF	I(1)	J (1988); JJ (1990)	...	No	Cointegration relationship exists for M2 but not M1.
Miller (1991)	1959:1-1987:4 Quarterly	ln (adjusted B); ln (M1); ln (M1A); ln (M2); ln (M3)	ln (real GNP)	ln (4-6 month CPR); ln (dividend-price ratio)	ln (IPD)	DF ADF	I(1)	EG AEG	...	Yes	Cointegration relationship exists among M2, real GNP, IPD, and the CPR. ECM for M2 suggests valid and significant error-correction term.
McNown and Wallace (1992)	1973:2-1988:4 Quarterly	log (real M1); log (real M2)	log (real GNP)	log (nominal T-bill rate)	log (NEER)	ADF	I(1)	J (1988)	...	No	Cointegrating relationship for M1 (but not for M2) with real GNP and T-bill rate. Adding NEER to the M2 equation, establishes the cointegrating relationship.
Mehra (1993)	1953:1-1991:2 Quarterly	ln (real M2) 2/	ln (real GNP)	ln (R-RM2) 3/	...	ADF	Interest rate is I(0); others I(1)	OLS; IVT	Chow	Yes [OLS and IVT]	Example of a model that estimates both the long- and short-run coefficients in one step. Cointegrating relationship for real M2 and real GNP; money demand function is stable throughout the sample period.
Japan											
Arize and Shwiff (1993)	1973:1-1988:4 Quarterly	ln (real M2) 1/	ln (real GNP); 1/ ln (real wealth) 1/	ln (1+R) 4/	ln (real XR); 1/ inflation rate; 1/ ln (IGNPD) 1/	DF ADF PP (1988)	I(1)	AEG	Ashley (1984); Chow; CUSUM; CUSUMSQ	Yes	Cointegrating relationship among real GNP, real wealth, and real XR; stable ECM throughout the sample period.
Germany											
Deutsche Bundesbank (1995)	1970:1-1994:4 Quarterly	log (M3/ GNPD)	log (real GNP) [GNPD-based]	yield on domestic bearer debt securities outstanding (r); r-it 5/	seasonal dummies	ADF	I(1)	EG (1987)	...	Yes	Cointegrating relationship exits among money, interest rate r, and real GNP. The EC term is calculated as the avg. of previous four quarters, and has the negative coefficient which is significant.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Country/ Author(s)	Sample Period/ Frequency	Monetary Aggregate(s)	Determinants			Unit Root Test(s)	Order of Integration	Cointegration Technique(s)/ Test(s)	Stability Test(s)	Error-Correction Model (ECM)	Findings
			Scale variable(s)	Interest rate(s)	Other(s)						
United Kingdom											
Drake and Chrystal (1994)	1976:2-1990:3 Quarterly	ln (M1d); ln (M2d); ln (M3d) where d stands for divisia aggregates	ln (real GDP)	benchmark rate of interest; own rates of interest on M2d and M3d;	ln (GDPD); inflation [GDPD based]; implicit divisia rental price or user cost indices for M1d, M2d, and M3d	DF ADF PP (1988)	I(1) except for implicit divisia rental price or user cost indices for M2d and M3d which are I(0)	J (1988) JJ (1990)	Chow CUSUM CUSUMSQ	Yes [General to Specific Approach]	Company sector money demand; cointegrating relationship exists for all monetary aggregates. ECMs indicate that the speed of adjustment of the EC term is faster for M1d than for M2d and M3d.
Canada											
Haug and Lucas (1996)	1953:1-1990:4 1968:1-1990:4 Quarterly	ln (real M1); 1/ ln (real M2); 1/ ln (real M2+) 1/ [IGDPD-based]	ln (real GDP) [IGDPD-based]	ln (91-day T-bill rate); ln (10-year T-bond rate)	...	DF	I(1)	AEG; JJ (1990); PO (1990)	Hansen (1992)	No	Results vary depending on the cointegration tests selected and the combination of money and interest rates; however, stable long-term relationship is found among real M1, real GDP, and the 91-day T-bill rate.
Australia											
Lim (1993)	1977:4-1990:2 Quarterly 1976:8-1990:6 Monthly	real currency; 1/ real bank deposits; 1/ real nonbank deposits 1/ [GDPD-based]	real GDP 1/	90-day bank bill rate; 2- and 5-year T-bond rate	inflation rate; 6/ structural dummy	ADF P (1987)	90-day bank bill rate is I(0); others are I(1)	PH (1990) "fully modified regression"; JJ (1990); PO (1990)	...	Yes	Cointegrating relationships exist for both monthly and quarterly models for each money variable (without the 90-day bank bill rate); ECM shows some evidence for the significance of the 90-day bank bill rate in influencing the short-run adjustments of the monetary aggregates.
Greece											
Ericsson and Sharma (1996)	1975:1-1994:4 Quarterly	ln (M3/CPI)	ln (GDP at factor cost in constant 1970 prices)	net return on TD; interest rate spreads for repos and deposits; 7/ LIBOR	DEPR using NEER; inflation rate; seasonal and structural dummies	ADF	I(1)	EG J (1988) J (1991a) J (1992a) J (1992b)	Chow	Yes [General to Specific]	Cointegrating relationship among money, scale variable, inflation rate, and domestic interest rates and the spreads; stable ECM.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Country/ Author(s)	Sample Period/ Frequency	Monetary Aggregate(s)	Determinants			Unit Root Test(s)	Order of Integration	Cointegration Technique(s)/ Test(s)	Stability Test(s)	Error-Correction Model (ECM)	Findings
			Scale variable(s)	Interest rate(s)	Other(s)						
New Zealand											
Orden and Fisher (1993)	1965:2-1989:4 1965:2-1984:2 Quarterly	log (M3)	log (real GDP)	annual rate on S-T trading bank loans	log (GDPD)	DF	I(1)	J (1988)	...	No	No cointegrating relationship for the full sample; but one for the 1965:2-1984:2 period.
Norway											
Bårdsen (1992)	1967:3-1989:4 Quarterly	ln (M1)	ln (real GDE)	interest rate on DD and TD; yield on long-term private bond; 3-month euro-krone rate	ln (GDED)	not explicitly shown	I(1) except for 3-month euro-krone rate (which may be stationary around a trend)	J (1988); JJ (1990)	Chow	Yes	At least two and possibly up to five cointegration vectors exist; money is endogenously determined by prices, real expenditure, and interest rates.
Developing countries											
Argentina											
Choudhry (1995a)	1935:1-1962:4 1946:1-1962:4 Quarterly	ln (M1/WPI); ln (M2/WPI)	ln (real NNI)	...	inflation rate [WPI-based]	ADF	I(1)	J (1988); JJ (1990)	...	Yes	Cointegration relationship exists among real money (M1 and M2), real NNI, and the inflation rate. ECM finds relationship between real money and inflation.
Bolivia											
Asilis, Honohan, and McNelis (1993)	1980:9-1988:1 Monthly	ln (B/CPI) ln (M1/CPI) ln (M2/CPI)	...	...	expected inflation; inflation uncertainty	ADF	I(1)	JJ (1990)	...	Yes	The null hypothesis of at least one cointegrating vector is not rejected. ECM contains time-varying EC term; estimated by Kalman filtering technique.
Cameroon											
Fielding (1994)	1976:1-1987:2 Quarterly	ln (M2/CPI)	ln (real GDP adjusted for terms of trade)	ln (1+CBDR)	ln $(1+\pi)$; mavarπ; mavarr; quarterly dummy variables 8/	DF; Hylleberg and others (1990)	I(1)	JJ (1990)	Chow [for ECM]	Yes	Three cointegrating relationships among real M2, real GDP, inflation, interest rate and mavarπ. ECM passes diagnostic tests; EC has nearly unit coefficient.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Country/ Author(s)	Sample Period/ Frequency	Monetary Aggregate(s)	Determinants: Scale variable(s)	Determinants: Interest rate(s)	Determinants: Other(s)	Unit Root Test(s)	Order of Integration	Cointegration Technique(s)/ Test(s)	Stability Test(s)	Error-Correction Model (ECM)	Findings
China											
Hafer and Kutan (1994)	1952-88 Annual	log (currency); log (currency plus SD)	log (NI/RPI); log (NI/NID)	log (one-year interest rate on SD)	expected inflation	DF	I(1)	JJ (1990)	...	...	Cointegrating relationship exists only when NID (and not RPI) is used as a price variable; currency plus SD is the preferred measure of the monetary aggregate.
Tseng and others (1994)	1983:1-1988:4 1989:1-1993:4 1983:1-1993:4 Quarterly	ln (C/RPI) 1/ ln (M1/RPI) 1/ ln (M2/RPI) 1/	ln (real NI) 1/	real interest rate for the M1 and M2 equations for 1989-93 9/	quarterly inflation rate (RPI-based) [for 1983:1-1988:4]	ADF	I(1)	EG J (1988) JJ (1990)	Chow	Yes	All monetary aggregates are sensitive to inflation although its impact drops during the 1989:1-1993:4 subperiod; interest rates exert significant influence on M1 and M2 in the 1989:1-1993:4 subperiod.
Cote d'Ivoire											
Fielding (1994)	1974:3-1987:4 Quarterly	ln (M2/CPI)	ln (real GDP adjusted for terms of trade)	ln (1+CBDR)	ln $(1+\pi)$; mavarπ; mavarr; quarterly dummy variables 8/	DF; Hylleberg and others (1990)	I(1)	JJ (1990)	Chow	Yes	At least two cointegrating vectors among real money, real GDP, inflation, interest rate, and mavarπ. The error-correction coefficient is calculated from the residuals of the first two cointegrating vectors. Very slow adjustment to long-run equilibrium.
India											
Moosa (1992)	1972:1-1990:4 Quarterly	log (CC/CPI) log (M1/CPI) log (BM (M1 plus QM)/CPI)	log (IO)	log (MMR; rate offered in Bombay interbank market)	...	DF; ADF	I(1)	EG; AEG; CRDW; JJ (1990)	...	Yes	Cointegration relationship exists for real money (except for BM using AEG) with IO and MMR. More stable relationship for CC and M1 than for M2. ECMs show better results for CC and M1 than for BM.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Country/ Author(s)	Sample Period/ Frequency	Monetary Aggregate(s)	Determinants			Unit Root Test(s)	Order of Integration	Cointegration Technique(s)/ Test(s)	Stability Test(s)	Error-Correction Model (ECM)	Findings
			Scale variable(s)	Interest rate(s)	Other(s)						
Indonesia											
Price and Insukindro (1994)	1969:1-1987:4 Quarterly	ln (real currency held by public); ln (real DD)	ln (real GDP)	rate of return on TD and on SD; LIBOR	dummy variable for 1983 [for ECM]	DF; ADF	I(1)	EG; J (1988)	Chow; Salkever (1976) dummy approach [for ECM]	Yes	EG: weak evidence of cointegration relationship for currency; J (1988) finds up to 2 cointegrating vectors for both money equations. ECM does not find LIBOR being an important variable.
Dekle and Pradhan (1997)	1974-95 Annual	log (M1); log (M2); log (real M1); log (real M2)	log (real GDP)	TDR [for M1]; MMR-TDR weighted by the share of quasi money in M2;	log (CPI)	ADF	I(1) except for log (CPI) which is I(0)	J (1988)	...	No	No cointegrating relationship for any definition of money.
Kenya											
Adam (1992)	1973:1-1989:2 Quarterly	log (M0/CPI) log (M1/CPI) log (M2/CPI) log (M3/CPI) log (M3d/CPI) where M3d is divisia M3	log (GNY/ CPI) where GNY is GNP adjusted for changes in terms of trade	T-bill rate	expected DEPR using parallel market XR; inflation; seasonal dummies	DF; ADF; CRDW	I(1)	J (1988); JJ (1990)	...	Yes	Two cointegrating vectors among 5 variables for each monetary aggregate. ECM validates the cointegrating relationships.
Fielding (1994)	1975:2-1989:2 Quarterly	ln (M2/CPI)	ln (real GDP adjusted for terms of trade)	ln (1+T-bill rate)	ln (1+π); ln (1+DEPR) using parallel market XR; mavarπ; mavarr; quarterly dummy variables 8/	DF; Hylleberg and others (1990)	I(0) for ln (1+DEPR); I(1) for others	JJ (1990)	Chow [for ECM]	Yes	Three cointegrating relationships among real money, real GDP, inflation, interest rate, mavarr, and mavarπ. The EC term is calculated based on the residuals from the first two cointegrating vectors. S-T elasticities are smaller than those of long run.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Country/ Author(s)	Sample Period/ Frequency	Monetary Aggregate(s)	Determinants			Unit Root Test(s)	Order of Integration	Cointegration Technique(s)/ Test(s)	Stability Test(s)	Error-Correction Model (ECM)	Findings
			Scale variable(s)	Interest rate(s)	Other(s)						
Korea											
Arize (1994)	1973:1-1990:1 Quarterly	ln (M1/CPI) ln (M2/CPI)	ln (real GDP)	yield on CB; interest rate on loans and TD on NCB; weighed avg. of S-T interest rates in 9 industrial countries; interest rate differential in favor of foreign country	expected rate of inflation; EER; standard deviation of the change in the log of the EER; dummy variable to measure the change in circumstances	ADF; Hylleberg and others (1990); Osborn (1990); Hasza and Fuller (1982); Perron (1988)	I(1)	EY (1987); J (1988)	Chow	Yes	Two to three cointegrating vectors among real money (both M1 and M2), real income, interest rate, and foreign exchange rate risk and return. Well-specified ECM.
Lebanon											
Eken and others (1995)	1964-93 Annual	log (B-P) log (M1-P) log FCD$ 10/ log (M2LL-P) 10/ log (M2)	log (real GDP); log (U.S. dollar-denominated GDP)	...	log (CPI); log (U.S. CPI); log (expected inflation); war year dummy variables	PP (1988)	I(1)	PO (1990)	...	...	Cointegrating relationship exits between various definitions of money and with real GDP, prices, and domestic inflation.
Malaysia											
Sriram (1998)	1973:8-1995:12 Monthly	ln (M2/CPI)	ln (IIP)	CBTD3M; discount rate on 3-month T-bills	expected inflation; nominal XR; seasonal and structural dummies	DF ADF	ln (IIP) and expected inflation are I(0); others are I(1)	J (1988) JJ (1990)	Chow	Yes [General to specific Approach]	Cointegration relationship exists between M2 and its determinants both under the closed- and open-economy framework. Stable ECM under both situations.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Country/ Author(s)	Sample Period/ Frequency	Monetary Aggregate(s)	Determinants			Unit Root Test(s)	Order of Integration	Cointegration Technique(s)/ Test(s)	Stability Test(s)	Error-Correction Model (ECM)	Findings
			Scale variable(s)	Interest rate(s)	Other(s)						
Morocco											
Hoffman and Tahiri (1994)	1959:1-1988:2 Quarterly	log (M1); log (M2)	log (GDP/ CPI); log (GNP/ CPI)	Swiss S-T interest rate; interest rate on TD	log (CPI)	ADF; KPSS	I(1) possibly about a deterministic trend; KPSS test fails to reject the null of stationary for swiss S-T interest rate	J (1991b); OLS; DOLS (Stock and Watson (1993))	Hansen and Johansen (1993)	No	Single cointegrating vector among measures of nominal money, prices, real income, and Swiss S-T interest rate.
Nigeria											
Fielding (1994)	1976:1-1989:2 Quarterly	ln (M2/CPI)	ln (real GDP adjusted for terms of trade)	ln (1+T-bill rate)	ln (1+π); ln (1+DEPR) using parallel market XR; mavarπ; mavarr; 8/ seasonal dummies	DF; Hylleberg and others (1990)	I(0) for ln (1+DEPR); I(1) for others	JJ (1990)	Chow [for ECM]	Yes	One cointegrating relationship among real money, real GDP, inflation, interest rate and mavarπ.
Teriba (1997)	1960-94 Annual 1962:1-1995:2 for M1; and 1962:1-1992:4 for M2 Quarterly	log (COB) log (M1) log (M2)	log (real DA)	log (interest rate for 12-month TD); log (interest rate for 3-month TD)	log (DAD); log (LTBR in Nigeria/LTBR in the United States)	DF	I(1) except for log M1 (I(2)) and for parallel market XR (I(0))	EG; AEG	...	Yes	Cointegration relationship exists among the monetary aggregates, DA, DAD, and interest rates in Nigeria. Foreign opportunity cost variable has influence on M1 equation only.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Country/ Author(s)	Sample Period/ Frequency	Monetary Aggregate(s)	Determinants			Unit Root Test(s)	Order of Integration	Cointegration Technique(s)/ Test(s)	Stability Test(s)	Error-Correction Model (ECM)	Findings
			Scale variable(s)	Interest rate(s)	Other(s)						
Pakistan											
Arize (1994)	1973:1-1990:1 Quarterly	ln (M1/CPI) ln (M2/CPI)	ln (real GDP) [WPI-based]	CMR; Govt. bond yields; weighted avg. of S-T interest rates in 9 industrial countries; interest rate differential in favor of foreign country	expected rate of inflation; EER; standard deviation of the change in the log of the EER; dummy variable to measure the change in circumstances	ADF; Hylleberg and others (1990); Osborn (1990); Hasza and Fuller (1982); Perron (1988)	I(1) except for expected rate of inflation which is I(0)	EY (1987) J (1988)	Chow	Yes	Two to three cointegrating vectors exist among real money (both M1 and M2), real GDP, interest rate, and foreign exchange rate risk and return. Well-specified ECM.
Hossain (1994)	1951-91 1972-91 Annual	log (M1/CPI) log (M2/CPI)	ln (real GDP)	ln (yield on Govt. bonds); ln (market call rate of interest)	expected inflation	DF; ADF	expected inflation is I(0); others I(1)	EG; AEG; CRDW; J (1988); JJ (1990)	...	No	EG, AEG, and CRDW tests show conflicting results. But JJ (1990) test finds 2 cointegrating vectors among money, real GDP, and call rate of interest for 1972-91 and one for 1953-91. M1 is found to be more stable than M2.
Singapore											
Arize (1994)	1973:1-1990:1 Quarterly	ln (M1/CPI); ln (M2/CPI)	ln (real GDP) [WPI-based]	CMR; 3-month FDR; weighed avg. of S-T interest rates in 9 industrial countries; interest rate differential in favor of foreign country	expected rate of inflation; EER; standard deviation of the change in the log of the EER; dummy variable to measure the change in circumstances	ADF; Hylleberg and others (1990); Osborn (1990); Hasza and Fuller (1982); Perron (1988)	I(1) except for expected rate of inflation which is I(0)	EY (1987); J (1988)	Chow	Yes	2-3 cointegrating vectors among real money (both M1 and M2), real GDP, interest rate, and foreign exchange rate risk and return. Well-specified ECM.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Country/ Author(s)	Sample Period/ Frequency	Monetary Aggregate(s)	Determinants: Scale variable(s)	Determinants: Interest rate(s)	Determinants: Other(s)	Unit Root Test(s)	Order of Integration	Cointegration Technique(s)/ Test(s)	Stability Test(s)	Error-Correction Model (ECM)	Findings
Dekle and Pradhan (1997)	1975-95 Annual	log (M1); log (M2); log (real M1); log (real M2)	log (real GDP)	TDR [for M1]; MMR-TDR weighted by the share QM in M2; LIBOR	log (CPI); expected depreciation rate	ADF	I(1)	J (1988)	...	No	Cointegrating relationships for nominal M1 and M2.
Thailand											
Dekle and Pradhan (1997)	1978-95 Annual	log (M1); log (M2); log (real M1); log (real M2)	log (real GDP)	TDR [for M1]; MMR-TDR weighted by the share of QM in M2;	log (CPI)	ADF	I(1)	J (1988)	...	No	Cointegrating relationships for nominal M1 only.
Tunisia											
Treichel (1997)	1962-95 Annual 1990-95 Monthly	ln (M2/CPI); ln (M4/CPI)	ln (real GDP)	monthly yield on T-bill; rediscount rate; MMR	inflation rate; seasonal dummies	ADF	I(1) except for inflation rate which is I(0)	AEG J (1988)	Recursive Chow [for ECM]	Yes	Stable long-term relationship between real money and real GDP using the annual data; real M2 is cointegrated with real GDP and T-bill rate for the monthly observations for 1990-95. Stable ECM.

Note: The following abbreviations are used:

Monetary aggregates: B = base money; BM = broad money; CC = currency in circulation; COB = currency outside banks; DD = demand deposits; QM = quasi-money; SD = savings deposits; and TD = time deposits.

Scale variable: DA = domestic absorption; GDE = gross domestic expenditure; GDP = gross domestic product; GNP = gross national product; IIP = index of industrial production; IO = industrial output; NI = national income; and NNI = net national income.

Interest rate: CMR = call money rate; CBDR = Central Bank discount rate; CPR = commercial paper rate; CBR = corporate bond rate; FDR = fixed deposit rate; LIBOR = London interbank offered rate; LTBR = Long-term borrowing rate; MMR = money market rate; CBTD3M = Three-month deposit rates at commercial banks; TDR = time deposit rate; T-bill = Treasury bill; and T-bond = Treasury bond.

Exchange rate: DEPR = depreciation; XR = exchange rate; EER = effective exchange rate; and NEER = nominal effective exchange rate.

Prices: CPI = consumer price index; RPI = retail price index; and WPI = wholesale price index.

Deflators: DAD = domestic absorption deflator; GDED = gross domestic expenditure deflator; GDPD = gross domestic product deflator; GNPD = gross national product deflator; IGDPD = implicit GDP deflator; IGNPD = implicit GNP deflator; IPD = implicit price deflator; and NID = national income deflator.

Table A1. Summary of Demand for Money Studies Involving Cointegration/Error-Correction Modeling in Selected Industrial and Developing Countries

Unit root tests: ADF = augmented Dickey-Fuller; CRDW = cointegration regression Durbin-Watson; DF = Dickey-Fuller; KPSS = Kwiatkowski, Phillips, Schmidt, and Shin (1992); P (1987) = Phillips (1987); and PP (1988) = Phillips and Perron (1988).

Cointegration tests: AEG = augmented Engle and Granger; CRDW = Cointegration regression Durbin-Watson; DOLS = dynamic ordinary least squares; EG = Engle and Granger; EY = Engle and Yoo (1987); IVT = instrumental variable technique; J (n) = Johansen (n) where n stands for 1988, 1991a, 1991b, 1992a, 1992b respectively; JJ (1990) = Johansen and Juselius (1990); OLS = ordinary least squares; PH = Phillips and Hansen (1990); and PO (1990) = Phillips and Ouliaris (1990).

General: avg. = average; CB = corporate bonds; EC = error-correction; Govt. = Government; NCB = nationwide commercial banks; and S-T = short-term.

1/ Seasonally-adjusted.

2/ Deflated by IGNPD.

3/ R = own rate of return for M2 (weighted average of explicit interest rates paid on the components of M2) minus RM2 (four-six month CPR).

4/ R is defined as the three-month average Gensaki rate minus the average return on holding broad money defined as weighted average of the interest rate on three-month certificates of deposit and the guideline three-month deposit rate.

5/ Where "it" stands of time deposit rate of deposits between DM 100,000 and DM 1 million.

6/ Calculated as the annual percentage change in the GDP deflator.

7/ spreads between yield on T-bill and net return on time deposits and between yield on T-bill and net return on repurchase agreements respectively.

8/ mavarπ is annual moving average of changes in inflation calculated as $|\Delta \ln(1+p)|_t$ and mavarr is for interest rates.

9/ Defined as one-year time deposit rate minus the rate of inflation.

10/ FCD$ and M2LL stand for U.S. dollar-denominated deposits and Lebanese pound component of M2 respectively.

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