The determination of M0 and M4

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Monetary aggregates play an important role as indicators of economic conditions and as routes through which monetary policy operates. This article summarises recent research undertaken at the Bank on M0 and M4[1]—the two aggregates for which monitoring ranges have been set—which attempts to quantify the factors determining the growth of these aggregates and to clarify the link between them and the rest of the economy.

The role of the monetary aggregates

Monetary aggregates have two roles in policy: as indicators of economic conditions and as means through which monetary policy is transmitted. This article is concerned primarily with the first of these—the relationship between money and economic activity.[2]

The two aggregates we examine here are M0 and M4, the only aggregates for which monitoring ranges have been set. The monitoring ranges (annual growth rates of 0% to 4% for M0 and 3% to 9% for M4) indicate rates of growth outside which there would be increasing cause for concern. Although M0 and M4 are the only monetary aggregates for which ranges are set, they are not the only aggregates that are useful in assessing monetary conditions. In practice, a wide variety of measures is considered, including various sectoral measures and Divisia money.[3]

The behaviour of M0

M0 consists of notes and coin in circulation (over 99% of the total) and bankers' operational deposits held at the Bank of England. Its prime importance as an aggregate stems from the fact that it is through the supply of M0 that the authorities influence short-term interest rates (by setting the interest rate at which the Bank of England provides liquidity to the banking system). This means that the quantity of M0 is determined by the demand at prevailing interest rates.

Given that M0 is demand determined, explaining its behaviour is a matter of identifying the factors that influence its demand. These factors can be split into two categories: those linked to the value of transactions for which money is used (cash-financed transactions); and those linked to the stock of money required to undertake those transactions (the velocity of circulation of money).

Measures of cash-financed transactions

Conventionally, the stock of money is assumed to be related to the value of total expenditure in the economy. Although

this may be appropriate for a broad aggregate like M4, in the case of M0 we know that the use of notes and coin is concentrated in transactions undertaken by consumers. In 1990, 66% of M0 was held by the personal sector; and other holdings (8% by companies, 19% by banks and 7% by the overseas and public sectors) were related largely to demand for cash by the personal sector (for example, till money held by banks). This suggests that the demand for M0 is most likely to be related to some measure of consumer transactions. It does not, however, indicate which measure should be used.

Charts 1 and 2 show estimates of the sources and uses of cash by the personal sector. Chart 1 shows that the most important source of cash is withdrawals from financial institutions, which suggests that the demand for cash is determined by expenditure rather than income. And Chart 2 shows that cash-financed expenditures, though concentrated in spontaneous retail transactions, are spread over a large

Chart 1
**Personal sector sources of cash**(a)
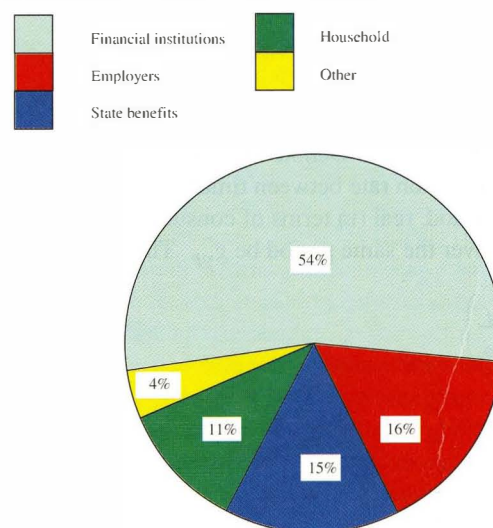
(a) APACS survey. 1990.

(1) This article is based on two working papers: Breedon, F J and Fisher, P G. 'M0: Causes and Consequences', *Bank of England Working Paper No 20*, 1993, and Fisher, P G and Vega, J L. 'An Empirical Analysis of M4 in the United Kingdom', *Bank of England Working Paper No 21*, 1993.
(2) The role of money in the transmission of monetary policy was investigated in an article in the November 1993 *Quarterly Bulletin*, 'Bank behaviour and the monetary transmission mechanism', by Dale, S and Haldane, A G.
(3) Divisia money was described in an article in the May 1993 *Quarterly Bulletin*, 'Divisia measures of money'.

range of transactions in non-durable goods. This implies that either retail sales or consumers' expenditure on non-durable goods may be reasonable measures of cash-financed spending. Statistical tests suggest that, of these, retail sales is the measure most closely related to M0.

Chart 2
Personal sector uses of cash[a]

Retail
Travel
Regular
Financial
Other
Leisure

46%
7%
7%
7%
29%
4%
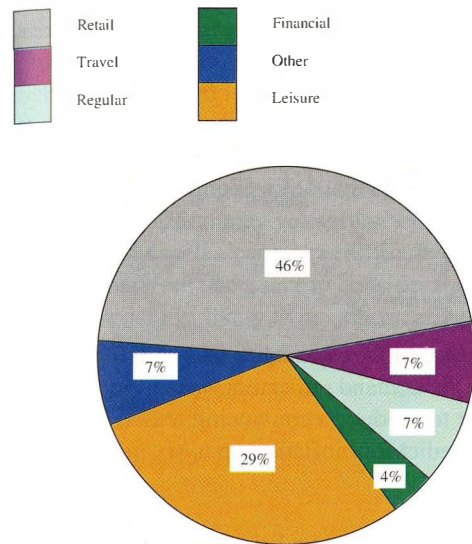
(a) Regular expenditures are those made on a pre-arranged basis and include regular spending in the other categories.

The velocity of circulation

Having chosen an appropriate measure of cash-financed expenditure, the next step in explaining the behaviour of M0 is to consider the relationship between cash holdings and cash-financed expenditure: the velocity of circulation. As Chart 3 shows, the most notable feature of the velocity of circulation of M0 is its steady upward trend. In other words, the stock of money as a proportion of total retail sales has been falling over time. Chart 4 shows that this is not just a recent phenomenon.
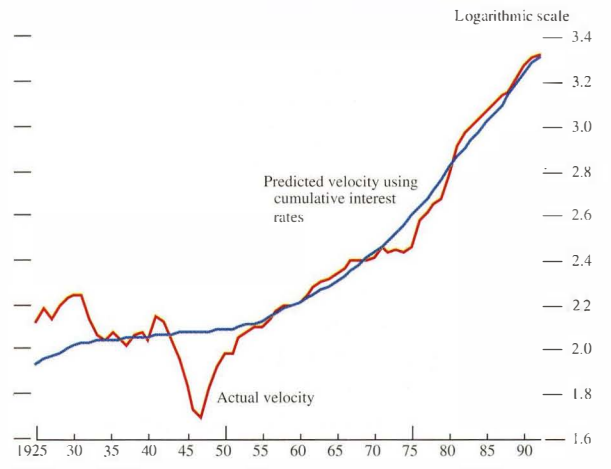
Chart 3
Velocity of circulation of M0[a]

1990=100
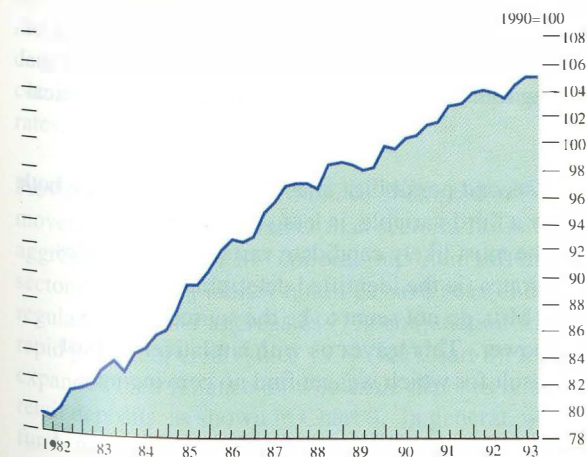
(a) Value of retail sales divided by the stock of M0.

Chart 4
M0 velocity and cumulative interest rates

Logarithmic scale

Predicted velocity using cumulative interest rates

Actual velocity

Four factors lie behind this upward trend:

● as people's overall expenditure rises, the required money holdings per transaction may fall. This reflects the changing pattern of expenditure at different levels of income;[1]

● the use of cash, even for retail sales, has tended to fall over time as the use of cheques and credit and debit cards has increased;

● new technology such as ATMs (Automated Teller Machines) may have reduced required cash holding for a given level of cash-financed expenditure; and

● a declining proportion of the working population is paid in cash.

But although these factors, which can all be described as forms of financial innovation, are clearly important, there is no satisfactory way of identifying their direct impact on money holdings or of predicting their future impact.

Previous work[2] has suggested that this trend towards lower money holdings can be identified by measuring the incentive to make innovations which affect the size of money holdings. Because cash bears no interest, high interest rates provide an incentive both to introduce and to exploit financial innovations that allow people to hold less cash. One result of this will be to increase both the demand for and supply of innovations (such as ATMs); and because innovations are unlikely to be reversed, they may have a permanent effect on money holdings. Temporary changes in interest rates can, therefore, have permanent effects on the demand for M0. The cumulation of interest rates over time may provide a reasonable proxy for the process of innovation. Clearly this cannot capture *all* the factors that determine the incentive to innovate, but it has proved relatively successful in explaining the trend in M0 over a long period. For example, Chart 4 shows that between 1925

(1) This factor was investigated in an article in the August 1992 *Quarterly Bulletin*, 'The demand for M0 revisited'.
(2) Hall, Henry and Wilcox, 'The long-run determination of the UK monetary aggregates'. *Bank of England Discussion Paper No 41*. 1989.

and 1992 cumulative interest rates seem to explain quite well the trend in M0 velocity (defined here in terms of GDP, because of data constraints).

In the short term, changes in interest rates can affect velocity relative to its long-run trend through the incentive they generate to economise on money holdings for a given level of financial innovation. This effect may be particularly important at present, when the velocity of circulation is rising less quickly after a period of falling interest rates. But gauging the extent to which this fall arises from recent changes in interest rates is difficult, because estimates of the short-run effect of interest rates on the demand for M0 vary widely. Chart 5 presents different estimates of the effect of a one percentage point reduction in short-term interest rates on the rate of growth of M0 using three different M0

Chart 5
### Comparative response of M0 to a one percentage point reduction in short-term interest rates

M0 annual growth rate (percentage differences from base)
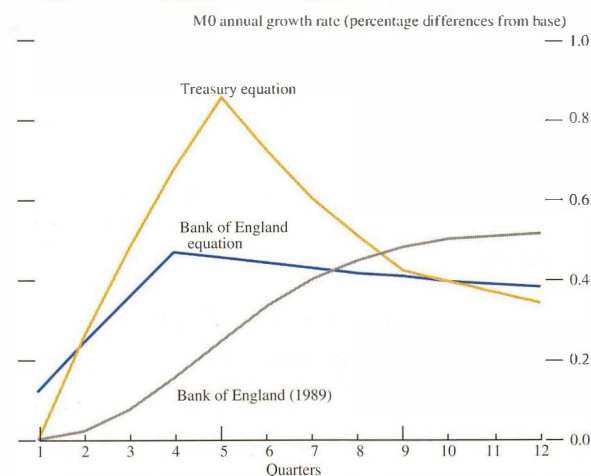
equations: the Treasury equation;[1] the current Bank quarterly M0 equation;[2] and an earlier equation estimated by the Bank in 1989.[3] These estimates show similar medium-term effects but very different short-term effects, and illustrate how difficult it is to predict M0 velocity shortly after a change in interest rates.

M0 and inflation

A recent *Bulletin* article[4] found that M0 was one of the most successful variables for forecasting inflation [RPI excluding mortgage interest payments (RPIX)] when used in simple leading indicator models. These leading indicator properties are clearly visible from plotting the growth of M0 and RPIX, as in Chart 6. This statistical association has been recorded in many studies,[5] but it has always been difficult to find a convincing economic interpretation. M0 is a narrow and demand-determined measure of money which should, theoretically, have little independent role in determining inflation in the short run. So, although M0 is likely to be a useful coincident indicator of consumer

Chart 6
Twelve-month growth rates of M0 and RPIX inflation[a]
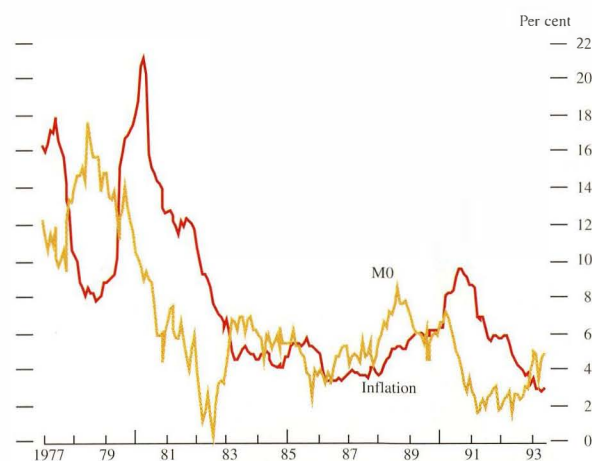
(a) RPIX= RPI excluding mortgage interest payments.

demand (since data on M0 are available several weeks before other domestic demand indicators, such as retail sales), it is difficult to produce a convincing reason why it should be a good predictor of inflation up to six months ahead.

Two possible explanations may lie behind the apparent predictive power of M0. First, the statistical result may simply be a coincidence. And second, M0 and inflation may both be influenced by some third variable. For example, since the level of consumer spending may be an important determinant of inflationary pressures, M0's predictive power may arise simply from its close link with spending: if prices change only slowly in response to a demand shock and M0 responds more quickly, then M0 would act as a leading indicator of prices.

A detailed look at M0's leading indicator properties for inflation shows that they are remarkably robust across various sample periods and specifications. And, if we consider the relative forecast performance one year ahead over the period between January 1990 and March 1993, a simple M0 model outperforms the VAR model presented in the May 1993 *Bulletin* article and also compares favourably with a prediction based on the Bank of England macroeconomic forecast. These results suggest that M0's leading indicator properties are not simply a statistical quirk.

Testing the second possibility, that M0 and inflation are both predicted by a third variable, is less straightforward. Certainly, the most likely candidate variables, retail sales and interest rates (ie the identified determinants of the demand for M0), do not seem to be the source of M0's predictive power. This leaves us with a relatively robust statistical result for which we can find no convincing explanation.

(1) Taken from the January 1993 Public Release of the Treasury macroeconomic model.
(2) Described in *Bank of England Working Paper No 20, op cit.*
(3) Described in Hall, Henry and Wilcox 1989, *op cit.*
(4) 'VAR models of inflation', May 1993 *Quarterly Bulletin.*
(5) See for example Crockett, A D, 'Timing relationships between movements of monetary and national income variables', *Quarterly Bulletin* December 1970 and Bladen-Hovell, R C and Zhang, W, 'A BVAR Model for the UK Economy: A forecast comparison with the LBS and NI Models', *University of Manchester Discussion Paper,* 1991.

The behaviour of M4

M4 was first introduced as an official monetary aggregate in 1987. Along with notes and coin, it includes the sterling deposit liabilities of all UK banks and building societies to other private sector UK residents.[1] The main challenge in explaining the recent behaviour of M4 is the decline in income velocity between 1980 and 1991, as shown in Chart 7. During this period, M4 growth averaged 14.2% a year, while nominal income grew by 9.5% a year. The single factor most likely to be responsible for generating such money growth is the process of financial liberalisation, which began with the abolition of exchange controls in 1979. This explanation would be consistent with earlier variations in velocity following institutional changes (such as the increase in broad money velocity when the 'corset' was applied). But such a process is difficult to quantify directly, and it is therefore necessary to consider the channels through which M4 is most likely to have been affected.

### Chart 7
M4 velocity[a]
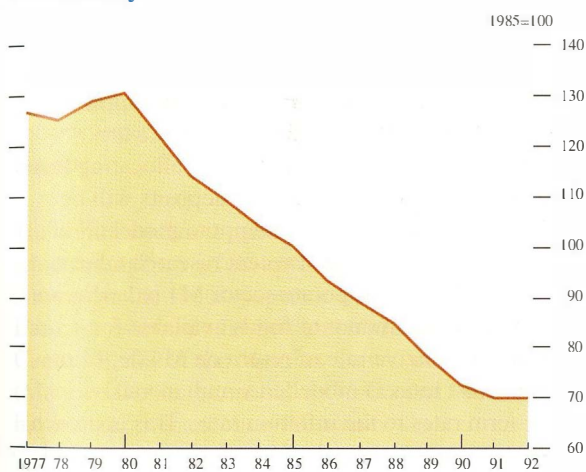
(a) Nominal GDP divided by the stock of M4.

Recent research work at the Bank[2] has used a basic behavioural model in which banks and building societies undertake all profitable lending activities and simultaneously raise sufficient deposits to fund this lending, adjusting the rates paid on these deposits accordingly. Before deregulation, building societies in particular were constrained both in their lending and in the setting of interest rates.

Previous Bank studies of M4 have attempted to explain movements in the total rather than sectoral flows.[3] But the aggregate figures for M4 conceal important differences and sectoral studies of money holdings have been undertaken regularly for other aggregates.[4] In conjunction with the rapid growth of credit since 1979 (see Chart 8), lenders have expanded their reliance on wholesale deposits relative to retail deposits, as shown in Chart 9. In general, wholesale funds will be available in large quantities relatively quickly

### Chart 8
M4 and credit flows
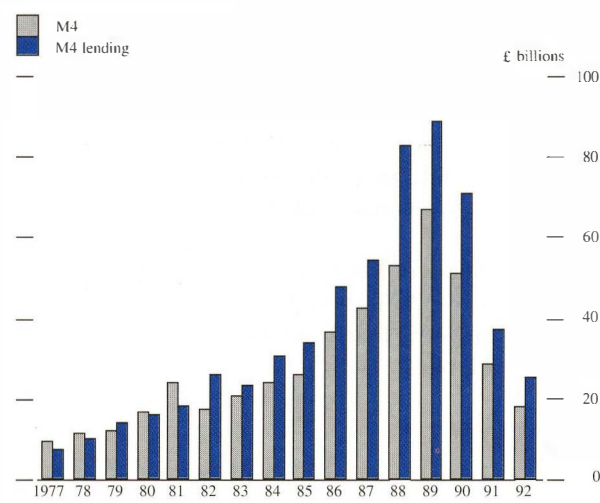
and will tend to be more price sensitive than retail funds. This suggests that a sensible modelling strategy would be to separate wholesale deposits from retail deposits. Retail deposits are likely to be less responsive to changes in the relative rates of return of bank and building society deposits and alternative assets.

In practice, the split between wholesale and retail deposits is closely related to the corporate:personal sector split, which is more convenient for empirical analysis since other information (for example on income) is available on a sectoral basis.

In addition to revealing important differences in the sectoral behaviour of M4, our analysis suggests that deposit rates will reflect the requirements of banks and building societies to raise deposits. An expansion of lending activity should lead to a rise in deposit rates relative to base rates. More importantly perhaps, interest differentials between assets

Chart 9
Retail and wholesale components of M4 flows
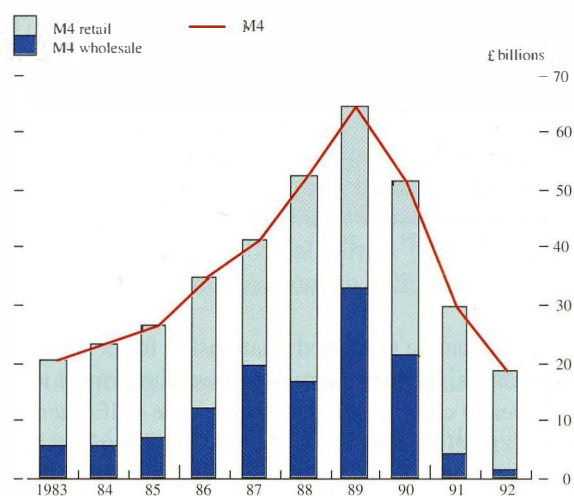
(1) For full details of the definition of M4 see the May 1987 *Quarterly Bulletin*.
(2) Bank of England Working *Paper No 21. op cit.*
(3) See for example Hall, Henry and Wilcox (1989). *op cit.*
(4) For an early example see Price. L D D. 'The demand for money in the United Kingdom: a further investigation', *Quarterly Bulletin*, March 1972.

will reflect financial deregulation. As the financial system becomes more efficient, liquidity constraints are reduced and relative rates of return across assets should more accurately reflect the relative risk of holding those assets. The price of previously illiquid assets—such as housing—will rise, increasing measured wealth. The inclusion of wealth and interest rate factors in explaining M4 trends appears to capture the effects of financial deregulation without resort to any arbitrary trends or dummy variables.

Previous Bank studies of M4 behaviour, from which the preferred empirical specifications have not proved to be robust over recent years, found an important role for wealth, but not for interest rates.

Personal sector M4

In the most recent research undertaken at the Bank, personal sector M4 balances are modelled using a simple 'demand for money' approach in which they are related to income, wealth, interest rates (on M4 and a competing asset) and the inflation rate. The approach also allows for a strong dynamic interaction between consumption and M4, which helps both variables to adjust to desired long-run levels. Consumption functions have generally had a poor record in tracking actual consumption over the recent cycle in activity, and have tended to underpredict consumption growth during the boom and to overpredict it during the recession. But the simultaneous estimation of money demand and a consumption function appears to reduce substantially the correlation of the residual errors in the consumption function with the cycle.

Chart 10
Personal sector wealth:income ratio(a)
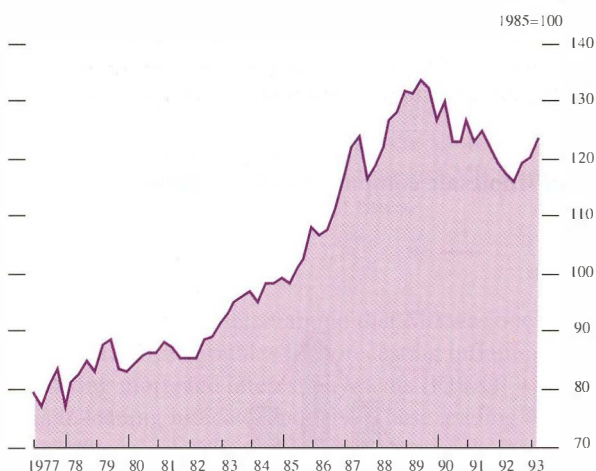
(a) Gross personal sector wealth, financial and tangible, divided by nominal GDP.

In statistical tests on the estimated relationship for personal sector M4 balances, the long-run elasticities with respect to income and wealth can each be restricted to one-half; there is a substantial positive effect from the interest differential between the rate of return on personal sector deposits and on a competing asset; and the inflation rate has an additional (negative) effect on money holdings.

These results suggest that the decline in M4 velocity in the personal sector during the 1980s can be explained principally by the build-up in gross personal sector wealth. In particular, as physical assets such as housing increase in value, a proportion of the equity is transferred into financial balances. This is consistent with the allocation of asset portfolios reflecting liquidity preference and the observation that M4 comprises some savings, as well as transactions balances. To the extent that the personal sector wealth:income ratio has now stabilised, after peaking in 1989 (as shown in Chart 10), we would expect M4 velocity to be more stable in future years.

Corporate sector M4

The empirical results for the corporate sector are less conclusive. Indeed, the corporate sector—which is defined so as to include both industrial and commercial companies (ICCs) and other financial institutions (OFIs)—will almost inevitably be more difficult to model if its deposits provide a marginal source of funds to banks and building societies. A particular difficulty arises in identifying the appropriate relative rates of return. OFIs and the larger ICCs are relatively active and sophisticated investors, allocating funds across a portfolio of assets of which M4 deposits will be only one component. Rather than attempt to model all of their financial decisions, our most recent research takes a partial approach in which corporate sector M4 balances are determined by the total amount of funds available for investment and the relative rate of return on M4 deposits. The level of interest rates is modelled simultaneously, linking short-term rates to the inflation rate. This approach delivers some encouraging results for corporate sector M4, although the interest rate equation is not wholly satisfactory.

Summary

M0 and M4 are very different monetary aggregates which, both theoretically and empirically, are determined by different factors and are unlikely to share a common relationship with inflation (at least over the short and medium term). But both may contain useful information about inflationary pressures, which can be interpreted most effectively if we understand the processes which determine these aggregates. This article has summarised some of our recent research on the modelling of M0 and M4, which has: enhanced our understanding of shifts in the growth of M0 velocity; confirmed the statistical leading indicator properties of M0; underlined the importance of adopting a sectoral approach to M4 and of the role of wealth in explaining broad money growth; and suggested the potential benefit of the simultaneous estimation of equations for consumption and for personal sector M4 holdings.