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The purpose of the "Temi di discussione" series is to promote the circulation of working papers prepared within the Bank of Italy or presented in Bank seminars by outside economists with the aim of stimulating comments and suggestions.

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AN ECONOMETRIC ANALYSIS OF MONEY DEMAND IN ITALY

by P. Angelini (*), D. F. Hendry (**) and R. Rinaldi (*)

Abstract

The paper presents quarterly and monthly econometric estimates for money demand in Italy, based on the recently redefined broad aggregate M2. Due to financial innovation and the introduction of new instruments for Treasury's funding, in the first half of the eighties money demand was unstable. In the following years, the velocity of M2 stabilised, enhancing its role in monetary policy. The paper presents a quarterly equation in which net financial wealth is the scale variable in the 1975-79 period, while more recently (1983-1992) this role is performed by domestic demand. In line with previous studies, we argue that this specification reflects a positive shift in the demand for Treasury's securities in the first half of the eighties, which reduced the demand for money as a store of value. The monthly equation is estimated over the 1983-1992 period, so as to reduce the impact of the instability. In the specification search, we considered, as additional criteria, forecasting performance and coherence between the quarterly and monthly equations. The estimated long-run elasticities of the final quarterly and monthly equations are coherent. Their forecasting performance is satisfactory in 1991 and in the first part of 1992; following the foreign exchange crisis in the Summer of 1992, signs of instability emerge.

Contents

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1. Introduction[1]

In 1984 the Bank of Italy announced for the first time a target range for the annual expansion of the broad monetary aggregate M2. The aggregate became part of a wider set of intermediate variables for monetary policy, that included the share of credit supplied to the non state sector[2], and the exchange rate.

The role, interpretation and relative importance of these variables in the design of monetary policy have changed over time (see Angeloni and Passacantando, 1991). Credit was given less emphasis due to the instability in its link with nominal macroeconomic variables and to its lack of controllability, that emerged following the lifting of the ceiling on banks' loans in 1983 and the liberalisation of capital movements in the second half of the eighties. In the latter decade the role of exchange rate increased: the parity of the lira in the ERM became the main guide for interest rate setting; the price of foreign currency the channel through which the anti-inflationary thrust of monetary policy was transmitted to the economy.

The role of money in the EMS period was mainly "informative" on the future evolution of prices. The practice of announcing explicit target ranges signalled the desired policy stance and aimed in fact at influencing expectations. In principle, the role of the money stock in monetary policy has changed with the fluctuation of the lira since September 1992.

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1 We wish to thank I. Angeloni, L. Buttiglione, F. Passacantando, I. Visco and an anonymous referee for helpful comments at various stages of the work. The suggestions by F.C. Bagliano, discussant at the Conference BI-CIDE on "Ricerche quantitative per la politica economica 1993", Perugia (Sadiba), 30.9-2.10.1993, improved the paper. A.P. Caprari prepared the text and the tables; A. Gattulli produced the charts.

2 This sector comprises households, enterprises, insurance companies and local authorities.

At present, the anti-inflationary stance of the monetary policy depends to a greater extent on the announcement and the realisation of the target on money growth.

At the EC level, the relevance of the monetary aggregates for policy purposes has been enhanced by the common practice of announcing targets for wide monetary aggregates. In 1990 the Committee of Governors of the Central Banks of the EC promoted a harmonisation in the definitions of national money aggregates, so as to enhance their comparability. The yearly national targets for money expansion and their coherence with the goal of achieving convergence in inflation rates are evaluated at the Community level. In Italy these developments, coupled with a broad methodological revision of banking statistics, led to a revision of monetary aggregates (see Banca d'Italia, 1991). Attention has been devoted to cross-border deposits ("extended" M2) that may deteriorate the controllability and the informational content of traditional monetary aggregates (see Angeloni, Cottarelli and Levy, 1992; Giucca and Levy, 1992).

From an econometric point of view the properties of the new aggregates have been analysed both by recourse to reduced form techniques (see Rinaldi, 1990) and by traditional structural methods.[3] This study is part of this second approach, reporting econometric estimates for the new broad aggregate and investigating its stability properties, in the spirit of the general-to-specific approach proposed by Hendry (1979). After a brief review of the literature in section 2, the study deals with the problem of instability of money demand in Italy in the late seventies and early eighties, following the reform of the Treasury bills market in 1975 and the introduction of floating rate credit certificates of the Treasury in 1977 (section 3). Section 4 reports the empirical results based on the quarterly and monthly data. Attempts at solving the instability problem following some of the main sug-

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3 See the review of the literature in this paper.

gestions proposed in the literature were not successful (section 4.1.1); estimates of a quarterly equation over the 1975-1991 period are reported in section 4.1.2, in which financial innovation is modelled by means of a deterministic trend. In section 4.2 monthly data are analysed to focus on the last decade, during which the effects of financial innovation on money velocity became less severe. It is shown that the results obtained with the quarterly and monthly datasets are coherent. Section 5 brings together the main conclusions.

Appendix 1 presents the econometric methodology, the data and how the problem of financial innovation has been addressed in the literature. Appendix 2 compares the new quarterly equation with the one previously incorporated in the quarterly model of the Bank of Italy.

2. Review of the literature

2.1 Analytical and methodological aspects

Among the traditional motives for holding money (transaction, precautionary and portfolio's motives) the literature has recently emphasised its role in the payment process.

This role is highlighted in cash-in-advance models (see Lucas, 1988), which emphasise the presence of legal and institutional arrangements that make the use of money for some payments virtually indispensable. McCallum and Goodfriend (1989), following a similar approach, define money as an asset accepted in payment for any commodity, and argue that the store of value and the unit of account functions follow indirectly from its basic transaction role.[4]

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4 They develop a model in which cash balances limit "shopping time" for a utility maximising consumer, who cares about consumption and leisure. Since shopping time reduces the latter, the consumer has a positive demand for fiat money, despite the availability of interest yielding assets. See

These new contributions are relatively distant from those theories that highlighted the store of value function of money. Tobin's (1958) liquidity preference model, for example, cannot account for the existence of money in the presence of other riskless assets offering higher yields. The same conceptual difficulty is shared by the restatement of the quantity theory of money by M. Friedman (1956).[5] On the contrary, the recent literature has several points in common with the classical contributions by Baumol (1952), Tobin (1956), Miller and Orr (1966), Ando and Shell (1975), who viewed money mainly as a transaction medium. The recent emphasis on the transaction role of money partly depends on the rapid evolution of financial markets, which increasingly offer higher yielding, highly liquid alternatives to money as a store of value. As we shall see, these developments play a central role in the empirical analysis of money demand.

From the empirical viewpoint, a large body of the econometric literature has aimed at determining the relevance of these different approaches to the demand for money. Until the mid-seventies the consensus on the appropriate econometric framework for the estimation of money demand was widespread. This framework, laid down by Goldfeld (1973), was based on the following building blocks:

a) the estimated equations were interpreted as structural relationships; the absence of major episodes of instability justified the use of the equations for forecasting and policy analysis;

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also Giannini (1988) and Grossman (1991) for definitions of money based on its use in transactions.

5 More recently, however, Friedman (1989) has proposed a wider scheme for its restatement that incorporates pure transaction models. The emphasis on the use of money as temporary abode to purchasing power, rather than on its use in transactions, is also shared by other theoretical contributions, such as those that view money, in overlapping generations models, as a means for transferring wealth over time.

b) most equations employed a partial adjustment mechanism to desired money balances, on the assumption that portfolios reallocations are costly.

The breakdown of money demand equations after the mid-seventies, particularly evident in the US. case, unsettled the general consensus, giving rise to two different approaches.

One line of research criticised both building blocks. The conventional interpretation of estimated equations as structural relationships was exposed to the Lucas' (1976) claim that estimated equations cannot be used for policy analysis.[6] Several examples in which traditional money equations are reduced forms have been pointed out in the literature.[7] The partial adjustment scheme was criticised along two lines. One strand of literature proposed "disequilibrium" models, based on the hypothesis that the money stock is exogenously determined

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6 See Lucas (1976). Goodfriend and McCallum (1989) and Lucas (1988) present formal transaction models in which the demand for money is derived from the first order conditions of utility maximisation. They argue that the arguments of such a function, beside traditional variables (past values of interest rates and consumption), are future expected realisations of the exogenous variables (interest rates, inflation). It is interesting to note, however, that they also derive an equation which links money balances to current consumption and interest rates only. According to the authors, such a relationship can be hardly considered the "true" demand for money since it links complementary variables of choice; however they stress the empirical stability of the relationship.

7 Bagliano (1991) points out that this may be the case when (a) the monetary authorities adopt a reaction function in terms of the interest rate or the monetary base and expectations are formed rationally; (b) the explanatory variables are affected by measurement errors (particularly likely for the scale variable and for the interest rate differential, which respectively proxy the volume of transactions and opportunity cost on money); (c) desired money balances depend on the expected values of the forcing variables and expectations are formed rationally. For each of these cases, the estimated parameters of conventional money equations depend on agents' behavioural parameters as well as on policy parameters, variance of the measurement error and parameters describing the expectations formation process.

by the central bank. In the aggregate, then, demand always equates the fixed supply, and discrepancies between desired and actual holdings trigger adjustments in the other macroeconomic variables (the price level, interest rates, output), which can therefore be modelled as endogenous by inverting the traditional money equations (see Artis and Lewis, 1976; Laidler, 1980 and 1984, but also Hendry and Ericsson, 1991 for an opposite view).

Other authors argued that adjustment costs to desired money balances might not be uniform vis-à-vis changes in income or interest rates, as assumed in the traditional stock adjustment framework; they might actually be nil at the individual level. The significance of the lagged dependent variable in traditional equations would therefore reflect factors other than slow adjustment to desired balances, such as sluggish adjustment of prices (see Gordon, 1984). On the other hand, it has been argued that the benefits of adjustment are also very low (see Akerlof, 1979, Akerlof and Milbourne, 1980).

A second line of research developed as a reaction to the critique raised by Lucas. It moved within the traditional scheme and aimed at devising formal testing procedures to ascertain the relevance of the critique on a case-by-case basis. The concept of exogeneity proposed by Engle, Hendry and Richard (1983) is crucial in this context; it gave new analytical support to the estimation of single equation models according to the traditional approach.

The partial adjustment mechanism was amended by recourse to less restrictive hypotheses. The general-to-specific approach to estimation, proposed by Hendry (1979), and the refinements of the error-correction models that followed the development of the theory of cointegrated variables (Granger and Engle, 1987) left short-term dynamics unrestricted, the role of economic theory being that of pointing to the long-run relationships among the relevant variables. Efforts were devoted to the analysis of financial innovation, which was deemed as the main cause of the observed instability in money demand equations, and to devise techniques to deal with it.

2.2 The Italian case

The first pioneering studies on money demand in Italy trace back to the early fifties.[8] Interest in monetary aggregates and in their relevance for monetary policy is however fairly recent, compared to the experience of other countries. In the seventies monetary aggregates were given less emphasis, due mainly to a monetary policy design based on administrative controls and on credit aggregates as intermediate targets.[9] The increased instability of the latter during the eighties, following the dismantling of the ceiling on bank loans in June 1983, renewed the interest in the monetary aggregates and in their relevance for the conduct of monetary policy.

As a result of these developments, in the eighties the studies on money demand became more frequent. Their contribution has been significant in three related fields.

A first group of studies stressed that the stability properties of the money demand in Italy, in the long and in the short run, could be exploited from a policy stand-point and brought the attention back on monetary aggregates as useful policy tools, after a period of relative neglect.[10]

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8 The first study on money demand (currency plus banks' saving deposits held by families) explicitly based on econometric techniques is Baffi and Occhiuto (1954). Fazio (1969) estimated demand functions for currency and postal deposits, at that time the two main components of the monetary base held by the non bank public. Cotula in 1971 published an ample study on money demand in the Keynesian tradition.

9 For example, in an early version of the quarterly econometric model of the Banca d'Italia (M2BI), bank deposits were obtained as a residual from the balance sheet of the private sector.

10 See Micossi, Caranza and Villani (1983) and Calliari, Spinelli and Verga (1983).

Another group of contributions fostered the application of new econometric techniques, linked to the theory of integrated and cointegrated variables, that allowed to improve the analysis of the properties of monetary aggregates.[11]

Finally, several studies contributed to the analysis of the instability of estimated money equations, and devised methods to deal with it econometrically. Studies in the early part of the eighties singled out financial innovation as the main cause for parameter shifts.[12] Vaciago and Verga (1982) is one of the earliest empirical works pointing out a permanent downward shift in the demand for bank deposits. In the quarterly model of the Banca d'Italia (1986) the instability is tackled by modelling separately the two roles of money as financial instrument and transaction medium, so as to capture the transition from the former to the latter.[13]

Bagliano and Favero (1989) point out however that parameter instability may be due to improper modelling of expectations. Following Cuthbertson and Taylor (1987), they adopt a rational expectations model which, unlike traditional feedback-only models, includes future values of the explanatory variables among the regressors. As stressed by Muscatelli (1991), they do not reach however conclusive results.

Bagliano, Favero and Muscatelli (1991) and Muscatelli (1991) point to a different type of instability in money demand

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11 See Papi (1988) and Banca d'Italia (1988) for applications of the general-to-specific method. Muscatelli and Papi (1988) applied both the Engle and Granger (1987) two-step procedure and the general-to-specific methodology to M2.

12 This factor, common to money demand equations in several countries, will be dealt with in more detail in Appendix 1.

13 In the monthly monetary model of the Bank of Italy (1988) the transition is assumed completed: income is the only scale variable in the equation for banks' deposits, while net wealth has only a buffer, short run effect.

equations in Italy, which arises in error-correction formulations when financial innovation is not explicitly modelled via deterministic trends. In these cases the coefficient of the error-correction term is positive, entailing apparent explosive behaviour for the long run solution. The authors show that this "dynamic instability" can be eliminated by estimating a simultaneous system which includes all the long-run relationships among the regressors. Parameter instability, however, is not directly assessed in this multi-equation context, due to the difficulty of computing the appropriate recursive test statistics whenever the estimation method is not OLS.

3. Financial innovation and money demand

For a long period of time, in Italy financial innovation took mainly the form of new financial assets issued by the Treasury for funding needs. Before 1975 financial markets were less developed relative to other industrialised countries. The Treasury issued T.bills and long-term fixed rate bonds, mostly purchased by the banking system and the central bank and held to maturity; no secondary market existed for these securities. The market for private firms debentures suffered from the inflation that followed the first oil shock, and to support their prices the Government enforced a portfolio constraint to induce banks to hold them. In this situation, financial wealth of the private sector was mostly held in the form of monetary assets: currency and bank deposits.

The reform of the T.bill market in 1975, the introduction of Treasury's floating rate certificates (CCT) in 1977 and of mutual funds in 1984 were fundamental steps in the development of money and financial markets in Italy. These financial innovations, allowing the private sector to choose over a wider range of assets, favoured a gradual portfolio reallocation which involved T.bills in the period 1979-1981, then mostly CCTs in the period 1982-86[14] and mutual funds shares in the period 1984-1986. The latter knew an exceptional growth in the years following their introduction, in close connection with the rapid rise of the stock market. Mutual funds' net capital went from 1,150 billion of Italian lire in 1984 to 65,100 in 1986.

The period 1979-1981 saw the surge in inflation following the second oil shock. In 1975 the share of M2 in total financial wealth was 76,2 per cent and it remained fairly constant until 1979; at the end of 1981 it was 69.6 per cent, a drop of 7 percentage points (Table 1). Over the same period, the share of T.bills in financial wealth increased from 5.6 per cent to 13.2 per cent; the velocity of circulation of the money aggregate (M2), calculated with reference to total domestic demand, experienced a dramatic increase (Fig. 1). In addition, due to high inflation rates, a strong substitution effect from monetary into real assets took place in the 1979-1981 period, favoured also by restrictions on capital movements.[15] As Figure 1 shows, the increase in velocity took place along with a sharp rise in the opportunity cost of holding money, measured by the differential between the T.bill rate and the own return on money.[16]

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[14] In 1981 the Government began to devote a serious effort to finance public spending through longer term bonds. To foster demand by the public, at the end of the year CCT issues were reformed: a fixed spread over the T.bill rate was introduced; the spread, in presence of falling nominal rates, favoured floating rate securities against shorter term ones. While these developments allowed better portfolio management through greater diversification, the policy objective underlying the development of the CCT market was to limit the liquidity of financial wealth, affected by increasing budget deficits.

[15] As suggested in the Annual Reports of the Bank of Italy in that period, there is evidence that wealth holders turned to the market for housing. The market experienced a strong rise in prices: in the period under examination, the price of houses increased by 22 per cent per annum on average (20 per cent the inflation rate).

[16] The opportunity costs calculated vis-à-vis the CCT rate show a similar pattern.

Table 1

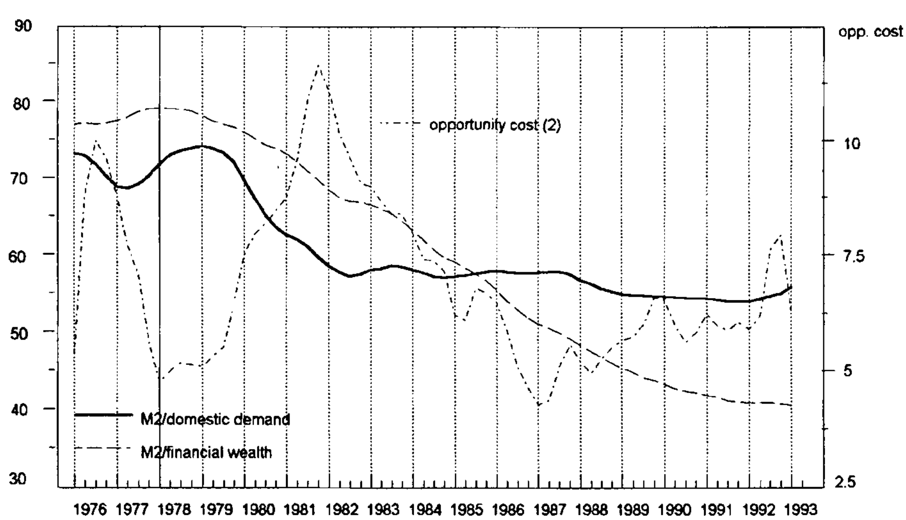
Composition of financial wealth
(percentage points) (1)

Years	Money (M2)	T.bills	Other liquid assets	CCT	T.bonds	Other financial assets	Total
1975	76.2	1.4	8.9	0.0	1.2	12.3	100
1976	76.9	1.5	8.6	0.0	1.8	11.2	100
1977	78.8	3.3	7.9	0.1	1.6	8.3	100
1978	78.6	3.9	7.8	1.0	2.1	6.6	100
1979	76.6	5.6	7.8	2.1	2.4	5.5	100
1980	73.7	9.3	7.9	2.5	1.8	4.8	100
1981	69.6	13.2	7.8	2.5	1.8	5.1	100
1982	66.4	15.6	7.9	3.6	1.4	5.1	100
1983	64.3	14.4	7.8	6.8	1.4	5.3	100
1984	59.5	15.0	7.3	10.7	1.9	5.6	100
1985	56.5	14.8	7.1	12.8	1.8	7.0	100
1986	51.8	13.5	7.2	14.2	2.7	10.6	100
1987	49.1	12.4	7.2	15.4	4.1	11.8	100
1988	45.9	14.3	8.3	14.9	5.7	10.9	100
1989	43.4	15.7	8.9	13.4	7.7	10.9	100
1990	41.7	16.1	9.1	15.3	7.0	10.8	100
1991	40.5	15.5	9.8	15.0	7.3	11.9	100
1992	40.0	15.3	12.3	13.6	7.0	11.8	100

(1) Annual averages of end of period figures on stocks outstanding.

Fig. 1

M2, domestic demand and financial wealth (1)
(percentage points)

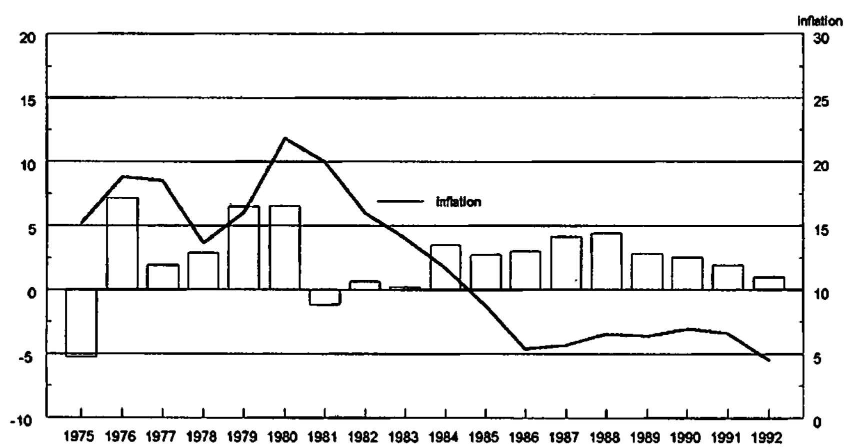


The behaviour of velocity was therefore broadly consistent with the movements in the opportunity costs and inflation, taking into account also the mentioned substitution effect away from financial assets into real wealth. In 1982-86, on the contrary, the velocity of circulation of M2 showed a negative correlation with the opportunity cost of holding money; this causes, as we shall see, difficulties in the econometric estimation phase.

The period 1982-86 was characterised by the fall in inflation and by the recovery in domestic demand growth (Fig. 2).[17] The share of M2 in financial wealth continued to fall at a rapid pace: from 66.4 per cent in 1982 to 51.8 per cent in 1986; the share of T.bills stabilised at 14-15 per cent, but the ratio of CCT to financial wealth jumped from 3.6 per cent in 1982 to 14.2 per cent in 1986 (Table 1).

Fig. 2

Domestic demand and inflation
(percentage points)



The dramatic increase in government securities in the private sector's portfolios that took place in this period can also be gauged from financial flows data: the private sector's purchases of T.bills amounted to 91.5 per cent of total net issues

17 From the peak reached in 1980 (21.8 per cent), the inflation rate, measured on the basis of the domestic demand deflator, fell to 5.4 per cent in 1986.

of this security (Table 2); the non-state sector purchases of CCT set at 47.3 per cent.

To foster demand of Government bonds by the public, at the end of 1981 the indexation mechanism of CCT was revised (see Banca d'Italia, Annual Reports, 1980 and 1981). The increased demand for floating rate securities was partly met, on the supply side, by the new debt management policy of the Treasury.

Table 2

T.bills and CCT by holding sector
(billions of lire and percentage points) (1)

	1975-78		1979-81		1982-86	
	T.bills	CCT	T.bills	CCT	T.bills	CCT
Non state sector	8,604 (29.4)	3,717 (24.5)	48,542 (70.9)	7,411 (47.4)	69,432 (91.5)	133,888 (47.4)
Commercial banks	17,704 (59.8)	6,801 (44.8)	14,961 (21.9)	3,748 (24.0)	-7,623 (-10.0)	76,706 (27.1)
Bank of Italy	-2,303 (-7.8)	4,501 (29.6)	4,112 (6.0)	3,445 (22.0)	14,957 (19.7)	24,361 (8.6)
Others	5,628 (19.0)	163 (1.1)	790 (1.2)	1,036 (6.6)	-913 (-1.2)	47,912 (16.9)
Total	**29,633**	**15,182**	**68,405**	**15,640**	**75,853**	**282,867**

(1) Cumulated flows in the reference periods; the item "Total" reports net issues of securities ratio. In parenthesis the change in securities' portfolios as a rate of net issues.

In the 1979-1981 period, faced by a fall in the demand for long-term securities, the Treasury relied mainly on T.bills;

over 1982-86 financing through CCT soared to 57,8 per cent of borrowing requirement (13.0 per cent in the previous period), while the share of T.bills fell to 15.5 per cent (57.2 per cent in the previous period; Table 3). At the same time, central bank interventions declined as the result of the increased demand for securities by the market: while in the period 1975-78 central bank interventions on the primary market accounted for 89 per cent of the public sector borrowing requirement, this share went down to 20.6 in the 1982-86 period (Table 3).[18]

Table 3

Financing of the Treasury borrowing requirement
(billions of lire and percentage points) (1)

	1975-78	1979-81	1982-86
Borrowing	**88,206**	**120,713**	**489.526**
(% of GDP)	(11.3)	(10,4)	(13,5)
Securities			
- on the market	**-2,958**	**1,166**	**310,753**
	(-3.4)	(1.0)	(63.5)
of which: T.bills	-12.514	1,279	16,155
	(-14,2)	(1.6)	(3.3)
of which: CCT	4,210	2,037	247,825
	(4.8)	(1.7)	(50.6)
- central bank	**78,684**	**82,885**	**100,929**
	(89.2)	(68.6)	(20.6)
of which: T.bills	42,147	67,126	59,698
	(47.8)	(55.6)	(12.2)
of which: CCT	10,972	13,603	35,042
	(12.4)	(11.3)	(7.2)

(1) Cumulated flows in the reference periods.

18 At the institutional level, this development was sanctioned in 1981 by the so-called "divorce" between the Bank of Italy and the Treasury. The divorce put an end to the central bank's commitment to purchase all unsold Government bonds in the primary market auctions.

4. The empirical analysis

4.1 The quarterly equation

The regressors in econometric estimation are the ones traditionally considered in the literature: a measure of transaction, a financial wealth variable, the own return on money and alternative rates on financial instruments.[19] A comment is in order on the scale variables. Although GNP is the most commonly used, consumption expenditure has also been adopted (see Goodfriend and McCallum, 1987; Mankiw and Summers, 1986), as well as domestic demand (see Hendry and Mizon, 1991). In the present paper the latter was eventually preferred, based both on goodness-of-fit criteria as well as on the belief that, relative to other commonly used scale variables, domestic demand should reflect more closely expenditure patterns. Our final quarterly equation also incorporates a measure of wealth, reflecting the store of value function of the M2 aggregate. We opted for net domestic financial wealth which, being the cumulated sum of the balance of payments and of the budget deficits, should not give rise to simultaneity bias.

We started with a general unrestricted linear model and proceed through the usual simplification process. The major empirical problem met when estimating the money demand equation over a period that comprises the seventies is that price homogeneity is rejected. If price homogeneity is imposed, a significant negative coefficient on financial wealth obtains; if the latter regressor is eliminated from the general unrestricted model, recursive estimation reveals signs of parameter instability. As was argued in the previous section, these difficulties may be due to the 1982-86 period, when a "wrong" sign in the relation between velocity and interest rates emerges.

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19 The details concerning the data are given in Appendix 1.

Several methods, generally consisting in some form of ad-hoc adjustment, have been proposed to eliminate the instability problem.[20] One possibility, which was at first pursued in this paper, is to model financial innovation by "adjusting" interest rates, leaving the scale variables (domestic demand and financial wealth) unadjusted.

4.1.1 Adjusted interest rates

In the empirical analysis of portfolio choices, observed yield differentials are generally adopted as arguments, even though portfolio decisions are plausibly made with a view to expected yields; factors like liquidity and risk features of alternative assets are generally overlooked. This is warranted under the assumption that such factors remain constant over the estimation period, as their omission is, under these circumstances, picked up by the constant term in the equation. When this is not the case (e.g. when new financial assets are introduced, or when the actual or perceived risk features of existing assets change) observed yields may not be appropriate to explain the behaviour of assets demand; adjusted opportunity costs, instead of observed ones, should be incorporated in asset demand functions.

Following Baba, Hendry and Starr (1992) learning on the new assets was modelled by weighting the rates of return on T.bills and CCT with logistic trends; we then let the data determine the shape and length of the learning process. However, the performance of equations adopting the weighted rates was not satisfactory. The coefficient on lagged money was very close to unity and price homogeneity was rejected. This may reflect the fact that imposing a maximum of five years for learning after the introduction of the new asset, as in Baba, Hendry and Starr (1992), the effect of weighting fades away at the latest in 1980 and 1982 for T.bills and CCT respectively

[20] See Appendix 1 for a discussion of this problem and for a review of the solution methods proposed in the literature.

and the period of declining opportunity cost and declining money demand, described in the previous section, is not affected. The reform of CCT in 1981 may require extending the learning period. Indeed, it has been argued that the growing demand for CCT stemmed from gradual learning of the new instrument starting from the 1981 reform (see. e.g. Bank of Italy, Annual Report for 1983). Even applying the weighting from this date, however, did not solve the empirical problems (instability, lack of price homogeneity) of the equation.

We tried also to adjust the returns for a measure of risk: since inflation was on a decreasing trend in the 1982-86 period, it is plausible that the risk of capital losses on securities due to nominal rates volatility was decreasing: while the measured opportunity cost of holding money was narrowing, the risk-adjusted spread could well be widening. The impact of these factors were tested by means of several proxies for uncertainty (the variability of inflation and of long-term bond yields), expecting to find a positive relationship between these measures and money demand. The results obtained using a three-period moving standard deviation of long-term bonds (BTP) yields were encouraging, but could not solve the instability problem.

We also considered that the lack of a secondary market could have had an effect on perceived securities yields. Although a fully fledged secondary market did not develop until the end of 1988, we have seen that in the early eighties markets began to grow thicker, making it gradually easier for securities holders to sell them prior to maturity. Taking this view, rates of return on CCT and T.bills were adjusted by a decreasing "illiquidity premium" estimated via a logistic trend, letting the data determine the shape of the trend. This proved to be a promising route, but the parameters of the equations estimated following this approach were not constant for sensible ranges of the illiquidity premium.[21]

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21 A proxy for the return on mutual funds (the growth rate of the capitalisation index) was also introduced among the ex-

4.1.2 From money as a financial asset to money as a medium of transactions

The different structure of money demand in the 1970's and in the following decade is highlighted by the regressions in Table 4, which only differ for the sample period.

The most remarkable feature of the Table is that over the period 1975-79 net financial wealth has a significant effect on money demand, contrary to domestic demand, whereas over the period 1983-1991 the opposite results obtains. This is consistent with the interpretation given in the quarterly econometric model of Banca d'Italia (1986), in which financial innovation is modelled as a transition from money as a store of value to money as a transaction medium through a change in the scale variable. The shift is captured by a trend that gives progressively more weight to the equilibrium money demand relation stressing the transaction motive.[22]

Table 4 also shows that the speed of adjustment is significantly lower in the more recent period; the short-run interest semielasticities show remarkable stability over the two subsamples.

Thus, we started with a general model that allowed us to test for structural breaks in the parameters of all the regressors over the period 1975-1991.

---

planatory variables (both adjusted and unadjusted for learning) but it turned out insignificant.

22 The coefficients and significance levels of the equations in Table 4 are considerably altered if the specification or the sample periods are changed, but the result concerning the shift of significance from net financial wealth to domestic demand seems fairly robust.

Table 4

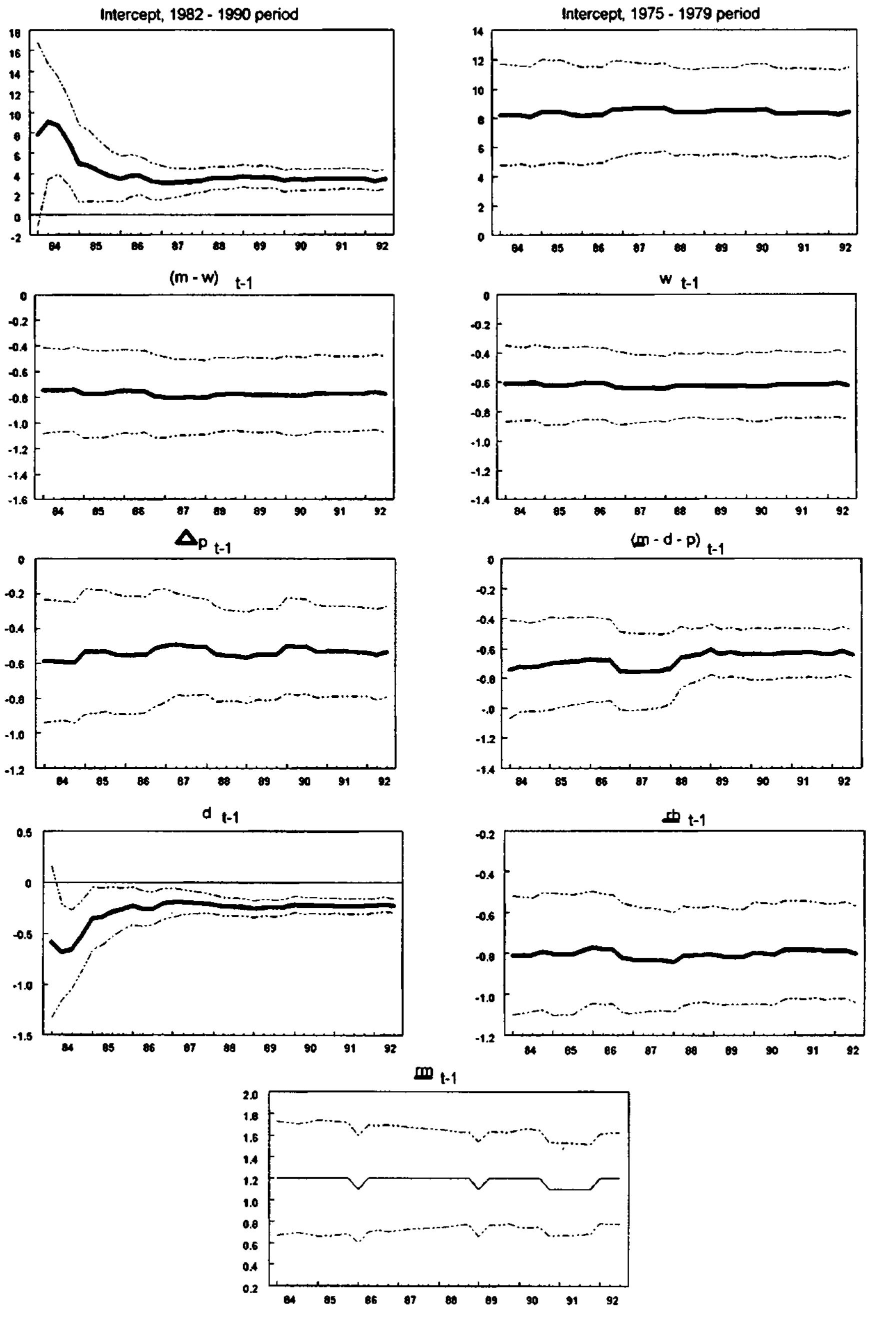
Money demand equations in two selected periods
(quarterly data)

	1975-1979	1983-1991
	Dependent variable	
	$\Delta(m-p)_t$	$\Delta(m-p)_t$
Regressors		
Constant	8.34 (1.67)	1.93 (1.14)
$(m-p)_{t-1}$	-0.71 (0.11)	0.41 (0.13)
$(w-p)_{t-1}$	0.12 (0.03)	0.01 (0.04)
d_{t-1}	0.03 (0.11)	0.30 (0.09)
Δp_t	-0.61 (0.14)	-0.45 (0.25)
$\underline{rb}_{t-1}$	-0.80 (0.13)	-0.83 (0.23)
$\underline{rm}_{t-1}$	1.32 (0.26)	1.22 (0.51)
R^2	0.96	0.49
σ	0.36%	0.57%
DW	2.92	1.84

Note: All variables, except interest rates, are in logs; coefficients' standard errors are in parenthesis. *m* is the money (M2) aggregate, *w* is net financial wealth, *p* is the domestic demand deflator, *d* is domestic demand in real terms, *rb* is the interest rate on T.bills, *rm* is the own return on money. Underlined variables represent two periods moving averages; the coefficients of $\underline{rb}$ and $\underline{rm}$ and their standard errors are multiplied by 100.

Fig. 3

Recursive coefficients of the error correction model
(quarterly data)



In order to model the transition from money as a financial asset to money as a transaction medium, we specify the following model:

(1) $$(m-p)_t = X_t * \alpha + [(1-s_t)*(X_t, d_t)]*\beta + [s_t*(w-p_t)]*\gamma$$

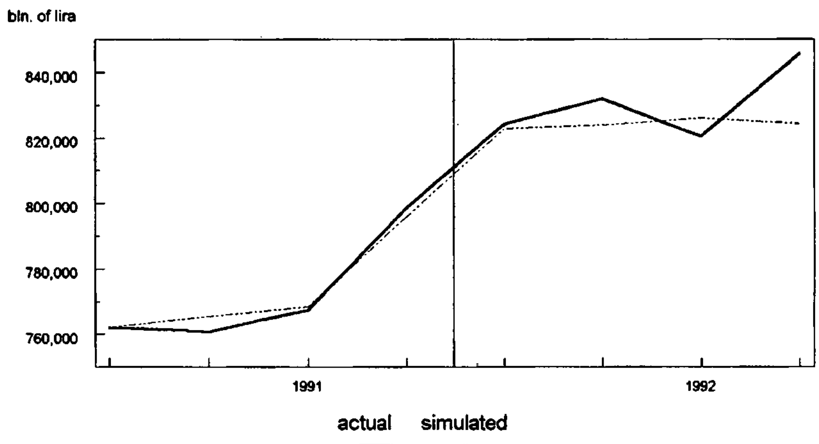
(2) $$s_t = 1 - 1/[1-\exp(\varpi_1 - \varpi_2)*(time)].$$

In equation (1), X is a vector of all the regressors, including lagged real balances; α, β, and γ are vectors of parameters of appropriate dimension. We chose a dummy of the logistic type, modelled in equation (2), where ϖ_1 and ϖ_2 are scalar parameters. Coherently with the evidence in Table 4, zero weights on net wealth in the post-1983 period and on domestic demand in the pre-1979 period were imposed. We estimated the model (1-2) with non-linear least squares so as to let the data determine which coefficients changed over time, as well as the shape of the dummy. We began with a specification including regressors up to two-lags, and proceeded through the usual simplification process. We reached the equations reported in Table 5.

The parameters of the equations display good stability properties (see Fig. 3); tests for linear homoscedasticity are almost significant, so heteroscedastic consistent standard errors are reported in parenthesis. The forecasting performance over the period 1991.1-1992.4 is satisfactory, except for the last quarter of 1992, when the one step ahead forecast error is over 2 per cent (Fig. 4). In this period, affected by the lira exchange rate crisis, the equation significantly underpredicts money growth. One reason for this unsatisfactory performance could be that the sharp increase of the differential between the T.bill rate and the own return of money in September 1992 reflected also the increased riskiness of assets alternative to money, such as T.bills and longer term Government bonds. This, in turn, led the public, guided by risk-adjusted returns, to increase money holdings relative to the level implied by interest rate elasticities and observed interest rates. This seems to point out that further effort should be devoted in the direction outlined in paragraph 4.1.1.

Fig. 4

Actual and simulated M2
(quarterly data)



One step ahead forecast errors
(quarterly data)

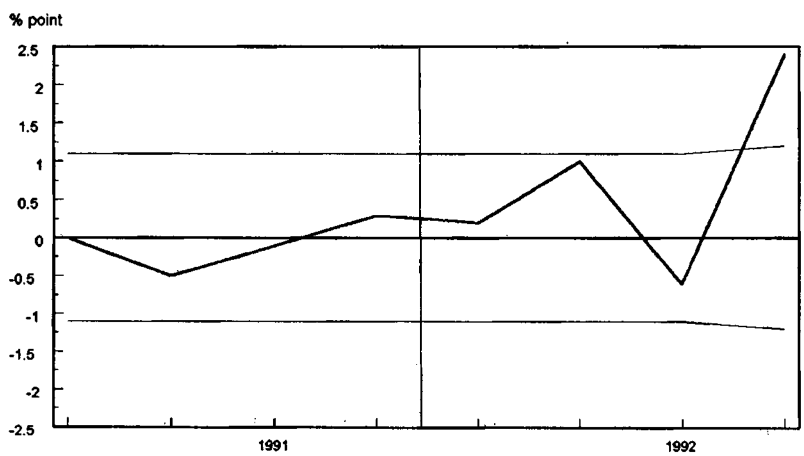


Table 5

The error-correction model for M2
(quarterly data)

$$(1')\quad \Delta(m-p)_t = s*\left[\underset{(1.44)}{8.34} - \underset{(0.15)}{0.77}*(m-w)_{t-1} - \underset{(0.11)}{0.62}*(w-p)_{t-1}\right]$$

$$+(1-s)*\left[\underset{(0.53)}{3.40} - \underset{(0.08)}{0.63}*(m-d-p)_{t-1} - \underset{(0.04)}{0.24}*d_{t-1}\right]$$

$$-\underset{(0.13)}{0.53}*\Delta p_t - \underset{(0.12)}{0.78}*\underline{rb}_{t-1} + \underset{(0.22)}{1.15}*\underline{rm}_{t-1}$$

$$(2')\quad s = 1 - 1/\left[1+\exp\left(\underset{(0.44)}{1.32} - \underset{(0.05)}{0.39}*(time)\right)\right]$$

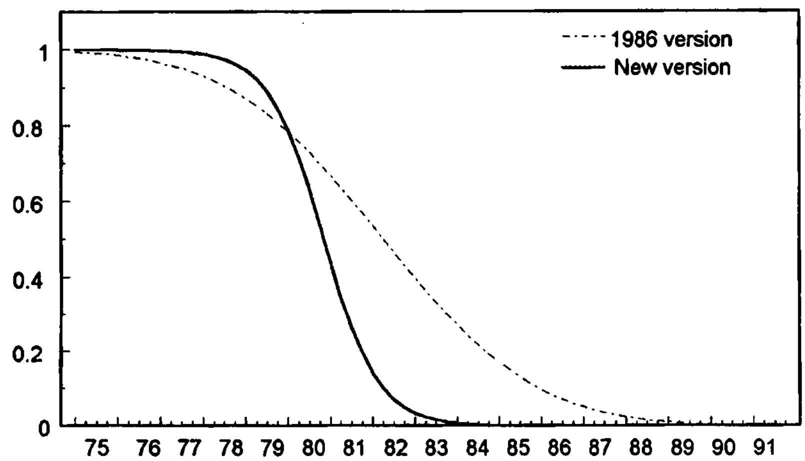
$R^2 =$	0.87
$\sigma =$	0.55%
$DW =$	2.26
$\eta_1(4.49) =$	1.64

Note: See Table 4 for the list of variables. The coefficients of $\underline{rb}$, $\underline{rm}$ and Δp and their standard errors are multiplied by 100. The estimation period is 1975.1-1990.4. Underlined variables represent two period moving averages. Heteroscedasticity consistent standard errors are shown in parenthesis.

Reflecting the evidence of Table 4, the error-correction model reported in Table 5, incorporates two equilibrium relations for money balances. The first, which holds until 1979, is given by the expression within square brackets, multiplied by the dummy s (which is practically equal to one before 1979; Fig. 5). The second equilibrium relation, given by the expression within square brackets multiplied by (1-*s*), is relevant after 1983, when the dummy *s* is nil. Interest rates and inflation have the same short-term effects on money balances in both subperiods. In the former, net wealth is the scale variable, in the latter this role is performed by domestic demand. In both subperiods homogeneity to yields is rejected; the speed of adjustment is lower in the more recent period, which is consistent with the a priori that money is predominantly demanded for transactions motives.

Fig. 5

Deterministic trends in the quarterly equations



Assuming zero growth in real money and domestic demand, the long-run equilibrium solutions in the two periods are given by the equations in Table 6.[23] In the more recent period, the elasticity of money balances to domestic demand in real terms is significantly less than unity (0.6 per cent); the semielasticity to the own return is 1.8 in percentage terms, significantly higher than in the pre-1979 period (1.5 per cent); similarly, the semielasticity to the alternative asset is -1.2 per cent, higher than in the first period (-1.0 per cent). The lack of homogeneity to the interest rates raises the question whether an increase in the T.bill rate lowers equilibrium money balances, once the interaction between the T.bill rate and the own return on money is accounted for. Ac-

23 When the variables are I(1), the equations estimate the cointegration vectors and explain their existence as the outcome of error-correction behaviour by agents seeking to control their money balances in relation to the scale variable and competing and complementary interest rates.

cording to recent estimates, an increase of 1 percentage point in the T.bill rate determines, in equilibrium, an increase of about .5 percentage points in the own return of money. Taking this interaction into account, a rise of one percentage point in the T.bill rate lowers real money balances by about .4 per cent in equilibrium.

Table 6

The long-run solutions of the error-correction model

Quarterly data

1975-1979

$$(m-p-w)=\underset{(0.16)}{10.83}-\underset{(0.01)}{0.80}*(w-p)-\underset{(0.05)}{0.17}*\Delta p+\underset{(0.21)}{1.49}*rm-\underset{(0.11)}{1.01}*rb$$

1983-1991

$$(m-p-d)=\underset{(0.41)}{5.41}-\underset{(0.03)}{0.37}*d-\underset{(0.05)}{0.21}*\Delta p+\underset{(0.30)}{1.83}*rm-\underset{(0.16)}{1.24}*rb$$

Monthly data

$$(m-p-\underline{d})=\underset{(1.01)}{0.68}-\underset{(0.09)}{0.27}*\underline{d}-\underset{(0.14)}{0.29}*\Delta p-\underset{(0.07)}{0.27}*\Delta d-\underset{(0.51)}{1.62}*(r_B-r_m)+\underset{(0.72)}{1.16}*r_m$$

Note: Δd is the annualised monthly growth rate of domestic demand; the coefficients of *rb* and *rm* and their corresponding standard errors are multiplied by 100. Δp is the inflation rate, annualised to allow the comparison with the interest rates.

This exercise raises a more general problem concerning the nature of the equilibrium relationship which is interpreted as a money demand equation. It has been argued that such relationship comprises the money stock and the scale variable and not the interest rate spread. According to this view, the presence of the latter in the error correction equation would be the result of the sensitivity of real money balances to the cointegrating relationship between the own return of money and the T.bill rate. In this case the estimates of the interest rate elasticity would be biased (see Bagliano, Favero and Muscatelli, 1992). These arguments are disputable. Theoretically, every approach to the demand for money (even the one that stresses the transaction motive) suggests the relevance of interest rates in the money demand equilibrium relation. It is therefore difficult to interpret as a money demand equation a cointegrating relationship that excludes the rate of interest. A related argument is whether the relationship between velocity and the interest rate spread concerns two stationary processes. It should be stressed that in the Italian context it is difficult to think of the spread as a mean reverting process: the cost of reserve requirement, passed on customers through lower deposit rates, is increasing with the level of interest rates; under these circumstances, the spread depends on the level of interest rates and is presumably of the same order of integration of the latter and hence of inflation. The problem of identification of the interest semielasticity can only be addressed in a multi-equation context. Preliminary results in this field seem to suggest that real money balances do not respond to disequilibrium in the relationship between the own return of money and the T.bill rate.

4.2 The monthly equation

The foregoing analysis has focused on the behaviour of M2 over a fairly extended period of time, to interpret the main episodes of financial innovation in Italy.

For short-term policy analysis and forecasting, however, it is often useful to look at shorter time horizons and at higher frequency data. This may yield interesting insights on the way monetary policy operates, particularly on the timing of the effects of policy measures. The analysis with monthly data may also constitute a useful check of the robustness of the results obtained with quarterly data.

Table 7

The general unrestricted model for M2
(monthly data)

Lag	0	1	2	Σ	t	F
m-p	-1.000 –	0.744 (0.100)	0.017 (0.101)	-0.239 (0.066)	-3.637	75.196(**)
d	0.111 (0.043)	0.043 (0.042)	0.023 (0.041)	0.17 (0.063)	2.802	3.158(**)
Δp	-0.764 (0.394)	-0.067 (0.392)	– –	-0.831 (0.500)	-1.663	2.031
w-p	0.066 (0.059)	-0.076 (0.078)	0.011 (0.062)	-0.0006 (0.0227)	0.026	0.447
rb	0.162 (0.202)	-0.335 (0.242)	-0.249 (0.233)	-0.421 (0.314)	-1.341	1.344
rm	0.206 (0.518)	1.264 (0.690)	-0.752 (0.453)	0.719 (0.354)	2.032	2.876(*)
rbc	0.040 (0.336)	0.121 (0.434)	-0.143 (0.263)	0.018 (0.239)	0.076	0.113
DUS	0.018 (0.004)	– –	– –	0.018 (0.004)	4.809	23.128(**)
Cons.	0.118 (0.477)	– –	– –	0.118 (0.477)	0.247	0.060

$R^2 = 0.996$ $\sigma = 0.448\%$ $DW = 1.870$

Information criteria: SC = -10.064 HQ = -10.398 FPE = $2.447*10^{-5}$.

Note: The estimation period is 1983.1-1990.12. Coefficients' standard errors are in parenthesis; one (two) asterix indicates 5 (1) per cent marginal significance level. The coefficients of interest rates and their corresponding standard errors are multiplied by 100. *SC*, *HQ* and *FPE* are respectively the Schwarz, Hannan-Quinn and final prediction error criteria (see Hendry, 1989). *DUS* is a dummy variable for banks' strikes at the turn of 1989; *rbc* is a weighted average on Treasury bonds and certificates; *p* is the consumer price index. See Table 4 for the list of the remaining variables.

In the monthly equation the sample period was selected so as to focus on the period when velocity of the broad monetary aggregate stabilised. Although the specification search was carried out independently of the quarterly equation, we considered coherency between the quarterly and the monthly equations an additional informal criterion for model choice.

In estimating a single equation generalised unrestricted model for M2, we specified two lags for all regressors. Table 7 reports the general unrestricted model estimates, together with t-tests of the hypothesis that the sum of each variable's coefficients is zero, and F-tests on the overall relevance of each variable. The t-test corresponds to a unit root in the associated lag polynomial and critical values pertain to non standard distributions; in this study a critical value of 4.8 is used (see MacKinnon, 1991).

Table 8

The long-run solution for M2
(monthly data)

$$\underset{}{(m-p)} = \underset{(1.956)}{+0.493} + \underset{(0.239)}{0.742*d} - \underset{(2.565)}{3.481*\Delta p} + \underset{(0.095)}{0.002*(w-p)}$$

$$-\underset{(1.508)}{1.765*rb} + \underset{(1.007)}{0.076*rbc} + \underset{(1.726)}{3.013*rm} + \underset{(0.028)}{0.076*DUS}$$

Note: Estimation period: 1983.1-1990.12. See Tables 4 and 7 for the list of the variables. Standard errors are in parenthesis. The coefficients of interest rates and their corresponding standard errors are multiplied by 100.

All the variables have the expected sign, with the exception of the weighted average of the returns on CCT and Treasury bonds, whose coefficient is however small and insignificant.

Table 9

The error-correction for M2
(monthly data)

$$\Delta(m-p)_t = 0.158 - 0.231*(m-p-\underline{d})_{t-1} - 0.063*\underline{d}_{t-1} + 0.255*\Delta\underline{d}_t +$$
$$\quad (0.245)(0.052) \qquad\qquad\qquad (0.028) \qquad (0.083)$$

$$+0.376*(rm_{t-2} - rb_{t-2}) + 1.167*\Delta rm_{t-1} + 0.268 rm_{t-2}$$
$$(0.052) \qquad\qquad (0.410) \qquad (0.142)$$

$$-0.803*\Delta p + 0.018*DUS$$
$$(0.314) \qquad (0.003)$$

$R^2 =$ 0.451
$\sigma =$ 0.433%
$DW =$ 1.920

Information criteria:
SC = -10.551 $\qquad$ HQ = -10.624 $\qquad$ $FPE = 2.058*10^{-5}$

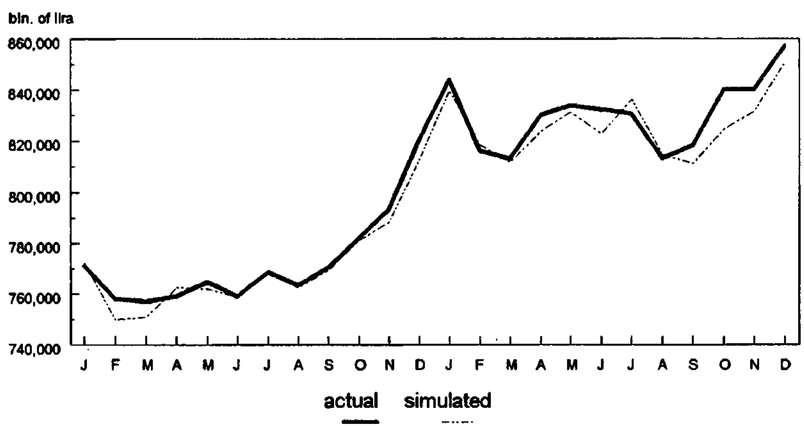
Tests:

$\eta_1(12.71) =$	1.702	(8.44)	$\eta_2(24.87) =$	1.875	(1.84)
$\eta_2(12.87) =$	1.261	(25.62)	$\eta_3(15.71) =$	0.759	(71.68)
$\eta_3(37.49) =$	0.675	(89.26)	$\eta_6(12.63) =$	1.086	(38.71)
η_7 (1.86) =	1.467	(22.91)	$\xi_9(24)/24 =$	2.7	($1.302*10^{-5}$)
$\xi_5(2)$ =	2.75	(25.28)	$\xi_9(12)/12 =$	1.5	(45.57)

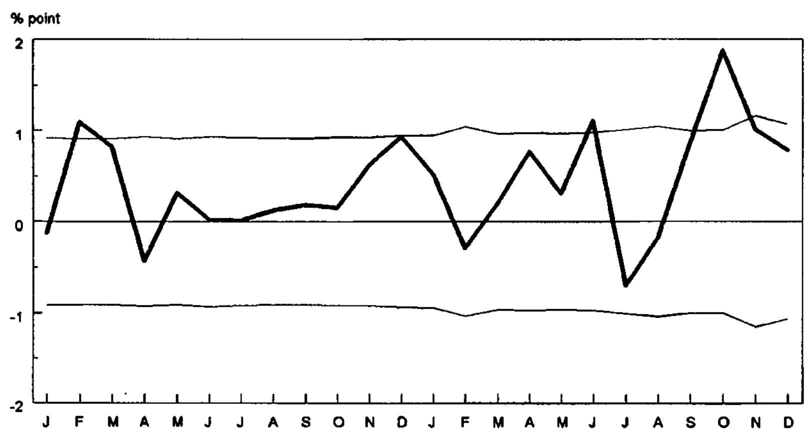
Note: Estimation period: 1983.1-1990.12. See Tables 4 and 7 for the list of the variables. Standard errors are in parenthesis. The coefficient and the standard error in the yield differential are multiplied by 100. The list of the tests is in the Appendix; the marginal significance level of the tests is shown in parenthesis.

Fig. 6

Actual and simulated M2
(monthly data)



One step ahead forecast errors
(monthly data)



According to the F tests, real domestic demand and the own rate of return are the only statistically significant regressors; the t tests are almost never significant at the 5 per cent level, using the critical value reported above. However, these results may follow from the profligate parameterization; in addition the significance of the interest rates might be negatively influenced by their degree of collinearity.

In Table 8 we report the solved long run solution of the general unrestricted model for monthly M2. The general unrestricted model was simplified, by expressing regressors in terms of first differences and in level (see Ericsson, Campos and Tran, 1991). On these transformations, the rate on CCT and Treasury bonds turned out to be insignificant ($\eta_4(3,75)=0.113$), as well as the wealth variable ($\eta_4(3,75)=0.447$). We eventually reached the model for M2 reported in Table 9.

The error correction term has a significant negative coefficient and strongly supports cointegration. Unit price elasticity cannot be rejected according to usual statistical criteria (η_8(p)(1,86)=1.012. In contrast with the results in the first version of the monthly monetary model of the Bank of Italy (1988), there is scant evidence on a buffer role of net financial wealth (η_8(w-p)(1,86)=1,867)). The median lag is about 2 months, so the estimated dynamic reactions are quite rapid. Each step of the reduction process was tested through usual F-tests (the η_4 statistic in the Appendix); all tests (not reported in the Table) were insignificant, pointing to the validity of the reduction process, which can also be gauged by noting that the standard error of the final model is lower then the one of the general unrestricted model: 0.43 per cent as opposed to 0.45 per cent. The interpretation of the equation in Table 9 is easiest by examining the properties of its equilibrium solution, in which we re-express the dependent variable as $(m-p-\underline{d})$; (Table 6). The equation is characterised by a domestic demand elasticity below unity (0.6/0.7); as in the quarterly equation, interest rates do not enter as a spread. The equilibrium semielasticity to the own return is 2,8 per cent, the elasticity to the alternative rate is 1.6 per cent. There are significant effects of inflation and of the growth of domestic demands on the equilibrium value of M2 velocity. A rise of 1 percentage point in the T.bill rate, taking into account the effect on the own return on money that was discussed previously, lowers real money balances by half percentage point in equilibrium, as in the quarterly equation.

The tests reported in Table 9 suggest that a congruent model for money demand has been reached; note however that the predictive Chow test ($\eta_2(24,87)=1,875$) obtained by estimating until 1990.12 and by forecasting over the following two years is significant (1.84 per cent the marginal significance level). The study of one step ahead forecast errors (Fig. 6) shows that this instability is due to the underprediction that is manifest in the last part of 1992, after the foreign exchange crisis of the Summer. This is confirmed by the recursive instability tests; for example the Chow test over 1991 only does not hint to any significant instability ($\eta_2(12,87)=1,261$; marginal significance level at 26 per cent)[24].

4.3 Comparison between the monthly and quarterly estimates

The two equations presents several analogies. In both equations the equilibrium elasticity to domestic demand is lower than one and of the same magnitude (0.6/0.7); price homogeneity cannot be rejected, the order of magnitude of the speed of adjustment is similar. In both formulations, the elasticity to the own return is higher than the one to the alternative yield; however the monthly equation shows higher elasticities. Finally, the equilibrium effect on money demand of a rise of 1 percentage point of the T.bill rate is 0.5 per cent in both equations.

5. Conclusions

The present paper presents an empirical analysis of money demand in Italy based on monthly and quarterly data on the new aggregate M2. The main focus of the analysis based on quarterly data over the sample period 1975-1992 has been

24 In September 1990 and in March 1991, however, the equation does not fully capture the observed acceleration of bank deposits. In these months the twelve month rate of change of checking accounts recorded an increase of 1 percentage point.

stability. In most empirical works on money demand in Italy some form of ad-hoc adjustment is necessary in order to model financial innovation and learning on new assets and to reach a stable relationship.

The empirical investigation initially assumed stability of money demand and relied on "adjustments" of interest rates on alternative assets. Firstly, the learning hypothesis could warrant an adjustment of observed yields on alternative assets. Learning on the new assets was modeled by weighting the rates of return on T.bills and CCT with logistic trends and letting the data determine the shape and length of the learning process. This strategy did not yield encouraging results. Secondly, we tried to adjust rates to account for the fact that liquidity and risk features of alternative assets have changed over the estimation period, making the use of observed rates unwarranted. Several proxies for uncertainty (the variability of inflation and of long-term bond yields) were constructed; an additive trend was introduced to represent the increasing liquidity of Treasury paper. This route proved more promising, but still the final equation was unstable.

Thus, we were led to the traditional hypothesis that a structural break, related to financial innovation, occurred in money demand. Our final quarterly equation is in line with the model of the Banca d'Italia (1986), according to which in the seventies money was demanded as a financial asset, whereas in the eighties, as new financial assets became available, the transaction purpose began to prevail. Accordingly, the estimated quarterly equation incorporates two long-run relations; in the earlier period, net financial wealth is the scale variable, whereas in the second one this role is performed by domestic demand.

The monthly equation, estimated over the more recent sample period to avoid instability problems, is in line with the quarterly model. Both equations have been derived through a general-to-specific approach. In the specification search, however, attention was also paid to forecasting performance and to coherency between the quarterly and the monthly models.

The main results can be summarised as follows:

1) the new aggregate M2 is characterised by a stable relationship with the traditional variables of money demand functions. This property makes the aggregate useful for monetary policy implementation. In the aftermath of the foreign exchange crisis of the Summer months of 1992, when the opportunity cost of holding money sharply increased, there is evidence of underprediction;

2) for the monthly equation the dynamic adjustment to equilibrium is rapid: the median lag is of two months approximately; a similar result is obtained for the quarterly model, for which the median lag is equal to about .6 quarters;

3) the long-run semielasticities to the own return and to the alternative yield are higher for the monthly equation (2.8 and 1.6 per cent, against 1.8 and 1.2 in the quarterly equation). However, the equilibrium effect of an increase of the T.bill rate is analogous in the two equation (-0.5 per cent, taking into account the relation between the own return and the return on the T.bill). Both models show a less than unitary elasticity to domestic demand in real terms; in equilibrium, an increase of one percentage point in the latter induces a 0.6/0.7 per cent increase in the demand for real money balances.

Appendix 1

The methodology and the data

Econometrics

Given the measurement system whereby the data are defined, constructed and recorded, empirical models represent reductions of the Data Generation Process (DGP). Since the dependent variable in an empirical model is observed, the disturbance, or unexplained component of the model, is a derived and not an autonomous process, defined by the specification of the model and its associated estimation procedure (see Hendry and Richard, 1990). Thus, the disturbance is susceptible to being re-designed by model re-specification to achieve certain objectives such as random errors or satisfy certain criteria such as a consistency with theoretical viewpoint (see Spanos, 1986; Hendry, 1987a and 1987b; Hendry, Neale and Srba, 1988; Hendry and Ericsson, 1991; Hendry and Mizon, 1991).

The statistical system is defined by the variables of interest, their status (modelled or not), their degree of integration, data transformations, the history of the process and the sample period. Let $\{x_t\}$ denote the complete vector of variables under analysis and for a sample period of size T, let $X_t^1 = (x_1 \ldots x_T)$. The statistical generating mechanism is $D_X(X_T^1 | X_0, \theta)$ where $D_X(\cdot)$ is the joint data density function, X_0 denotes the initial conditions and $\theta \varepsilon \Theta \subseteq R^q$ is the parameter vector in a q-dimensional parameter space Θ. This is called the Haavelmo distribution after Haavelmo (1944), and is first sequentially factorized as:

(1) $$D_X(X_T^1 | X_0, \theta) = \Pi_{t=1}^T D_X(x_t | X_{t-1}, \theta),$$

where θ allows for any necessary transients such as dummy variables, and $X_{t-1} = (X_0 : X_{t-1}^1)$.

Let $x_t' = (y_t' : z_t')$ and $X_T^{1'} = (Y_T^{1'} : Z_T^{1'})$ where y_t is the $n \times 1$ vector of endogenous variables (here m_t, r_t, p_t and w_t say for money, interest rates, prices and financial wealth) and z_t is the $k \times 1$ vector of conditioning variables (here i_t, for income, and dummies for special effects). z_t is assumed to be weakly exogenous for the parameters of interest in the model. If so, analysing the conditional distribution of y_t, given z_t and the history of the process, involves no loss of information relative to analysing the joint distribution of x_t. From (1):

(2) $$\Pi_{t=1}^{T} D_x(x_t | X_{t-1}, \theta) = \Pi_{t=1}^{T} D_{Y|Z}(y_t | z_t, X_{t-1}, \lambda_1) D_Z(z_t | X_{t-1}, \lambda_2) \quad \text{where } \lambda = f(\theta).$$

Then z_t is weakly exogenous for λ_1 if the parameters of interest ϕ are a function of λ_1 alone and λ_1 and λ_2 are variation free: see Engle, Hendry and Richard, 1983.

We restrict attention to log-linear systems with data generated by a log-normal distribution, so that conditional models are also log-linear. The system formulation is, therefore, complete when the degrees and roots of every lag polynomial are specified. Let $N(\mu, \Omega)$ denote a normal distribution with mean μ and variance matrix Ω then:

(3) $$y_t | z_t, X_{t-1} \sim N\left(P_0 z_t + \sum_{i=1}^{s} P_i x_{t-1}, \Omega\right),$$

so that the longest lag is s periods, and the conditional system of n linear equations is:

(4) $$y_t = \sum_{j=0}^{s} \delta_{1j} z_{t-j} + \sum_{i=1}^{s} \delta_{2i} y_{t-i} + v_t \quad \text{where } v_t \sim IN(0, \Omega),$$

with $P_0 = \delta_{10}$ and $P_i = (\delta_{1i} : \delta_{2i})$ for i=1, .., s. Some of the variables in y_t are linked by identities (e.g. financial wealth contains money), but otherwise Ω is symmetric, positive-definite and unrestricted. Thus, (4) is the unrestricted, conditional dynamic system once s is specified, with the derived error process v_t. Let $\Phi = (\delta_{10} .. \delta_{1s} \;\; \delta_{21} .. \delta_{2s})$, then Φ and Ω are the variation free parameters of interest in the conditional distribution, although they are not the parameters of interest in the overall analysis.

The system in (4) should be a congruent representation of the data since it will be the specification against which all other simplifications are tested. Congruency requires that:

a) $\{v_t\}$ is a homoscedastic innovation process against X_{t-1}, which depends on the specification of the lag structure (see Hendry, Pagan and Sargan, 1984);

b) z_t is weakly exogenous for (Φ, Ω) (see Engle, Hendry and Richard, 1983);

c) (Φ, Ω) is constant $\forall$t.

Tests can be constructed for residual autocorrelation, dynamic mis-specification, weak exogeneity, normality, further lagged non-modeled variables, cross-equation independence and constancy. Once a congruent system has been established, a theory-based model thereof can be constructed.

Many economic time series appear to be non-stationary, affecting the statistical distributions of estimators and tests. Conventionally, large-sample approximations to distributions in econometrics have been predicated on weak stationarity in the DGP such that $\sqrt{T}(\hat{\gamma}-\gamma)$ tends to a normal distribution for an estimator $\hat{\gamma}$ of a parameter vector γ (see e.g. White, 1984). In practice, two important forms of non-stationarity are when the autoregressive representation in (1) has unit roots, which induces integrated series, and when there are regime shifts, which induces non-constancy in the system. We briefly consider these in turn.

The degree of integration of $\{x_t\}$ is denoted by *I(d)* where *d* usually equals unity. Differencing *d* times to create $\Delta^d x_t$ will produce an *I(0)*, or non-integrated, series. Co-integration occurs if some linear combinations of the x_t are I(0), denoted by $\beta' x_t \sim I(0)$ (see Granger and Weiss, 1983;

Engle and Granger, 1987; Oxford Bulletin, 1986). If $\beta' x_t$ is a cointegrated combination, then there exists an error correction representation and conversely: this is one aspect of the Granger representation theorem (see Granger, 1986). The number of cointegrating vectors equals the rank of β, denoted k, which is usually unknown and has to be determined from the data at the level of the joint density.

Reconsider the system in (1) written in linear form as:

$$\Delta x_t = \sum_{i=1}^{s-1} \Pi_i \Delta x_{t-1} + \delta x_{t-s} + \upsilon_t$$

(5)

$$= \Psi f_t + \delta x_{t-s} + \nu_t$$

where $f_t = (\Delta x'_{t-1} \ldots \Delta x'_{t-s+1})'$, $\Psi = (\Pi_1, \ldots, \Pi_{s-1})$ and $\upsilon_t \sim IN(0, \Gamma)$. Equation (5) corresponds to $D_x\left(x_t | X_{t-1}^{t-s}, \theta\right)$ re-parameterized into levels and differences, so that θ now comprises (Ψ, δ, Γ).

The next step is determining the number of cointegrating vectors $0 \leq \kappa \leq n+k$. Underestimating κ entails omitting empirically relevant error correction mechanism (ECMs), whereas overestimating κ leads to the distributions of statistics being non-standard so that incorrect inferences will result from using conventional critical values in tests. A test for κ cointegrating vectors can be based on the maximum likelihood approach proposed by Johansen (1988). The test equivalent to testing whether $\delta = \alpha\beta'$, where β and α are $N \times \kappa$ when N is $(n+k)$, and hence the test is for δ having a reduced rank. Once κ is known, estimation of β and α follows. The high frequency of x_t in the monthly case and the short sample period (a decade) makes such an analysis unattractive, especially as z_t seems likely to be weakly exogenous for (Φ, Ω) (λ_1 in (2)), so that a conditional analysis is feasible from the outset. Cointegration was then investigated for the single equations and was established for the equations of interest.

Turning to the issue of regime shifts, if the parameters λ_1 of $D_{y|z}(y_t | z_t, X_{t-1}, \lambda_1)$ depend on those of $D_z(z_t | X_{t-1}, \lambda_2)$, then the former will not be invariant to changes in the latter and super exogeneity will be violated. Consequently, if λ_2 changes, (4) will change due to invalid conditioning even if it is otherwise correctly specified.[25]

Many empirical econometric equations manifest non-constancies, and it is essential to uncover the reasons for predictive failure if scientific progress in modelling is to result. If behavioural equations involve parameters which are functions of policy rules, then the appropriate econometric model is very different from that required if breaks are due to model mis-specification. Several routes are open to resolving such debates: for example, (a) by finding de facto constant equations, or (b) by establishing that variations are due to policy changes etc. The former solution depends on discovering constant parameterizations, so it is a function of the flair of the investigator, and need no result in any given instance. The latter, however, is open to direct testing as in Engle and Hendry (1993). Either way, prior to policy scenarios being asserted, tests for historical invariance should be conducted.

Since empirical econometric models are viewed as derived representations of the economic mechanism, obtained by data reduction, in-sample test statistics provide model selection criteria. The main reduction steps in model derivation are:

1) Data transformations, which entail no loss of information;
2) Marginalization with respect to disaggregated or unwanted information;
3) Sequential conditioning on the history of the process to create an innovation error;
4) Approximating the model by a linear and finite lag length form;

25 See Lucas (1976), Engle and Hendry (1993), who propose tests for super exogeneity, Favero and Hendry (1992) and Muscatelli (1991).

5) Conditional factorisation for contemporaneous variables if they are weakly exogenous for the parameters of interest (see Engle, Hendry and Richard, 1983);
6) Simplification to yield a parsimonious and interpretable data characterisation.

The initial empirical model must be sufficiently general to encompass previous findings, salient data features and theoretical knowledge, so that any need for a still more general model would be surprising. The feasible general unrestricted model (GUM) is estimated and tested on the full sample. The variables are transformed to near-orthogonality to correspond to decision variables of the economic agents, contingent on information they could have had. The transformed model is then simplified to eliminate irrelevant variables; the modelling strategy designs congruent models so that such models cannot be dominated within-sample on existing data.

Once a model is selected, various tests can check its congruency. The reduction steps delineate the information sets against which model validity can be checked:

- The past of the investigator's own data, i.e. testing for homoscedastic innovation errors;
- The contemporaneous values of the conditioning variables, i.e. testing for weak exogeneity for the parameters of interest;
- Future data, i.e. testing for constancy of the parameters of interest and hence their invariance;
- Theory information, that is testing for theory consistency;
- Measurement information associated with data admissibility;
- Data in rival models, that is testing for encompassing (see Mizon, 1984; Mizon and Richard, 1986; Hendry and Richard, 1990).

The specific tests used to evaluate the various aspects of congruency comprise:

$\eta_1(m-n, T-k-m)$	*F*-test for N^{th} to M^{th} order residual autocorrelation in a model with *k* regressors and *T* observations (see Harvey, 1981);
$\eta_2(h, T-h-k)$	Chow *F*-test of parameter constancy over *h* forecasts (see Chow, 1960);
$\eta_3(n, T-n-k)$	*F*-test of functional form misspecification-heteroscedasticity for *n* variables (see White, 1980);
$\eta_4(m, T-m-k)$	F-test of the restricted model against the generalised unrestricted model for *m* restrictions;
$\xi_5(2)$	χ^2-test for normality (see Jarque and Bera, 1980);
$\eta_6(r, T-r-k)$	F-test for autoregressive conditional heteroscedasticity (ARCH) of r_{th} order (see Engle, 1982);
$\eta_7(j, T-j-k)$	F-version of the RESET test for *j* powers (see Ramsey, 1969);
$\eta_8(\chi_t)(1, T-k-1)$	F-test on the significance of adding χ_t as a regressor;
$\xi_9(h)/h$	χ^2-test for predictive failure over *h* forecasts, standardised by its degrees of freedom (see Hendry, 1979; Kiviet, 1987).

η_1, η_3, η_4, η_6 and η_8 test for homoscedasticity innovation errors; η_3 and η_7 for functional form mis-specification; ξ_5 for normality; and η_2 and ξ_9 for constant parameters; also, η_4 and η_8 test for a priori restrictions to be imposed on the generalised unrestricted model. Such tests are part of the design strategy and are conducted in the Lagrange Multiplier spirit (see Engle, 1984).

The data

This study is based on the new definition of broad money, M2. The revision of the monetary aggregates has aimed at a more equal treatment of assets with a similar degree of liquidity and at improving the comparability and homogeneity of the aggregates within the European Community. Besides M2, calculated as a monthly average,[26] we included in the analysis real domestic demand, and net financial wealth of the non state sector. The interest rates considered are the own return on money, constructed as a weighted average of the net yields of the various components, the after-tax yields on T.bills, on Treasury bonds and on floating rate Credit Certificates. In designing the regressors, we introduced minor differences between the quarterly and the monthly equation: in the latter the price variable is the consumer price index instead of the deflator of domestic demand; a weighted average of the returns on floating rate securities and Treasury bonds was introduced, together with a dummy for bank strikes at the end of 1989. Domestic demand in real terms on a monthly basis was estimated by adding real net imports to monthly real GDP. The latter was estimated by disaggregation (based on industrial production) of quarterly GDP.

Modelling of financial innovation

In the UK and the USA, where banks were not allowed to pay interests on checking accounts, the introduction of Now and Super Now accounts and of money market deposit accounts caused a rapid decrease of M2 velocity (see e.g. Porter and Small, 1989). The rapid diffusion of automated teller machines and points of sale has also been changing the attitude of agents towards transaction media (see Paroush and Ruthenberg, 1990).

In the empirical analysis of the money demand function, several methods have been adopted to account for the effects of

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26 Since data on average bank deposits are available only since 1985, the data before that year have been backcasted on the basis of end of period deposits. The reconstructed series might therefore contain errors. The econometric analysis shows however that these errors can be considered I(0) processes; the goodness of fit of the final models for M1 and M2 (errors are around .4/.5 per cent of the money stock) suggests that specification problems remain in fact the main source of variability.

financial innovation. Most of the literature models the transition phase with non-linear deterministic trends, developing the suggestion of Hester (1981), who fits a logistic function to the time path of the coefficient under investigation.

Thus, when the purpose is to model a learning process, the yield on the newly introduced asset should be given less weight in the phase immediately after its introduction and a weight close to one after a number of periods sufficient for the adjustment process to be completed, reflecting the assumption that learning starts slowly, picks up speed and eventually completes slowly. Multiplying the yield series by an S-shaped trend seems the most appropriate way of doing this.[27]

Although trends of this form are indeed the most popularly used in money demand equations, in practice they are often introduced in the right-hand side of the equations in various specifications. In some cases they are entered as separate regressors;[28] in some other instances whole subsets of the regressors are multiplied by the trend.[29] Dummies and linear trends are also sometimes used in ways analogous to these non-linear trends.[30] Finally, some authors suggest the

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27 Baba, Hendry and Starr (1992), Hendry and Ericsson (1990) adopt this method, using exponential functions.

28 Vaciago and Verga (1989) model the adjustment process following the introduction of T.bills with a logistic type of trend, whereas two linear trends are employed to model, in the order, the early phase of deposits' growth and the period of reduced money demand characterising the period examined in their paper. Muscatelli and Papi (1990) use two separate logistic trends to model, in the order, the learning process ensuing the introduction of T.bills and of CCT. Adopting the Engle-Granger two-stage approach, they use a linear combination of these trends in the static regression, and then use the residuals as an explanatory variable in the dynamic formulation.

29 The money demand equation in the quarterly model of the Bank of Italy (1986) belongs to this category.

30 Vaciago and Verga (1982), Bedoni and Verga (1982) use dummies to estimate demands for bank deposits in Italy. Cesarano (1990) multiplies the yield differential by a linear

use of proxies in money equations to account for the most relevant episodes of financial innovation.[31]

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trend. Estimating over the subperiods 1970.1-1975.4 and 1976.1-1985.4, he does not reject the null hypothesis of no structural break in the elasticity of the demand for money to the interest rate differential, although his estimates display a somewhat lower value of the elasticity in the second subperiod. Unlike other authors, a logistic curve introduced to model the learning process does not enter the equation significantly.

31 Bordo and Jonung (1990), building on previous work, propose three financial innovation proxies. As a specific proxy for financial development, they use the ratio of total non-bank financial assets to total financial assets, expecting a negative effect on money demand. They also use the share of the labour force employed in non agricultural activities as a proxy for magnetisation, which should enter a money demand equation with a positive sign, and the currency to deposit ratio as a proxy for the development of commercial banking, which should be negatively correlated with the use of money.

Appendix 2

Comparison with the equation of the quarterly econometric model of the Banca d'Italia

A straightforward comparison of the equation estimated in this paper with the equation in Banca d'Italia (1986) is difficult due to the different specifications adopted.

However, both equations are built on the assumption that financial innovation caused a structural shift in the demand for money, that can be appropriately modeled by reference to two equilibrium relations for money in the seventies and in the eighties. Further, both models indicate that the long run elasticities to interest rates increase in the most recent period. The quarterly equation previously estimated displays:

- a constant speed of adjustment in the two subperiods;
- different short-term elasticities to interest rates in the two subperiods;
- homogeneity to interest rates; i.e. the yield on money and on alternative assets enter as a differential;
- a trend dummy declining more smoothly (see Figure 5).

Over the years, the 1986 version of the equation has been substantially revised and reestimated; the latest version is reported in Table 10. We compared the forecasting performance of this equation with that of our quarterly equation by estimating over the period 1975-1988 and computing static and dynamic forecasts for the period 1989.1-1991.4.

Our equation performs slightly but consistently better according to a number of indicators: the mean percentage error of the static simulation is 0.027 as opposed to 0.23 of the old equation; for dynamic simulation the values are, respectively, -0.87 and 1.64. The static forecast RMSE is also lower, and its decomposition reveals that the part attributable to bias is less than one per cent in the equation reported in Table 5 and over 57 per cent in the old equation. Over the forecasting period 1989-1991, a formal Chong-Hendry test of predictive performance does not allow the old equation to be rejected in favour of ours, but over a longer period (1984-1991) rejection is allowed both for the static and dynamic forecast.

Table 10

The equation for M2 in the quarterly model

$$(M/Y)_t = .652 * M_{t-1}/Y_t + n_t * [.270 * (W/Y)_t + .275 * (VARCOR * W/Y)_T$$
$$\quad (8.3) \qquad\qquad (4.9) \qquad\qquad (3.5)$$

$$- .064 * \underline{\Delta P} * W/Y - .191 * ((\underline{rb} - \underline{rm}) W/Y)_t]$$
$$(-3.1) \qquad\qquad (-3.3)$$

$$+ .895 (1 - n_t) - 1.87 * ((1 - n) * (\underline{rb} - \underline{rm}))_t + .042 * du824$$
$$(4.4) \qquad\qquad (-2.7) \qquad\qquad (2.3)$$

R^2 = 0.99
σ = 1.71
DW = 1.92

Note: *M, W* and *Y* are respectively the money stock, financial wealth and nominal income; *n* is a deterministic trend obtained from a normal c.d.f., $\underline{\Delta P}$ is the fourth difference of a four terms moving average of annual inflation, *VARCOR* is the variance of a measure of long-term bonds quotations that captures uncertainty-related increases in money demand, $\underline{rm}$, $\underline{rb}$ denote four period moving averages, and du824 is a point dummy accounting for an exceptional money growth in the last quarter of 1982.

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