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Tuomas Välimäki

Monetary Policy Department
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The Overnight Rate of Interest under Averaged Reserve Requiremets

Some Theoretical Aspects and the Finnish Experience

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Abstract

Averaging the reserve requirement is often considered an efficient way to reduce volatility at the very short end of the money market yield curve. The Bank of Finland began to apply an averaging provision at the beginning of October 1995. Notably, the volatility of the overnight rate of interest in the Finnish money markets has increased since the start of the averaging scheme. This paper builds up a simple model of the determination of the overnight rate of interest. The effects of both the averaging scheme and the central bank's reaction to the bids it receives in money market tenders are evaluated against the model. The paper ends with an evaluation of the empirical evidence from the first two years that have passed since the introduction of the averaging provision in Finland.

Keywords: money market tenders, minimum reserves, liquidity, averaging, convexity, interest rate volatility

JEL classification: E43, E52

Tiivistelmä

Vähimmäisvarantovelvoitteiden keskiarvoistamista pidetään usein tehokkaana keinona vaimentaa rahamarkkinoiden tuottokäyrän heilahteluja lyhyimmissä maturiteeteissa. Suomen Pankki aloitti pankkien vähimmäisvarantovelvoitteiden keskiarvoistamisen lokakuussa 1995. Rahamarkkinoiden yön yli-koron vaihtelut ovat kuitenkin voimistuneet keskiarvoistamisen aikana. Tässä keskustelualoitteessa rakennetaan yksinkertainen malli kuvaamaan pankkienvälisen yön yli -koron määräytymistä. Mallin avulla punnitaan vaikutuksia joita mahdollisesti aiheutuu vähimmäisvarantovelvoitteen keskiarvoistamisesta ja keskuspankin reaktioista rahamarkkinahuutokaupoissa saamiinsa tarjouksiin. Keskustelualoitteen lopuksi arvioidaan lyhyesti Suomen keskiarvoistamisesta keräämiä kokemuksia kahden ensimmäisen järjestelmän käyttöönoton jälkeisen vuoden ajalta.

Asiasanat: rahamarkkinahuutokaupat, vähimmäisvarantojärjestelmä, likviditeetti, keskiarvoistaminen, konveksisuus, korkojen vaihtelevuus

Contents

1 Introduction

Since the beginning of October 1995, banks in Finland have been able to fulfill their minimum reserve requirement on the basis of a monthly average rather than a formal daily requirement. In this paper, we attempt to examine the effects that averaging the reserve requirement has on the level and volatility of the interbank overnight rate of interest.

Averaging the reserve requirement is currently a commonly considered tool for reducing the daily variation of short-term interest rates.[1] While the averaging provision brings increasing interest rate elasticity of demand for liquidity, it is still not a reliable means to reduce volatility in the overnight rate of interest. Indeed, Finland's experience over the past two years clearly shows us that the interest rate volatility in the very short end of the yield curve can actually *increase* under the averaging scheme – especially when the central bank allows the banking sector as a whole to take advantage of the averaging provision (ie the central bank does not scale back the bids it receives in tenders in order to bring the money market liquidity to its neutral level). Further, the Finnish experience reveals that averaging the reserve requirement has potential to increase considerably the variation in the demand for the liquidity of the tender period. Thus, averaging may increase the volatility of the liquidity in overnight markets.

The implication here is clear: when considering the effects the averaging scheme has on the volatility of the overnight rate of interest, we must take into account the effects it exerts on both the demand and supply of the overnight liquidity.

The paper is organized as follows. First, we briefly review liquidity facilities in Finland. Next we examine the determination of the interbank overnight rate of interest under the averaging scheme. Chapter 3 examines the effects that arise when the central bank scales back bids in money market liquidity tenders. Chapter 4 deals with the Finnish experience under the averaging scheme. Chapter 5 contains a brief summary and conclusions.

1.1 Liquidity facilities in Finland

The banks can currently fulfill their minimum reserve requirement by monthly average. This means that each bank can now hold its reserve balances whenever it assumes the cost of holding them to be at its lowest within the maintenance period. This has increased the interest rate elasticity of the demand for bank reserves, ie money market liquidity.[2]

As long as the interbank overnight rate of interest stays below the cost of acquiring liquidity credit, the overnight liquidity in the banking system is

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[1] See e.g. "Reserve Requirement Systems and Their Recent Reforms in Major Industrialized Countries: A Comparative Perspective." Bank of Japan Quarterly Bulletin (1995).

[2] We use terms money market liquidity and bank reserves as synonyms throughout this paper. Here, overnight liquidity means bank reserves in the system available for same-day settlement (T). Tender liquidity means reserves that are settled two banking days after the trade day (T+2).

predetermined. Overnight trading only distributes the overnight liquidity among the banks themselves. In other words, it might be more appropriate to say that the overnight rate of interest has become more inelastic with changes in overnight liquidity than to talk about the increased interest rate elasticity of the demand for liquidity.

Under the former facility, the banks' required reserves were held with the Bank of Finland in accounts where they could not be used for any other purpose, so they were not included in the money market liquidity. A bank had to acquire liquidity credit when its current account with the Bank of Finland would otherwise have been overdrawn. End-of-day debit balances are still forbidden under the current averaging scheme, but the probability of being overdrawn due to unexpected entries is now much lower. This probability has decreased as the banks' required reserves are now held as reserve balances with the banks' current accounts at the Bank of Finland. Under the present averaging scheme, the required reserves can be used as working balances of the banks, and they are considered as a part of the money market liquidity. To illustrate the size of the reduction in the probability of being overdrawn, it should further be noted that under the new facility the banking sector's aggregate reserve requirements have varied from FIM 6.2 billion (per day) to FIM 6.6 billion and the total money market liquidity (ie required reserves + excess reserves) has been FIM 7.0 billion on average. During the one-year period prior to October 1995, the average amount of liquidity in the overnight market was approximately FIM 1 billion.

Under the current facility, a bank must acquire liquidity credit not only to cover possible debit balances on its current account, but also to fulfill its reserve requirement at the end of the maintenance period if it cannot otherwise hold sufficient reserve balances.

Under the averaging scheme, the Bank of Finland pays interest on a bank's excess reserves, ie balances on a bank's current account exceeding its required reserves. The interest on these reserves is paid at the end of each maintenance period. This rate of interest corresponds the call money deposit rate used in the former system. The interest on call money deposits was paid daily to banks that had positive end-of-day balances with the Bank of Finland.

The tender rate can be thought as an opportunity cost on both acquiring liquidity credit and holding excess reserves. A bank that holds excess reserves with the Bank of Finland could have placed the liquidity as a Bank of Finland CD tender. Thus, instead of using the liquidity credit facility, the bank could have obtained liquidity earlier in a Bank of Finland's repo tender.[3]

Earlier, assuming the banks operated under certainty, it would have been optimal for a bank to have zero end-of-day balance on its current account with the Bank of Finland. In such a case the bank would have had neither excess reserves nor it would have had to acquire liquidity credit. Under the averaging scheme, a similar situation would be one in which each bank holds reserve balances with the Bank of Finland on average just as much as its reserve requirement is. In practice, however, banks lack certainty on the movements in their current accounts between

[3] The tender rate used in a liquidity-increasing repo tender equals that of a liquidity-absorbing BoF CD tender.

a Bank of Finland tender and the end of trading the interbank overnight liquidity.[4] It is because of this uncertainty that the difference between the cost of holding excess reserves and acquiring liquidity credit has become one of the most important factors affecting the optimal path of reserve holdings and the banks' willingness to hold excess reserves.

The size of the margins between the tender rate and both the liquidity credit rate and the rate on excess reserves have been equal in size in Finland (r^{LC} = Tender rate + 2%; r^{ER} = Tender rate -2%). However, during the study period of 2 Oct. 1995 to 31 Oct. 1997 (discussed in Chapter 4), banks in Finland faced much higher cost in acquiring liquidity credit compared to the opportunity cost of holding excess reserves. The reason for this was the longer maturity (one week) applied to the liquidity credit.[5] In other words, due to the cost structure of the liquidity facilities in Finland, stochastic deviations from the reserve requirement (former deviations from zero end-of-day balance) were much more costly to the banks in the direction of liquidity shortage than in the cost of holding excess reserves.

Besides the parameters of the liquidity facilities, there are many other factors affecting the determination of the interbank overnight rate of interest, eg how liquidity is distributed among the banks prior to interbank overnight trading,[6] and the heterogeneity of banks in terms of their size and operating procedures. However, these factors are not (at least not as directly as the parameters of liquidity facilities) under the control of the central bank. Thus, these other variables are not included in the examination at this point.

2 Determination of overnight rate of interest under the averaging scheme

2.1 The case without interest rate expectations

Figure 1 is an attempt to illustrate the determination of the interbank overnight rate of interest in Finnish money markets and the change in demand for overnight liquidity due to the averaging scheme.

The upper part of the figure shows the demand for and supply of liquidity in money market tenders.[7] Supply (S_{1mo}) consists of Bank of Finland tenders, whereby the Bank offers either liquidity by repos (in the case of a liquidity shortage) or by Bank of Finland CDs (in the case of a liquidity surplus). Under current policy, the

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[4] For early articles on the demand for reserves under uncertainty, see Poole (1969) and Modigliani, Rasche and Cooper (1970).

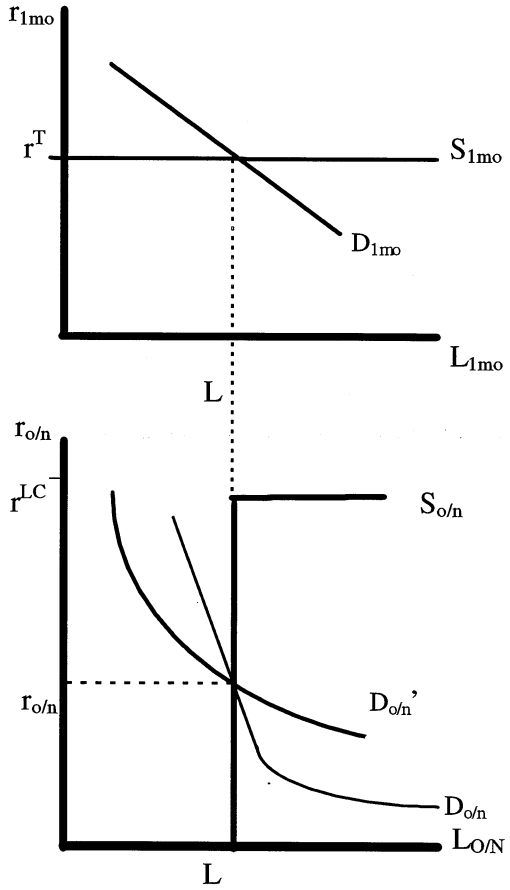
[5] At the beginning of November 1997, the Bank of Finland shortened the maturity applied in its liquidity credit from seven days to one day (overnight).

[6] This factor is of major importance in Finland's case, because only a few mandatory reserve holders' reserve requirements are large enough to have relevant impact on total money market liquidity.

[7] The maturity of money market tenders in Finland was one month during the study period examined in Chapter 4. However, the maturity was reduced to two weeks at the beginning of November 1997.

interest rate used in these tenders (r^T) is always pre-announced by the Bank, ie the Bank of Finland uses fixed rate tenders. D_{1mo} is the banking sector's demand for tender period liquidity. In equilibrium, money market liquidity will be determined at level L. If banks expect the Bank of Finland to leave its tender rate unchanged during the ongoing maintenance period, the amount of liquidity should equal the required daily balances for the remaining maintenance period (RDB).[8] We call this amount the neutral liquidity.[9]

Figure 1. **Determination of the Interbank Overnight Rate of Interest in Finnish money markets**



[8] We will assume, if not otherwise stated, that average reserve requirements are larger than the amount of reserve balances banks would be willing to hold for other purposes.

[9] If the cost of holding excess reserves (C^{ER}) differs from the cost of acquiring liquidity credit (C^{LC}), the neutral liquidity will differ from the RDB at least on the last day of the maintenance period. If $(C^{LC})>(C^{ER})$, the neutral liquidity will equal the RDB plus the excess reserves the banks are willing to hold. If $(C^{LC})<(C^{ER})$, the neutral liquidity could even be smaller than the RDB. In a system without averaging provision, the neutral liquidity would be the call money deposits that banks are willing to hold voluntarily (ie the demand for working balances).

The lower part of the figure illustrates the interbank overnight market that corresponds to the value date of the upper part of the figure.[10] Under current practice, the supply of overnight liquidity ($S_{o/n}$)[11] is predetermined when the interbank overnight rate of interest remains below the cost of liquidity credit (r^{LC})[12]. The supply of liquidity is perfectly elastic when the liquidity credit rate is reached.[13]

The thinner demand curve ($D_{o/n}$) is the demand for overnight liquidity in a system without averaging scheme. Here we have assumed the interest rate elasticity of the demand to increase rapidly when money market liquidity reaches a certain point. The reasoning behind this assumption is that the demand for overnight liquidity should become nearly perfectly elastic as the interest rate approaches the interest rate paid on excess reserves (call money deposit rate).[14]

The thicker curve ($D_{o/n}'$) is the demand for overnight liquidity with increased interest rate elasticity under the averaging scheme. If there was no uncertainty about the future development of the tender rate and if overdrafts were freely allowed, $D_{o/n}'$ would be a straight horizontal line at the level of the tender rate. However, banks cannot be perfectly certain about future movements in the tender rate, so the demand curve will be downward sloping. The slope of the demand curve is assumed to increase as the (positive) money market liquidity approaches zero. This is based on the fact, that negative end-of-day balances must be covered with liquidity credit, and the probability of a single bank being overdrawn will increase as the total liquidity decreases. A third element shaping the demand curve is the interest paid on excess reserves. The demand should be almost perfectly elastic as the interest rate paid on excess reserves is reached. Based on these three factors, then, we have assumed the demand curve for overnight liquidity to take

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[10] Until the end of October 1997, the value date applied in Bank of Finland tenders (upper part of the figure) was T+2, ie trading of tender liquidity occurred two banking days prior to the overnight trading (lower part of the figure). At the beginning of November 1997, the Bank of Finland changed its value date practise to T+1.

[11] The supply of the overnight liquidity at liquidity levels below L is normally thought to be horizontal at the rate of interest paid on excess reserves. However, here the interest on excess reserves is taken into account, so that the demand for overnight liquidity approaches the expected value of interest rate paid on excess reserves as the amount of liquidity increases. This is based on the idea that, under the averaging scheme, a bank cannot hold excess reserves before it has fulfilled its reserve requirement *for the entire maintenance period.* Even when a bank holds excess reserves, they do not actually reduce money market liquidity. However, excess reserves held before the last day of the maintenance period can increase the RDB.

[12] For simplicity, we call the cost of liquidity credit here the liquidity credit rate, even though the real ceiling for the overnight trading can be much higher than the actual liquidity credit rate if the maturity of the liquidity credit is not overnight.

[13] The supply of liquidity credit to a single bank was limited to the larger of the amounts that either brings the bank's end-of-day balances to zero or raises its average reserve balance during the ongoing maintenance period up to the average daily reserve requirement. However, these limits were ineffective, as no bank is willing to acquire more liquidity credit than it has to. These limits were abolished at the beginning of November 1997.

[14] In section 4.2.2, we give empirical evidence in line with the assumptions made here.

convex form.[15] Of course, convexity is not a necessary condition for most of the conclusions drawn in this paper, and wherever our assumption seems restrictive, we also refer to the case with linear demand for comparison. The interest rate elasticity of the demand for overnight liquidity also depends on the size of neutral liquidity. We will deal with this question later in section 2.3.

We can see from the lower part of Figure 1 that $r_{o/n}$ will become the equilibrium overnight rate of interest, regardless of whether the reserve requirement is averaged. In this case, the overnight rate of interest should effectively equal the tender rate.

As we have discussed above, averaging the reserve requirement increases the interest rate elasticity of the demand for overnight liquidity. The increase in the elasticity reduces the volatility of overnight rate of interest, *ceteris paribus*. However, we cannot say anything final on the development of the volatility, unless we know what kind of effects averaging has on *both* the volatility of the supply of the money market liquidity ie shifts in the demand for tender period liquidity *and* the shifts in the demand for overnight liquidity.

2.2 The effects from interest rate expectations

In a system with an averaged reserve requirement, the demand for the overnight liquidity will shift with changes in the interest rate expectations of the banks. According to the optimal path of reserve holdings, the demand for liquidity increases when banks expect the central bank to increase its steering rate, and decreases under the expectations of an interest rate cut. The demand for the tender period liquidity is mainly determined by the demand for overnight liquidity. However, under the averaging provision the demand may also be effected by eg. the banks' possibility to make speculative gains from interest rate movements as they affect the CD prices[16], and possibly by the banks' expectations on foreign exchange interventions by the central bank[17].

If we did not know the relative size of shifts that the demand curves for both of these periods move as a result of the interest rate expectations, even the direction in

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[15] In the case of Finland, the asymmetry of the cost structure of the standing facilities has probably increased convexity.

[16] Here, speculative gains means the situation where a bank buys Bank of Finland CDs with one-month maturity when it expects a cut in interest rates in the near future. After the rate cut, the bank can sell the same CDs at a profit.

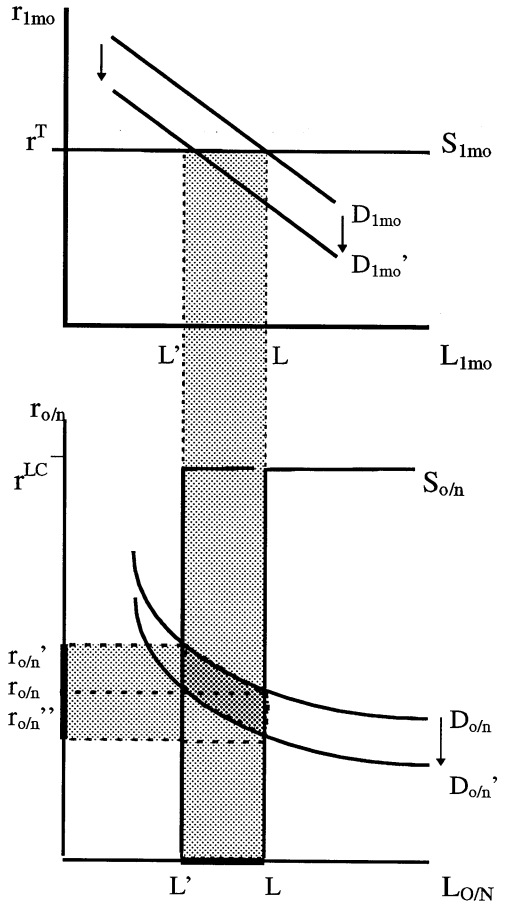
[17] When banks expect the Bank of Finland to defend the value of the markka by buying FIM, they might (when considering their bids in the tenders) take into account the expected liquidity effect of these foreign exchange interventions. In such a case, the anticipation of foreign exchange interventions would affect the demand for tender period liquidity. However, the demand for overnight liquidity would not change due to these interventions, even though they change the overnight liquidity when their effects are not sterilized. There will be no uncertainty left about the foreign exchange operations effects on the overnight liquidity for banks trading overnight liquidity in interbank markets.

which the overnight rate of interest shifts would be unknown to us. This uncertainty is illustrated in Figure 2, where the banks are expecting an interest rate cut.[18]

In the upper part of Figure 2, the banks' demand for tender period liquidity falls due to the expectation of an interest rate cut. If we know only that the maximum reduction in the demand for tender period liquidity would shift the demand curve down to D_{1mo}', we can only say that the money market liquidity will be determined somewhere between L' and L. This means that the vertical part of the supply of overnight liquidity would lie in the range of [L' , L].

The overnight rate of interest will depend on the relative size of the shifts in money market liquidity and in the demand for overnight liquidity. This means that in the lower part of Figure 2, the equilibrium overnight rate of interest can be found anywhere between $r_{o/n}''$ and $r_{o/n}'$. The liquidity-interest rate point will lie somewhere in the darkly shaded area of the figure. The overnight rate of interest is higher the larger the shift in the demand for tender period liquidity in relation to the shift in the demand for overnight liquidity.

Figure 2. **Movement in the overnight rate of interest when banks expect the Bank of Finland to cut its tender rate**



[18] When the banks expect the Bank of Finland to increase the tender rate, the situation would be opposite to the one given here.

In this model the maximum overnight rate of interest ($r_{o/n}'$) turns out to be the equilibrium rate when the banks change their demand only for tender period liquidity. An example of such a situation would be one where banks reduce their demand for domestic liquidity when they anticipate that the central bank will intervene in the foreign exchange market in a way that will increase domestic liquidity. In this case, the demand for overnight liquidity does not change. Correspondingly, the minimum overnight rate of interest ($r_{o/n}''$), would appear in a situation where the demand for overnight liquidity decreases while supply remains unchanged. This is the case, for example, when the central bank scales back the bids received in a liquidity tender so that the money markets are provided with neutral liquidity.

We cannot anticipate the overnight rate of interest without assuming how the interest rate expectations affect the demand curves of both maturities, and how the central bank is going to react to bids received in liquidity tenders. In other words, *even if we can assume that the interest rate elasticity of the demand for overnight liquidity increases under the averaging scheme, we are not able to say accurately what should the total effect of the scheme be on the volatility of the overnight rate of interest.*

2.3 On the size of the neutral liquidity

The size of the reserve requirement determines the initial level of the neutral liquidity in the beginning of a reserve maintenance period.[19] After the beginning of the period, the path of the banks' reserve holdings will affect neutral liquidity. The path of reserve holdings will itself depend mainly on the banks' interest rateexpectations and on stochastic liquidity shocks.[20] As mentioned in section 2.1, a factor affecting the interest rate elasticity of demand for overnight liquidity is the size of neutral liquidity. In other words, both the size of the reserve requirement and earlier interest rate expectations during the ongoing maintenance period will affect the volatility of the overnight rate of interest due to stochastic shocks in money market liquidity. This effect is illustrated in Figures 3a and 3b.

The two demand curves for overnight liquidity in Figures 3a and 3b reflect the effect that the level of neutral liquidity has on demand. In Figure 3a the interest rate elasticity of demand for overnight liquidity diminishes as neutral liquidity decreases. The reduction in the elasticity comes with the increasing probability of a bank running into an end-of-day debit balance due to stochastic entries into and out off its reserve account with the central bank. The thicker demand curve (D^{RR}) corresponds to overnight demand, when neutral liquidity equals the banks' average reserve requirement (at least at the beginning of each period). Curve D^{RR-} corresponds the demand when neutral liquidity has dropped below the average

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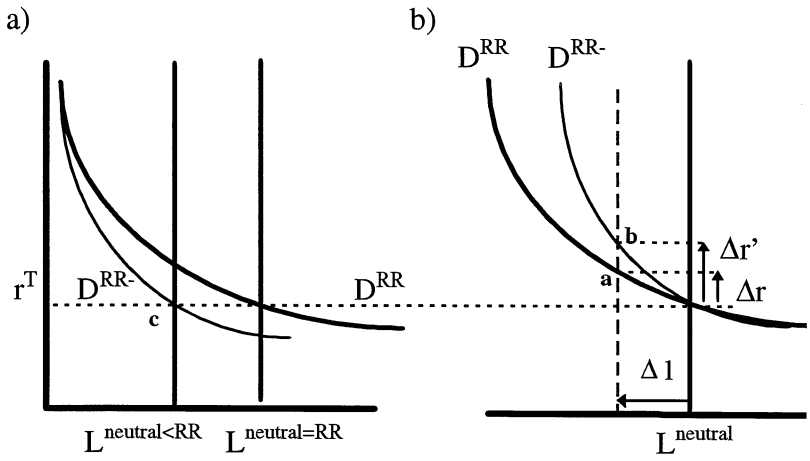
[19] In section 2.1 (footnote 8) we made an assumption under which we ruled out the situation, in which the banks' demand for overnight working balances could be larger than the reserve requirements. The neutral liquidity will naturally be determined by the demand for working balances instead of by the reserve requirements, if the optimal working balances exceeds the reserve requirements.

[20] The central bank's reaction to the bids it receives in tenders also has a major effect on the path of reserve holdings. We return to this question in the next chapter.

reserve requirement, ie when the banks have held more reserves on average during the ongoing period than their average requirements dictated.

Figure 3. **Overnight rate of interest and the neutral size of money market liquidity**



In Figure 3b, the demand curves are scaled so that neutral liquidities correspond to each other. The figure shows that a stochastic fall (Δl) in liquidity from its neutral level increases the overnight rate of interest more the more inelastic the demand ($\Delta r' > \Delta r$). *This means that as the banks' current expectations about interest rates will mainly affect the level of the overnight rate of interest, the prior expectations during the ongoing maintenance period may affect the volatility of the overnight rate of interest that comes with stochastic liquidity shocks.*

In Figures 3a and 3b, the banks are expecting the central bank not to change the tender rate in the near future. Point a in Figure 3b may lie on demand curve D^{RR-} instead of on curve D^{RR} when the banks expect the central bank to cut its tender rate. Correspondingly, point c in Figure 3a may lie on either one of the curves shown (or on any other demand curve) when we do not know the banks' expectations. Thus, analysing the interest rate-liquidity observations quite difficult when we can not measure the banks' expectations easily.

2.4 Averaging and the volume of the interbank overnight trading

As shown above, the size of reserve requirement has an effect on the demand elasticity of overnight liquidity, because it determines the initial level of neutral liquidity. However, there is also another channel through which the size of the averaged reserve requirement may affect the interbank overnight markets.

Averaging the reserve requirement provides the banks with an opportunity to avoid use of the interbank overnight markets when the stochastic changes in their current account balances are smaller than their reserve requirement. This means that the banks' need for interbank trading gets smaller under the averaging scheme. The banks' willingness to trade in the interbank market in order to reduce the gap between their actual (positive) reserve balances and their neutral liquidity might be

very low if there are market imperfections, for example, in the form of wide bid-ask spreads.

Lippman and McCall have shown (Lippman & McCall, 1986) that interest rate volatility of a particular maturity is inversely related to liquidity in the market of instruments of the same maturity.[21] Such liquidity is related to the thickness of the market. In other words, *if the volume of overnight liquidity trading reduces with the averaging scheme, it might increase the volatility of the interest* rate.

This may lead us to conclude that if the central bank wants to use the reserve requirement as a tool in cutting down the volatility of the overnight rate of interest, it should try to design the requirement system so that the two effects will be in balance. On the aggregate level, the reserve requirement should work as an effective buffer, exceeding both the aggregate demand for working balances and the bulk of the liquidity shocks. On the other hand, the buffer the requirements provided for a single bank should not be larger than the shocks the bank may face. Otherwise, the volume in the interbank overnight markets may collapse.

We will next examine the supply of the overnight liquidity and the possible effects of scaling back bids in liquidity tenders.

3 Scaling back bids in liquidity tenders

The effect the averaging scheme has on the overnight rate of interest depends to a great extent on whether the central bank lets the banking sector as a whole make use of the averaging provision or attempts to steer the total amount of liquidity in the money markets.

If the central bank always provides the banking sector with liquidity that corresponds the reserve requirement, the banks cannot average their reserves in aggregate terms. In such a situation the banking sector as a whole cannot use the reserve requirement to speculate on the development of the interest rates. Thus, an individual bank can make use of its view of the future interest rate path by holding reserves in excess of its average requirement only if another bank holds reserves less than its average requirement.

By contrast, if a central bank only sets the price of the liquidity and lets the banks determine the amount of liquidity the money markets are provided with, the banking sector can average its reserves as a whole. In this case, the quantity of the money market liquidity will vary in accordance with the banks' view on the future development of the tender rate.

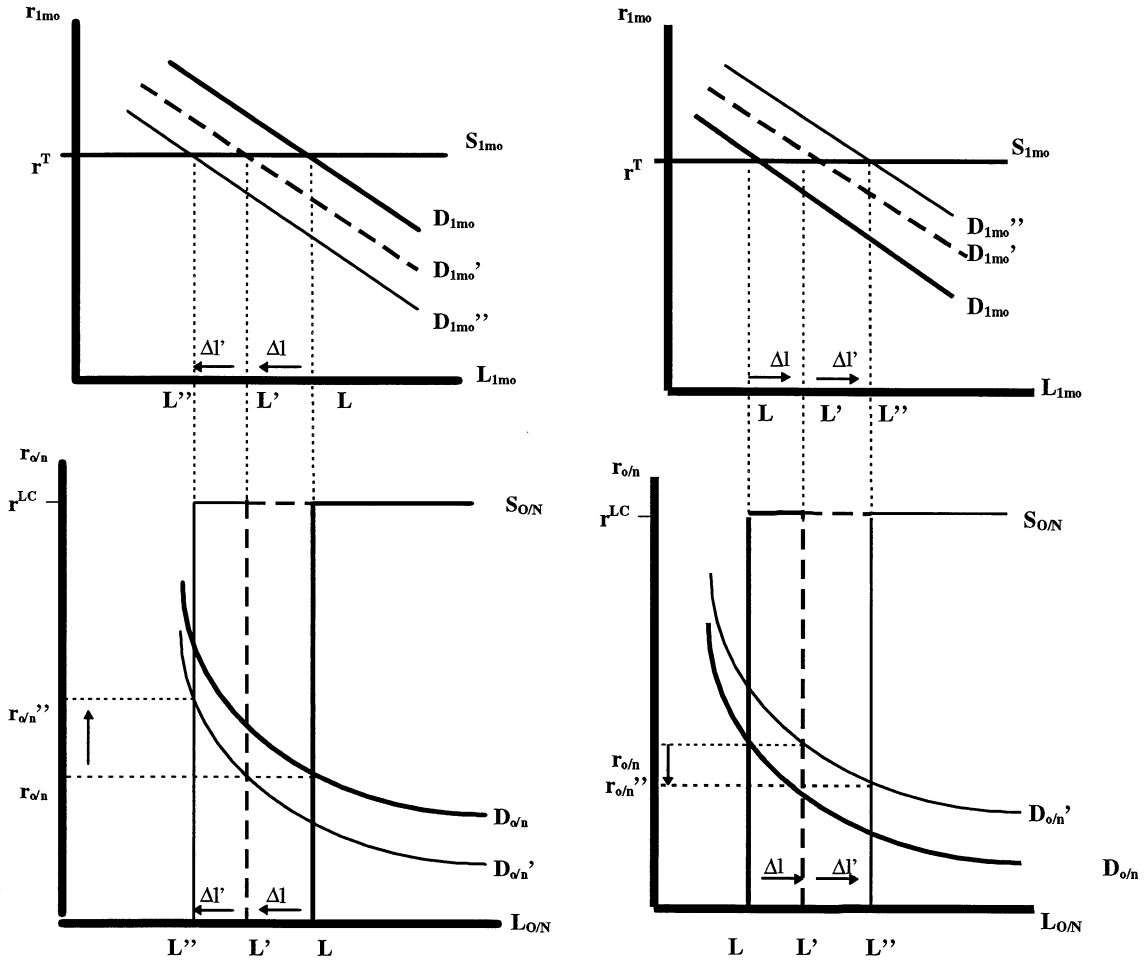
The effect that the banks' interest rate expectations have on the overnight rate of interest when the central bank does not scale back the bids in a fixed rate tender is illustrated in Figures 4a and 4b. The effect of scaling back bids in a fixed rate tender is shown in Figure 5. In the latter case, the central bank is expected to scale the bids in such a manner that the money markets are always provided with liquidity

[21] Note that liquidity in the sense that Lippman and McCall uses it does not refer to the bank reserves.

that equals the required daily balances of the remaining maintenance period (ie neutral liquidity).[22]

Figure 4. **Interest rate determination, when all bids received are accepted**

a) banks expect a rate cut **b) banks expect a rate hike**



In Figure 4a the banks are expecting the central bank to cut its tender rate in the near future. Due to these expectations the banks are willing to reduce their demand for overnight liquidity from $D_{o/n}$ to $D_{o/n}'$. If the optimal path of reserve holdings was the only component determining the demand for liquidity of tender period, the banks would be willing to lower their bids in a fixed rate liquidity tender so that the overnight rate of interest would remain unchanged at the level which effectively corresponds the tender rate. In Figure 4a the desired effect is achieved with the reduction of the banks' demand for tender liquidity from D_{1mo} to D_{1mo}'. As the

[22] For the sake of simplicity, we assume here that the central bank can always provide the markets with as much liquidity as it wants to by scaling the bids back. In reality, however, the Bank of Finland can do this only when the aggregate amount of bids received is greater than the amount of liquidity the Bank of Finland wants to drain from (CD tender) or provide to (repo tender) the markets.

central bank accepts all bids submitted, the supply of overnight liquidity would consequently drop and the money markets would be provided with L' instead of L.

There are, however, other factors besides the optimal path of holding reserves affecting the demand for liquidity of tender period (eg the opportunity for speculative gains from interest rate changes, as the tender period is normally longer than overnight).[23] Due to these other factors, we expect the demand for the liquidity in money market tender to reduce further down to D_{1mo}". The money markets will then be provided with liquidity L". In this case, *the equilibrium overnight rate of interest ($r_{o/n}$") will rise above its neutral level, when the banks are expecting the central bank to cut its tender rate in near future.*

The increase in the cost of overnight liquidity should equal the amount of expected profits gained by deviating from the suboptimal path of reserve holding (additional profit from investing "extra" liquidity into the central bank CDs).

Figure 4b shows that the interbank overnight rate of interest will fall below its neutral level when banks expect the central bank to increase its tender rate.

The shift in the overnight rate of interest initiated by change of a given size in the demand for liquidity in a money market tender will be larger under the expectations of a rate cut than when a rate hike is expected. This effect derives from the convex form we have assumed for the demand for overnight liquidity.[24] Consequently, due to the convexity the banks' additional (over the optimal path of reserve holdings) demand for liquidity in a tender might be larger when a rise in the tender rate is expected.

Figure 5 illustrates the case in which the central bank scales back the bids it receives in tenders. Here we assume for simplicity's sake that the central bank will scale back bids in such a way that the overnight market is *always* provided with neutral liquidity (L). The figure shows that when banks are expecting the central bank to increase the tender rate, the tender period's money market rate of interest will rise above the tender rate in equilibrium ($r^{\uparrow}_{1mo}$). Correspondingly, the market rate falls below the tender rate under the expectations of a rate cut ($r^{\downarrow}_{1mo}$). The magnitude of the difference between the tender rate and money market rate with similar maturity depends on the size of the expected rate change, the expected timing of the change and the length of the remaining maintenance period.

When overnight liquidity is always scaled back to its neutral level, the overnight rate of interest will increase ($r^{\uparrow}_{o/n}$) when banks expect the central bank to increase its tender rate. It falls ($r^{\downarrow}_{o/n}$) when a rate cut is expected. The size of the expected shift in overnight rate should only depend on the magnitude, not the direction of interest rate expectations. In the situation described above, the expected (effective) overnight rate of interest should always equal the banks' expectations of the future tender rate.

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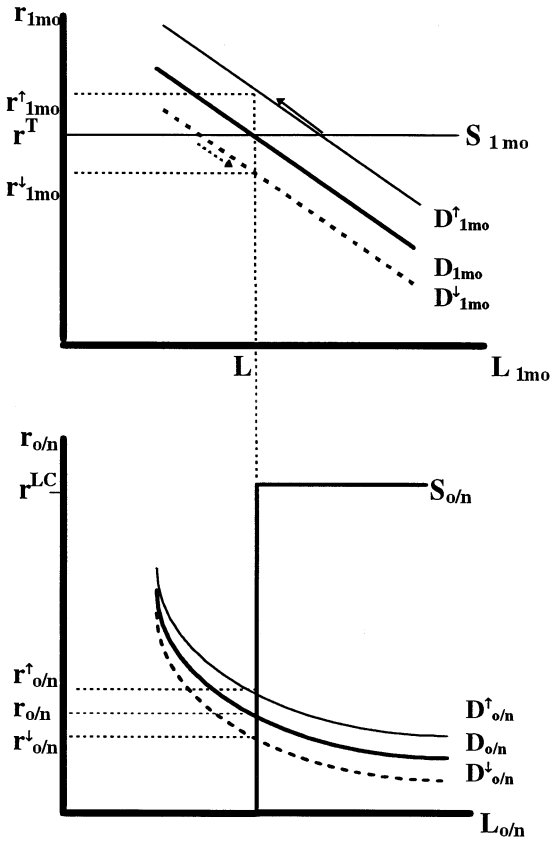
[23] See footnote 16. The speculative demand for the liquidity of the tender period increases with the maturity of the tender. The longer the maturity the greater the value of discount papers will change as the rate of interest changes. If the tenders were conducted as overnight operations, such speculative demand for liquidity of the tender period would not exist.

[24] If the demand curve is linear, neither the size of the change in the overnight rate of interest due to banks' interest rate expectations nor stochastic changes in money market liquidity depend on the direction of expectations.

Figure 5. **Interest rate determination when bids in tenders are scaled back**



If the central bank scales back the bids, the money market liquidity should always be at its neutral level, which should be constant in this case.[25] Correspondingly, the volatility of the overnight rate of interest due to stochastic liquidity changes should not depend on current or past interest rate expectations.

According to the model described above, market expectations about the tender rate can be observed directly from short-term money market rates when the central bank scales back the bids it receives in a tender. The expectations must be read from the amount of money market liquidity when the central bank accepts all bids.

The growth of the size of the bids the banks submit could become a problem when the central bank scales back bids. For example, it pays for a bank to make as large a bid as possible in a liquidity draining tender when the banks are expecting a rate cut, because the bank's share of the total accepted bids grows as the bank increases its bid. However, the total amount of bids accepted in the tender, as well as the total money market liquidity after the tender, will remain constant. Because total liquidity does not change, the bank can assume that there will still be cheap liquidity available in the interbank overnight market, so it draws down its current account as far as possible to increase its share of the accepted bids.

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[25] Even if the central bank does scale back the bids, the neutral level of liquidity would change at least for the last day of the maintenance period. For simplicity we do not pay attention to this question for now.

The following table summarizes some of the differences between the two approaches we have been considering.

ALL BIDS ACCEPTED	BIDS SCALED BACK
• The overnight rate of interest moves in the opposite direction as the banks' expectations on future tender rate.	• Movements in the overnight rate are in the same direction as the banks' expectations on future tender rate.
• The direction of the banks' expectations of future interest rate affects the size of the shifts in the overnight rate of interest and/or the magnitude of changes in money market liquidity.*	• Changes in the overnight rate of interest caused by interest rate expectations are symmetrical with the direction of the expectations.
• Volatility of overnight rate of interest due to stochastic liquidity shocks is larger when an interest rate cut is expected than when a rate increase is expected.*	• The volatility of overnight rate of interest due to stochastic liquidity changes does not depend on interest rate expectations.
• Volatility of overnight rate of interest due to stochastic changes increases the larger the reserve balances held by banks. *	• Banks can choose their path of reserve holdings only when they want to bid too little to bring the liquidity into its neutral level (ie. when the central bank does not want to scale back the bids).
• Money market rates in the tender period are tied very closely to the tender rate.	• Money market rate of interest of the tender period may differ from the tender rate, according to the markets expectations
• When banks decide on their bids, they cannot know what the *aggregate* money market liquidity is going to be like after the tender.	• The banks can anticipate quite well what the *aggregate* money market liquidity is going to be after the tender, when deciding on their own bid
• Banks will know how the tender affects their *own* liquidity.	• The banks can not be sure how large proportion of their bids is going to be accepted (leads to difficulties in cash management)
• The bids probably reflect the banks' real demand for reserves.	• The bids may grow to be manifolds compared with the real need

*The second, third and the fourth points in this list do not hold, if the demand for overnight liquidity is not convex.

The conclusions drawn above change considerably if the bids submitted are stochastic and do not reflect the banks' view of future price of the liquidity.[26] Here, the liquidity in the overnight market varies randomly without real shifts in the demand for the liquidity of the tender period. Consequently, the central bank could prevent unnecessary volatility in the market rates by scaling bids whenever it could. Of course, when bids deviate from the amount that keeps money market liquidity at its neutral level it is impossible for the central bank to differentiate whether the cause is interest rate expectations or stochastic factors.

[26] The bids might become stochastic, eg if the central bank is unable to forecast the money market liquidity correctly, if it does not publish the liquidity estimate for the settlement day, or due to the banks' inability to estimate their liquidity needs for the end of the settlement day.

When the Bank of Finland scaled back bids earlier, the changes in money market liquidity were still partly stochastic (for the banks), because the Bank of Finland had not announced an explicit policy rule for scaling bids. Another factor contributing to randomness was that sometimes banks did not place enough bids to drain or raise liquidity to a neutral level.

Under the averaging scheme, as the interest rate elasticity of the demand for liquidity increases, a stochastic change in money market liquidity does not alter the overnight rate of interest as much as it does when the reserve requirement is not averaged. Due to this, accepting all the bids can be seen fitting much better into the averaging scheme.

Under the assumptions made in the model presented in this paper, we have shown that the tender period's market rate of interest follows the tender rate more closely if the central bank accepts all bids. This should clarify the signals of the monetary policy stance, especially if the maturity of the operational target of the central bank is close to the tender period. However, if the central bank's operational target is the overnight rate, it might be preferable to steer the money market liquidity actively (which does not necessarily mean that the central bank should scale back the money market liquidity to its neutral level) and let the market rate of the tender period float with interest rate expectations.

When the central bank tries to control money market liquidity very closely, it is possible that the amount of liquidity in the market is always seen as a monetary policy signal, even though the central bank cannot always determine the amount of liquidity while using fixed rate tenders. Currently, the Bank of Finland normally drains liquidity from the money markets because of the present liquidity position of the banking sector. In most cases the banks could leave the markets "over-liquid" by underbidding. Thus, by scaling back the bids in fixed rate tenders the Bank of Finland could normally prevent money market liquidity only from getting too tight.

We now examine how overnight liquidity supply and demand have changed in Finland and how the volatility of the overnight rate of interest has developed since the implementation of the averaging scheme.

4 The Finnish experience under the averaging scheme

As mentioned, the reserve requirement for banks in Finland have been averaged since the beginning of October 1995. During the first six months of the averaging scheme, the Bank of Finland scaled back the bids it received in liquidity tenders.[27] Within this period, the Bank of Finland, on average, scaled back bids in two out of three liquidity absorbing tenders and in every third liquidity increasing tender.[28] Since the end of March 1996, the Bank of Finland has accepted all bids it has received in tenders.

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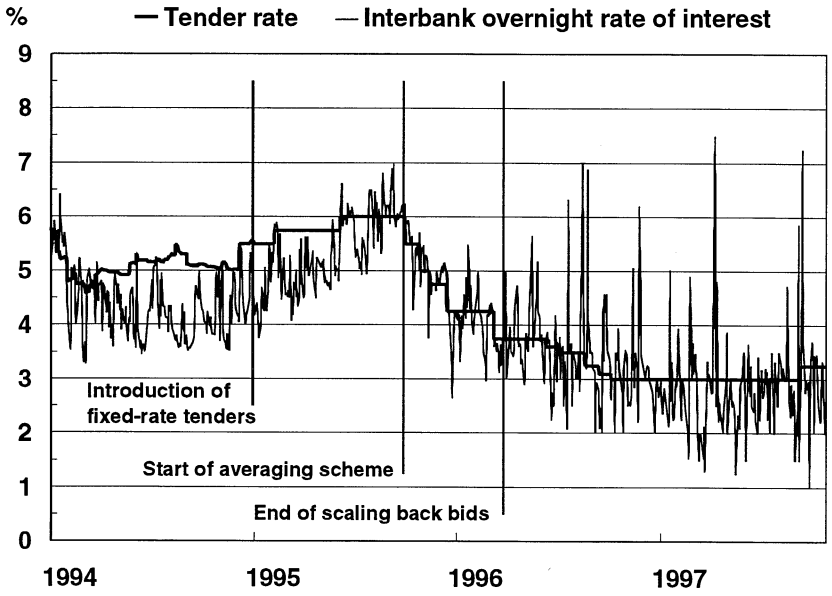
[27] The amount of the bids the Bank of Finland accepted in a tender was mainly affected by the average required daily balances for the remaining maintenance period and by the short-term money market rates of interest.

[28] During the same period, banks left no bids in five liquidity-increasing tenders.

The interbank overnight rate of interest from the beginning of 1994 until the end of October 1997 is illustrated in Figure 6.[29, 30] The figure shows that the overnight rate has been moving rather symmetrically around the tender rate since the introduction of the averaging scheme. From the beginning of 1994 to September 1995, 82% of overnight rate of interest observations were below the tender rate. Under the averaging scheme, the respective share has been 56%. This considerable change in the determination of the overnight rate reflects the fact that in the former facility the banking sector in aggregate held excess reserves (call money deposits) nearly every day, while under the averaging scheme, reserve balances held by the banks are considered as excess reserves only after they have filled the reserve requirement for the whole period.

Figure 6. **Interbank overnight rate of interest and the tender rate**



When analysing the change in the system one should keep in mind, that during the period in which the Bank of Finland applied fixed rate tenders, but the reserve requirements were not averaged the Bank increased its tender rate twice, while it did not make any rate cuts at all. On the contrary, during the first two years under the averaging scheme the Bank of Finland cut its tender rate for seven times, and increased it only once (September 1997). We next examine the development of the volatility of the overnight rate of interest.

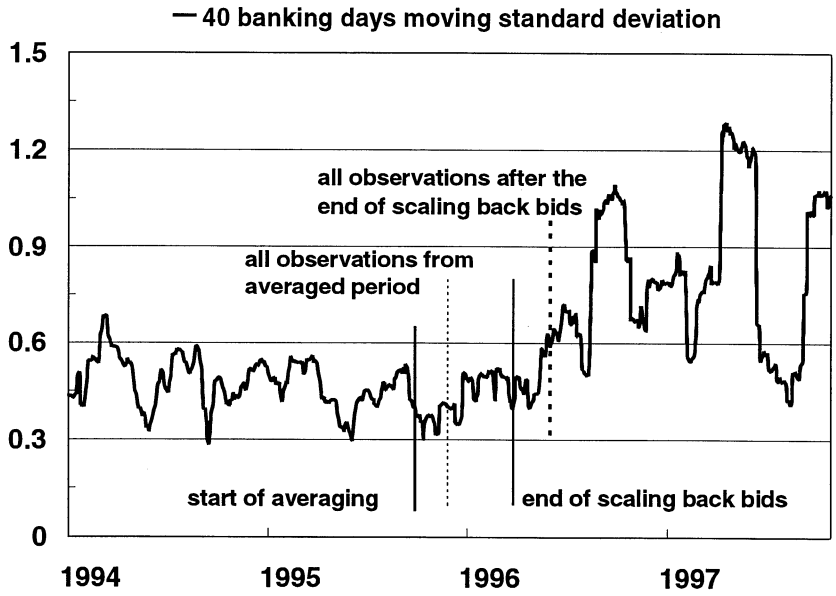
[29] The overnight rate of interest has never been the operational target of the Bank of Finland. In the 1990s, the operational targets have mainly been one- and three-month money market rates (ie one- and three-month Helibor rates).

[30] Pulli (1992) provides a comprehensive study of the overnight rate and the banks' demand for reserves in Finland.

4.1 The volatility of the overnight rate

The volatility of the interest rates can be measured in many ways, none of which is unambiguously superior to all others. Kuosmanen (1996) has measured the interest rate variation in the Finnish interbank overnight markets as the average of the absolute values of daily changes in the interest rate during four periods (1 Jan–30 Nov 1994, 1 Dec 1994–30 Sept 1995, 1 Oct 1995–31 Mar 1996 and 1 Apr 1996–30 Sept 1996). The first period covers the time when the Bank of Finland used variable rate tenders in draining and supplying liquidity to the money markets. The variation according to Kuosmanen was 0.274 during this period. The second period applies to the time when the Bank of Finland turned to use fixed rate tenders, but the averaging scheme was not yet in use. The figure for the second period was 0.271. In the third and fourth periods the Bank of Finland has applied both fixed rate tenders and the averaging scheme. However, in the third period, the Bank of Finland scaled back the bids it received in tenders. In the fourth period, all bids were accepted. The measures, according to Kuosmanen, for third and fourth periods were 0.266 and 0.524, correspondingly.

Figure 7. **Standard deviation of the overnight rate of interest**



In addition to Kuosmanen's approach, interest rate volatility can be measured eg by standard deviation. The 40 banking days moving standard deviation of the difference between the interbank overnight rate of interest and the tender rate is illustrated in Figure 7. The figure shows that variation in the overnight rate of interest grew rapidly during the late summer of 1996. The rate was especially high during August and September 1996 and again in April, May and October 1997. According to the figure, not only did the average standard deviation of the overnight rate of interest increase, but so did the volatility of standard deviation.

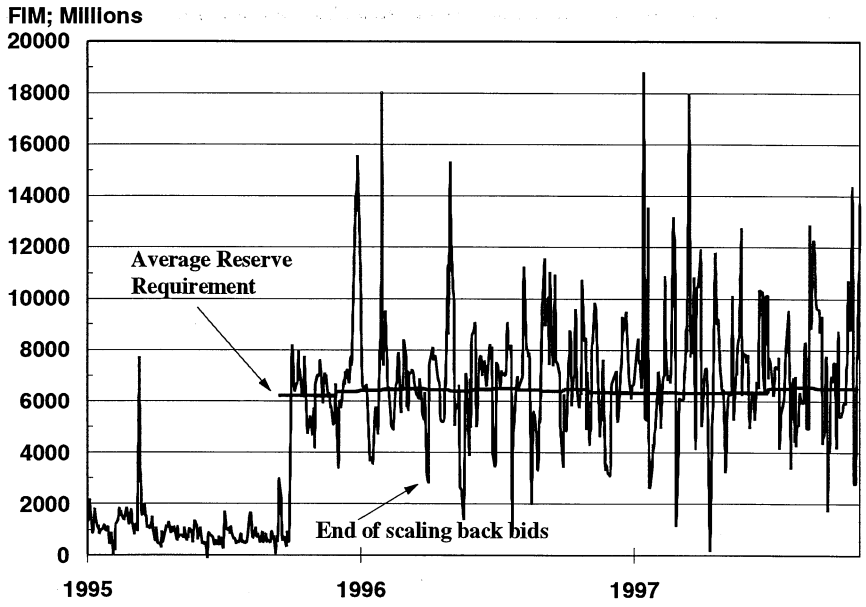
Both the figures by Kuosmanen and Chart 7 show that the increase in the volatility does not appear at the start of the averaging scheme. The increase in the volatility seems to match better the end of scaling back bids.

We now consider how the amount of liquidity in the overnight market has changed after applying the averaging scheme and especially after the Bank of Finland started to accept all bids in liquidity tenders.

4.1.1 The supply of overnight liquidity

The amount of liquidity[31] in the money markets (ie banks' reserve balances) is illustrated in Figure 8. It shows us, that the variation in the liquidity has grown considerably after moving to the averaged system. We may also see that after the Bank of Finland started to accept all bids in tenders, there were days with very low liquidity compared to the average reserve requirement. By contrast, there were days with large amounts of liquidity also when the bids were usually scaled back. The reason for this was simply that as the Finnish money markets have operated on structural surplus in the 1990s, the money markets will have a lot of liquidity as long as the banks do not bid enough to bring liquidity down to its neutral level.

Figure 8. **Money Market Liquidity (call money deposits before 2 Oct 1995, reserve balances thereafter)**



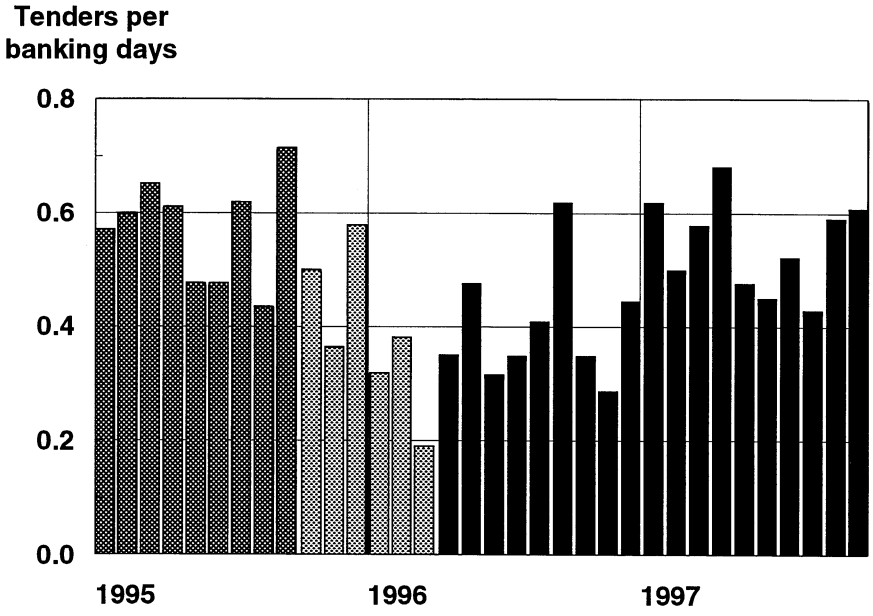
The standard deviation of the money market liquidity in 1995 before the averaging was FIM 700 million. During the period of averaging with scaled back bids, it grew to FIM 2,050 million, and from the beginning of April 1996 until the end of October 1997 it has increased further to FIM 2,560 million. The rise in the variation of money market liquidity is shown also in the average size of the absolute values of daily changes in liquidity. The figures for the same three periods are (in millions of FIM) 340, 990 and 1,500. An additional way to describe the change in the volatility of money market liquidity is to note that in the first period, money market liquidity

[31] Here liquidity means money market liquidity without new liquidity credits. Acquiring liquidity credit is always the last transaction in the interbank market and the interbank overnight rate of interest is based on trading before this increase in liquidity.

deviated only three times by more than FIM 2,000 million from its average (once every three months). During the second period the difference between money market liquidity and average reserve requirement was larger than FIM 2,000 million on 19 days (on 3.2 days in an average month), and the figure for the third period was 196 (on 10.3 days in an average month).

Besides deciding whether to scale back bids, the central bank has to decide the frequency of tenders. In Finland, the tenders are not held according to any pre-specified schedule. The timing of the tenders is largely depending on autonomous changes in the money market liquidity (eg maturing Bank of Finland operations or government foreign exchange payments). The frequency and timing of tenders has an effect on the volatility of money market liquidity. Figure 9 shows us the frequency the Bank of Finland has intervened in the money markets with tenders between January 1995 and October 1997.[32]

Figure 9. **The share of days with tenders in a month**



In 1995, prior to reserve requirement averaging, the Bank of Finland held tenders, on average, slightly more often than every second day. During the first six months of averaging, as the bids were still scaled back, the frequency fell so that a tender was held, on average, every third day. The frequency rose again during the first months of 1997, due in part to the need to sterilize money market effects arising from large foreign exchange interventions by the Bank of Finland in January 1997.

The figures above clearly indicate that during the period with scaled back bids, the Bank of Finland was unable or unwilling to scale back the bids to leave money markets with neutral liquidity. It is also obvious that the increase in the volatility of overnight rate of interest is related to changes in the supply of overnight liquidity. The increase in the variation of the money market liquidity is generated, on one hand, by the change in the demand for liquidity of the tender period, and on the other, by the Bank of Finland's altered reaction to the bids it received in tenders.

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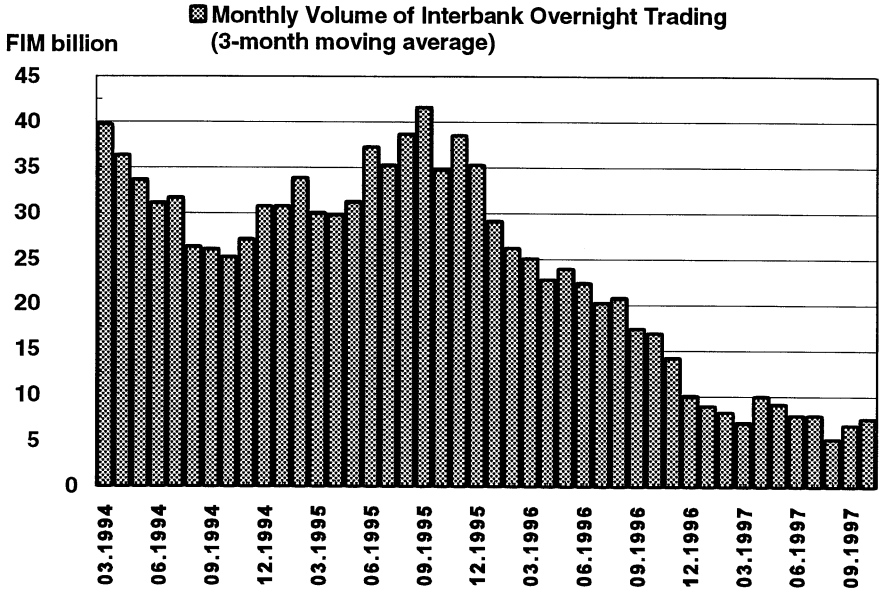
[32] The Bank of Finland did not make any outright interventions in the money markets during this period.

4.1.2 The volume of interbank trading

Figure 10 illustrates the monthly volume of interbank overnight trading as a three-month moving average. In the first half of 1995, the monthly trading volume was around FIM 30-40 billion. With the introduction of the averaging scheme, volume falls steadily so that by end-1997 it is below FIM 10 billion. In other words, banks increasingly preferred to make use of the possibility to average their reserve balances instead of using the interbank overnight market to smooth their stochastic liquidity changes. In Chapter 2, we stated according to Lippman and McCall, that interest rate volatility of a specific period is inversely related to the volume of trading of the instruments with the same maturity. So, the reduction in the volume of trading might be an additional significant factor behind the increased volatility of the interbank overnight rate of interest.

Figure 10. **The Volume of Interbank Overnight Trading**



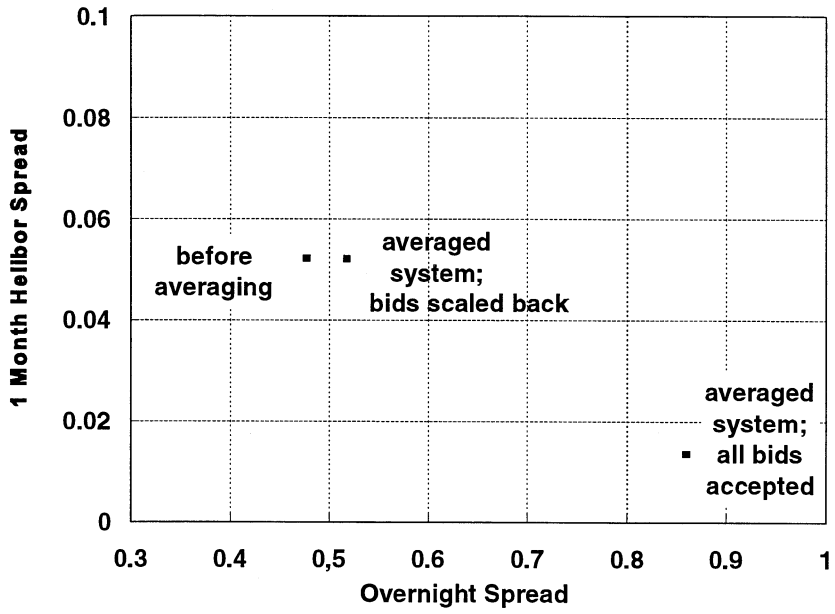
One factor blurring the analysis of the change in the reserve facilities in Finland is that the competition in the money markets has changed dramatically in recent years. The three biggest mandatory reserve holders' share of the aggregate reserve requirement has grown considerably after the merger of the two largest Finnish commercial banks in 1995. Also the number of marketmakers in the Finnish money markets has fallen from ten in 1994 to seven at present.

4.1.3 The volatility of other market rates

The role of overnight rate of interest in the Finnish monetary policy settings has been almost negligible. The operating interest rate target has traditionally been in considerably longer maturities (1 and 3 months money market rates during the 1990s).

The volatility of the spread between tender rate and one month Helibor rate against the corresponding volatility for overnight rate spread is shown for three different periods in Figure 11. These volatilities are measured by the averages of the monthly standard deviations of each spread. The periods that the volatilities are calculated for are January– September 1995, October 1995–March 1996 and April 1996–October 1997.

Figure 11. **Volatilities of some money market rates of interest**



As we have already seen, the volatility of the overnight spread rose slightly after moving to an averaged system. Notably, the large increase occurred after the Bank of Finland started to accept all bids it received in tenders. The volatility of the spread between the tender rate and one month Helibor rate has decreased considerably since the start of accepting all bids.

As the volatility of the overnight rate of interest seems not to have moved along the money market yield curve into the longer periods that are seen as more relevant for transmission of monetary policy, the Bank of Finland has not been overly concerned about the increase in the volatility of the overnight rate.

We next briefly examine how the banks have averaged their reserve balances in practice.

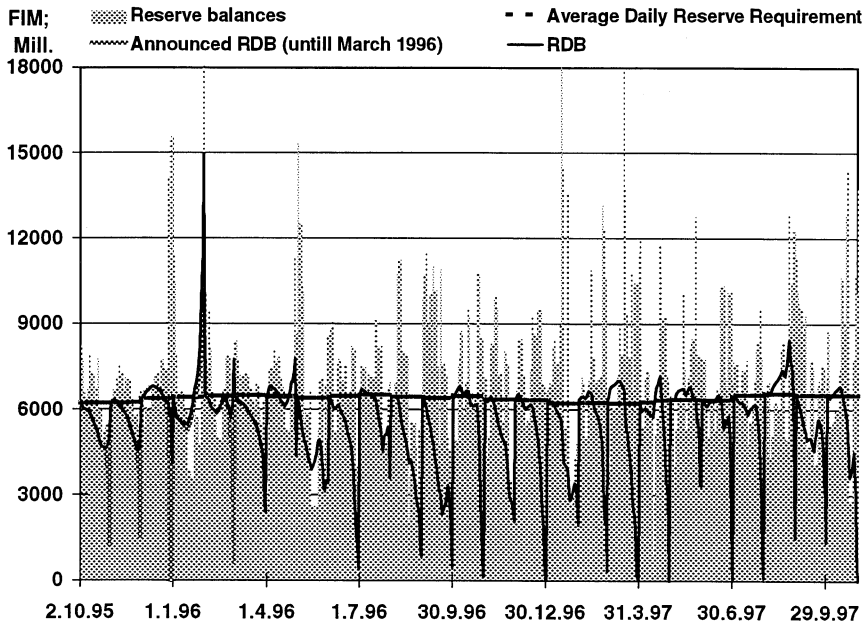
4.2 Averaging the reserve requirement in practice

4.2.1 The realized path of reserve holdings

We assume here that banks act rationally so that banks hold reserve balances when the expected cost of holding them is lowest during the maintenance period. Under this assumption, the banks should hold reserve balances earlier in the maintenance period when they are expecting an increase in the Bank of Finland's steering rate

than when they expect a rate cut. Figure 12 illustrates the banks' aggregate reserve balances on each day and the required daily balances for the remaining maintenance period (RDB) for the respective days. The chart shows both actual RDB and the figure that the Bank of Finland released to the markets.[33]

Figure 12. **Reserve balances and the Required Daily Balances, 2 Oct 1995 – 31 Oct 1997**



The reserve balance needed to fulfil the requirement on the last day of the maintenance period has usually been smaller than the average reserve requirement for the period as a whole. The only exceptions are January, February and April 1996 (however, at the end of February the announced RDB was considerably below the average requirement). On 62% of the days, banks held higher reserve balances than the average requirement at that time, and on 74% of the days, reserve balances have been higher than the RDB.

The path of reserve holdings during an average month is illustrated in Figure 13 for the period when all bids have been accepted. We can see that the RDB drops during an average month to about 80% of the average reserve requirement when there are ten days left in the month.[34] RDB reduces to half of the average reserve requirement when there are three days left, and in the last day of the maintenance period the remaining need for reserve balances has averaged only about 20%of the average daily requirement.

The banks have held reserve balances maybe even surprisingly early in the maintenance period. Especially so, if we keep in mind, that the Bank of Finland has cut its tender rate seven times since the start of applying averaging scheme. The

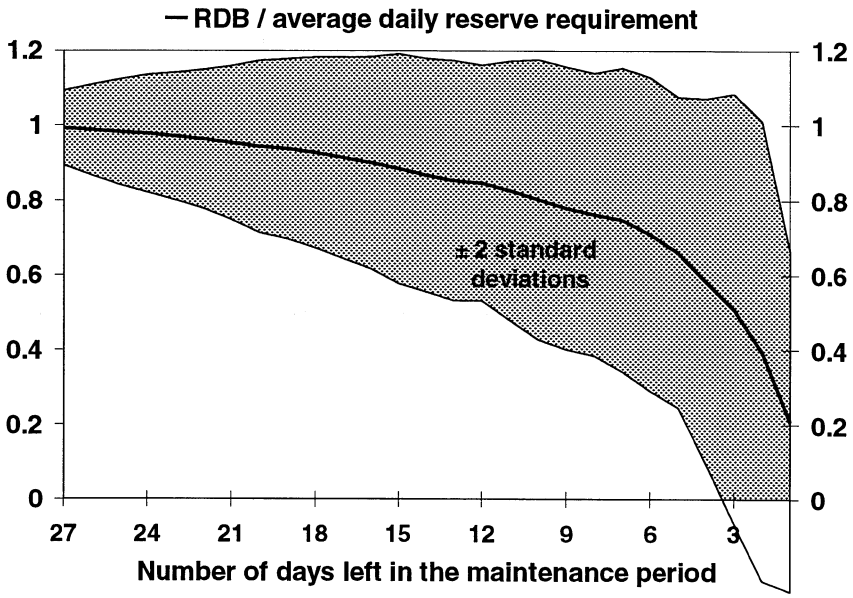
[33]These two figures may differ from each other during the last few days of each maintenance period until March 1996. The figure announced until March 1996 did not take into account the fact that the banks are not allowed to hold end-of-day debit balances in their current accounts.

[34] In Finland, the maintenance period of the reserve requirement is the calender month.

banks do not seem to use in full the possibility to average their reserve balances. They seem to decide only *how much to hold reserves over the RDB.*

Because banks hold usually more liquidity than needed on average to fulfill the reserve requirement, the RDB (our estimate of neutral liquidity) reduces as the period gets shorter. In Chapter 3, we showed that the elasticity of the interest rate depends on the size of neutral liquidity. This means first, that as the length of the remaining period reduces, the volatility of the overnight rate of interest due to stochastic liquidity shocks should increase. Second, the speculative demand for liquidity in the tender period may fall as the period gets shorter due to diminishing elasticity.

Figure 13. **Required daily balances by the length of remaining maintenance period (April 1996 – July 1997)**



Here, we try to illustrate the effect reduced RDB has on the volatility of the overnight rate of interest by calculating the standard deviation of the overnight spread (overnight rate minus tender rate) for the first ten, and for the last ten, days of each maintenance period. The figure for the beginnings of the periods averaged 0.49 and for the ends of periods, 0.76.

4.2.2 On the heterogeneity of the banks

If the banks have correctly not expected the Bank of Finland to raise its tender rate after applying the averaging scheme, why have the banks held so much liquidity so early in the maintenance period? One possible explanation might be found from the heterogeneity of the banks.

The averaging of the reserve requirement provides the banks with a buffer against the effects of negative liquidity shocks. However, to become an effective buffer the reserve requirement of a bank have to be larger than the bank's demand for working balances. This may become a restrictive criteria especially, if the banks'

capability to forecast (at the time the tender is held) their end-of-day reserve balances for the value date of the tender does not correlate with the size of their reserve requirement. The consequence might be, that for some banks the required reserves are not large enough to cover the amount of reserve balances they are otherwise willing to bid for. In such a case the banking sector's aggregate RDB does not equal the neutral liquidity (at least while the tender is held), and the RDB will decrease as the length of the remaining period reduces.[35]

It is ambiguous how such extra liquidity (reserve balances exceeding the RDB) demanded affects the following days' neutral liquidity. Let us assume that there are some banks that bid (in the money market tenders) for more liquidity than what is needed to bring their estimated reserve balances to their RDBs, even when they are not expecting the Bank of Finland to change the tender rate.[36] However, let us further assume that when there is no more uncertainty left on the end-of-day reserve balances of the banks, none of the banks (with neutral interest rate expectations) is willing to demand for more overnight liquidity than its RDB. In this case, the effect the excess liquidity has on the following days' neutral liquidity depends on which bank is holding it. If it is held by the banks that bid for it, the real size of the neutral liquidity on the following days, ie the liquidity the banks will be willing to bid for with neutral interest rate expectations, is unaffected even though the RDB reduces. On the contrary, if the excess liquidity is held by the banks that did not bid for it (ie the banks who bid only according to their RDB), the size of the neutral liquidity diminishes with the RDB.

This means that, if the banks are heterogenous, and if some of the banks are willing to bid for more liquidity than their reserve requirement are, it is possible that even under neutral interest rate expectations *both* the size of the neutral liquidity might decrease as the remaining maintenance period gets shorter *and* the RDB might become a worse estimator of the neutral liquidity as the remaining length of the period reduces.

The path of reserve holdings in excess of the RDB during an average maintenance period is shown in Figure 14 (April 1996 – October 1997).

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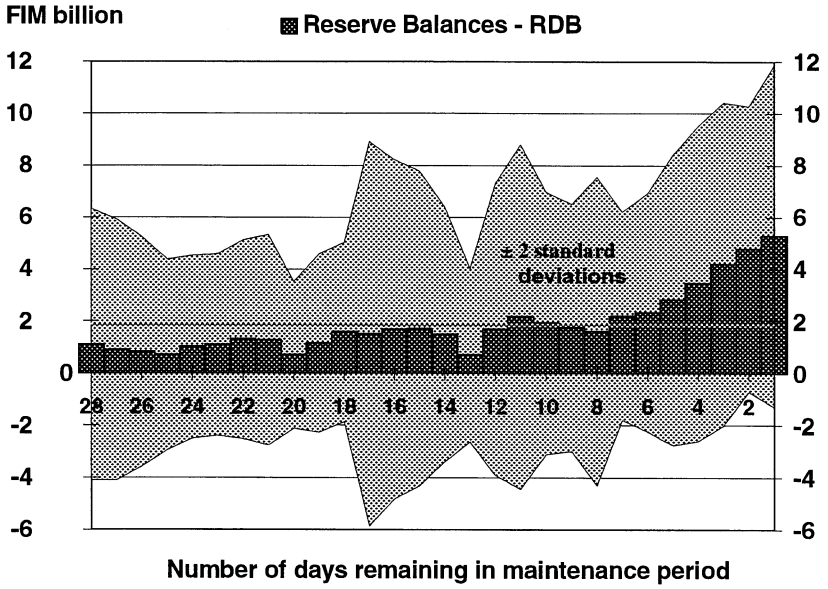
[35] Under the averaging scheme, the aggregate reserve requirement in Finland has been more than six times larger than the average amount of liquidity in the period before averaging. Based on that it seems to be reasonable to assume, that the banks should not be willing to hold reserves above the requirements (to reduce the possibility to be overdrawn) before the last few days of the maintenance period.

[36] The reason for this kind of overbidding derives from the banks inability to forecast the entries in their current accounts with the Bank of Finland.

Figure 14. **Reserve Balances in exceeding the Required Daily Balances for the remaining period**



We can see two things from Figure 14. First, on average (and at aggregate level) banks have been holding more reserves than their RDB every day of the maintenance period. Second, the amount of reserves exceeding RDB seems to grow as the remaining period falls. These both observations support the idea that some banks are willing to hold reserves above their average requirement even when they do not expect an increase in the tender rate.

If we regress the reserve balances exceeding RDB by the RDB, we find that the independent variable is statistically highly significant, and the coefficient of determination is 0.27. Performing the same regression for the last days of maintenance periods, we find that (as expected) the excess reserves that banks are willing to hold do not correlate at any statistically meaningful level with the amount of reserves that are needed on the last day of the period to meet the reserve requirement. Banks have held more than FIM 5 billion on the last day of the maintenance period to prevent them from falling into a situation where they must acquire liquidity credit to meet their reserve requirement. This amount is unexpectedly high, bearing in mind that before the averaging scheme (when every day could be thought as the last day of the maintenance period) the average amount of excess reserves was around FIM 1 billion.[37]

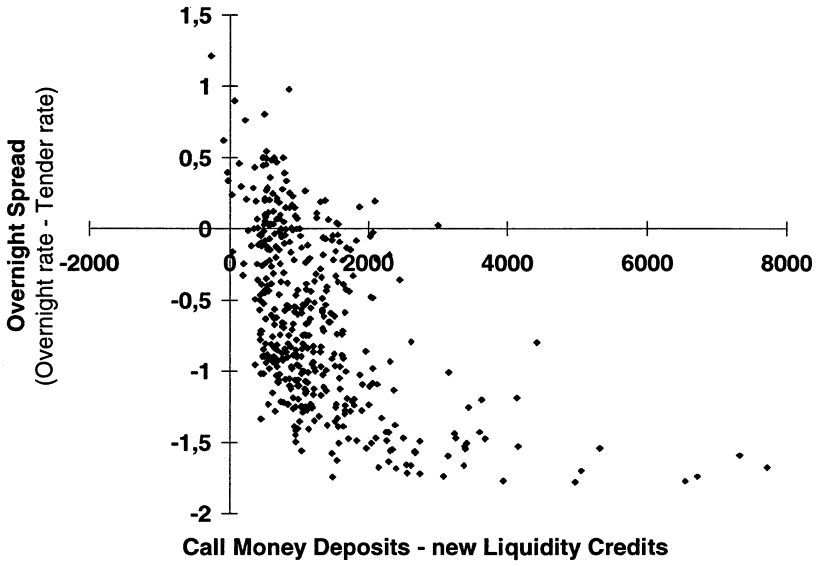
Based on the above evidence, we may conclude that the reserve requirement may not always be large enough to cover banks' reserve needs for other purposes as well. Thus, RDB cannot be construed as a perfect estimator of neutral liquidity.

[37] Even though reserves exceeding the reserve requirement have, on average, exceeded FIM 5 billion, the reserves held by banks that exceed the reserve requirement have been approximately FIM 610 million per day compared with nearly FIM 1 billion before averaging.

4.2.3 Overnight liquidity-interest rate observations

Finally, let us briefly consider the realized liquidity-overnight rate of interest observations. Figure 15 is a scatter plot of the overnight spread (the overnight rate-tender rate) and the banking sector's call money deposits from the period before the averaging (3 Jan 1994 – 30 Sept 1995). The plot indicates a convex relationship between the overnight rate of interest and call money deposits as expected. The observations are heavily concentrated between FIM 500 – 1500 million, which on one hand reflects the amount of liquidity the banks were willing to bid for and on the other hand the Bank of Finland's willingness to scale back the money market liquidity into this level.

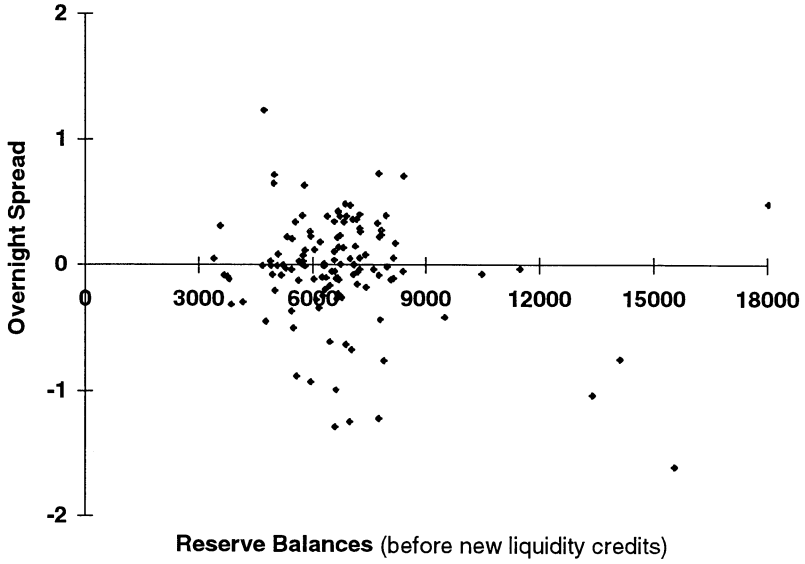
Figure 15. **Overnight rate of interest and money market liquidity before averaging (3 Jan 1994 – 30 Sept 1995)**



The interest rate elasticity of the demand for overnight liquidity seems to be very small when the money market liquidity is below FIM 2,000 million. When liquidity rises above this level, it increases the elasticity considerably. The spread between the overnight rate and tender rate seems to approach two percentage points when call money deposits exceed FIM 3 billion. The Bank of Finland paid an interest rate on call money deposits determined as the tender rate minus two per cent.

We can draw similar plot also for the period under the averaging scheme. However, we have divided the period into two parts according to the way the Bank of Finland has reacted to the bids. Figure 16 shows us the situation when the Bank of Finland used to scale back the bids when considered necessary (October 1995–March 1996).

Figure 16. **Overnight rate of interest and money market liquidity under averaging scheme when the Bank of Finland scaled back bids (October 1995 – March 1996)**



There are only 124 observations from this period. There seems to be very weak correlation between the money market liquidity and the overnight rate of interest.[38] This weak dependence of the variables may be seen as a consequence of the Bank of Finland's inability to scale back bids in some situations. According to the model presented in Chapter 3, an expected tender rate cut raises the overnight rate of interest when bids are not scaled back and decreases it when the bids are scaled back. During the first six months under the averaging scheme, bids were scaled back in about half of the tenders.

The overnight liquidity-interest rate observations from the period when the Bank of Finland accepted all bids are shown in Figure 17. There are 300 observations from this period. The correlation between the money market liquidity and overnight spread seems much higher for this period.[39]

[38] If we regress the overnight spread with reserve balances, we see that the function can explain only 3% of the variation in the overnight spread.

[39] If we regress the overnight spread with reserve balances, we see that the function can explain over 30% of the variation in the overnight spread. The coefficient of determination is over 43% when we allow for logarithmic dependence between variables.

Figure 17. **Overnight rate of interest and money market liquidity under averaging scheme, all bids accepted (April 1995 – October 1997)**

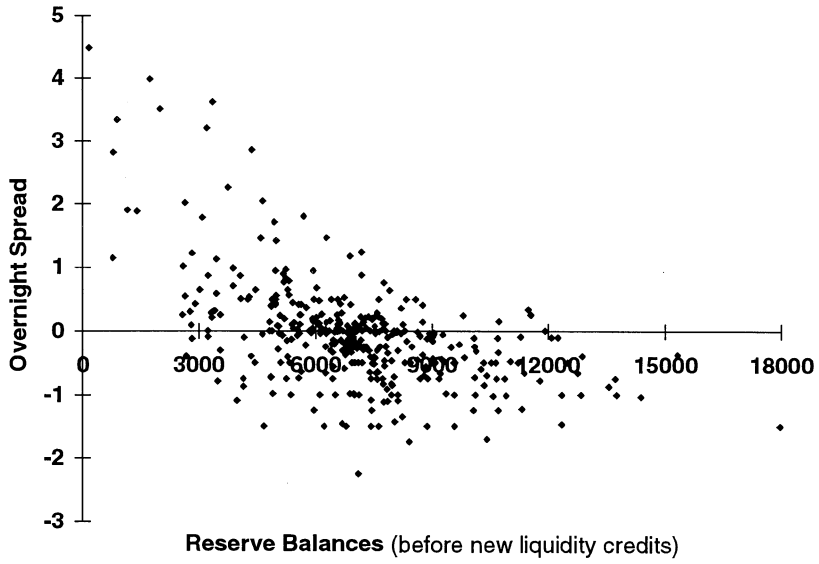
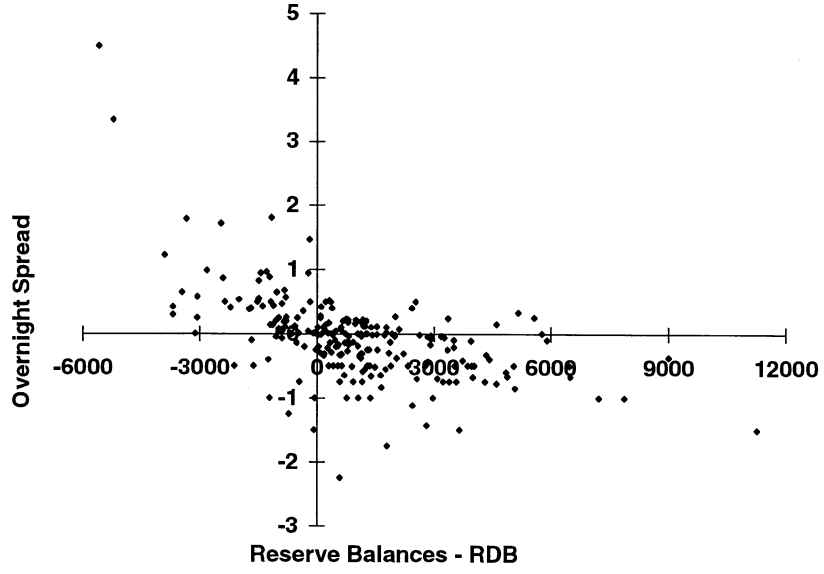


Figure 17 does not take into account the fact that the size of the neutral liquidity is not constant. That is why we try to illustrate the relation between the overnight spread and the deviations from the neutral liquidity by showing in Figure 18 on the X axis the difference between reserve balances and the required daily balances for the remaining period (RDB). In previous section we showed that there are problems in using the RDB as an estimator of the neutral liquidity. Because of these problems we show only the observations for which the RDB has been larger than FIM 5,200 million.[40]

Figure 18. **Overnight spread and deviations from the neutral liquidity**



[40] FIM 5,200 million is the average amount of liquidity that the banks have on average held over the RDB in the last day of each maintenance period.

It would be unwise to make hasty conclusions about the demand curve for overnight liquidity based on the Figure 18. Even if we accept RDB as a reasonable estimator of neutral liquidity for days with RDB over FIM 5,200 million, there still remains the problem that interest rate expectations are not taken into account in this figure. As we already show in section 2.3, the overnight rate of interest-liquidity points may lie on different demand curves, depending on the banks' interest rate expectations. However, if we compare Figure 15 with 17 and 18, it should be quite safe to say that the interest rate elasticity of demand for overnight liquidity has grown since starting the averaging scheme.

5 Summary and conclusions

Based on a simple model of the determination of the overnight rate of interest in the Finnish money markets presented in Chapter 2, it was shown that Finland's current averaging scheme increases the interest rate elasticity of demand for overnight liquidity. However, an increase in elasticity *per se* may be inadequate to cause a decrease in the volatility of the overnight rate of interest, because rising interest rate elasticity of demand for overnight liquidity also permits shifts in demand for liquidity during the tender period, which may occur, eg, when there are interest rate expectations. This may increase the variation in the supply of overnight reserves, which may consequently increase the volatility of the overnight rate of interest.

Chapter 2 further discussed how both the size of the reserve requirement and the path of reserve holdings affect the interest rate elasticity of demand for overnight reserves. To become an effective buffer against stochastic liquidity shocks and to increase the interest rate elasticity of the demand for liquidity, the size of the reserve requirement should be bigger than banks' aggregate demand for working balances. However, increasing the size of the averaged reserve requirement decreases the banks' need to resort to overnight markets. This may reduce the volume of interbank overnight trading so that the overnight rate of interest in the thinner market is subject to greater volatility.

Chapter 3 dealt with the what happens when the central bank scales back bids in liquidity tenders. Under the assumptions made over the shifts in the demand for liquidity, we show that when the central bank accepts all bids it receives in tenders, the overnight rate of interest increases (decreases) if banks expect the central bank to cut (raise) its tender rate in the near future. When the central bank scales back bids so that the money markets are always provided with neutral liquidity, the overnight rate of interest falls (increases) under the expectation of a rate cut (an increase in the tender rate). The maturity of the operational target of the central bank was seen to affect the decision of whether to scale back bids in tenders. The logical argument applied says that the allotment decision will not only be reflected in the overnight rate of interest, but also will strongly affect the market rate of interest with the maturity of the tender.

Chapter 4 examined the Finnish experiences with an averaging scheme. Under averaging, the overnight rate moves more symmetrically around the tender rate than before averaging. The volatility of both the money market liquidity and the overnight rate of interest have increased – especially since spring 1996, when the

Bank of Finland decided to accept all bids in tenders. The volatility of the one-month money market rate (the same maturity as the tender) has decreased, while the volatility of the overnight rate has increased. The volume in the interbank overnight trading has fallen considerably under the averaging scheme, which may have contributed to the increase in the volatility of the overnight rate. We end by observing the realized path of the banks actual reserve holdings, and take a very brief look at the possible effects that heterogeneity of banks might have had on the path.

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