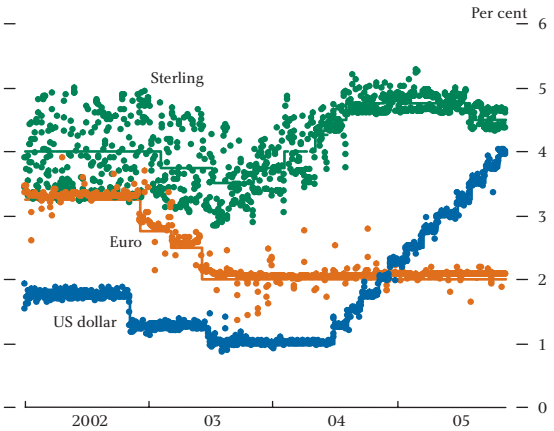
Stabilising short-term interest rates

By Seamus Mac Gorain of the Bank's Foreign Exchange Division.

This article describes how the Bank's new arrangements for implementing the Monetary Policy Committee's interest rate decisions should tie market interest rates more closely to the Committee's official rate. In the new framework, banks and building societies will be able to hold an average level of reserves at the Bank over a month-long 'maintenance period'. The article shows that the Bank's commitment to adjusting the supply of reserves on the final day of the maintenance period should ensure that the market rate is expected to be on target on that day. It also describes how the ability of scheme members to run their reserve balances up and down from day to day in response to changes in market rates should mean that the rate expected on the final day of the maintenance period prevails over the rest of the period.

Next year, the Bank of England will adopt new arrangements for implementing the Monetary Policy Committee's interest rate decisions through operations in the sterling money market. The primary reason for reforming the Bank's current operations is that they leave sterling overnight rates more volatile than is desirable, as evidenced by comparison with market rates in other major currencies (Chart 1).(1) The Bank's reforms also aim to bring about: an efficient, safe and flexible framework for banking system liquidity management; a simple, straightforward and transparent operational framework; and competitive and fair sterling money markets. This article focuses on the Bank's main objective of reducing the volatility of sterling interest rates at maturities out to the date of the next scheduled MPC policy decision, and describes how the new framework should tie these short-term market interest rates more closely to the Bank's official rate.

Chart 1
Overnight interest rates and policy rates(a)



Source: Bloomberg.

(a) Lines are policy rates and dots are overnight interbank interest rates.

As described in detail by Clews (2005), the new framework will be based on extending the ways in which banks and building societies can deal with the Bank.(2) In the current system, the settlement banks have to balance their accounts at the Bank each day. In the new framework, a wider group of banks will be able to commit to holding an average level of balances (reserves) at the Bank over a 'maintenance period', which will run from one MPC decision date to the next. In advance of each maintenance period, the banks will be free to choose a target level of reserves between zero and the larger of £1 billion or 2% of their eligible liabilities.(3) Banks will not be obliged to meet their reserve targets precisely: provided average reserves over the maintenance period are within a range of +/– 1% around the reserve target, they will be remunerated at the MPC's official interest rate. However, banks will be penalised if their average reserves fall outside the range or if their accounts at the Bank are overdrawn on any day.

(1) The volatility of overnight rates has been lower since the Bank announced that it was to review its money market operations. And longer-maturity money market rates have generally tended to be much less volatile than overnight rates (see Vila Wetherilt (2002)).
(2) The term 'banks' will be used to refer to both banks and building societies in the rest of this article.
(3) Eligible liabilities are a measure of banks' sterling deposit liabilities (net of interbank deposits).

The Bank will also make unlimited overnight standing lending and deposit facilities available. The rates on these facilities will be 25 basis points above and below the official interest rate on the final day of the maintenance period, and 100 basis points above and below on other days. The Bank will also conduct open market operations(1) each week, and on the final day of the maintenance period, in order to ensure that the supply of reserves is as close as possible to the level that will enable banks to meet their reserve targets.

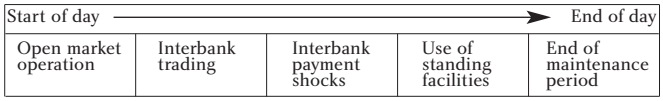
This article will first discuss how the Bank's commitment to adjust the supply of reserves on the final day of the maintenance period should mean that banks expect the market rate to be on target on that day. It will then show that the narrow spread between the lending and the deposit facilities on the final day of the period, as well as the range for reserve targets, should dampen interest rate volatility on that day. Finally, it discusses how the flexibility that reserve averaging gives banks in their liquidity management should mean that the interest rate expected on the final day of the maintenance period prevails over the rest of the period. The article summarises the Bank's work to model the new arrangements; a forthcoming Bank working paper will present these results in more detail.

The final day of the maintenance period

On the final day of the maintenance period, banks must meet their reserve targets. This means that the final day of the period is in effect a one-day maintenance period system, like the Bank's current system. As described earlier, on the final day banks will be allowed to borrow (against collateral) from the Bank in unlimited quantities at a rate 25 basis points above the official rate, and to deposit unlimited quantities at a rate 25 basis points below the official rate. As no bank would borrow in the money market at more than the lending facility rate, or lend funds for less than the deposit facility rate, the standing lending and deposit facilities should create a binding symmetrical 'corridor' for the market rate. Where the rate lies within the corridor should depend on the likelihood that banks will have to make use of each of the standing facilities. This should depend in turn on the accuracy of the Bank's supply of reserves, and the uncertainty faced by banks over their end-of-day balances at the Bank.

A simple model of a one-day maintenance period can illustrate the impact of these factors on the overnight interest rate.(2) However, a stylised model of this kind may not be a perfect guide to interest rate behaviour in the Bank's new system; as such, the article refers to 'the central bank' rather than 'the Bank' in describing the model results. Chart 2 shows the sequence of events over the course of the day in this model. The central bank conducts an open market operation at the start of the day, attempting to supply the correct amount of funds for the market rate to be on target, consistent with the central bank's policy rate. However, in choosing its supply of funds, it must make a forecast of factors other than open market operations which may affect the supply of reserves, including changes in banknotes in issue, and other movements of funds across the central bank's balance sheet. Because of uncertainty over these 'autonomous factors', errors will inevitably occur in the central bank's supply of funds.

Chart 2
Simple one-day maintenance period model



After the open market operation, a large number of banks trade the available reserves among themselves in a perfectly competitive money market. However, at the time of trading, they are still unsure of their individual end-of-day balances at the central bank, although they are assumed to know the size of the central bank's forecast error. This is because late payments from other banks could mean that their final balances are above or below their reserve target.(3) Suppose that banks must meet their reserve targets exactly. As such, if a bank's final balance is below its reserve target, it must make up the shortfall by borrowing at the central bank's overnight standing lending rate (in order to avoid the larger interest charges for missing its target). On the other hand, if a bank exceeds its reserve target, it must deposit the excess funds at the central bank's overnight standing deposit rate (or else they will receive no interest on these funds).

(1) In its open market operations, the Bank lends funds (against collateral) to the banking system at its official interest rate.
(2) The model is based on one proposed by Woodford (2001), among others. Bindseil (2004) discusses more complex models of overnight interest rate determination.
(3) For simplicity, throughout this article we assume that interbank payments uncertainty is the only source of uncertainty over banks' end-of-day balances. But in practice it is one of a number of sources of such uncertainty; others include the possibility of bookkeeping and operational errors.

In this model, banks base their choice of what quantity of funds to borrow or lend in the interbank market on the probability of having to use each standing facility. This means that the market rate is an average of the rate on the deposit facility and the rate on the lending facility, weighted by the probability of having to use each facility, that is to say the probabilities of exceeding and falling short of the reserve target respectively.(1) Because the interest rate corridor is symmetric, the market rate should match the official rate when these probabilities are equal. Provided the uncertainty faced by banks over their end-of-day balances is symmetrically distributed, this will happen when the funds supplied by the central bank equal the sum of the reserve targets of commercial banks plus any additional funds to offset the day's changes in autonomous factors, and when these funds are distributed optimally among banks.(2)

Even though the central bank aims to supply the correct amount of funds for the market rate to be on target, the difficulty of forecasting the autonomous factors means that errors in central bank supply are unavoidable. If the central bank's forecast errors are small relative to the uncertainty about payments faced by commercial banks, then any forecast error will have little effect on banks' expected likelihood of using the standing facilities — the error in central bank supply will be dwarfed by the uncertainty over possible unexpected late payments from other banks. But if the central bank's forecast errors are relatively large, they would significantly change the probability of using one or other of the standing facilities, and therefore move market interest rates. For example, a large positive error in central bank supply — an oversupply of funds — would increase the likelihood of banks using the deposit facility, and so would lead market rates to fall.(3)

To demonstrate this relationship, Charts 3 and 4 show the aggregate reserve demand curve in the model described above given two different levels of payment uncertainty. The market rate is given by the intersection of the demand curve with the central bank's supply (shown by the vertical lines). The lower the level of payments uncertainty, the steeper the demand curve, and so the greater the effect of a central bank forecast error on the market rate. For example, if banks faced no payments uncertainty at all, then the demand curve would be vertical at the optimal level of central bank supply; any central bank forecast error would leave banks certain of using the standing facilities, and so would move the market rate to the edge of the interest rate corridor. So the size of the central bank's forecast errors relative to commercial banks' uncertainty about payments determines the position of the market rate within the interest rate corridor, and hence the level of the market rate on any given day.

Chart 3
Illustrative demand curve

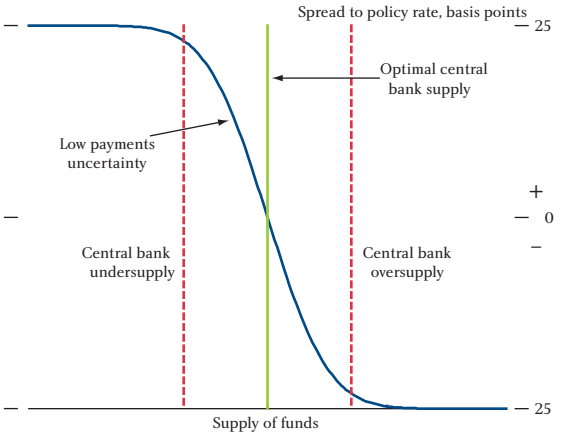
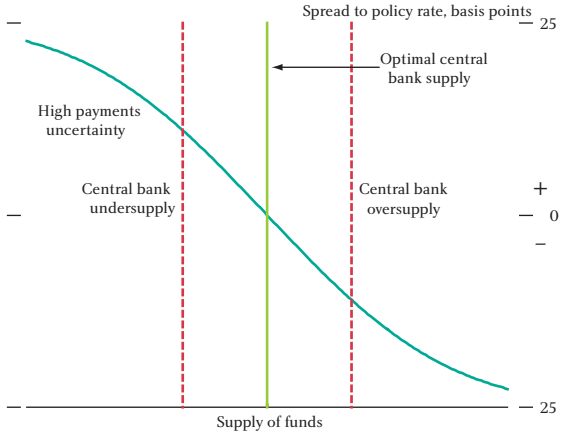


Chart 4
Illustrative demand curve

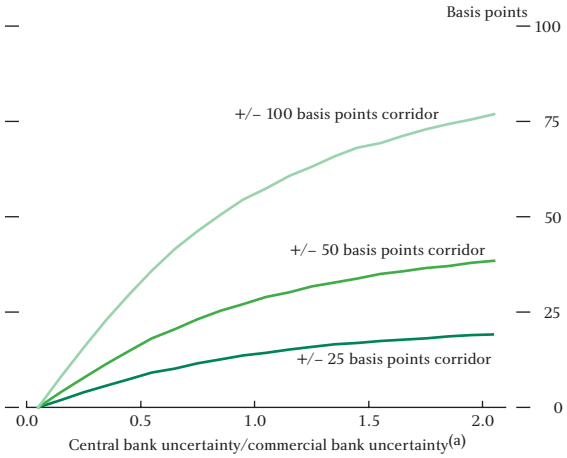


Provided that the central bank's forecast errors are symmetrically distributed around zero, banks will be equally as likely to exceed their reserve targets as to fall short of them. So, on average, the market rate should be on target. If banks expect the Bank to supply the correct amount of reserves for them to meet their reserve targets on the final day of the maintenance period, then they should expect the market rate to be on target on that day.

(1) The determination of the market interest rate is discussed in more detail in the technical appendix.
(2) That is, distributed in such a way as to minimise the expected aggregate recourse to the standing facilities.
(3) See Whitesell (2003) for a discussion of the effect of central bank forecast errors and commercial banks' uncertainty over their end-of-day balances on the market rate.

With regard to the volatility of the market rate, Chart 5 shows that interest rate volatility is higher when the central bank's forecast errors are large relative to commercial banks' payments uncertainty.(1) It also shows that, because the market rate is a combination of the lending rate and the deposit rate, volatility is proportional to the width of the interest rate corridor. This implies that the narrower corridor of +/– 25 basis points on the final day of the maintenance period in the Bank's new system should bring lower volatility than a wider corridor.

Chart 5
Interest rate volatility



(a) The ratio of the standard deviation of the central bank's forecast errors to the sum across commercial banks of the standard deviation of their payment shocks.

The range for reserve remuneration

Rather than requiring banks to meet their reserve targets exactly, the Bank will remunerate average reserve holdings at the official interest rate provided they fall within a range of +/– 1% of the point target. This 'reserve range' should mitigate the effect of central bank forecast errors on the market rate. This is because it reduces the probability that the standing facilities will be used, as small deviations from the reserve target will simply result in a higher or lower balance within the reserve range, rather than forcing banks into the standing lending or deposit facilities. A range of +/– 1% should be sufficiently large to absorb most likely errors in the Bank's liquidity forecast on the final day of the maintenance period, based on forecast errors over the past five years.

In the stylised model described above, with a reserve range, the market rate is a combination of the lending rate, the deposit rate, and the reserve remuneration rate (which, in this case, is the official interest rate), weighted by the probability of falling short of the reserve range, exceeding it, or falling within the range. This means that the range creates a flat portion of the aggregate demand curve around the level of supply consistent with banks meeting their reserve targets precisely, as shown in Charts 6 and 7. The larger the reserve range, the more closely the market rate is anchored to the remuneration rate. For example, an infinitely large range (with no penalty for daily overdrafts) would imply that the central bank was prepared to borrow and lend in unlimited quantities at the remuneration rate, so that the market rate would be identically equal to the remuneration rate.(2) As with the conventional corridor system, the market rate will be on target if the central bank supplies funds equal to the banks' reserve targets, as well as the correct amount to offset any changes in the autonomous factors.

Chart 6
Illustrative demand curve

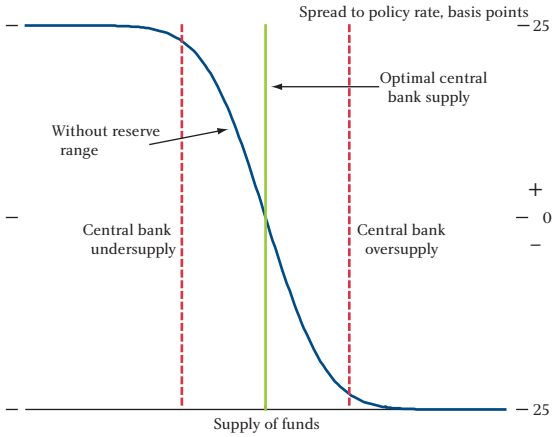
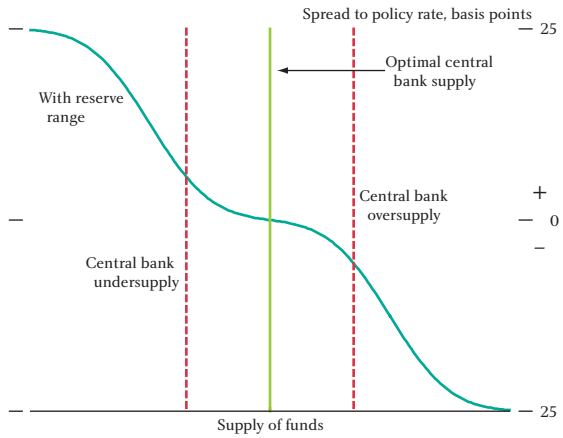


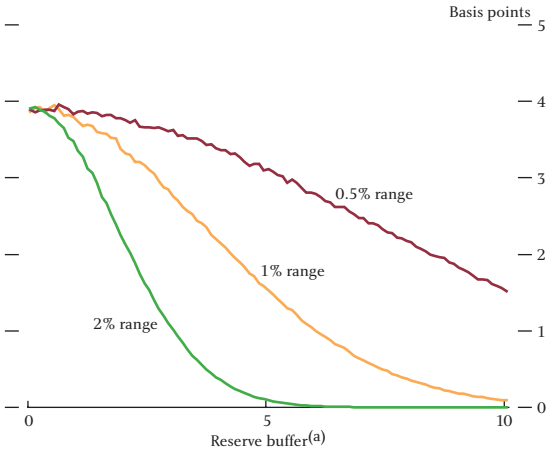
Chart 7
Illustrative demand curve



(1) The chart is based on a large number (20,000) of simulations of the one-day model described above.
(2) While an infinitely large range should tie down the market rate, it would have several disadvantages. In particular, if banks were permitted to run their balances at the central bank up and down without limit instead of dealing with other banks, the money market could become less liquid and the central bank's balance sheet might become very large.

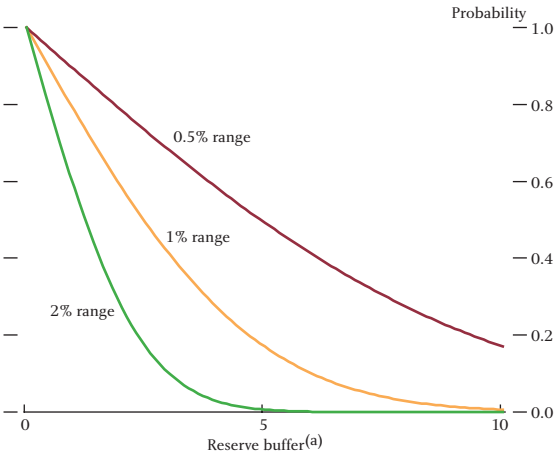
The effectiveness of the reserve range in lessening volatility will depend, among other things, on the level of reserve targets chosen by banks. Chart 8 shows how the volatility of the market rate depends on the size (in money terms) of the reserve range, which depends in turn on the reserve targets chosen by banks (shown in the chart as 'reserve buffers' — the ratio of reserve targets to banks' payments uncertainty), and on the percentage width of the range around these targets (each line in the chart represents a different percentage width).(1) This is because the larger the reserve range, the less likely banks are to be forced to make use of the standing facilities as a result of central bank forecast errors or late payments from other commercial banks, as shown in Chart 9.

Chart 8
Illustrative rate volatility
(Central/commercial bank uncertainty = 1/5)



(a) The ratio of aggregate reserve targets to the sum of the standard deviation of payment shocks across commercial banks.

Chart 9
Probability of using standing facilities
(Central/commercial bank uncertainty = 1/5)



(a) The ratio of aggregate reserve targets to the sum of the standard deviation of payment shocks across commercial banks.

In summary, the model suggests the Bank's proposed new system should ensure that the market rate is expected to be on target on the final day of the maintenance period. It should also dampen volatility on that day. The next section discusses how reserve averaging can ensure that the market rate remains close to target over the rest of the maintenance period.

Reserve averaging and the martingale property

Meeting a reserve target on average over the course of a month gives banks much greater flexibility in their liquidity management than if they have to balance their accounts every day. In particular, on any given day they can hold a balance which is higher or lower than their average reserve target, to take advantage of any divergence between the market rate and the rate expected on the remaining days of the maintenance period. In fact, if meeting the reserve target at the end of the maintenance period was the only constraint faced by banks, their ability to run their reserve balances up and down, and so to arbitrage between rates on different days of the period, should mean that market rates over the period would not deviate at all from the rate expected on the final day.(2)

This result is known as the martingale property. It implies that as long as the central bank is expected to provide the correct amount of liquidity to the market on the final day of the maintenance period, and so the market rate is expected to be on target on that day, the rate should be on target throughout the entire maintenance period. For example, any bank which had an average reserve balance below its reserve target early in the maintenance period would know that it could borrow the shortfall at the official interest rate on the final day of the period. Likewise, any bank with an average reserve balance above its target could lend any excess reserves on the final day at the official interest rate. Because banks know that they will be able to adjust their reserve position on the final day of the maintenance period by borrowing or lending at the official interest rate, no bank has an incentive to borrow in the money market at a higher rate or lend at a lower rate on any day of the period. This means that banks' demand curves should be perfectly elastic (flat) at the official interest rate, so that changes in the supply of reserves would have no impact on the market rate.

(1) Chart 8 shows the results of a large number (20,000) of simulations of the one-day model with a reserve range based on the final day of a 28-day maintenance period. As discussed in the previous section, the level of interest rate volatility depends in part on the ratio of central bank forecast errors to commercial bank payment uncertainty. The simulations underlying the chart assume that the latter is five times as great as the former. This means that the level of volatility in Chart 8 might not be the same as the level of volatility in the Bank's new system.
(2) Davies (1998) examines such a case, as do Bartolini, Bertola and Prati (2002).

However, if banks cannot arbitrage perfectly between holding reserves on different days of the maintenance period, then changes in their reserve positions may cause the market rate to deviate from the rate expected on the final day. Indeed many studies, including that by Hamilton (1996), have found that the martingale property does not hold for the US federal funds rate. One possible constraint on interday arbitrage is the penalty applied if banks' accounts at the central bank are overdrawn on any day.(1)

The effect of the overdraft constraint

Because daily overdrafts are penalised, a bank which exceeds its cumulative reserve target before the end of the maintenance period cannot run an overdraft in order to correct its position without incurring interest rate penalties. Equally, it will not want to hold additional reserves, which would receive no interest. This means that a bank which has exceeded its reserve target before the end of the maintenance period will tend to target a reserve balance of zero on each of the remaining days of the period, and so will be at risk of being forced into the standing facilities by unexpected liquidity flows. So in choosing the quantity of reserves to borrow or lend on the earlier days of the maintenance period, a bank must consider not only how its decision affects the probability of using the lending and deposit facilities on that day, but also how it affects its cumulative reserve balance, and so the probability of using the standing facilities later on in the same period. Changes in the aggregate supply of reserves (and changes in the distribution of that supply, due to interbank shocks) can therefore affect banks' probabilities of using the standing facilities, and so influence market rates.

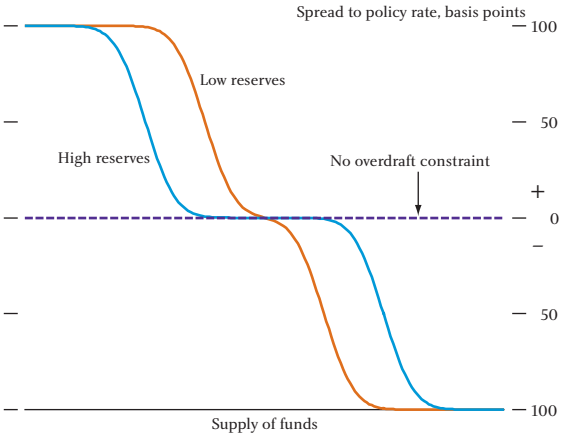
The magnitude of this effect depends on the level and distribution of banks' reserve targets. If reserve targets are low relative to banks' payments uncertainty, then a large negative swing in the supply of reserves could put them at risk of going overdrawn; equally, a large positive swing could put banks at risk of being forced into the deposit facility either on that day or later in the maintenance period.

On the other hand, if reserve buffers are high, banks would be unlikely to be at risk of using the standing facilities even in the presence of large swings in the supply of reserves, as their reserve buffers would be more than sufficient to absorb the change in reserve supply.

In particular, if each bank chooses a sufficiently high reserve target relative to its payments uncertainty, so that the probability of going overdrawn on any day is negligible, then it will also face only a minimal chance of being forced into the deposit facility. With a negligible probability of going overdrawn, it can simply reverse a positive or negative unexpected payment received on one day by lending to or borrowing from other banks on the following day. It follows that day-to-day changes in the supply of reserves will have little effect on the market rate if banks' reserve buffers are high.

By way of illustration, Chart 10 show how the aggregate demand curve for the penultimate day of the maintenance period depends on the level of banks' aggregate reserve targets. The larger the reserve buffer, the less likely changes in the supply of reserves are to affect the banks' probabilities of being forced into the standing facilities. Correspondingly, supply changes are less likely to affect the market rate, and the demand curve is closer to the case where there is no overdraft constraint.

Chart 10
Illustrative demand curve
(Penultimate day of the maintenance period)



For the averaging system to work most effectively in keeping the market rate close to target, reserve buffers must be not only high in aggregate, but also uniformly high across banks. If some banks targeted low levels of reserves relative to their payments uncertainty then, from time to time, they would have to trade in the market to offset unexpected payments flows, in order to avoid having to borrow or deposit funds using the standing facilities. In a competitive market, these trades would take place at close to the market rate. However, the

(1) Other possible constraints on interday arbitrage include transactions costs on interbank trading and limits on banks' credit exposures to any one institution.

banks targeting high reserves, from which some of the unexpected payments flows would originate, would not be obliged to trade them away, as they could simply hold a higher or lower reserve balance on that day. So if, for example, these banks wanted to avoid any transactions costs associated with trading in the interbank market, the rate might have to deviate from target in order to induce them to trade.

More generally, the effectiveness of the averaging system depends on how far the market rate needs to deviate from target in order to induce banks to arbitrage between rates on different days by running their reserve balances up or down. And the system also relies on the funds supplied by the central bank, typically through open market operations, being distributed roughly in proportion to banks' reserves targets. If not, one bank could hold a disproportionately large share of the available liquidity on one day, leaving other banks short of reserves and at risk of having to use the lending facility.

So the frequency of open market operations needed for the central bank to keep the market rate on target depends on the level of reserves held by the banking system. If reserve buffers are low, then day-to-day changes in the supply of reserves, caused by changes in autonomous factors, can have a significant effect on the market rate. In order to keep the market rate on target, the central bank would have to intervene frequently to offset changes in the autonomous factors. However, if reserve holdings are uniformly high, then the market rate should be close to target even if the central bank operates infrequently.

In the United States, where the level of reserves is relatively low, the Federal Reserve conducts open market operations on most days in order to keep the federal funds rate close to target. On the other hand, reserve holdings are considerably higher in the euro area, and the European Central Bank has succeeded in keeping market rates close to target during its reserve maintenance period with weekly operations.

Implications for the Bank's new averaging system

As reserve targets in the new system will be voluntarily chosen by banks, there is no guarantee that they will be uniformly high. However, discussions with market participants suggest that reserve holdings will be relatively high compared to their uncertainty over their end-of-day balances, perhaps in excess of £20 billion, and well distributed across the banking system. In fact, it was partly to encourage a high level of reserve holdings that the Bank decided to remunerate reserves at its official interest rate, and it was in anticipation of high demand for reserves that it imposed ceilings on banks' reserve holdings.

With a high and well-distributed level of reserves, there should be little chance of being forced into the standing facilities until the very end of the maintenance period, and weekly operations should be sufficient to keep the market rate on target, as in the euro-area system. The Bank expects that the standing facilities will not play a crucial role in rate-setting on the earlier days of the maintenance period, but instead will be used as liquidity insurance. So the rates on these facilities will, in normal circumstances, be at a wider spread of +/– 100 basis points to the official interest rate, except on the final day of the maintenance period.

Conclusion

This article has discussed how the Bank of England's new reserve averaging system should tie market rates more closely to the MPC's official interest rate. The Bank's commitment to 'fine tune' the supply of reserves on the final day of the period should mean that the market rate is expected to be on target on that day. Interest rate volatility should be proportional to the width of the corridor formed by the lending and deposit facilities, so the narrow corridor of +/– 25 basis points on the final day of the maintenance period in the Bank's new system should ensure low volatility. And having a range for the remuneration of reserves makes it less likely that errors in the Bank's liquidity forecast would force banks to make use of the standing facilities, which should dampen volatility further.

By allowing banks to run their reserve balances up and down in response to changes in market rates, averaging should also ensure that the rate expected on the final day of the maintenance period prevails over the rest of the period. In theory, the penalty applied to any daily overdrafts on banks' accounts at the Bank could hamper their ability to arbitrage between market rates on different days of the period. But this should not happen if the reserve targets voluntarily chosen by banks are uniformly high in relation to payments uncertainty across those banks facing significant payments uncertainty, as the Bank's discussions with market participants suggest they will be.

Technical appendix

This appendix outlines in more detail the model for the determination of the market interest rate underlying the article.(1) In the model, a large number of identical banks dealing in a perfectly competitive market must hold an average target level of reserves in their accounts at the central bank over a maintenance period. Initially, consider the case where any shortfall from its average reserve target at the end of the period, or a negative balance on any day, must be made up by recourse to the central bank's lending facility. Meanwhile, any reserves held in excess of the bank's cumulative reserve target must be deposited with the central bank at its deposit facility rate.

Each day banks choose their demand for reserves, x_t, in the knowledge that they will face interbank payment shocks after trading. Assuming that banks' end-of-day payment shocks are identically and symmetrically distributed, the market interest rate on the last day of the maintenance period, T, is given by

$$r_T = F\left(\frac{RR - Z_T - \mu_T - x_T}{\sigma}\right)l + \left[1 - F\left(\frac{RR - Z_T - \mu_T - x_T}{\sigma}\right)\right]d \qquad \textbf{(1)}$$

where RR is the banks' cumulative reserve target (ie the average reserve target times the number of days in the maintenance period), Z_T is the level of reserves accumulated at the start of the day, μ_T is the change in the autonomous factors on that day, l is the lending facility rate, d is the deposit facility rate, σ is the aggregate uncertainty over banks' payment flows and $F()$ is the cumulative distribution of the shock to banks' end-of-day balances. The market rate will be on target if the central bank offsets the day's change in the autonomous factors, and supplies what remains of banks' reserve targets (ie if supply equals $RR - Z_T - \mu_T$), so that banks are equally likely to make use of each standing facility.

If reserves are remunerated provided they fall within a range of the reserve target, and if the level of accumulated reserves at the start of the last day of the maintenance period lies below bottom of the reserve range for each bank, then the market interest rate is(2)

$$\begin{aligned} r_T = {} & F\left(\frac{(1-\lambda)RR - Z_T - \mu_T - x_T}{\sigma}\right)l + \left[1 - F\left(\frac{(1+\lambda)RR - Z_T - \mu_T - x_T}{\sigma}\right)\right]d \\ & + \left[F\left(\frac{(1+\lambda)RR - Z_T - \mu_T - x_T}{\sigma}\right) - F\left(\frac{(1-\lambda)RR - Z_T - \mu_T - x_T}{\sigma}\right)\right]r_{rem} \end{aligned} \qquad \textbf{(2)}$$

where λ is the percentage deviation from the reserve target allowed by the central bank and r_{rem} is the rate at which reserves are remunerated (in the case of the Bank's new system, this is the official policy rate). The larger the reserve range, the higher is the probability that banks' final balances will fall within it (the last term in brackets in the equation), and so the more closely the market rate is tied to the remuneration rate. Again the market rate will be on target if supply equals $RR - Z_T - \mu_T$.

On the penultimate day of the maintenance period, and assuming for simplicity that banks must meet their reserve targets exactly, the market rate is

$$\begin{aligned} r_{T-1} = {} & F\left(\frac{-\mu_{T-1} - x_{T-1}}{\sigma}\right)l + \left[1 - F\left(\frac{RR - Z_{T-1} - \mu_{T-1} - x_{T-1}}{\sigma}\right)\right]d \\ & + \left[F\left(\frac{RR - Z_{T-1} - \mu_{T-1} - x_{T-1}}{\sigma}\right) - F\left(\frac{-\mu_{T-1} - x_{T-1}}{\sigma}\right)\right]E(r_T) \end{aligned} \qquad \textbf{(3)}$$

(1) Similar models are developed in, for example, Poole (1968), Whitesell (2003) and Woodford (2001).
(2) Equation **(2)** relies on the assumption that all banks hold identical reserves buffers (RR/σ).

Equation **(3)** shows that market rate on the second-last day, r_{T-1}, is an average of the lending rate, the deposit rate, and the rate expected to prevail on the final day of the period, $E(r_T)$, weighted by the probability of going overdrawn, the probability of exceeding the reserve target, and the probability of avoiding both standing facilities. By implication, if the probability of being forced into each standing facility on the second-last day of the period is very close to zero, the market rate will be very close to the rate expected to prevail on the last day. In the same way, if banks are very unlikely to be forced into the standing facilities throughout the maintenance period (until the last day), the market rate should also remain very close to the rate expected on the last day.

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