Interest Rate Control in a Model of Monetary Policy

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Abstract

We extend the model of Bernanke and Blinder (1988) to consider formally the interactions between the monetary authorities and the banking sector. Monetary policy is characterised in terms of the authorities' control over prices in the base money market, rather than quantities. Those market rates directly impinging upon real activity are, however, distinct from - although not independent of - this administered rate. Imperfect control over market interest rates obtains. An empirical illustration is given for the UK.

1. Introduction

"Central banks almost everywhere usually implement their policies through tight control of money market interest rates. Academic monetary economists almost everywhere discuss monetary policy in terms of the monetary stock. These facts say something about either central bankers or academic monetary economists, or both." (Poole (1991))

This well-documented distinction between economic theory and policy reality is not typically thought of as constituting a significant flaw in our understanding of monetary policy. In a textbook *deterministic* environment, it does not matter whether the central bank is modelled as operating on quantities or prices; one is just the obverse of the other. In a model subject to *stochastic* disturbances, it is possible to consider the implications of operating with alternative (price and quantity) policy instruments by utilising the form of analysis first introduced by Poole (1970). The contention of this paper, however, is that simply inverting the policy rule in existing monetary - specifically IS/LM - models may be misleading.

Although such models often take explicit account of the inability of a central bank to exert exact control over the supply of inside money which lies off its balance sheet, they tend to take no account of the limitations affecting the authorities' influence over interest rates in the economy. In the conventional IS/LM framework, this is principally a reflection of the fact that the model contains only one interest rate - the bond rate - which simultaneously clears the money, bond and (with horizontal aggregate supply curve) output markets. This is clearly counter-factual.

In practice, there exists a vast array of market-clearing interest rates, some of which impact directly upon real behaviour, others of which do not. Central banks exert a *direct* influence over only a narrow subset of these interest rates: the rate at which they supply marginal funds to the commercial banking system. Accordingly, the market interest rates which impinge upon real activity are distinct from - though not independent of - this administered rate. Market rates are not directly controlled by the monetary authorities, but rather are determined by behavioural interactions among *private* sector agents. Consequently, as the private sector's behavioural relations shift, so too does the interest rate control mechanism.

The recognition that the monetary authorities may exercise only *imperfect* control over market interest rates has wide-ranging implications for our understanding of monetary policy, both practically and theoretically. At a practical level, without knowing the relationship between the official interest rate set by the authorities and the market rates impinging upon the real economy, it is difficult to judge the appropriate movement in official rates necessary to achieve a given impact on the real economy. At a theoretical level, and taking Poole's (1970) seminal analysis as the benchmark, the recognition that the central bank cannot perfectly control market interest rates implies that the use of an interest rate instrument may not necessarily shield the economy from underlying monetary disturbances.

The rest of the paper is planned as follows. Section 2 discusses the behavioural interactions addressed by the model. In Section 3 the model is formally set down and the comparative statics of an official interest rate change are outlined. Section 4 analyses the authorities' control over interest rates in a deterministic setting, while Section 5 offers some illustrative empirical evidence on the extent of imperfection in interest rate control. Section 6 generalises the interest rate control problem into a stochastic setting. Section 7 concludes with some brief policy considerations.

2. The 'First Black Box' of Monetary Policy

The model discussed in this paper extends a class of models, developed initially by Bernanke and Blinder (1988), which augment the conventional IS/LM framework so as to incorporate an explicit role for banks and bank credit (see also Kashyap, Stein and Wilcox (1993), and Romer and Romer (1990)). The textbook IS/LM framework assumes that bank credit and bonds are perfectly substitutable. This allows the assets side of the banks' balance sheet and, as a counterpart to this, the liabilities side of the non-bank private sector's (nbps) balance sheet, to be suppressed. The augmented framework suggested by Bernanke and Blinder relaxes this perfect substitutability assumption and thus accommodates an explicit role for the banking sector.

In an earlier paper (Dale and Haldane (1993)), we stressed the importance of analysing the behaviour of the banking sector when considering the transmission mechanism of monetary policy. In particular, we characterised the transmission mechanism as comprising two black boxes: the first referred to the relationship between the monetary authorities and the commercial banking system; and the second to the relationship between the commercial banks and the nbps. In that paper, we explored the second black box by considering a variant of the Bernanke and Blinder model. While providing an explicit role for the banking sector, this class of augmented IS/LM models does not consider formally the interactions between the banking sector and the monetary authorities - the first black box. Monetary policy is implemented simply by the authorities exogenously varying the quantity of borrowed reserves available to the banking system, and thus the size of the banks' balance sheets.

This paper seeks to accommodate the stylised fact that monetary policy, in practice, is operated via the authorities' control over short-term interest rates. This is achieved by modelling explicitly the market in which the central bank conducts its open market operations - the market for borrowed reserves. This is the one market in which the central bank exercises monopoly power. The exogenous instrument of monetary policy is then characterised as the administered rate at which the central bank elastically supplies reserves to the commercial banking system. Importantly, this market in reserves is distinct from those in which the nbps participate: monetary policy works exclusively through commercial banks, which then intermediate monetary impulses through to the real economy.

The importance of understanding the role of the monetary authorities in the conduct of monetary policy, and the need to adapt existing models to reflect more accurately the open market operations of central banks, has been stressed recently by a number of authors (Bernanke and Mishkin (1992), Sims (1992), Eichenbaum (1992), Goodfriend (1991)). Endogenising the first black box highlights behavioural interactions between the central bank and the commercial banks, which determine the degree of pass-through of (exogenously-set) administered interest rates to (endogenously-determined) market interest rates.

3. The Model and Comparative Statics of a Monetary Shock

The model developed in Dale and Haldane (1993) was defined across four endogenous markets: credit, deposits, bonds and goods; and three sectors: commercial banks, the nbps and the central bank. The extension of this framework to model explicitly the market in borrowed reserves implies that the model is now defined across five markets. This extended model is given by equations **(1)-(12)** below:

Sectoral Balance Sheets

NBPS	$D^s \equiv L^d + B^s$	**(1)**
Banks	$B^d + L^s + (1/m)\, D^s \equiv D^d + R^d$	**(2)**
Central Bank	$R^s \equiv (1/m)\, D^s$	**(3)**

Credit market

Loan demand	$L^d = L^d(i,\rho,y)$	$L^d_i > 0, L^d_\rho < 0, L^d_y > 0$	**(4)**
Loan supply	$L^s = L^s(i,\rho,r)$	$L^s_i < 0, L^s_\rho > 0, L^s_r < 0$	**(5)**

Deposit market

Deposit demand	$D^d = D^d(i,\rho,r)$	$D^d_i > 0, D^d_\rho > 0, D^d_r < 0$	**(6)**
Deposit supply	$D^S = D^S(i,\rho,y)$	$D^S_i < 0, D^S_\rho < 0, D^S_y > 0$	**(7)**

Borrowed Reserves Market

Reserves Supply	$R^S = R^S(r)$	$R^S_r = \infty$	**(8)**
Reserves Demand	$R^d = (1/m)\, D^d(i,\rho,r)$		**(9)**

Goods Market

	$y = y(i,\rho)$	$y_i < 0, y_\rho < 0$	**(10)**

(Residual) Bond Functions

Bond demand	$B^d = B^d(i,\rho,r)$	$B^d_i > 0, B^d_\rho \gtrless 0, B^d_r \gtrless 0$	**(11)**
Net bond issue	$B^S = B^S(i,\rho,y)$	$B^S_i < 0, B^S_\rho \gtrless 0, B^S_y \gtrless 0$	**(12)**

where:

$L^d, L^S, D^d, D^S, R^d, R^S, B^d, B^S$: demand and supply schedules for bank loans, bank deposits, borrowed reserves and bonds respectively

y : level of income

r: official interest rate

m : inverse of the target bankers' balance ratio

i, ρ : bond and bank loan interest rates respectively

X_z : denotes the partial derivative of X with respect to z

The balance sheets of the three sectors are given by equations **(1)-(3)**. The banking sector supplies loans to the nbps and invests in nbps bonds. As the liability counterpart to these investments, the banks hold deposits supplied by the nbps. In addition, the banks borrow reserves from the central bank in order to satisfy their target balances of base money. These target balances are assumed to be a constant proportion of the banks' deposits and are set exogenously to the model (see below).

The nbps' liabilities comprise their borrowings from the banking sector and their *net* issue of bonds. These liabilities are balanced by their bank deposits. These deposits are assumed to be non-interest-bearing. This assumption implies that there is no distinction between the nbps' holdings of bank deposits and cash in the model, and hence allows cash-holdings to be suppressed. This ensures that the market in which the central bank conducts its open market operations is distinct from those in which the nbps participate. In practice, this separability is a familiar feature of the operation of monetary policy. The public sector is also suppressed from the model; bonds are only issued by the nbps and government expenditure is set to zero.

The exogenous instrument of monetary policy is the administered interest rate (r) at which the central bank lends reserves to the commercial banks to meet their target balances. This interest rate is determined by the interaction of the commercial banks' demand for base money and the supply of borrowed reserves by the central bank. As the monopoly supplier of reserves, it is assumed that the central bank chooses to supply that amount of borrowed reserves which, given the banks' demand schedule, is consistent with its target interest rate: the supply of borrowed reserves is perfectly price-elastic at r. Base money is thus endogenous; it responds passively to shocks to base money demand.

The banks' demand for reserves derives from their positive target balances for base money. This assumption serves as an analytical device to capture two (related) features of modern-day economies. First, a necessary condition for a central bank to be able to influence interest rates is that there is a demand for its liabilities. This demand tends to arise *naturally* in monetary economies: banks seek to hold sufficient discretionary reserves to meet the flow of (stochastic) claims on their deposit liabilities. This demand, in turn, reflects the *institutional* arrangement that banks in the UK are required to settle the clearing at the central bank and are prohibited from going overdrawn at the central bank - so target bankers' balances are positive.(1) It is the combination of these institutional and economic features which in practice generates base money demand. The assumption of positive bankers' balances, related proportionally to the size of banks' balance sheets, can be viewed as mimicking this demand in the deterministic, pure chequing, economy characterised in the present model. It is, in effect, a cash-in-advance constraint for the commercial banking system in aggregate (see Fuerst (1992)).

Second, a central bank's influence over interest rates in an economy can be seen as stemming from its ability to influence the size of the commercial banks' balance sheets.(2) In the absence of positive bankers' balances, and with the deposit rate set to zero, it would be costless for the banks to expand their balance sheets: banks' balance sheets would continue to expand as long as the return on bank loans or bonds is non-zero. The banks would, in effect, have an infinite demand for nbps deposits. The existence of positive target balances allows the central bank to influence the marginal cost of the banks raising new deposits and hence the marginal profitability of banking intermediation. This, in turn, is reflected in the optimal size of the banks' balance sheets and the general level of interest rates in the economy.

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(1) The prohibition of central bank overdrafts in the UK is equivalent to the authorities imposing a reserve requirement set to zero. Similar institutional arrangements are found in other economies, often in the form of positive reserve requirements.

(2) The authorities' influence over market rates may also stem directly from the impact of official interest rates on the expected future path of short rates, and hence on the yield curve. Evidence of this effect along the yield curve is provided by Cook and Hahn (1989) for the US, and by Dale (1993) for the UK. This can be thought of as a third, dynamic, channel for the transmission of monetary impulses, which acts as a complement to the conventional IS/LM monetary multiplier, and the credit multiplier identified by Bernanke and Blinder (1988).

With money endogenous in our model, banks optimise over both the allocation of their disposable assets (ie, assets net of target balances) between bank loans and bonds, *and* the optimal level of their assets and liabilities in aggregate. This latter decision reflects a trade-off between the cost to the banks of expanding their balance sheet and the associated benefits. Given the assumption that bank deposits are non-interest bearing, the marginal cost to the banks of expanding their balance sheets is the interest rate charged by the central bank on the borrowed reserves required to satisfy the banks' increased target balances.(3) This cost is then compared with the returns available from investing in either bank loans or bonds.

Since the banks' holdings of deposits are their sole (net) liability, this optimal balance sheet decision is reflected in the banks' demand for deposits, (6). The banks' demand for deposits depends positively on the loan and bond interest rates, and negatively on the cost of borrowing reserves. This decision also forms the basis for the banks' demand for reserves, (9), which is a derived demand determined by the banks' demand for deposits scaled by their target bankers' balance ratio.

Due to the balance sheet constraint, the banks' loan supply schedule, (5), depends inversely on the cost of borrowing reserves: an increase in r causes the banks to reduce their optimal balance sheet size and hence their level of lending. In addition, the banks' supply of loans is assumed to depend positively on its own rate and inversely on the return on bonds, the alternative asset in the banks' asset portfolio. These own and cross-price elasticities reflect both income and substitution effects. For example, a rise in the loan rate leads to both an increase in the size of the banks' balance sheet (the income effect, as given from (6)), and a switch from bonds into loans, the relatively

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(3) Alternatively, the deposit rate could be modelled as having a fixed relationship with official interest rates. The comparative statics of the model would carry across equivalently.

higher yielding asset (the substitution effect). These two effects both increase the sensitivity of the banks' supply of loans to changes in the loan rate. Similar income and substitution effects operate for the cross-price elasticity, the only difference being that the income effect then serves to *offset* the substitution effect (rather than augment it). For example, in the limit, a change in the bond rate, if fully accommodated by a change in banks' balance sheet size, may leave loan supply unaltered: $L^s_i \rightarrow 0$. These income and substitution effects, through their impact upon the own and cross-price elasticities of loan supply, influence the dynamics of the loan and bond rate in the model (see below). Note that this general characterisation of the banks' loan supply (and demand for bonds) behaviour requires that the banks' portfolio preferences are non-degenerate: L^s and B^d are strictly positive. This assumption rests on the banks viewing bonds and bank credit as imperfect substitutes in their asset portfolio.(4)

The nbps' demand for money (deposit supply) schedule, (7), is slightly unusual. In the absence of government bonds, the nbps does not have any alternative instruments in its asset portfolio. Hence, it is not immediately clear what is the opportunity cost of their money holdings. Given the absence of net wealth, the opportunity cost of the nbps' deposits must, however, be reflected in the cost of their borrowings from the banking sector, through either bank credit or bonds. By reducing their deposits, the nbps can reduce its outstanding debts, thus contracting the size of its (and the banks') balance sheet.(5) Hence, the nbps' demand for money depends inversely on the two borrowing rates: the higher the interest rate charged on borrowing, the greater the incentive to run down money balances to reduce (more

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(4) Dale and Haldane (1993) provide a more thorough rationalisation of this assumption.

(5) Strictly, the opportunity cost is given by the interest rate *differential* between borrowing and deposit rates. However, given that the deposit rate is zero, this cost can be written simply in terms of the two borrowing rates.

costly) gross liabilities. As is conventional, money demand also depends positively on income, reflecting a transactions motive.

The nbps' demand for bank loans, (4), is more straightforward; loan demand depends negatively upon its own rate and positively on the cross (bond) rate. The nbps is modelled as holding non-degenerate preferences across loans and bonds as a means of borrowing. As with the banks, this reflects an assumption that bank credit and bonds are viewed as imperfect substitutes by the nbps. The various microeconomic arguments which may give rise to this imperfect substitutability are reviewed by Kashyap and Stein (1993).

Agents' expenditures are financed solely from their borrowings, either by their net issue of bonds, or by borrowing directly from the banks. Hence, the nbps' demand for goods is defined in terms of the two borrowing rates i and ρ. This demand schedule, given the assumption of a horizontal aggregate supply curve, also defines the goods market equilibrium condition.(6) By Walras' Law, equilibrium in the bond market (and the implied bond functions (11) and (12)) are derived - by residual - from the other equations in the system.

The general equilibrium of the model is solved for the nine endogenous variables $(L^d, L^s, D^d, D^d, R^d, R^s, y, i$ and $\rho)$ by imposing credit, deposit, reserves and output market equilibrium, together with the condition that the banks' adding-up constraint is satisfied. When the model is solved in output, this enables us to outline the comparative statics of a monetary policy shock. These can be shown to take the form:(7)

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(6) Our model could be straightforwardly augmented with a Phillips curve relation (non-horizontal aggregate supply) to allow a real/nominal split of income. But since the 'explanation' of the split in nominal income would typically be subsumed within an exogenously-given speed of adjustment parameter, this would not add any additional insights.

(7) Alternatively, this comparative static can be reparameterised in terms of slopes of, and shifts in, the IS and LM schedules; that is, in terms of monetary (LM) and credit (IS) multipliers - see Dale and Haldane (1993).

$$\frac{dy}{dr} = \frac{D^d_r \left[y_i L_\rho + y_\rho L_i \right] + L^s_r \left[y_i D_\rho + y_\rho D_i \right]}{D^s_y \left[y_i L_\rho + y_\rho L_i \right] + L^d_y \left[y_i D_\rho + y_\rho D_i \right] + L_\rho D_i - D_\rho L_i} \qquad (13)$$

where:

$$L_i = L^s_i - L^d_i$$
$$L_\rho = L^d_\rho - L^s_\rho$$
$$D_i = D^s_i - D^d_i$$
$$D_\rho = D^d_\rho - D^s_\rho$$

As in conventional IS/LM models, a contractionary monetary policy serves to decrease the equilibrium level of income: $dy/dr < 0$ (for plausible parameter values). Consider the implied transmission mechanism underlying this comparative static. Suppose the central bank raises the interest rate at which it supplies reserves to the commercial banking system. This increase serves to reduce the marginal profitability of banking: the implicit cost of bank liabilities - via the reserve requirement - rises. Thus banks' optimal balance sheet size falls. This balance sheet contraction is achieved by the banks raising loan rates in an attempt to restore margins. In response, nbps loan demand is choked-off. The nbps use their deposit holdings to reduce their now more costly bank borrowings. By this mechanism, the balance sheets of the banks and the nbps are simultaneously - and endogenously - collapsed by a monetary tightening. Associated with this contraction in the quantity of bank credit and bonds is a corresponding increase in bank loan and bond interest rates which, in turn, stimulates a fall in the equilibrium level of expenditure.(8)

The explicit modelling of the authorities' control over interest rates results in a relatively complex transmission mechanism. Monetary

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(8) This contractionary impact of monetary policy is partially offset by a number of second-round income effects operating in the deposit and credit markets.

policy impulses are transmitted from prices (official interest rates), to quantities (banks' balance sheets), back to prices (loan and bond interest rates) and only then on to output.[9] More conventional IS/LM models (both *money only* and *credit augmented* models) assume that monetary policy is conducted via the authorities' control over the quantity of reserves. As such, these models tend to ignore the first stage of the transmission mechanism process - the prices to quantities link, operating through the base money market, and the behavioural parameters reflected therein.

4. Interest Rate Control in a Deterministic Environment

As the monopoly supplier, the monetary authorities can perfectly control the interest rate in the base money market. This interest rate is distinct, however, from those market rates directly impinging upon the real economy. Commercial banks intermediate the change in official interest rates through to market interest rates. These market interest rates are thus not directly controllable by the central bank, but rather are determined by the behavioural interactions between the central bank, the commercial banks and the nbps. It is this distinction between *official* and *market* interest rates, and the dynamic relationship between them, which underlies the notion of imperfect control over interest rates by the authorities. These interest rate relationships, and the attendant imperfections in interest rate control, can be considered in either a deterministic or a stochastic environment. Consider first the deterministic framework developed in Section 3.

The relationships between official and market interest rates can be considered by analysing the responses of the bond and bank loan rates to changes in the official interest rate in the general equilibrium of the model. These can be shown to take the form:

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(9) This discussion ignores the complementary transmission mechanism through which changes in official interest rates may influence the expected future path of short rates and hence the yield curve directly (see footnote 2 on page 9).

$$\frac{di}{dr} = \frac{D_r^d \left[L_\rho + y_\rho L_d^y \right] + L_r^s \left[D_\rho - y_\rho D_y^s \right]}{D_y^s \left[y_i L_\rho + y_\rho L_i \right] + L_y^d \left[y_i D_\rho + y_\rho D_i \right] + L_\rho D_i - D_\rho L_i} \qquad (14)$$

$$\frac{d\rho}{dr} = \frac{D_r^d \left[L_i - y_i L_d^y \right] + L_r^s \left[D_i + y_i D_y^s \right]}{D_y^s \left[y_i L_\rho + y_\rho L_i \right] + L_y^d \left[y_i D_\rho + y_\rho D_i \right] + L_\rho D_i - D_\rho L_i} \qquad (15)$$

The relationship between the bond and bank loan interest rates and the official interest rate depends upon the entire structure of the economy; that is, a combination of both the first and second black box behavioural interactions. Accordingly, these relations will not necessarily equal unity: there need not be a perfect pass-through of official interest rates onto other market rates. Some of the determinants of this pass-through are worth briefly outlining.

The responses of loan and bond rates are greater, the larger are $D_r{}^d$ and $L_r{}^S$. These parameters are proxies for the leverage which the central bank exercises over the balance sheets of the commercial banks. The greater this leverage, the more fully a given change in official rates will be reflected in market interest rates. Put another way, if the optimal level of bank intermediation was as sensitive to changes in official interest rates as it was to changes in bank loan and bond rates, there would be an exact correspondence between movements in the different interest rates.(10)

But *behaviourally* there would seem to be relatively little likelihood of these perfect pass-through restrictions holding. To see this, observe that (14) and (15) approximate the dynamic behaviour of banks' margins in our model: they compare the movements in the cost of the

(10) Setting aside income effects.

banks' liabilities (πr), and the return on its assets (i and ρ). Only under the highly restrictive assumption that banks' margins are constant would **(14)** and **(15)** both equal unity. More realistically, when bank margins adjust - either across the cycle or over time - so too will the degree of pass-through of official rates to market rates. The endogenous response of banks' margins underlines the potential extent of imperfection in interest rate control.

The imperfect substitutability between bonds and credit may, for some sectors of the economy, result in private sector agents being unable to access non-bank sources of credit. Bank lending is 'special' for these agents. Intuitively, this has the effect of reducing the competitive forces which equilibrate loan and bond rates. As a result, banks' loan rates become insulated from movements in other market interest rates ($\delta\rho/\delta i < 1$); they become sticky.

The stickiness of loan rates can be shown formally by considering the response of loan rates to a change in bond rates. Combining **(14)** and **(15)**:

$$\left.\frac{\delta\rho}{\delta i}\right|_{dr} = \frac{D^d_r\,(L_i - y\,L^d_{iy}) + L^s_r\,(D_i + y\,D^s_{iy})}{D^d_r\,(L_\rho + y\,L^d_{\rho y}) + L^s_r\,(D_\rho - y\,D^s_{\rho y})} \qquad \textbf{(16)}$$

Imperfect substitutability, as defined above, can be modelled as the excess of the (absolute value of the) own-price elasticity of loan demand and supply over its cross-price elasticity (Dale and Haldane (1993)). It can be seen from **(16)** that the greater this divergence between the own and cross-price elasticities, the lower is $\delta\rho/\delta i$; that is, the lower the substitutability between bank and non-bank sources of credit, the stickier the loan rate.(11)

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(11) This effect is exaggerated by the income and substitution effects alluded to above. These serve to amplify the extent to which own-price elasticities exceed cross-price elasticities, and thus the stickiness of loan rates.

This stickiness of loan rates, stemming from credit rationing or from other sources of imperfect substitutability between bank and non-bank sources of finance, is well-documented in the literature. At a macro level, evidence of sluggish loan rate adjustment has been provided by, for example, Goldfeld (1966), Jaffee (1971) and Slovin and Sushka (1983). More recently, Berger and Udell (1992) have provided evidence of this sluggishness using a micro-data set. Section 5 presents some illustrative evidence of this for the UK.

The imperfection in the authorities' interest rate control has wide-ranging implications for the implementation of monetary policy. Even in a stable, deterministic environment, the authorities must be in a position to evaluate behavioural relationships such as **(14)** and **(15)** if they are to gauge accurately the way in which their actions will ultimately affect output. Without such information, it is difficult for the monetary authorities to judge the appropriate movement in official interest rates necessary to achieve a given effect on the real economy. In practice, this monetary control problem is more problematic still: **(14)** and **(15)** are likely to be complex *dynamic* relations, whose behavioural parameters are apt to shift with time. Allowing for stochastic disturbances in these relations adds further complexity to the control problem: see section 6. But the important point from the above model is the recognition of an additional layer of behavioural relationships within the transmission mechanism process - first black box behavioural relationships - the presence of which further complicates the mapping between the instrument of monetary policy and its final objective.

5. Some Illustrative Empirical Evidence

The notion of imperfect interest rate control, and the potential for interest rate stickiness, can be illustrated using recent empirical evidence for the UK. In particular, we consider the mean wedge between an illustrative set of market rates and official interest rates, and the mean responsiveness of these market rates to official rate changes.

Official rates are proxied here by UK banks' base rate.[12] For market rates we consider a range of assets, covering a number of sectors. This may help to provide some indication as to whether differing degrees of sectoral substitutability influence the stickiness of market interest rates. The market rates used were: a corporate bond yield; a sterling commercial paper yield; the rate charged on personal loans by banks; the rate charged on corporate loans by banks; the rate charged on credit card debt by banks; bank and building societies' average mortgage rate; and bank and building societies' average deposit rate. The data are no more than illustrative: they are *ad hoc* in their coverage, reflecting the paucity of published UK data on interest rates. (A full description of the data and their sources is given in the Appendix.) All of these market rates clearly directly impact upon the nbps. Importantly, the first two of the rates are determined within auction markets (proxies for i in the model), whereas the remainder are rates set directly by the commercial banks (proxies for ρ).

The sample covers base rate changes between March 1987 and October 1992 - 37 in total.[13] This sample is broken down into observations for each base rate change (that is, into real time units), rather than by more conventional time-series units. This follows the event-day study methodology of Cook and Hahn (1989) and Dale (1993).

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(12) Strictly, the rate which is directly controlled by the authorities in the UK is the minimum dealing rate (the 'stop' rate) on band 1 and band 2 bills; that is, eligible bills with less than 14 days and between 15 and 33 days to maturity respectively. Over our sample, however, the wedge between these stop rates and the base rate has been constant; for example the wedge between the band 1 stop rate and the base rate was always equal to 1/8% point. Hence using the base rate makes negligible difference to the reported results.

(13) For sterling commercial paper the sample begins in May 1991, thus covering only nine base rate changes. This market has only recently established itself in the UK.

Figure 1 charts the mean wedge between each of the market rates and base rate over our sample, together with the range exhibited by this wedge. A number of points are worth noting:

(i) The average margins over base rate are much higher for rates set by commercial banks, than for auction market rates. The differing risk characteristics of the markets go some - if not most - of the way towards explaining these spreads. But they are also consistent with the 'specialness' of banks and bank loans (see, for example, Kashyap and Stein (1993) and Dale and Haldane (1993)), deriving from information asymmetries between borrowers and lenders which banks are able to span in their role as specialist monitors. This 'specialness' generates a degree of quasi-monopoly power, allowing the banks to earn, on average, a higher expected rate of return.

(ii) The margins for commercial bank-set interest rates differ widely, ranging from an average spread of 1% on mortgage rates, to an average spread of 5% on corporate loans, up to spreads of over 11% and 15% on personal loans and credit cards. The ordering of these margins appears consistent with the substitutability hypothesis: banks are able to exercise greatest leverage over those sectors for whom liability substitutability appears lowest.

(iii) The size, and variability, of these margins is indicative of the extent to which the official interest rate in isolation - in this case the base rate - may provide a distorted summary statistic of the effective stance of monetary policy.

Figure 1

Average and Range of Margins over Base Rate

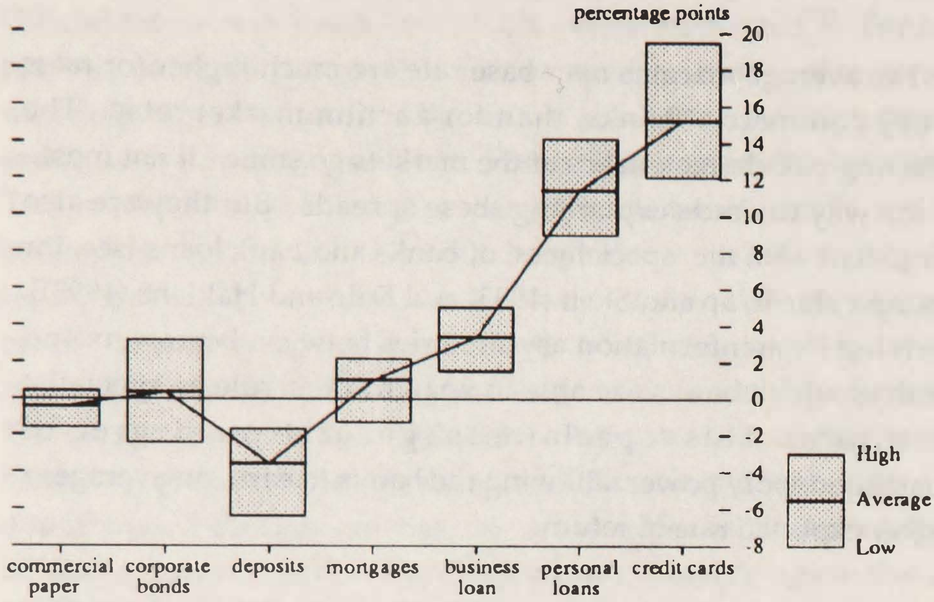


Figure 2 summarises the mean responsiveness of each of the market rates to a base rate change.(14) Again, a number of points are noteworthy:

(i) The mean response of all the market rates to a base rate change is significantly less than 100%: all exhibit, on average, a degree of stickiness. This is consistent with evidence from the US (for example, Berger and Udell (1992)).

(ii) The responsiveness of market interest rates appears to be lower, the lower is the implied degree of liability substitutability for the nbps: around 30% for personal loans and credit card debt; rising to 38% for corporate loans; and above 50% for mortgage

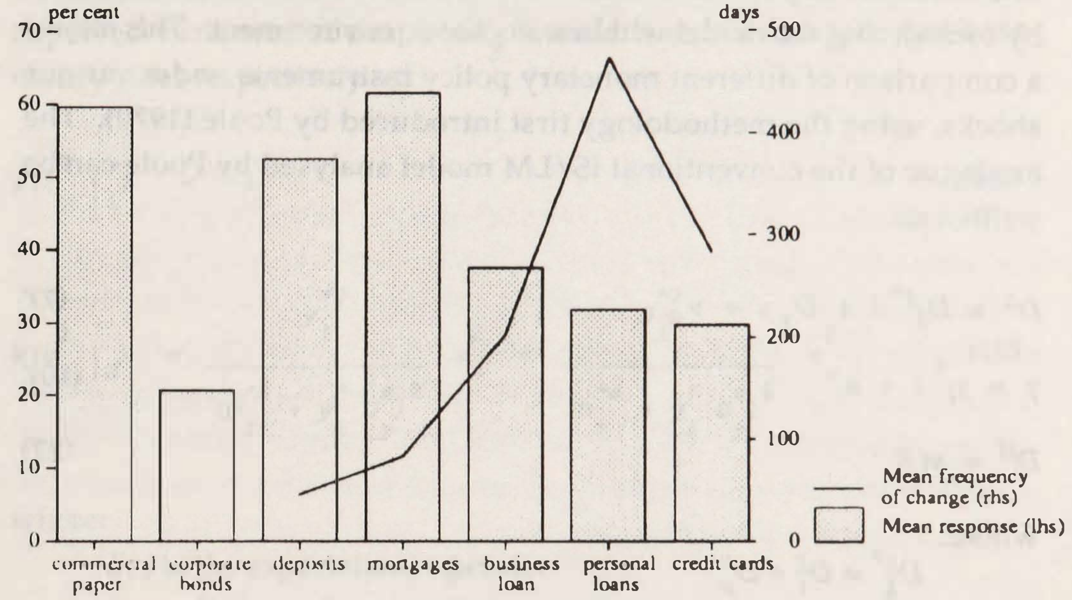
(14) Where the change in market rates is measured in the period spanning the two base rate changes - thus allowing time for rates which are set only periodically to change.

and deposit rates. This is consistent with the substitutability hypothesis.

(iii) From a macro - specifically transmission mechanism - perspective, the evidence presented has far-reaching implications. As market rates are sticky, the marginal impact of a policy change may be less, and potentially much less, than suggested by a given base rate change. Moreover, this stickiness suggests that such

Figure 2

Mean Response to a Base Rate Change; and Mean Frequency of Change of Commercial Bank Rates



spreads may contain useful information about the effective stance of monetary policy and hence future movements in activity following a monetary policy shock. This is consistent with evidence from the burgeoning 'spreads' literature (see Stock and Watson (1989) and Friedman and Kuttner (1992) for some of the earliest evidence). An alternative means of gauging the responsiveness of commercial bank rates to base rate changes is to consider the average frequency with which they were altered over the sample. This is also plotted in Figure 2.[15] The benchmark frequency is that for the base rate, which on average changed every 38 days over the sample. Not surprisingly, the mean frequency of change is lowest for those bank assets which are least substitutable - personal loans (every 473 days) and credit cards (every 284 days). This frequency rises for more substitutable bank assets - business loans (202 days) and mortgages (84 days). Interestingly, deposit rates (every 46 days) appear to change much more frequently than do loan rates.[16]

6. Interest Rate Control in a Stochastic Environment

The notion of imperfect interest rate control can be formalised further by considering the model within a stochastic environment. This allows a comparison of different monetary policy instruments under various shocks, using the methodology first introduced by Poole (1970). The analogue of the conventional IS/LM model analysed by Poole can be written as:

$$D^s = D_i^{s*} i + D_y y + v \qquad \textbf{(7)'}$$

$$y = y_i^* i + u \qquad \textbf{(10)'}$$

$$D^d = m R \qquad \textbf{(17)}$$

where:

$D_i^{s*} = D_i^s + D_\rho^s$

$y_i^* = y_i + y_\rho$

u and v are disturbance terms satisfying $u \sim (0, \sigma_u^2)$, $v \sim (0, \sigma_v^2)$ and $\sigma_{uv} = 0$.[17]

(15) For this exercise we choose one bank (Barclays) as our benchmark when sampling rates. An average of banks would distort our measure if - as typically occurs - banks change rates at different speeds following a given policy shock.

(16) This could be interpreted as indirect evidence of liability management by banks.

(17) The covariance term was assumed by Poole to be non-zero. The zero covariance assumption is made here purely for simplicity.

Equations (7)' and (10)' can be interpreted as linear (stochastic) analogues of (7) and (10). The conventional IS/LM model used by Poole assumed perfect substitutability between credit and bonds. As a result, the loan and bond rates moved one-for-one, allowing the former to be suppressed without loss of generality. Further, the banks' demand for deposits (and hence the size of the banks' balance sheet) was assumed to be exogenously controlled; it is written as a simple money multiplier relation, (17).

The assumption made by Poole was that the aim of the policymaker was to stabilise income around its deterministic value; that is, its value in the absence of the stochastic shocks *u* and *v*. Writing the variables as deviations from their deterministic values, enables us to solve for the expected variances of output (σ_y^2) under the interest rate and base money rules respectively as:

$$E(\sigma_y^2 \mid_i) = \sigma_u^2 \qquad (18)$$

$$E(\sigma_y^2 \mid_R) = \frac{y_i^{*2}}{(D_i^{*s} + y_i^{*} D_y^{s})^2} \sigma_v^2 + \frac{D_i^{*2}}{(D_i^{*s} + y_i^{*} D_y^{s})^2} \sigma_u^2 \qquad (19)$$

where:

$E(.)$ is the expectations operator

$|_{i(R)}$ denotes the expectation conditional upon an interest rate (base money) rule.

These results are well-known from Poole.[18] Under a base money rule, the variance of output reflects a combination of the shocks to both the

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(18) And are robust to simple generalisations of the model; for example, the accommodation of endogenously-determined inside money, and the inclusion of a supply-side with price dynamics. See Friedman (1990).

goods and money markets. In contrast, the variance of output under an interest rate rule is completely insulated from shocks to money demand and has a unit relationship with the variance of shocks to aggregate demand (σ_u^2). The interest rate rule solution, in particular, is both restrictive and counter-intuitive. For example, such a formulation of the model would suggest no role for exogenous shifts in the size of banks' balance sheets - such as financial liberalisation - upon output. Essentially, monetary policy is being conducted independently of stochastic behaviour in the money market. Nominal monetary shocks do not influence output.(19) Further, the interest rate rule, as specified, is immune to the Lucas critique: no behavioural parameters enter **(18)**. These results stem from the fact that simple IS/LM models contain only one, all-equilibrating, interest rate - the bond rate. If this rate is then assumed to be perfectly controllable, a trivial result obtains.

But the basic insight from the models presented in Section 3 and in Dale and Haldane (1993) was that the assumption that all interest rates were proximately equalised (or at least moved *pari passu*) was not well-founded - particularly once account was taken of endogenous bank behaviour in the base money and credit markets. Accordingly, any discussion of the optimality of different monetary policy rules which takes no account of these intermediary interactions runs the risk of over-simplification. This can be seen by considering the variance of output under the base money and interest rate rules in models with endogenous bank behaviour.

The interest rate rule case is simplest. It can be formalised as a linear, stochastic version of the model presented in Section 3, with the system of equations **(1)-(12)** rewritten in the form of **(7)'** and **(10)'**. The one significant difference from the Poole formulation is, of course, that the instrument of monetary policy is not now the bond rate, *i*, but the rate which clears the base money market, *r*. The bond rate, together with

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(19) Paradoxically, conventional IS/LM comparative statics condense to those suggested by real business cycle theory - its main competitor as a macroeconomic paradigm.

the loan rate, is endogenously determined. The same system is used to analyse the base money rule, with the exception that the banks' deposit demand and loan supply schedules are respecified to reflect the change in monetary policy instrument. In particular, the banks' deposit function is replaced with the simple monetary multiplier relation (17) used in the Poole model, and the banks' loan supply function is re-specified such that it depends on the quantity of borrowed reserves rather than their price (Dale and Haldane (1993)):

$$L^s = L^s_i i + L^s_\rho \rho + L^s_R R \tag{20}$$

Assuming that the only shocks affecting the economy continue to come from money demand and aggregate output, the variance of output under the two policy instruments can be shown to take the form:

$$E(\sigma^2_y \mid r) = \frac{(y_i L_\rho + y_\rho L_i)^2}{x^2}\sigma^2_v + \frac{(D_i L_\rho - D_\rho L_i)^2}{x^2}\sigma^2_u \tag{21}$$

$$\text{where } x = D_i L_\rho - D_\rho L_i + D^s_y(y_i L_\rho + y_\rho L_i) + L^d_y(y_i D_\rho + y_\rho D_i)$$

$$E(\sigma^2_y \mid R) = \frac{(y_i L_\rho + y_\rho L_i)^2}{y^2}\sigma^2_v + \frac{(D^s_i L_\rho + D^s_\rho L_i)^2}{y^2}\sigma^2_u \tag{22}$$

$$\text{where } y = D^s_i L_\rho + D^s_\rho L_i + D^s_y(y_i L_\rho + y_\rho L_i) - L^d_y(y_i D^s_\rho - y_\rho D^s_i)$$

A number of points are worth noting about (21)-(22). First, there is an obvious symmetry between (19) and (22), the base money rule solutions. Both are weighted sums of the variance of shocks to money demand and output. The coefficients on both the variance terms lie below unity; that is, shocks to both money and output are dampened under a base money rule. The intuition behind this result carries across exactly from the original Poole version of the model. For example, a positive shock to money demand bids up interest rates and contracts output. But the resulting fall in output then dampens money demand, partially offsetting the initial impact upon output. The one key difference from the Poole analysis is that the bank loan rate, as well as the bond rate, now helps determine the ultimate impact of the disturbance on output. Hence the additional credit market terms in **(22)**.

A more relevant, and contrasting, comparison is that between **(18)** and **(21)**, the interest rate rule solutions. Crucially, the variance of output in **(21)** is shown to depend upon the (weighted) variances of shocks to both output *and* money demand. This result arises because the loan and bond rates are now determined endogenously in the money, credit and bond markets. As such, they are susceptible to the stochastic disturbances affecting these markets. Shocks to portfolio behaviour influence aggregate output.[20] There is ample empirical evidence to support the contention that portfolio shocks influence output dynamics. VAR-based variance decompositions provide perhaps the clearest evidence of this (for the US see, for example, Friedman (1983), Bernanke (1986), Bernanke and Blinder (1992), Gali (1992)).

The above observations underlie exactly the notion of imperfect loan rate control. Even if the authorities knew the behavioural responses of everyone in the economy exactly - they exercised perfect *deterministic* control over the effects of monetary policy - monetary, as well as real, shocks would still be capable of deviating the economy from the authorities' desired path.

Two sources of uncertainty will complicate further this control problem. First, the possibility of shocks to behavioural *parameters*, which are at least as likely as shocks to behavioural variables. From **(21)**, these parameters now influence the variance of output under an

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(20) As with the base money rule, the loading coefficients on the variance terms are both dampening (ie, lie below unity). This compares with the degenerate (0,1) weightings given to these coefficients in (18).

interest rate rule in a way not true previously: the interest rate rule is no longer immune to the Lucas critique. Second, the potential for shocks to behavioural variables other than money demand and output. Once the endogeneity of commercial bank behaviour is recognised, the possibility of shocks to credit and base money demands and supplies is opened up in a way which was not possible within the conventional IS/LM framework. Shocks emanating from these markets will further hinder interest rate control. Indeed, these imperfections in interest rate control will be amplified if - as seems likely as an economic matter - there are positive covariances between the disturbance terms. Financial liberalisation, for example, could be thought likely to generate precisely such covariances.

Two further questions are of interest from a policy perspective: (i) whether the choice of an optimal instrument - a price or a quantity - remains theoretically ambiguous within this extended model (as in Poole (1970)); and (ii), how the relative size of the nominal and real disturbance terms, σ_v^2 and σ_u^2, influence this choice of optimal instrument. On the first question, Poole's basic insight - not surprisingly - remains intact: the choice of optimal instrument is ambiguous *a priori*. The set of restrictions defining this choice (from **(21)-(22)**) are far richer than those suggested by **(18)-(19)**, however, since they accommodate a distinct, endogenous role for bank behaviour.

On the second question, again as in Poole, the interest rate rule can be shown to be preferred the larger are shocks to money demand, and the base money rule preferable the larger are shocks to aggregate demand.(21) While this comparative static conclusion is the same as that from Poole's original analysis, the intuition underlying it is considerably different. In our model these results derive from the deposit demand response of banks - that is, the endogeneity of banking behaviour - rather than from any inherent degeneracy in specification of the interest rate rule.

7. Conclusions

In this paper we have developed an extended IS/LM model of the transmission mechanism of monetary policy. The extensions included: the accommodation of behavioural interactions between *both* the monetary authorities and the commercial banks, and the commercial banks and the nbps; and the implementation of monetary policy according to an interest rate rule.

The model generated a number of theoretical conclusions. These derive from the *endogenous* relationship between official and market interest rates. The pass-through of official interest rate changes to market rates depends upon the behavioural interactions between the monetary authorities, the commercial banks and the nbps. It is likely these relationships will vary across sectors, over the cycle and through time.

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(21) Subject to the restrictions:

(a) $$-y_i L_y^d D_\rho^d < -y_\rho L_y^d D_i^d - D_i^d L_\rho - D_\rho^d L_i$$

(b) $$L_y^d D_\rho^s D_i < L_y^d D_i^s D_\rho - D_y^s D_i^d L_\rho - D_y^s D_\rho^d L_i$$

where (a) is the condition for money demand shocks to result in a smaller output variance under an interest rate rule, and (b) the condition ensuring aggregate demand shocks are felt less by output under a base money rule.

From a policy perspective, this suggests that the authorities may exert only imperfect control over those interest rates directly impacting upon the real economy. Even in a stable world, free from shocks, the authorities need to understand the behavioural responses of private sector agents (bank and non-bank) to gauge accurately how a given monetary policy response would affect output, and with what lags. In a more realistic setting, where behavioural responses shift and/or where shocks are hitting the system, this interest rate control problem becomes more complex still.

As a corollary of imperfect interest rate control, our analysis suggests that, as a minimum, official interest rates in isolation may be an imperfect summary statistic of the effective stance of monetary policy. As a maximum, it suggests that, when considering the transmission mechanism of monetary policy, there is a need to delineate precisely the market interest rates facing agents at the margin: rarely will the official interest rate accurately encapsulate this marginal impact.

References

Berger, A N and G F Udell (1992), 'Some Evidence on the Empirical Significance of Credit Rationing', *Journal of Political Economy*, 100, 51, 1,047-77.

Bernanke, B S (1986), 'Alternative Explanations of the Money-Income Correlation', *Carnegie-Rochester Conference Series on Public Policy*, 25, 49-100.

Bernanke, B S and A S Blinder (1988), 'Credit, Money, and Aggregate Demand', *American Economic Review, Papers and Proceedings*, 435-39.

Bernanke, B S and A S Blinder (1992), 'The Federal Funds Rate and the Channels of Monetary Transmission', *American Economic Review*, 82, 901-21.

Bernanke, B S and F S Mishkin (1992), 'Central Bank Behaviour and the Strategy of Monetary Policy: Observations from Six Industrialised Countries', *NBER Macroeconomics Annual*.

Cook, T and T Hahn (1989), 'Effects of Changes in the Federal Funds Rate Target on Market Rates in the 1970s', *Journal of Monetary Economics*, 24, 331-51.

Dale, S (1993), 'Effects of Changes in Official UK Rates upon Market Interest Rates since 1987', *Manchester School, Proceedings of the Money, Macroeconomics and Finance Research Group*, 76-94.

Dale, S and A G Haldane (1993), 'A Simple Model of Money, Credit and Aggregate Demand', *Bank of England Working Paper No 7*.

Eichenbaum, M (1992), 'Comments on "Interpreting the macroeconomic time series facts: the effects of monetary policy"', *European Economic Review*, 36, 1,001-11.

Friedman, B M (1983), 'The Roles of Money and Credit in Macroeconomic Analysis', in J Tobin (ed.) *Macroeconomics, Prices and Quantities*, Basil Blackwell.

Friedman, B M (1990), 'Targets and Instruments of Monetary Policy', in B M Friedman and F H Hahn (eds.) *Handbook of Monetary Economics*, North-Holland.

Friedman, B M and K N Kuttner (1992), 'Money, Income, Prices and Interest Rates', *American Economic Review*, 82, 472-92.

Fuerst, T (1992), 'Monetary Policy and Financial Intermediation', *mimeo*, Northwestern University.

Gali, J (1992), 'How Well Does the IS-LM Model Fit Post-War US Data?', *Quarterly Journal of Economics*, 709-38.

Goldfeld, S M (1966), *Commercial Bank Behaviour and Economic Activity: A Structural Study of Monetary Policy in the Postwar United States*. Amsterdam: North-Holland.

Goodfriend, M (1991), 'Interest Rates and the Conduct of Monetary Policy', *Carnegie-Rochester Conference Series on Public Policy*, 34, 7-30.

Jaffee, D M (1971), *Credit Rationing and the Commercial Loan Market*. New York: Wiley.

Kashyap, A K and J C Stein (1993), 'Monetary Policy and Bank Lending', *NBER Working Paper No. 4,317*.

Kashyap, A K, Stein, J C and D W Wilcox (1993), 'Monetary Policy and Credit Conditions: Evidence from the Composition of External Finance', *American Economic Review*, 83, 78-98.

Poole, W (1970), 'Optimal Choice of Monetary Policy Instrument in a Simple Stochastic Macro Model', *Quarterly Journal of Economics*, 84, 197-216.

Poole, W (1991), 'Interest Rates and the Conduct of Monetary Policy: A Comment', *Carnegie-Rochester Conference Series on Public Policy*, 34, 31-40.

Romer, C D and D H Romer (1990), 'New Evidence on the Monetary Transmission Mechanism', *Brookings Papers on Economic Activity*, 1, 149-213.

Sims, C A (1992), 'Interpreting the macroeconomic time series facts: the effects of monetary policy', *European Economic Review*, 36, 975-1,001.

Slovin, M B and M E Sushka (1983), 'A Model of the Commercial Loan Rate', *Journal of Finance*, 38, 1,583-96.

Stock, J H and M W Watson (1989), 'New Indexes of Coincident and Leading Economic Indicators', *NBER Macroeconomics Annual*, 4, 351-94.

Appendix: Data Definitions

Corporate bond yield: average gross redemption yield on 25 year debentures and loans.

Sterling commercial paper yield: average of offer rates quoted by BZW and NatWest.

Personal loan rate: average APR on all sizes of personal loan. The sample covers rates offered by Barclays, Lloyds, Midland, and the Woolwich.

Corporate loan rate: rate charged on Barclays Flexible Business loan, on unsecured amounts between £15-100,000.

Credit card rate: APR (including annual fee) on Barclaycard.

Bank and building society mortgage rate: average repayment mortgage rate for existing borrowers, on amounts up to £60,000. Rates are taken on the first of each month. The banks sampled were: Abbey National, Barclays, Lloyds, Midland, NatWest; and the building societies: Alliance and Leicester, Halifax, Leeds, Nationwide Anglia and the Woolwich.

Bank and building society deposit rate: average rate for instant access (sight) deposits up to £20,000. Rates are taken on the first of each month. The sample was the same as that used for the mortgage rate.

All data were collected from publicly available sources.

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