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MONETARY POLICY IN A WORLD WITHOUT MONEY

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ABSTRACT

This paper considers whether the development of "electronic money" poses any threat to the ability of central banks to control the value of their national currencies through conventional monetary policy. It argues that even if the demand for base money for use in facilitating transactions is largely or even completely eliminated, monetary policy should continue to be effective. Macroeconomic stabilization depends only upon the ability of central banks to control a short-term nominal interest rate, and this would continue to be possible, in particular through the use of a "channel" system for the implementation of policy, like those currently used in Canada, Australia and New Zealand.

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The revolution in information technology all around us has led to eager speculation about the ways in which business practices may be fundamentally transformed. The promise of the "New Economy" has excited the imaginations both of young people seeking careers with a bright future and investors hoping for dazzling capital gains. Many executives in the established firms of the "old economy" must also ask themselves, with some trepidation, how precarious their present market situations may be. Among those institutions of the "old economy" that ask if they may soon be rendered obsolete we may now list central banks, who are beginning to ask themselves if their capacity to stabilize the value of their national currencies may not be eroded by the development of electronic means of payment.

The alarm has been raised in particular by a widely discussed recent essay by Benjamin Friedman (1999).[1] Friedman begins by proposing that it is something of a puzzle that central banks are able to control the pace of spending in large economies by controlling the supply of "base money" when this monetary base is itself so small in value relative to the size of those economies. The scale of the transactions in securities markets through which central banks such as the U.S. Federal Reserve adjust the supply of base money is even more minuscule when compared to the overall volume of trade in those markets. He then argues that this disparity of scale has grown more extreme in the past quarter century as a result of institutional changes that have eroded the role of base money in transactions, and that advances in information technology are likely to carry

[1] For an example of the attention given to Friedman's analysis in the press, see "Who Needs Money?", *The Economist,* January 22, 2000.

those trends still farther in the next few decades.[2] In the absence of aggressive regulatory intervention to head off such developments, the central bank of the future will be "an army with only a signal corps" --- able to indicate to the private sector how it believes that monetary conditions should develop, but not able to do anything about it if the private sector has opinions of its own.

Mervyn King (1999) has recently offered an even more radical view of the (somewhat more distant) future, in a discussion of the prospects for central banking in the twenty-first century. King proposes that the twentieth century was the golden age of central banking --- a time in which central banks rose to an unprecedented importance in economic affairs, notably as a result of the rise of managed fiat currencies as a substitute for the commodity money of the past --- and one in which they achieved an influence that they may never again have, as the development of "electronic money" eliminates their monopoly position as suppliers of means of payment. King's discussion is more elegiac than alarmist; he does not suggest that regulation could do much to hold off the progress of technology, and instead proposes that central bankers display a degree of humility, lest they be hustled from the stage with undue indignity.

Will Money Disappear, and Does it Matter?

But do prospective advances in information technology really threaten central banks' capacity to regulate the overall level of spending in the economy, and hence to stabilize the general level of prices? The claim that they do depends, first, upon the premise that the effectiveness of monetary policy depends upon the private sector's need

[2] Henckel *et al.* (1999) review similar developments, though they reach a very different conclusion about the threat posed to the efficacy of monetary policy.

to hold base money (directly or indirectly, through financial intermediaries) in order to execute purchases of goods and services, and second, upon the premise that improved methods of information processing should substantially or even completely eliminate the need to hold base money. Let us first consider the nature of this second claim.

The monetary base --- the liabilities of the central bank that are held by private parties in order to facilitate payments --- can be broadly divided into two parts, the *currency* (notes and coins) that private parties hold for use as a means of payment, and the *reserves* that commercial banks hold in accounts at the central bank in connection with the transactions services that they supply their customers. These bank reserves, in the typical textbook account, are held in proportion to the size of the transactions balances (such as checking accounts) that the public maintains at the banks, owing to the existence of legal reserve requirements; and this still accounts for most of actual bank reserves in a country like the U.S. In countries such as the U.K., Sweden, Canada, Australia and New Zealand, among others, there are instead no longer any reserve requirements,[3] but commercial banks still hold *settlement balances* with the central bank in order to allow them to clear the payments made by their clients. Regardless of the component of the monetary base with which we are concerned, the private sector's demand for such assets is plausibly proportional to the money value of transactions in the economy, and it is in this way that it is often supposed that variations in the supply of base money directly determine the flow of spending in dollar terms.

How should advances in information technology affect the demand for base money of these various types? The most obvious possibility is through the development

[3] See Borio (1997), Sellon and Weiner (1996, 1997) and Henckel *et al.* (1999) for further discussion of the worldwide trend toward reduction or elimination of such requirements.

of convenient ways of executing payments that might in the past have required the use of currency. Electronic funds transfer at point of sale (EFTPOS), already quite common in countries like New Zealand, are an obvious example. The widespread use of stored value cards, currently being experimented with in a number of countries might well erode the demand for currency even more significantly, by being practical for use in an even broader range of purchases, owing to the absence of a need for communication with the buyer's bank.

Charles Goodhart (2000) has argued that currency is unlikely to ever be completely replaced, owing to its uniquely convenient features as a means of payment, and as we shall see, this is in any event not the potential innovation that poses the greatest challenges to current methods of implementation of monetary policy. But while the replacement of currency is probably the threat to receive the greatest recent attention, improvements in information technology might well erode demand for other components of the monetary base as well.

In the case of the demand for reserves owing to reserve requirements, faster information processing facilitates the transfer of funds between accounts not subject to such requirements and the "transactions balances" that are, thus allowing payments to be made while maintaining low average balances subject to the reserve requirements. This possibility has made the concept of "transactions balances" increasingly unsustainable from a conceptual point of view, and is surely one of the reasons for the worldwide trend toward the elimination of reserve requirements. It is likely that countries like the U.S. will follow suit before long.

But monetary policy remains effective even in those countries that have completely eliminated required reserves, even if the methods that they use to implement monetary policy are rather different than those still employed in the U.S. Still, this arguably depends upon a residual demand for central-bank settlement balances. The demand for these might also be reduced by advances in information technology. For even if all payments are cleared through the central bank, commercial banks' demand for a non-zero level of settlement balances depends upon their inability to perfectly forecast their payment flows, and to arrange transactions in the interbank market throughout the day so as to maintain settlement balances constantly at zero. With more efficient communications between banks, it should in principle be possible to borrow overnight cash from another bank only in the instant that it is needed for final settlement of a payment, at which time the paying bank's settlement account would return to a zero balance. Since every payment that is made is received by someone, a sufficiently efficient market for the reallocation of funds among banks should allow all banks to operate with settlement balances near zero.

A final possibility, raised by Mervyn King in particular, is the eventual elimination of the demand for settlement balances owing to the development of electronic networks allowing payments to be settled without even the involvement of central-bank settlement accounts. This prospect is highly speculative at present; most current proposals for variants of "electronic money" still depend upon the final settlement of transactions through the central bank, even if payments are made using electronic signals rather than old-fashioned instruments such as paper checks. And some, such as Charles Freedman (2000), doubt that the special role of central banks in providing for

final settlement could ever be replaced. Yet the idea seems conceivable at least in principle, since the question of finality of settlement is ultimately a question of the quality of one's information about the accounts of the parties with whom one transacts --- and while the development of central banking has undoubtedly been a useful way of economizing on limited information-processing capacities, it is not clear that advances in technology could not make other methods viable.

I shall not here seek to evaluate which of these various attempts to imagine the payments technologies of the future are more likely to be correct. Instead, I shall argue that concerns about the consequences of the IT revolution for the role of central banks are exaggerated, not so much on the ground that advances in computing are unlikely to fundamentally transform the payments mechanism, but on the ground that even such radical changes as might someday develop are unlikely to interfere with the conduct of monetary policy.

There are several reasons why I believe that the articles mentioned above exaggerate the potential problem. These all have to do with the inadequacy of the common assumption that the effects of monetary policy depend upon a mechanical connection between the monetary base and the volume of nominal spending, which is then presumably dependent upon a need to use base money as a means of payment. This assumption leads easily to a number of misconceptions.

The first misconception is a failure to recognize that a central bank only needs to be able to control the level of short-term nominal interest rates to achieve its stabilization goals. In practice, central banks generally seek to achieve an operating target for an overnight interest rate in the inter-bank market for reserves held at the central bank.

Control of this rate then directly affects other short-term interest rates, which in turn determine longer-term interest rates and exchange rates, which ultimately determine spending and pricing decisions.

It is important to note that there need not be a stable relation between this overnight interest rate and the size of the monetary base in order for the central bank to effectively control overnight interest rates. Innovations in means of payment may complicate the use of quantity targets to achieve a given level of overnight interest rates, or even render it infeasible. As a result, some central banks, like the U.S. Federal Reserve, may have to modify their operating procedures, in order to more directly fix overnight interest rates. But this would require no change in the way in which the Fed adjusts its operating target for the federal funds rate in response to changing economic conditions, and should not in any way impair the effectiveness of the Fed's stabilization policy.

A second misconception is the apparent assumption that the use of *currency* for retail transactions is important for the monetary transmission mechanism. It is true that the demand for currency is the largest part of private-sector demand for the monetary base under current conditions[4] --- and so a significant reduction in the use of currency would greatly reduce the size of the monetary base. But a large monetary base is in no way essential for effective central-bank control of short-term interest rates.

Furthermore, the overnight interest rate that a typical central bank actually seeks to control is determined in the interbank market for bank reserves. The public's demand for currency affects this only insofar as it affects *the supply of bank reserves.* If people

[4] For example, it accounts for more than 84 percent of central bank liabilities in countries such as the U.S., Canada and Japan (Bank for International Settlements, 1996, Table 1).

wish to hold more currency, then banks must reduce their reserves at the central bank in order to acquire the currency. In order for this not to reduce the supply of bank reserves, an offsetting open-market operation by the central bank is required. But under typical circumstances this is a relatively minor complication. Furthermore, the complete elimination of the use of currency in minor transactions would only make monetary control under current operating procedures *easier,* by making it simpler for the central bank to control the supply of bank reserves.

A final misconception is the assumption that in order to "tighten" policy --- raising overnight interest rates --- the central bank must ration bank reserves, making reserves scarce enough for banks to be willing to hold the remaining supply, even though the opportunity cost of holding reserves has risen. The capacity for rationing of supply to have this effect would obviously depend upon the non-existence of sufficiently good substitutes for the use of bank reserves, so that even a large spread between the interest rate available on other liquid assets and that paid on reserves does not result in complete substitution away from reserves. It thus requires a sort of monopoly power on the part of the central bank, and one might worry that innovations in means of payment could seriously undermine this.

But conventional analysis on this point implicitly assumes a *zero rate of interest on reserves,* so that raising interest rates in the economy at large (what the central bank needs to do to rein in spending) requires that the central bank be able to increase this *spread.* This standard assumption remains true in the United States, but is not true in many other countries. Furthermore, in several other countries (below I shall discuss in particular the implementation of policy in Canada, Australia and New Zealand), changes

in the *level* of interest rates are currently brought about without any variation in the size of the spread between the overnight rate available in the interbank market and the interest rate paid on funds held overnight with the central bank. Instead, the interest rate in the interbank market and the interest rate on reserves are always raised (or lowered) in tandem.

Because such a system does not require variation in the spread between the return on other assets and that on bank reserves, or even the *existence* of any substantial spread, it does not depend upon bank reserves fulfilling a unique function that gives the central bank monopoly power. My conclusion is that while advances in information technology may well require changes in the way in which monetary policy is implemented in countries like the United States, the ability of central banks to control inflation will not be undermined. And in the case of countries like Canada, Australia or New Zealand, the method of interest-rate control that is currently used (the "channel" system to be described below) should continue to be perfectly effective, even in the face of the most radical of the technical changes that are currently envisioned.

I now elaborate upon each of these points. I shall first consider the effects of erosion of demand for central-bank liabilities in the case that diminution of monetary frictions does not eliminate the central bank's ability to control the interest-rate spread between its own liabilities and other financial assets, and argue that in this case monetary policy could still be effective even in the absence of interest payments on reserves. I shall then consider the more radical possibility of a loss of the central bank's ability to materially affect this spread. In this case, I shall argue that more significant changes in the implementation of monetary policy would be required in countries like the U.S., but

that the method currently used in countries like Canada, Australia and New Zealand would continue to be perfectly effective.

As the crucial monetary policy decision would continue to be the adjustment of the central bank's operating target for an overnight interest rate (such as the U.S. federal funds rate), this would still require no fundamental change in the way in which monetary policy is conceived, and would imply no reduction in a central bank's ability to stabilize either economic activity or inflation. Thus there is every reason to expect that in the coming century the role of central banks in the control of inflation will be essentially the same as it is now.

Interest-Rate Control with Zero Interest on Bank Reserves

In considering whether interest-rate control should still be possible even without the payment of interest on base money, it is useful to begin by discussing how short-term nominal interest rates are determined under current U.S. institutional arrangements (which involve no interest payments on bank reserves). We can then take up the question of what changes might be required by the development of new payments media.

In the U.S., Federal Reserve policy is formulated in terms of an operating target for the federal funds rate, an overnight interest rate in the interbank market for reserves held at the Fed. The determination of the equilibrium federal funds rate can be explained using the diagram in Figure 1. The effective supply of reserves at any given level of the funds rate can be described by a relation of the form

$$TR = NBR + b(FF\text{-}DR), \qquad (1)$$

where *TR* denotes total reserves, *NBR* the quantity of non-borrowed reserves, and the

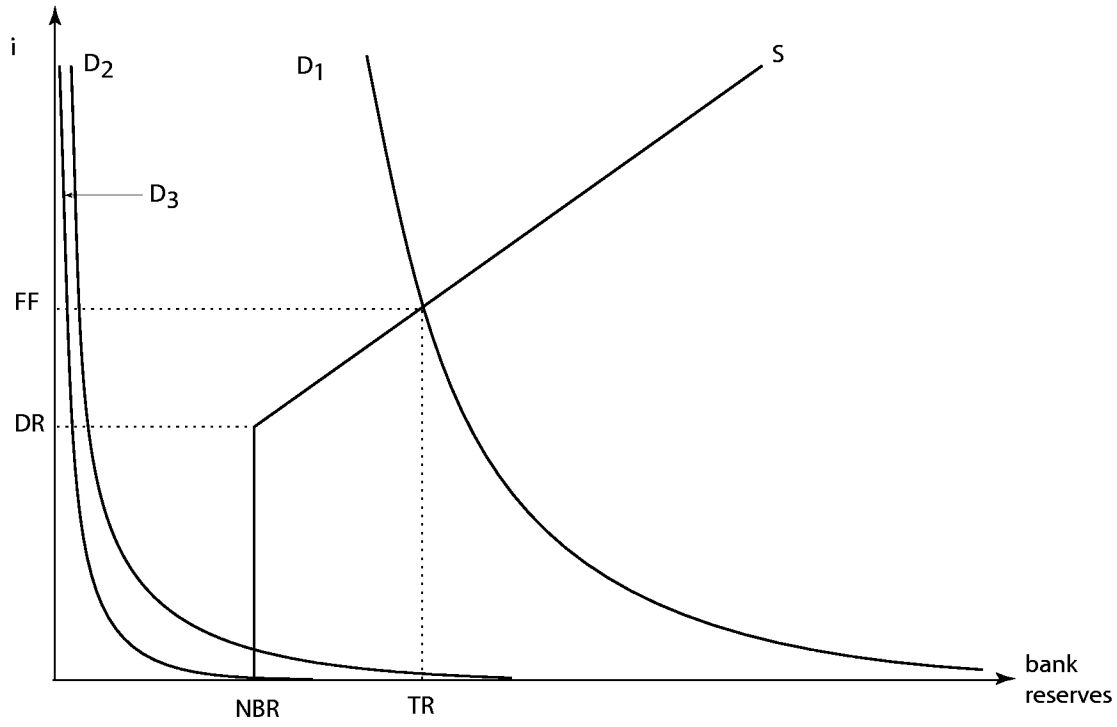

Figure 1. The market for bank reserves (U.S.)

function *b(s)* the quantity of reserves that banks are willing to borrow at the discount window, as a function of the spread *s* between the federal funds rate *FF* and the discount rate *DR*.

This last function increases from zero in the case of a zero spread, becoming a progressively greater positive quantity as the spread increases. Here the idea is that there will be no willingness to borrow at the discount window if reserves are obtainable on the interbank market at a funds rate lower than the discount rate. When the funds rate exceeds the discount rate, banks are willing to borrow, but not an unlimited amount in the case of only a small difference in rates, as there are also implicit costs of borrowing at the

discount window. These implicit marginal costs are generally assumed to be increasing in the amount borrowed, resulting in a well-documented increasing relationship between discount-window borrowing and the differential between the funds rate and the discount rate. The total effective supply of reserves implied by equation (1) can then be graphed as the schedule *S* in Figure 1.

Banks' aggregate demand for reserves, primarily as a result of reserve requirements, plotted as a function of the funds rate, is indicated by the schedule D_1 in the figure. The equilibrium funds rate *FF* and the associated level of total reserves *TR* are then determined by the intersection of the two schedules. The Fed influences the equilibrium funds rate through open-market purchases or sales of government securities that change the quantity of non-borrowed reserves *NBR* available to the banks in aggregate. Such an open-market operation shifts the entire schedule *S* horizontally. This in turn changes the equilibrium funds rate. (Specifically, an open-market sale of securities decreases non-borrowed reserves, resulting in a higher equilibrium funds rate.) Typically, the demand for reserves schedule D_1 is assumed to be relatively interest-inelastic, especially in the short run. Then the size of open-market operation required to bring about a given increase in the funds rate depends mainly upon the amount by which the willingness to borrow at the discount window is expected to be increased by the higher spread between the funds rate and the discount rate. One reduces the supply of non-borrowed reserves, requiring the banks in aggregate to increase their discount-window borrowing by that amount, so that the funds rate is bid up to a level reflecting the implicit cost of discount-window borrowing to the increased extent.

How should this mechanism be affected by the development of electronic means of payment? As noted earlier, the development of "electronic cash" as a substitute for the use of currency in small transactions should have no material effect upon the possibility of monetary control through this mechanism at all. Note that we have said nothing about the demand for currency at all in the above account. In fact, if the demand for currency is interest-sensitive, this complicates the above story only slightly; the size of the open-market operation required to raise short-term interest rates a given amount has to be corrected for the increase in the supply of non-borrowed reserves that occurs when households and firms choose to reduce their currency holdings by depositing the currency with banks. If the development of "electronic cash" were to eliminate the use of currency altogether --- or if currency came to be used solely for special types of transactions, such as illegal ones, so that the remaining currency demand became more completely interest-inelastic --- then the above method of control of the federal funds rate through open-market operations would work all the more perfectly.

A less trivial question arises in the case of innovations that might sharply reduce the demand for bank reserves, for reasons of the sort discussed earlier. One might envisage a radical shift to the left of the demand schedule D_1, to a schedule such as D_2 or D_3 instead. This would admittedly create problems for the Fed's method of achieving its funds rate targets, as set out above. That method is based upon creating a shortfall of non-borrowed reserves (relative to banks' aggregate desired reserves) of a sufficient size to induce the desired interest-rate spread. But if desired reserves themselves came to be negligible, if would not be possible in this way to ever induce any very substantial quantity of borrowing at the discount window.

Of course, one could still vary the supply of reserves through open-market operations. But if the demand for reserves were extremely inelastic (as implied by schedule D_2 or D_3), and it were also not possible to bring about significant variations in discount-window borrowing, it would be quite hard to calculate the exact size of (very small) open-market operation required to bring about a given size change in the funds rate. In particular, if the remaining demand for bank reserves were also *unstable* --- say, fluctuating arbitrarily between schedules D_2 and D_3 --- then control of the quantity of non-borrowed reserves through open-market operations could result in extreme funds-rate volatility.[5]

Still, this is really just a problem with the attempt to achieve one's funds-rate targets through choice of *a target level of non-borrowed reserves,* which is then arranged through a given size of open-market operation; there is no genuine infeasibility of interest-rate control by the central bank in such an environment. The demand schedules D_2 and D_3 still imply that any positive funds rate is a possible equilibrium, in the case of an appropriate supply of bank reserves; it is simply necessary that the Fed supply the quantity of reserves that happens to be demanded at its target funds rate. Neither a highly inelastic demand for reserves nor an unstable demand would create any problem,[6] as long

[5] In practice, countries in which bank reserves are held only for settlement purposes (as required reserves have been eliminated) find that the aggregate quantity of overnight settlement cash held by commercial banks can vary sharply over short periods of time, in the absence of any notable changes in interest rates or the volume of real transactions in the economy. See, for example, the high-frequency variation in settlement cash in New Zealand plotted in Figure 5 below, in a period in which the overnight interest rate (shown in Figure 4) is extremely stable from one day to the next. There are, in particular, two surges in settlement cash holdings in the space of a year, in which the level of settlement cash briefly achieves levels as much as 50 times the normal level of overnight settlement cash. This sort of instability of banks' desired settlement cash holdings would clearly make interest-rate control through adjustment of a quantity target for settlement cash unreliable, at least as far as day-to-day variation in overnight rates would be concerned. The reduction in the volatility of overnight interest rates under the "channel" system described in the next section is considered to be one of its more obvious advantages; see Brookes and Hampton (2000).

[6] Even if desired reserves came to be *completely* interest-inelastic, there would be no reason for the Fed not to be able to determine the equilibrium funds rate. As long as banks are required (in aggregate) to borrow at

as the Fed were simply to announce the interest rate at which it intended to supply reserves to the market, rather than trying to calculate in advance the quantity of reserves that should be supplied in order to achieve a particular funds-rate target.

This would require some modification of the Fed's current operating procedures. Variations in the supply of non-borrowed reserves would no longer be a useful policy tool, and it would be sensible to maintain a target supply of zero non-borrowed reserves.[7] Such reserves as banks wished to hold would be supplied at the discount window. There would furthermore be little point in the Fed's continuing to use "moral suasion" to limit discount-window borrowing, thus making the implicit cost of funds from this source significantly higher than the discount rate; for borrowed reserves would in any event always be quite small. The discount window might as well be operated as a borrowing facility of the kind provided by many other central banks,[8] at which an arbitrary quantity of reserves may be borrowed (with suitable collateral) at an announced rate. Under such circumstances, the equilibrium federal funds rate should simply equal the discount rate. Variations over time in the discount rate would then be the crucial tool by which desired variations in the federal funds rate would be achieved.

This analysis assumes that there still remains *some* small positive demand for bank reserves, no matter how large the interest-rate spread between the federal funds rate

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the discount window to satisfy their inelastic demand for reserves, any bank that borrows will assign a value to marginal funds obtained on the interbank market equal to the cost of funds at the discount window. If funds were furthermore supplied freely at the discount window (contrary to current practice), it would not be possible for the equilibrium funds rate in the interbank market to be either higher or lower than the discount rate.

[7] This would still require open-market operations, in order to offset the effects upon the supply of non-borrowed reserves of changes in currency holdings (if these have not entirely vanished) and of government payments (which surely would not vanish). This is the residual function of open-market operations under "channel" systems like those discussed in the next section, under which the target level of settlement cash is never adjusted as an instrument of monetary policy. For a discussion of the use of open-market operations for "liquidity management" under the current regime in New Zealand, see Brookes (1999).

[8] See Borio (1997) for a survey of alternative provisions.

and the (zero) rate paid on reserves may be. Woodford (1998) provides a simple model of technical progress in payment media that illustrates how that could easily be the case. In this model, households purchase a large number of differentiated goods; some of these ("cash goods") must be purchased using a means of payment that requires households to (directly or indirectly) hold base money in proportion to the volume of expenditure on these goods, while others ("credit goods", adopting the terminology of Lucas and Stokey, 1987) may be purchased using a payment technology that does not require base money at all. The fact that no interest is paid on the monetary base increases the cost of purchases using "cash", and so optimizing households substitute away from consumption of these goods to some extent, and the extent depends on the level of nominal interest rates; but the preferences assumed imply that for any finite level of interest rates, a positive level of consumption of "cash" goods is still desired, and there thus remains a positive demand for the monetary base. This continues to be true no matter how small the number of goods that are "cash goods", as long as *some* such goods continue to exist.

This model allows one to show, not only that central-bank control of short-term nominal interest rates need not be problematic even in a world in which cash has been displaced as a means of payment for virtually all purchases, but also that such a development introduces no complications for the way in which such control of nominal interest rates affects the economy and in particular the price level. Woodford (1998) shows the existence of a well-defined "cashless limit", in the sense that the equilibrum price level path (as a function of the sequence of disturbances affecting the economy, including random variation in the central bank's rule for setting short-term nominal interest rates) is virtually the same in *all* cases in which the number of "cash" goods is

sufficiently small. This is because the effects of interest rates upon spending and pricing decisions depend upon the way the marginal utility of additional expenditure (and hence of additional income) varies with the level of real expenditure at that point in time. This relation depends in general upon the nature of the monetary frictions, and upon the level of real money balances in the economy; but in the case of any economy sufficiently close to the "cashless limit", this relation is essentially the same, and essentially *independent* of variations in the level of real money balances.

Thus while shifts over time in the demand for base money from a schedule like D_2 to one like D_3 (due, for example, to time variation in the fraction of purchases that happen to be of "cash" goods) create problems for the use of *quantity-targeting techniques* to control interest rates, they do not necessarily create any problems for successful control of short-term nominal interest rates. Moreover, they need not create any problems for the central bank's determination of the level of interest rates that is required at each point in time for successful stabilization of the price level. In practice, this will often involve difficult questions of judgment on the part of the central bank --- essentially, it will need to track variation over time in the Wicksellian "natural rate of interest" (Woodford, 1999) --- but these problems are made no *more* difficult by the substitution of electronic means of payment for payments using central-bank money. And so there is no reason to regulate the development of such means of payment in order to facilitate this aspect of monetary control, either.

Interest-Rate Control without Control of a Rate Spread

The analysis in the previous section has assumed that even in the "cashless limit" it continues to be possible for the central bank to vary the spread between the return on base money and on other financial assets to an arbitrary extent. It has been argued that this may well continue to be possible even if total demand for the monetary base comes to be minimal in size and subject to arbitrary (percentage) variations, and under circumstances where the remaining uses for the monetary base impose only trivial costs upon the private sector. Nonetheless, one may wonder whether sufficient progress in information technology might not lead to an alternative endpoint, in which the central bank ceases to be able to induce private parties to hold base money *at all*, in the event of any substantial return differential between base money and other liquid assets.

In terms of our simple diagram, one might conjecture that instead of the demand for bank reserves shifting from D_1 to something like D_2 or D_3 in Figure 1, technical progress might lead to a shift from D_1 to something like D_2 in Figure 2. Here it is assumed that there is a certain finite cost advantage to using central-bank money, proportional to the size of the transaction, so that it will not be used *at all* in the event of a return spread larger than a critical value determined by the proportional cost.[9]

If advances in information technology are imagined to lower this cost, then the interest rate at which the base money demand schedule intersects the vertical axis

[9] It is important for our argument that we now assume that the demand for *all* components of the monetary base vanishes at some finite interest rate. In Figure 1, it suffices that the demand for *reserves* remain positive at arbitrarily high interest rates; the demand for the monetary base will then remain positive whether there continues to be positive currency demand or not. But our argument here that the central bank should be unable to increase market interest rates more than a finite amount above the zero rate paid on base money would not be valid if there continued to be a positive demand for central-bank-supplied currency.

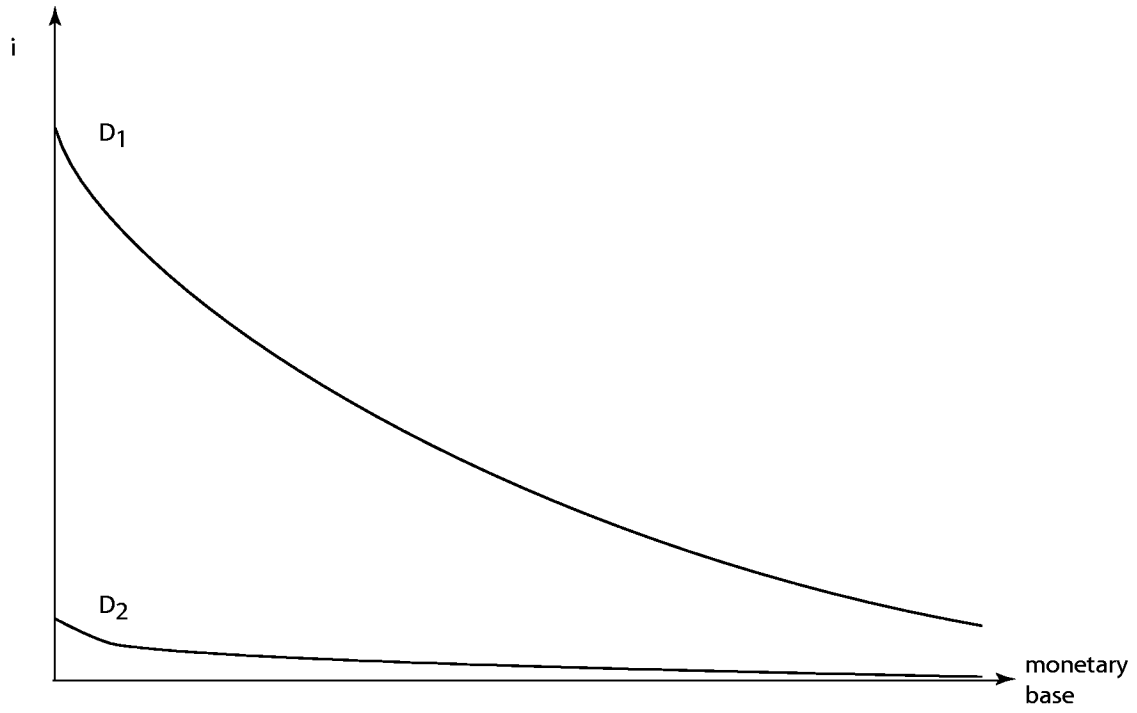

Figure 2. Alternative possibility for reduction in demand.

becomes progressively closer to zero. In such a case, it will not be possible for the central bank to force the interest rate above the level represented by that intercept, no matter how much it restricts the supply of the monetary base.

Given the fact that there is also necessarily a limit (of zero) on how much this interest-rate spread can be reduced by increasing the supply of the monetary base, a situation of the kind represented by the schedule D_2 in Figure 2 would severely limit the extent to which a central bank could move short-term interest rates through variation in the terms on which it supplies reserves. In particular, as Ingemar Bengtsson (2000) and Bennett McCallum (2000) note, in a *fully* frictionless economy --- one in which the demand for money has fallen to exactly zero at any positive interest differential, and not

simply to a very small positive quantity --- the method of price-level control expounded in the previous section would be inapplicable.

However, an inability to affect the interest-rate *spread* between base money and other assets does not imply that a central bank is powerless to control short-term nominal interest rates. For it is still possible to change the equilibrium short-term nominal interest rate by changing *the interest paid on reserves.* We have assumed above that the interest on reserves equals zero at all times. But there is no necessity for this interest rate to be zero, or even for it to be constant; a central bank could easily enough vary it daily should it choose. Furthermore, the choice of the nominal rate of interest upon central-bank liabilities is an arbitrary choice of the central bank's. There is thus another instrument through which a central bank can seek to affect the level of overnight nominal interest rates, an instrument that happens not to be used when, as in the U.S. at present, there is no interest on reserves. This additional instrument is in fact redundant when the central bank can effectively control the interest-rate differential by varying the supply of base money.[10] But if new payments technologies were to eliminate the possibility of substantial variation in the interest-rate spread, it would still be possible to vary equilibrium short rates by varying the interest paid on base money, and this would then become a crucial tool in the implementation of monetary policy.[11]

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[10] Of course, it has often been argued that the payment of interest on bank reserves is desirable in order to reduce the cost to banks of holding such reserves, and so to reduce inefficient attempts to economize on reserves and upon reservable deposits. See Friedman (1959) for a classic statement of this position. A similar argument would apply to the payment of interest on currency, were that feasible at low cost. But such *efficiency* considerations are independent of the question of price-level *control* with which we are here concerned.

[11] Hall (1983, 1999) and Woodford (1999) both propose this as a method of price-level control in the complete absence of monetary frictions. (Grimes (1992) similarly shows that this method would be effective in an environment in which central-bank reserves are no more useful for carrying out transactions than other liquid government securities, so that open-market purchases or sales of such securities are completely ineffective.) Hall also proposes a specific kind of rule for adjusting the interest rate on bank reserves in order to ensure a constant equilibrium price level; but this particular rule is not essential to the

Would a variable rate of interest payments on the monetary base be feasible? When one thinks of the currency component of the base, there is an obvious technical advantage to a fixed nominal yield of zero: a bill that is stamped "ten dollars" at the time of issuance is simply worth ten dollars at all later points in time, and there is no need to track it as it changes hands in order to ensure that. Charles Goodhart (1986) and Huston McCulloch (1986) have nonetheless proposed that interest payments on currency would be feasible, through a lottery based upon the serial numbers of individual notes. However, interest payments on currency would not really be necessary under the system of interest-rate control just proposed; it would suffice to pay a time-varying (non-negative) interest rate on bank reserves. Under the hypothesis represented in Figure 2 --- that a small positive interest-rate spread would suffice to induce complete substitution away from all uses of base money --- this might mean the complete elimination of currency holdings. But that would pose no threat to the control of short-term nominal interest rates by varying the interest paid on bank reserves; interest rates would simply be determined in the market for bank reserves.[12] Indeed, this is the crucial nexus under current arrangements already.

And there is no doubt that it is easy to pay interest on bank reserves. Indeed, a number of countries do so already.[13] Indeed, there are already central banks that control short-term interest rates by *varying* the interest rate paid on balances held with the central bank, rather than by varying the differential between that interest rate and overnight interest rates paid by banks to one another. This is true of the "channel" system of

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general idea. One might equally well simply adjust the interest paid on reserves according to a "Taylor rule" or a Wicksellian price-level feedback rule (Woodford, 1999).

[12] The same would be true if there remained a positive demand for currency, say for illegal transactions, that was almost completely interest-inelastic.

interest-rate control used by central banks such as the Bank of Canada, the Reserve Bank of Australia, and the Reserve Bank of New Zealand.[14] The successful experience of these central banks indicates that such a system of monetary control is perfectly feasible under current circumstances; but given such a system, there is little reason to expect monetary control to be any more difficult following the development of new electronic media for making payments.

The basic mechanism through which the overnight interest rate in the interbank market is determined under a "channel" system can be explained using Figure 3. (For the sake of concreteness, I shall describe in particular the system used in New Zealand since March 1999, as I am writing this at the Reserve Bank of New Zealand.) We again focus on the market for bank reserves, which in the countries just referred to are maintained as settlement balances, despite the fact that reserve requirements no longer exist.[15] Under a "channel" system, the central bank chooses a target overnight interest rate (indicated by *TR* in Figure 3), which is periodically adjusted in response to changing economic conditions. This is called the "official cash rate" (OCR) in New Zealand.

In addition to supplying a certain aggregate quantity of settlement cash (which can be adjusted through open-market operations), the central bank offers a lending facility, through which it stands ready to supply an arbitrary amount of additional overnight settlement cash at a fixed interest rate, which is slightly higher than the target

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[13] Again, see Borio (1997) for a comparative survey of international arrangements as of a few years ago.
[14] For details of these systems see, *e.g.,* Archer *et al.* (1999), Bank of Canada (1999), Borio (1997), Brookes and Hampton (2000), Clinton (1997), Reserve Bank of Australia (2000), Reserve Bank of New Zealand (1999), and Sellon and Weiner (1997).
[15] Under the hypothesis of this section --- innovations in payment mechanisms of a kind that would result in a complete abandonment of methods of payment requiring the use of central-bank balances in the event of any cost differential above a small ceiling --- it seems particularly plausible to suppose that reserve requirements would be abandoned, in order to maintain the clearing of payments through the central bank. Hence we shall assume in this section a system under which reserve requirements no longer exist.

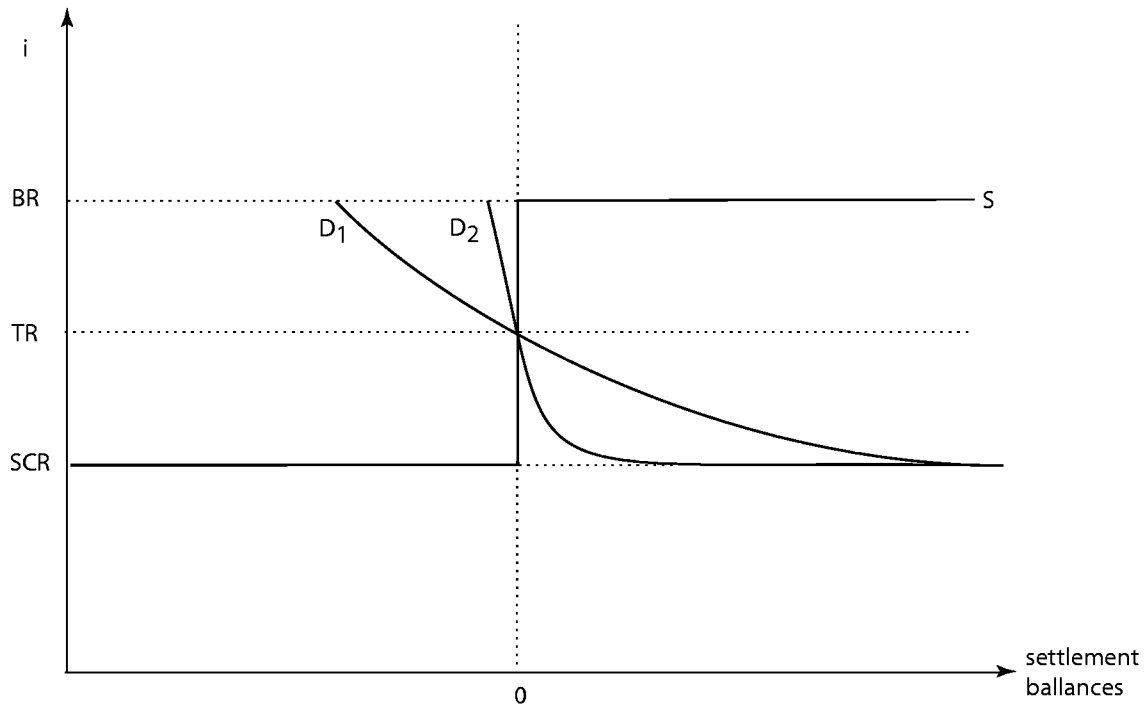

Figure 3. The market for settlement balances (N.Z.)

overnight interest rate. (The lending rate is indicated by the level *BR* in Figure 3, which stands for "Bank Rate", the term for this lending rate in Canada.) In New Zealand, this lending occurs through reverse repo transactions, at the Overnight Repo Facility (ORF), and the ORF rate is generally set exactly 25 basis points higher than the OCR.

Finally, commercial banks that clear transactions through the central bank also have the right to deposit excess settlement cash overnight with the central bank at a deposit rate (indicated by the level *SCR* in Figure 3), which is positive but slightly lower than the target overnight rate. Typically, the target rate is the exact center of the band whose upper and lower bounds are set by the lending rate and the deposit rate, and it is

actually only the latter two rates that have any significance in terms of central bank commitment to intervene in the market for settlement balances.[16] In New Zealand, the deposit rate is called the "Settlement Cash Rate" (hence the label in Figure 3), and is generally set exactly 25 basis points lower than the OCR.[17]

The lending rate on the one hand and the deposit rate on the other define a "channel" within which overnight interest rates should be contained. Because these are both standing facilities (unlike the Fed's discount window in the U.S.), no bank has any reason to pay another bank a higher rate for overnight cash than the rate at which it could borrow from the central bank; similarly, no bank has any reason to lend overnight cash at a rate lower than the rate at which it can deposit with the central bank. Furthermore, the spread between the lending rate and the deposit rate give banks an incentive to trade with one another (with banks that find themselves with excess settlement cash lending it to those that find themselves short) rather than depositing excess funds with the central bank when long and borrowing from the lending facility when short. The result is that the central bank can control overnight interest rates without having to engage in large transactions volumes itself through either of the standing facilities; the bank's willingness to transact in large volume largely eliminates any need for it to do so (Brookes and Hampton, 2000).

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[16] While policy announcements at some central banks, such as the Reserve Bank of New Zealand, emphasize the current setting of a target rate (the OCR in New Zealand) in the center of the "channel" established by the lending and deposit rates, the Bank of Canada instead announces the setting of the Bank Rate (i.e., the lending rate), with the deposit rate being defined as 50 basis points below Bank Rate. However, the center of the channel is still considered to define the Bank's target overnight rate (Bank of Canada, 1999).

[17] A 50 basis-point spread between the lending rate and the deposit rate is also typical under current practice at the Bank of Canada and the Reserve Bank of Australia. However, the Reserve Bank of New Zealand briefly narrowed its channel to a width of only 20 basis points late in 1999, in order to reduce the cost to banks of holding larger-than-usual settlement balances in order to deal with possible unusual liquidity demands as a result of "Y2K" panic. See Hampton (2000) for details of the latter episode.

The two standing facilities result in an effective supply curve for settlement cash of the form indicated by schedule *S* in Figure 3. The vertical segment corresponds to the central bank's settlement cash target (essentially equivalent to the supply of non-borrowed reserves in Figure 1); in the figure this is shown as being zero, since in practice central banks using this sort of system choose a settlement cash target that is very small relative to the size of daily transactions flows in the economy, and that remains largely unchanged from day to day.[18] The horizontal segment to the right at the lending rate (unlike the upward sloping schedule in Figure 1) indicates that overnight borrowing is possible at a standing facility, unlike the Fed's discount window. The horizontal segment to the left at the deposit rate indicates that the payment of interest on deposits puts a floor on how low the equilibrium overnight rate can fall, no matter how low the demand for settlement balances may be. (One may view such a segment as also existing in Figure 1, but at a federal funds rate of zero.)

The equilibrium overnight rate is then determined by the intersection of this schedule with a demand schedule for settlement balances, represented in the figure by the curve D_1. A simple model of the determinants of this schedule is provided by Graeme Guthrie and Julian Wright (2000).[19] Guthrie and Wright model the overnight rate as being

[18] Keeping the equilibrium overnight rate near the target rate seems generally to require a small positive target value for settlement balances. In New Zealand, the settlement cash target under the OCR system has generally been about $20 million NZ. At the Bank of Canada, the target level of settlement balances was actually zero during the early months of the LVTS system, but this led to overnight rates above the target rate (*i.e.,* the center of the channel) on average, and sometimes even above the Bank Rate at times of particular liquidity demand. Since late in 1999, the Bank has switched to targeting a positive level of settlement balances, typically about $200 million Canadian, and this target is increased on days when especially high transactions volume is expected (Bank of Canada, 1999, Addendum II).

[19] Guthrie and Wright introduce their model as a way of explaining how monetary policy was implemented in New Zealand prior to the introduction of the OCR system in 1999; under this system, both the lending rate and the deposit rate were "market-linked," as we discuss further below. However, the Guthrie-Wright analysis of the determinants of the demand for settlement balances given standing facilities of the two types applies equally well in the case that the interest rates associated with the standing facilities are determined

determined in competitive trading among commercial banks, prior to complete knowledge of their end-of-day clearing positions. The trades made in the interbank market thus shift the mean of each bank's probability distribution of possible end-of-day positions, without being able to alter the bank's degree of uncertainty about where it will end up relative to that conditional mean. Each of the risk-neutral banks trades to the point where the marginal reduction in the expected cost of borrowing from the lending facility (in the case that the bank ends up short) by borrowing additional cash on the interbank market exactly matches the marginal increase in the expected loss from having to deposit with the central bank (in the case that the bank ends the day with positive settlement cash). The mean end-of-day position that each bank will target will thus depend upon where the interest rate in the interbank market lies relative to the two boundaries of the channel; the closer the interbank rate is to the deposit rate, the greater the positive level of settlement balances that each bank will wish to target, as the cost of being short is increased relative to the cost of ending the day with excess cash. (Once the interbank rate falls to the level of the deposit rate, there is no opportunity cost to holding additional settlement cash, and so if there is any risk at all of a large negative payment flow late in the day, a bank's target level of settlement cash should become very large, as assumed in Figure 3.)

The specific relation implied by the model of Guthrie and Wright takes the form

$$F(-C/V) = (OR-SCR)/(BR-SCR) \qquad (2)$$

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in some other way, and we use it here for that purpose. Similar models are discussed in Grimes (1992) and in Henckel *et al.* (1999).

where C is the quantity of settlement cash targeted the banks (through trades in the interbank market) as a function of the overnight rate OR in that market.[20] Here BR and SCR are the lending and deposit rates, as in Figure 3, V is a parameter that scales the banks' uncertainty about their end-of-day cash positions, and $F(x)$ denotes the probability that end-of-day cash will be no more than Vx greater than its expected value. The fact that the cumulative distribution function F is increasing means that C will be a decreasing function of OR, as indicated by the schedule D_1 in Figure 3.

Symmetry of the probability distribution of possible levels of end-of-day cash then implies that each bank will target a zero end-of-day balance if the overnight rate is exactly halfway between the deposit rate and the lending rate. Hence the schedule D_1 in Figure 3 implies zero aggregate desired settlement cash when the overnight rate exactly equals the target rate. This implies that a settlement cash target of zero on the part of the central bank should achieve an overnight rate equal to the target rate, regardless of what that target interest rate may be. In practice, it seems that a small positive level of aggregate settlement balances are typically desired when the overnight rate remains in the center of the channel. The more important prediction of the model, however, is that the demand for settlement balances should be a function of the location of the overnight rate *relative to the lending rate and deposit rate,* but *independent* of the absolute *level* of any of these interest rates. This means that an adjustment of the level of overnight rates by the central bank need not require any change in the supply of settlement cash, as long as the location of the lending and deposit rates relative to the target overnight rate do not change.

[20] Grimes (1992) derives a similar relation in a model with lending and deposit facilities of the kind just described. However, the inter-bank market for overnight cash is not modeled by Grimes; in his model, it is

Thus under a "channel" system like New Zealand's, changes in the level of overnight interest rates are brought about by simply announcing a change in the OCR, which has the implication of changing the lending and deposit rates at the central bank's

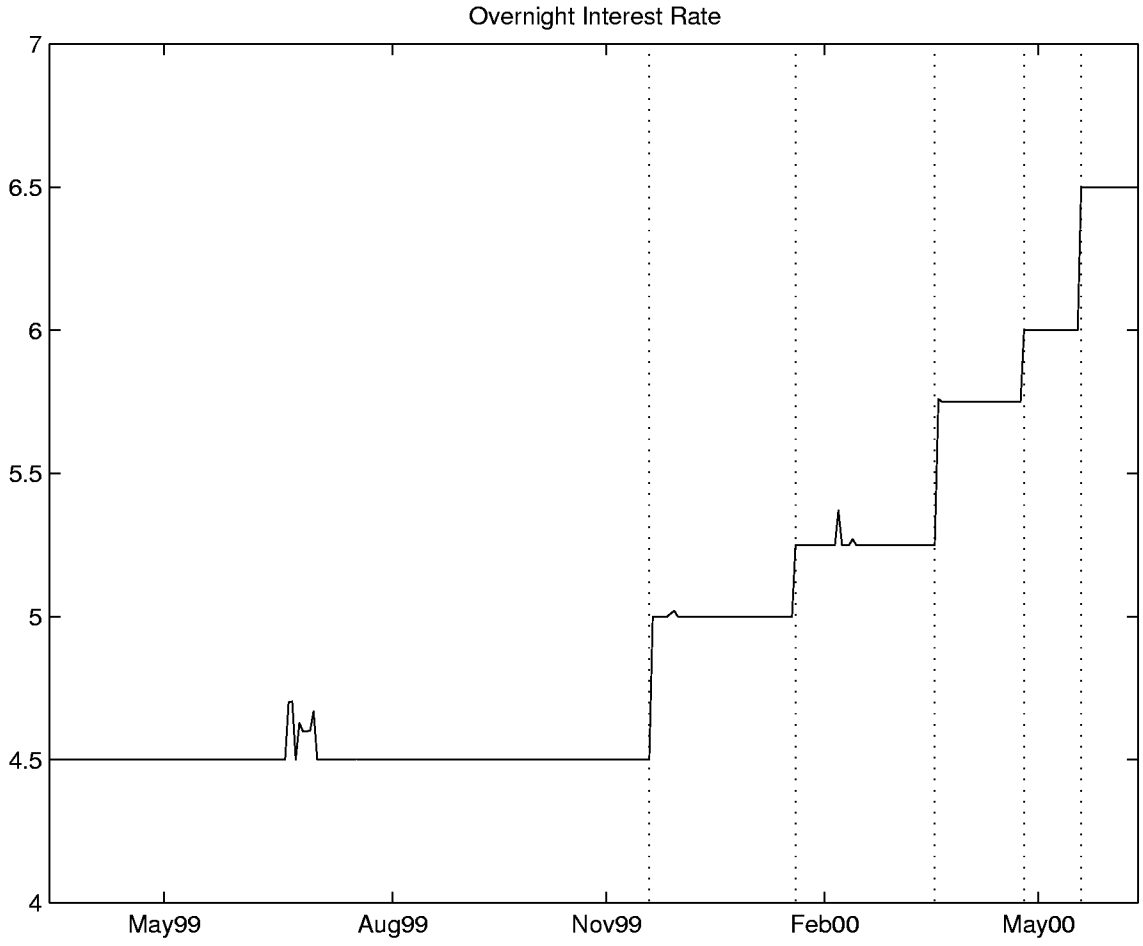

Figure 4. Overnight cash rate under the OCR system (New Zealand).

standing facilities; no quantity adjustments in the Reserve Bank's settlement cash target are required.[21]

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the equilibrium interest rate on bank loans that plays the role of *OR* in equation (2).

[21] Guthrie and Wright (2000) document the fact that under the system used in New Zealand prior to 1999, interest-rate changes were also achieved without any change in the Reserve Bank's settlement cash target,

The degree to which the system succeeds in practice is shown in Figures 4 and 5. Figure 4 plots the New Zealand overnight interest rate since the adoption of the OCR system in March 1999. (Here the vertical lines mark the dates of the five increases in the OCR during this period.) One observes that the overnight interest rate is extremely

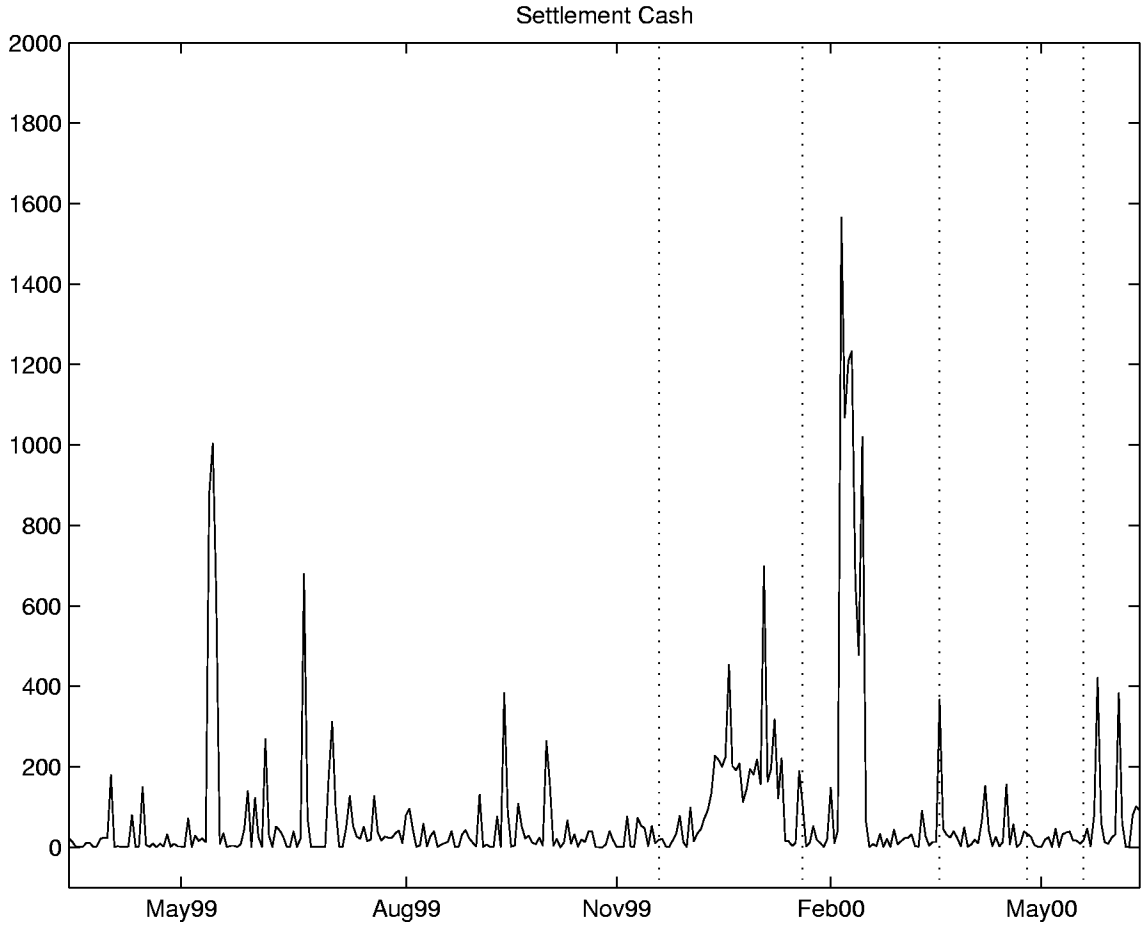

Figure 5. Settlement cash balances under the OCR system (New Zealand).

stable between adjustments of the OCR; in fact, it is exactly equal to the OCR (to the nearest basis point) on all but 11 days within the sample period. And on the dates at which the OCR was raised by either 25 or 50 basis points, the overnight interest rate

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though under that regime the lending and deposit rates adjusted automatically in response to market interest-rate movements, rather than as a direct result of a policy decision of the Reserve Bank.

immediately jumped to equal the new target rate. As shown in Figure 5, these dates were not associated with reductions of the aggregate level of settlement cash. Thus the ability of the Reserve Bank to "tighten" policy is in no way dependent upon the creation of a greater "scarcity" of bank reserves. This is a direct consequence of the fact that interest rates are raised under this system without any attempt to change the *spread* between market rates of return and the interest paid on bank reserves.

This does not mean that the supply of settlement cash has become completely irrelevant for overnight interest-rate determination. The degree to which the overnight interest rate tracks the OCR in New Zealand at present is due to an implicit convention among the commercial banks, according to which overnight cash is lent among them at the OCR rather than any other rate. This convention obviously simplifies negotiations among the banks, and does not represent a great departure from the trade that would result from an idealized competitive auction market, if the equilibrium demand for settlement cash is approximately that predicted by the model described above.[22] On the other hand, the convention comes under pressure when desired liquidity (at an interest rate equal to the OCR) is too great relative to the Reserve Bank's settlement cash target.

In general, the Reserve Bank of New Zealand does still engage in daily open market operations, to offset changes in the supply of settlement cash (owing to changes in

[22] This particular convention is presumably one of a large number of patterns of exchange that could be sustained as a Nash equilibrium of the repeated game played by the relatively small number of banks that clear payments with one another in New Zealand. Note that each bank's reservation level of expected profits would be the one that would result from a refusal of other banks ever to trade with it in the interbank market, in which case it would always have to borrow from the central bank when short and deposit with the central bank when long at the end of the day. Since the variability of each bank's end-of-day position (in the absence of interbank lending of settlement cash) is large relative to the average level of settlement cash per bank, this would imply a significant expected loss from the spread between the lending rate and deposit rate, relative to what can be achieved by trading in the interbank market so as to never hold much more than the average level of settlement cash. The size of the possible losses from failure to cooperate can be judged from the size of the increases in aggregate settlement cash on those occasions when cooperation has actually broken down, namely in May 1999 and February 2000.

the demand for currency or to government payments, for example) that would otherwise occur. If these "liquidity management operations" did not occur, the supply of settlement cash would be quite variable relative to its average level,[23] and the convention of trading overnight cash at the OCR would likely be unsustainable on most days. Indeed, on at least two important occasions since the introduction of the OCR system in New Zealand (in May 1999 and February 2000), large government payments have meant that the Reserve Bank has been unable to conduct "liquidity management operations" of sufficient size to prevent a shortage of settlement cash from developing.[24] On these occasions, banks with excess settlement cash have not been willing to lend at the OCR, so that the overnight rate has temporarily risen above the OCR.[25] It is quite possible that more frequent occurrences of a similar sort would break down the convention altogether.

Furthermore, it is clear that the Reserve Bank would be able to force a change in overnight rates, should it wish to, through a sufficiently drastic change in the settlement cash target. This can be illustrated by the occasional use of this tool by the Reserve Bank prior to the introduction of the OCR system, when the interest rates associated with the standing facilities were given by a fixed spread over "market" interest rates.[26] That system relied upon market interest rates to follow a suggested path indicated by Reserve Bank announcements; upon occasion, a failure of market rates to follow the Reserve

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[23] See, *e.g.,* Figure 6 in Brookes (1999).

[24] I am grateful to Andy Brookes for discussion of these episodes.

[25] On these occasions, the "short" banks have resisted the attempts of "long" banks to lend their excess balances at a rate above the OCR, and instead in many cases have borrowed from the Overnight Repo Facility despite the higher interest rate, leaving the "long" banks to deposit their funds with the Reserve Bank. The result was very large temporary surges in aggregate settlement balances, owing to the breakdown of cooperation; these can be seen in Figure 5. The possibility of such events from time to time, of course, despite the efforts of the Reserve Bank to target the aggregate quantity of settlement cash through "liquidity management operations" and despite the mutual interest of the commercial banks in trading among themselves to avoid use of the standing facilities, is an important reason why variation in the settlement cash target is not a useful tool for achieving the Reserve Bank's desired variations in overnight interest rates.

Bank's suggestions required action by the Reserve Bank to demonstrate its capacity to intervene if necessary. For example, a failure of interest rates to rise as suggested by the Reserve Bank in the last two weeks of 1992 resulted in the settlement cash target being cut from $20 million NZ to zero on January 7, 1993. This resulted in an immediate 500 basis point increase in overnight interest rates, and significant increases in longer rates as well.[27] However, under a system with zero reserve requirements like New Zealand's, this sort of quantity adjustment seems a rather blunt instrument, one that could be used to "discipline" the banks but that would not provide a precise means of directly achieving a desired level of overnight interest rates without the use of other means of guiding the banks to that level.

Given a "channel" system for the implementation of monetary policy like that currently used in New Zealand and several other countries, there is little reason to fear that either the development of "electronic cash" for retail transactions or of alternative electronic methods of settlement of payments among banks should threaten a central bank's ability to control the path of overnight nominal interest rates, and through them spending and pricing decisions in the economy. Let us first consider the possibility of the replacement of currency by "electronic cash" of one kind or another. Once again, this would merely *simplify* the task of controlling overnight interest rates using a "channel" system, by eliminating one source of variations in total settlement cash that have to be offset by "liquidity management operations" on the part of the central bank. Similarly, the development of systems that payments to be made without holding any significant wealth in bank deposits subject to reserve requirements poses no threat, as we have seen

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[26] See Huxford and Riddell (1996) and Guthrie and Wright (2000).
[27] See Guthrie and Wright (2000, sec. 3.1).

that a "channel" system is perfectly effective in the absence of bank reserves held to satisfy reserve requirements.

A more subtle question would be the consequences of improvements in the ability of banks to accurately forecast their end-of-day cash positions, allowing them to maintain their end-of-day positions nearer to exactly zero. This would correspond to a secular decrease in the parameter V in equation (2), so that according to the Guthrie-Wright model, the demand curve for settlement balances would shift from D_1 to something like D_2 in Figure 3. However, such a development would not change the fact that desired settlement balances are a function of the location of the overnight rate within the channel rather than of the absolute level of overnight rates, so that it should still be possible to move the overnight rate by simply moving the lending and deposit rates, holding fixed the settlement cash target.[28]

The only possible problem would result from the demand for settlement balances becoming less interest-elastic (as shown in the figure). This could significantly increase the need for precisely calibrated open-market operations in order to prevent variations in settlement cash of a size sufficient to shift the location of the equilibrium overnight rate within the channel to an undesirable extent. But this problem could be dealt with by shrinking the width of the channel. This would obviously limit the size of possible variations in the overnight rate. But even more, equation (2) implies that the elasticity of the demand for settlement balances is increased by narrowing the spreads between the deposit rate, the target rate and the lending rate, reducing the size of the shift in the

[28] A similar conclusion was reached in the pioneering analysis of Grimes (1992). The conclusion to that paper considers a future in which uncertainty about end-of-day cash positions has been eliminated as a result of "real-time banking accompanied by a continuously operating, competitive interbank market." Grimes argues that such a development would undermine the effectiveness of open-market operations as

equilibrium overnight rate that should result from a given size forecast error in the central bank's "liquidity management operation". Thus an appropriate reduction in the width of the channel can fully offset the effect on the elasticity of demand resulting from the reduction in V. Furthermore, the main reason for not choosing too narrow a channel --- concern for the degree to which the standing facilities might be resorted to in this case instead of reallocation of cash among banks through the interbank market (Brookes and Hampton, 2000) --- becomes less of a concern under our hypothesis of improved forecastability of end-of-day positions, so a narrower channel would seem entirely reasonable.

Finally, let us consider the threat that may be posed by the development of payment systems that do not require payments to be cleared using central-bank settlement balances. In the sort of world imagined by Mervyn King (1999), there would be no *necessity* for clearing payments using accounts held with the central bank at all. What this would mean (assuming that the problems with assuring parties of the finality of payments not guaranteed by the central bank could be solved) is that there would be a limit on the costs that clearing payments through the central bank could impose upon the banks, before they would choose to simply abandon the use of that clearing system. But even granting this, it is not obvious that banks should cease to settle payments through the central bank.

For the success of a "channel" system of interest-rate control does not depend upon the imposition of any significant costs upon commercial banks (similar to those resulting, for example, from a requirement to hold non-interest-earning reserves). As we

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instrument of policy, but that the central bank should still be able to control interest rates, and hence the price level, by varying the interest rate paid at the central bank's deposit facility.

have seen, a system without reserve requirements like New Zealand's results in extremely low aggregate settlement balances at most times, and the spread between market overnight rates and the interest paid on these balances is relatively modest (only 25 basis points at present). And the sorts of improvements in information technology that we have hypothesized should only make these costs lower: banks should be able to maintain lower average settlement balances by forecasting their end-of-day cash position more precisely, and central banks should be willing to reduce the width of their channels under such circumstances.

There are a variety of reasons why clearing payments through the central bank ought to remain attractive, even in the absence of a legal requirement to do so, as Charles Freedman (2000) stresses. These include the fact that the creditworthiness of the central bank cannot be doubted, and the fact that banks will need to clear at least some payments through the central bank if the government maintains its own account with the central bank.[29] But even if many payments came to be cleared through some independent mechanism, and indeed even if a settlement account at the central bank ceased to be of any interest whatsoever as a convenient way of clearing payments arising out of private transactions, there should still be no reason why the central bank could not continue to determine the level of overnight interest rates with a high degree of precision.

For the logic of the method of interest-rate control sketched above does not really depend upon the continued use of central bank settlement balances as a means of clearing payments between banks. Let us suppose that balances held with the central bank ceased

[29] Both of these arguments do depend upon the government not severing its traditional links with the central bank. But a privileged relation between the central bank and the government does not restrict private transactions in the way that regulations suppressing the development of private clearing mechanisms would.

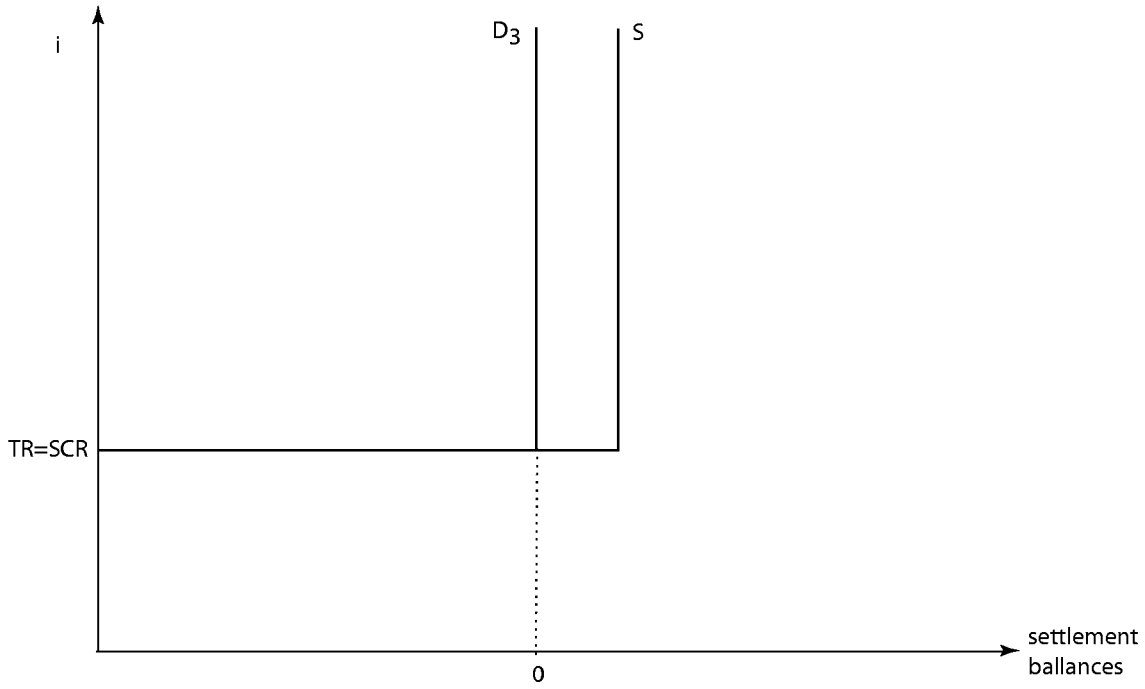

Figure 6. The interbank market when central-bank balances are no longer used for clearing purposes.

to be any more useful to commercial banks than any other equally riskless overnight investment. In this case, the demand for settlement balances would collapse to a vertical line at zero for all interest rates higher than the settlement cash rate, as shown in Figure 6, together with a horizontal line to the right at the settlement cash rate. That is, banks should still be willing to hold arbitrary balances at the central bank, as long as (but only if) the overnight cash rate is no higher than the rate paid by the central bank. In this case, it would no longer be possible to induce the overnight cash market to clear at a target rate higher than the rate paid on settlement balances. But the central bank could still control the equilibrium overnight rate, by choosing a positive settlement cash target, so that the

only possible equilibrium would be at an interest rate equal to the settlement cash rate, as shown in Figure 6.

Such a system would differ from current channel systems in that an overnight lending facility would no longer be necessary, so that there would no longer be a "channel". (This presumes a world in which no payments are cleared using central-bank balances. Of course, there would be no harm in continuing to offer such a facility as long as the central-bank clearing system were still used for at least some payments.) And the rate paid on central-bank balances would no longer be set at a fixed spread below the target overnight rate; instead, it would be set at exactly the target rate. But perfect control of overnight rates should still be possible through adjustments of the rate paid on central-bank balances, and changes in the target overnight rate would not have to involve any change in the settlement cash target, just as is true under current channel systems.

The Source of Central-Bank Control over Short-Term Interest Rates

In contemplating this final, most radical possibility, we are led back to the puzzle upon which Benjamin Friedman (1999) remarks: how is it that such small trades by central banks can move rates in such large markets? In the complete absence of any monopoly power on the part of central banks (because their liabilities no longer supply any services not also supplied by other equally riskless, equally liquid financial claims), it might be thought that any remaining ability of central banks to affect market rates should depend upon a capacity to adjust their balance sheets by amounts that are large relative to the overall size of financial markets. One might still propose that central banks should be able to engage in trades of any size that turned out to be required, owing to the fact that

the government stands behind the central bank and can use its power of taxation to make up any trading losses, even huge ones. (This seems to be the position of Goodhart, 2000.)

But I shall argue instead that massive adjustments of central-bank balance sheets would not be necessary in order to move interest rates, even in a world where central-bank liabilities ceased to supply any services in addition to their pecuniary yield. Note that in the situation depicted in Figure 6, the central bank can raise the equilibrium overnight rate without any change in the quantity of central-bank balances at all. Furthermore, the constant supply of central-bank liabilities (the settlement cash target, in the terminology used under current channel systems) can be quite small relative to the overall volume of financial transactions in the economy, though it needs to be positive.

Why is this possible? Certainly, if a government were to decide to peg the price of some commodity (say, oil), it might be able to do so, but only by holding stocks of the commodity that were sufficiently large relative to the world market for that commodity, and by standing ready to vary its holdings of the commodity by large amounts as necessary. What is different about controlling short-term nominal interest rates?

The key to an answer is to note that there is no inherent "equilibrium" level of interest rates to which the market would tend in the absence of central-bank intervention, and against which the central bank must exert a significant countervailing force in order to achieve a given operating target. This is because there is no inherent value (in terms of real goods and services) for a fiat unit of account such as the "dollar", except insofar as a particular exchange value results from the monetary policy commitments of the central bank. Alternative price-level paths are thus equally consistent with market equilibrium in

the absence of intervention, and associated with these alternative paths for the general level of prices are alternative paths for short-term nominal interest rates.

Even recognizing this, one might suppose, as Fischer Black (1970) once did, that in a fully deregulated system the central bank should have no way of using monetary policy to select among these alternative equilibrium; the path of money prices (and similarly nominal interest rates, nominal exchange rates, and so on) would then be determined solely by the self-fulfilling expectations of market participants.[30] From whence does any special role of the central bank in equilibrium determination derive?

The answer is that the unit of account in a purely fiat system is *defined* in terms of the liabilities of the central bank.[31] A financial contract that promises to deliver a certain number of "dollars" at a specified future date is promising payment in terms of settlement balances at the central bank (the Fed in the case of the U.S. dollar, the Reserve Bank in the case of the N.Z. dollar, and so on), or in terms of some kind of payment that the payee is willing to accept as a suitable equivalent. In the technological utopia imagined by Mervyn King, financial market participants are willing to accept as final settlement transfers using electronic networks in which the central bank is not involved; but settlement balances at the central bank still define the thing to which these other claims are accepted as equivalent.[32]

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[30] Bengtsson (2000) offers a recent example of a similar view, but allows for the possibility that the central bank can provide a "focal point" that serves to coordinate the expectations of private parties upon a particular future path of prices, making this path self-fulfilling.

[31] See Hall (1999) for a similar view.

[32] White (2000) makes much the same point, stressing the role of legal tender statutes in defining the meaning of a particular currency such as the New Zealand dollar. It is important, however, to stress that such statutes do not represent a restriction upon the means of payment that can be used within a given geographical region --- or at any rate that there need be no such restrictions upon private agreements for White's point to be valid. What matters is simply the definition of what contracts written in terms of a particular unit of account are taken to mean.

This explains why the nominal interest yield on settlement balances at the central bank can determine overnight rates in the market as a whole. The central bank can clearly define the nominal yield on overnight deposits in its settlement accounts as it chooses (it is simply promising to increase the nominal amount credited to a given account, after all). It can also allow banks to exchange such deposits among themselves on whatever terms they like. But the market value of a dollar deposit in such an account cannot be anything other than a dollar --- *because this defines the meaning of a "dollar"!*

This is not possible for a private financial institution, which can offer to the market liabilities that promise to pay a certain number of dollars in the future, but must accept the market's view as to the number of dollars that such liabilities are worth at present. More precisely, even if the liabilities of the private entity are not regarded as perfect substitutes for other financial instruments, it cannot indetermine *both* the quantity that it issues *and* the nominal yield on the investment --- it must either auction a certain quantity and let the market determine the price (and hence the yield), or it can announce a yield and see what quantity the market will buy. But a central bank can determine both the quantity of settlement balances in existence and the nominal yield on those balances; banks do so daily. And the power to do so does not depend upon the non-existence of close substitutes for these liabilities of the central bank. The central bank's position as monopoly supplier of an asset that serves a special function is necessary in order for variations in the quantity supplied to affect the yield *spread* between this asset and other market yields, but not in order to allow separate determination of the yield on central bank liabilities and the quantity of them in existence.

The special feature of central banks, then, is that they are entities the liabilities of which happen to be used to define the unit of account in a wide range of contracts that other people exchange with one another. There is perhaps no deep, universal reason why this need be so; nor, perhaps, is it essential that there be one such entity per national political unit. One might imagine, as Friedrich Hayek (1986) did, a future in which private entities manage competing monetary standards in terms of which people might choose to contract. But even in such a world, the Fed would still be able to control the exchange value of the U.S. dollar, the Reserve Bank of New Zealand would be able to control the exchange value of the New Zealand dollar, and so on, by adjusting the nominal interest rates paid on the respective central banks' liabilities.

The only real question about such a future is how much the central banks' monetary policies would *matter.* This would depend upon how many people still chose to contract in terms of the currencies the values of which they continued to determine. Under present circumstances, it is quite costly for most people to attempt to transact in a currency other than the one issued by their national government, and under these conditions, the central bank's responsibility for maintaining a stable value for the national currency is a grave responsibility. In a future in which transactions costs of all sorts have been radically reduced, that might no longer be the case, and if so, the harm that bad monetary policy can do would be reduced. Nonetheless, it would surely still be convenient for contracting parties to be able to make use of a unit of account with a stable value, and the provision and management of such a standard of value would still be a vital public service. Thus central banks that demonstrate both the commitment and the

skill required to maintain a stable value for their countries' currencies should continue to have an important role to serve in the century to come.

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