NATIONAL BANK OF HUNGARY

ÁRON GEREBEN

The Interbank Money Market in Hungary

(Lesson from the Period between September 1998 and March 1999)

NBH OCCASIONAL PAPERS
7

ÁRON GEREBEN

The Interbank Money Market in Hungary

(Lessons from the period between September 1998 and March 1999)

NBH OCCASIONAL PAPERS 7

The views and opinions expressed here are the author's
and do not necessarily represent those of the National Bank of Hungary.

Compiled by: Áron Gereben
member of the Monetary Policy Department of the National Bank of Hungary
Tel.: 302–3000/1074
E-mail: gerebena@mnb.hu
Published by the Secretariat of the National Bank of Hungary
Publisher: Dr. József Kajdi Managing Director
Szabadság tér 8–9, H-1850 Budapest .
Prepared for printing by the publications Group of the Bank's Information Department
Date of Printing: 15 May 2000
ISSN 1216-9293

Contents

Summary

Between September 1998 and spring 1999 the Hungarian interbank money market was facing severe liquidity shocks. As a consequence, overnight interest rates were showing higher variability compared to previous periods. This paper aims to reveal the underlying causes of this market disequilibrium and also to assess the experiences of the period from the viewpoint of monetary policy.

The higher variability of overnight interest rates is undesirable for central banks only if it affects the interest rates with longer maturity. In general this is not the case, but as deviations of the overnight rate proved to be "persistent" within the period examined, the daily liquidity situation affected the longer-term yields as well. Econometric evidence shows that variations in the overnight rate were influencing the 3-month interbank rates.

Hectic changes in the market's liquidity position and high variability in overnight interest rates were partly caused by the Russian crisis and the modification of the instruments of monetary policy. Furthermore, the deficiencies of banks' inappropriate liquidity management also exacerbated the market turbulence. Analysis of market data reveals several occasions when the participants of the interbank market behaved irrationally, which contributed to the persistence of the liquidity anomalies.

Several factors might cause the operations of treasuries to deviate from rational behaviour. Both the internal regulatory framework of the treasuries within the banks and the external regulatory environment – legal and accounting rules – might hinder the development of an efficient interbank market (e.g. the more widespread use of repo operation instead of outright lending). Fur-

thermore it is likely that – at least in their current phase of development – it is more profitable for a large share of banks to spend resources on divisions other than the treasury and especially liquidity management.

By shortening the maturity of its main policy instrument from one month to two weeks the central bank managed to ease the liquidity disturbances. On the other hand, such a step could not, of course, solve the efficiency problems inherent in the interbank market.

The author is grateful to the staff of the Monetary Policy Department and the Economic and Research Department of the NBH for their helpful comments and assistance.

1 | Introduction

Between September 1998 and spring 1999 the Hungarian interbank money market was facing severe liquidity shocks. As a consequence, overnight interest rates showed higher variability compared to previous periods. This paper aims to reveal the underlying causes of this market disequilibrium and to assess the experiences of the period from the viewpoint of monetary policy.

Section 2 briefly describes the main characteristics of the development of overnight interest rates from September 1998 to March 1999.

Section 3 examines different aspects of the link between the behaviour of overnight rates and the monetary transmission mechanism, and presents the instruments that are used by central banks for smoothing the path of overnight rates.

Section 4 presents empirical evidence to show that from Autumn 1998 liquidity shocks influenced those longer rates that are considered to be essential for monetary control.

Section 5 classifies the primary reasons that led within the period specified to the volatility of the overnight interest rate, which had not been experienced previously.

Section 6 deals with the efficiency problems of the interbank money market: some elements of the current institutional and regulatory framework significantly contribute to the treasuries' inability of fully exploiting the market opportunities.

Section 7 briefly evaluates how the shortening of the maturity of the central bank's main policy instrument from one month to two weeks affected the banks' liquidity management. Section 8 concludes the paper.

2 | Overnight interest rates between September 1998 and March 1999

August 1998 was a pivotal point in the history of the Hungarian interbank money market

The end of August 1998 was certainly a pivotal point in the history of the Hungarian interbank money market. Substantive changes were effectuated in the instruments of monetary policy, while at the same time short-term foreign capital inflows ceased, causing a drop in the permanent liquidity surplus experienced previously. The resulting shocks in market liquidity posed a challenge for banks' liquidity managers, who were accustomed to a balanced structural liquidity surplus and to the rather "comfortable" set-up of the central bank instruments. The new environment forced treasuries to revise their reserve accumulation strategies and pushed them to operate more active liquidity management.

market anomalies

The banking system as a whole was facing the new conditions of liquidity management with difficulties. One sign that showed the anomalies of the interbank money market was the increased use of the central bank's marginal lending and deposit facilities. While during the first eight months of the year the NBH's overnight active repo instrument was effective only in January, from September until December there was need for overnight central bank lending in each and every month. Such tendency can be shown on the deposit side as well. From January to August 1998 there were only 4 days when the volume of overnight deposits exceeded Ft 50 billion, while between September and December it happened 9 times. Furthermore 3 out of the 4 "extreme" cases of the first 8 months occurred at the end of August.

increased fluctuation of the overnight rate

The tightness of the liquidity situation was mirrored by the overnight interest rates. Figure 1 shows that before August 1998 overnight rates followed a rather smooth path except for some few peaks which occurred generally on the last one-two days of the reserve maintenance period. During the last months of the year, however, the overnight rate fluctuated between the upper and lower edge of the interest rate corridor defined by the NBH's marginal lending and deposit rates. Moreover, while previously extreme peaks occurred only for one or two days at the end of the maintenance period, during the last months of 1998 the overnight rate often remained on the edge of the corridor for several weeks.

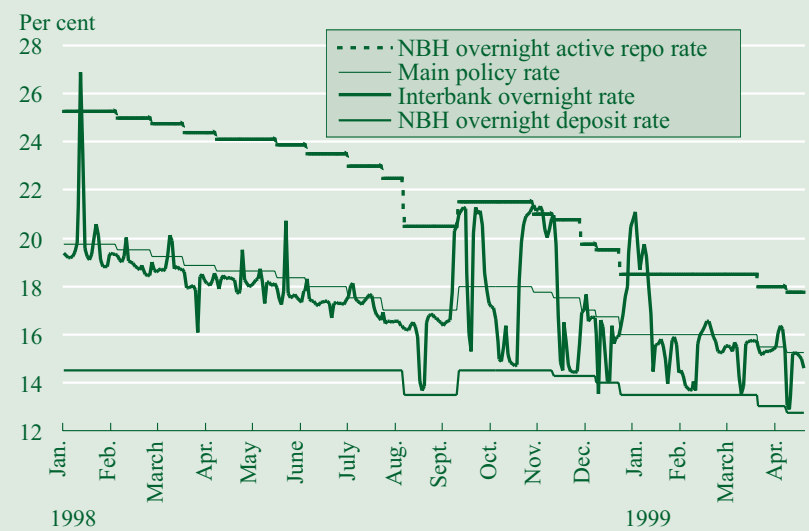
Higher interest rate variability is also reflected in the increase of the overnight rate's deviation from the main policy rate: in the latter

period the measured standard deviation is 2.5 times higher than during the first part of the year.

Market turmoil persisted during the first two months of 1999. January was characterised by shortage of liquidity and by permanently high overnight rates, while in February, on the contrary, there was a constant surplus of funds on the market. Stabilisation of the market conditions occurred only in March, when the maturity of the NBH's main policy instrument was shortened from one month to two weeks.

Chart 1

The overnight interest rate



3 The variability of overnight interest rates and the monetary transmission mechanism

From the central bank's point of view it is a crucial question whether the alternation of the periods with tight and loose liquidity and the subsequent high variability of overnight interest rates influences the efficiency of the monetary transmission mechanism.

the volatility of the overnight rates is considered to be harmful only if it also affects interest rates at longer maturities

The operating target of the NBH is defined as a certain level of the money market rates with maturities between 3 to 6 months. The bank influences these yields through its instruments. The volatility of the overnight rates is usually considered to be harmful only if it also affects interest rates at longer maturities, i.e. if moves in the overnight rates induce changes in those longer rates which are of primary concern for the central bank.

This is certainly unfavourable as in this case the prevailing liquidity situation affects the dynamics of the central bank's operating target rates, causing an unwanted noise in the transmission mechanism. As a result changes in the main policy rate are not necessarily reflected unambiguously in market yields; the signalling effect of rate changes might fade. Consequently, monetary policy is less capable of influencing investment and saving decisions, aggregate demand and inflation.

It is often assumed implicitly or explicitly in the literature that the variations of the overnight rate are passing through automatically to the longer maturities. This is not necessarily true.[1] The following paragraphs attempt to answer the following questions:

- In which circumstances can overnight interest rate volatility be considered harmful?
- When is it necessary to reduce this volatility?
- What are the instruments that central banks might use for that purpose?

[1] Empirical evidence on the effects of the overnight rate volatility on the transmission mechanism is rather ambiguous. *Kasman* (1993) used data from six developed countries between 1988 and 1991. He concluded that overnight rate volatility affected 3-month money market rates only in Switzerland. *Borio* (1997) on the contrary found that in 11 of the 12 countries he examined volatility of the overnight rates significantly influenced the variability of the 3-month rates.

Transitory and permanent deviations

two types of interest rate variations

Let us distinguish two types of interest rate variations. Variability of an interest rate might mean rapid alternation of positive and negative deviations from a typical value – in the case of the overnight interest rate this typical value might be the level of the key policy rate. But it might also mean longer-term (positively auto-correlated) deviations to the same direction, which are followed by a reversion to the typical value.

only permanent variability can be considered as harmful

If market participants behave in a rational way and markets work efficiently, then high-frequency variability of the overnight interest cannot be considered as harmful. Volatility affects the efficiency of the transmission mechanism only if overnight yields show permanent deviations from the level of the central bank's key policy rate – by "permanent deviations" we mean deviations that last at least for 1–2 weeks.

efficient markets are characterised by transitory variability

On efficient interbank markets deviations of the overnight interest rate are transitory phenomena that last only for a couple of days. Such deviations usually result from short-term liquidity shocks. For example such shocks can be caused by sudden inflows or outflows to the government's current account at the central bank, or by unexpected changes in the demand for cash. Such events may reduce or expand the overall liquidity of the banking system. If the interbank money market works in an efficient way and the banks' liquidity management is forward-looking enough, such liquidity shortages and surpluses can be resolved by altering the volume of the banks' time deposits at the central bank.

Let us assume that on a given day of the reserve maintenance period the banking system is short of liquidity and overnight money is available only for high rates. This does not necessarily mean that this tight liquidity situation will remain for a longer period – a week or a month. In an efficient interbank market today's level of the overnight interest rates does not contain any additional information about the level of tomorrow, as the overnight rate is determined by the daily liquidity situation. This also means that we cannot assume that deviations of the overnight rate will necessarily influence the rates at higher maturities.

interbank liquidity and the government securities market

On the Hungarian market for government securities banks play a significant role as investors.[2] Even taking this into account, it is difficult to find a rational explanation for short-term liquidity shocks affecting longer-term yields. Someone could argue that in a govern-

[2] Thirty percent of the traded government securities is held by commercial banks and specialised financial institutions.

ment securities market dominated by the banks it could easily happen that in times of liquidity shortages the banking system does not want to use its scarce money to buy government bonds. This could lead to a fall in demand for government securities and to a rise in longer-term yields. On the other hand, if banks consider liquidity shortage to be a temporary phenomenon this behaviour is not rational. If a certain deal on the government bond market seems to be profitable, the bank should make that deal, irrespective of the liquidity situation. During periods of liquidity shortage – when overnight rates are high – it is worthwhile to maintain a lower working balance on the bank's current account to finance the deal, and to use the averaging facility for compensating the deficit later. Even at the end of the reserve maintenance period it is rewarding to finance a profitable purchase of government securities from overnight interbank loans or central bank credit facilities, as liquidity shortage is usually a temporary phenomenon that lasts only for two or three days, while government securities are longer-period investments. In the case of temporary liquidity shocks, therefore, investment decisions can be separated from liquidity management considerations. Thus, even if the market for government securities is dominated by banks, it is not necessary to assume that short-term liquidity shocks influence longer-term yields.

permanent deviations of the overnight rates might affect longer-term rates

In the above we were assuming that changes in overnight interest rates are considered to be transitory phenomena lasting only a few days. If deviations of the overnight rates are not considered to be caused by some short-term liquidity shock, but by some more permanent shortage, then as a consequence longer-term yields can be affected, too. If market participants are aware of the fact that liquidity might be scarce for some weeks and overnight rates will be high, then by rolling overnight interbank deposits it is possible to achieve a higher overall yield than the yield of the central bank's key operating instrument. In such a case overnight rates might affect longer-term rates through forward interest parity.

Generally speaking, the longer the expected time of a deviation of the overnight rate, the more it can influence the longer rates. It can be shown that a 2–3 percentage point deviation of the overnight rate that is expected to last for two weeks can result in a 40–50 basis point increase or decrease of the 3-month rate.

the effect of short-term...

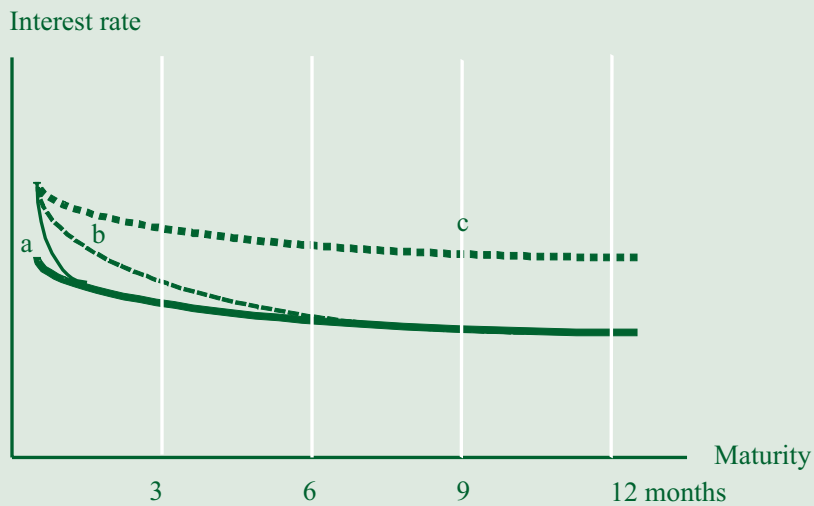
Chart 2 depicts the effect of the expected length of an increase in overnight rates on the yield curve. The thick solid line represents the baseline yield curve. In case (a) the increase of the overnight rates is caused by a short-term liquidity shock, therefore it significantly affects only the very short end of the yield curve.

...medium-term...

Case (b) represents the event when the expected liquidity shortage lasts for a relatively long period – e.g. a whole reserve maintenance period. In such cases the raise in the overnight rate

Chart 2

The effect of an increase in the overnight rates on the yield curve with different market expectations



might affect the 1–3–6 month maturities through the forward interest parity. The longer the maturity, the less it is affected by the overnight rate deviation. Such a situation was observed on the Hungarian market in November 1998. In that particular maintenance period the whole banking system was suffering from permanent liquidity shortage, due to having tied down a vast amount of reserve money in the central bank's one-month deposit in late October. During this period the overnight interest rate exceeded the key policy rate by some 200-250 basis points, which was reflected in a significant raise of the 3-month rates as well.[3] Similar cases were observed in January 1999.

... and permanent overnight rate changes on the yield curve

Case (c) stands for the event when the rise in the overnight rate signals a once-for-all raise in the level of interest rates. This happens only in extreme circumstances, as shifts in the yield curve usually do not appear first with the overnight maturity, but generally result from a change in the central bank's main policy rate. A good example of this rare situation was observed in September 1998. As a consequence of the Russian crisis the Hungarian forint reached the lower edge of the intervention band. The market was expecting an increase in the key policy rate, but the NBH did not make that move for a relatively long period. The overnight rate rose to the ceiling of the over-

[3] By that time the permanent liquidity shock was not mainly due to random shocks but it resulted from the speculation of banks to an expected change in the policy rate.

night interest rate corridor, and the market was expecting the NBH to shift the whole corridor upwards. All benchmark yields followed the rise in the overnight maturity, raising the whole yield curve to a higher level.

To conclude, it can be said that variations in the overnight rate *per se* do not weaken the efficiency of the monetary transmission mechanism. Variability can be considered harmful only if it is paired with permanent deviations, i.e. when liquidity shocks die out slowly, keeping the overnight interest rates on the upper or lower edge of the interest rate corridor for a relatively long time.

Overnight rates and the expectations about the central bank's key policy rate: pivoting

the effect of market expectations concerning the central bank's rate changes

The above analysis implicitly assumes most of the times that the level of the central bank's key policy rate is constant, or at least market participants do not expect changes in the central bank rates. If we take into account the effects of market expectations concerning the central bank's rate changes, we can find a reason that can explain some permanent deviations of the overnight rates. As will be shown in this section, these sort of deviations can be considered harmful only if the banking system does not take the liquidity effects of its speculative strategy into consideration when speculating in relation to the central bank's expected rate changes.

monetary control and forward interest parity

The central bank can influence longer-term yields through fixing the rate at a relatively short maturity and exploiting the forward interest parity. If the central bank's main policy instrument is a 1-month deposit, then the 3-month risk-free yield should be equal to the expected yield on rolling over 3 times the central bank's 1-month instrument. As a consequence, if the market expects the central bank rate to be constant in the next 3 months, then the nominal yield of the 3-month risk-free bill must slightly exceed the policy rate to take compounding into account. If the market generally expects a rate cut, then the 3-month rate is usually lower than the policy rate (the short end of the yield curve is downward sloping). This is because the reinvestment in the central bank's deposit facility is expected to occur at a lower rate than the actual one.

rate cut expectations: pivoting

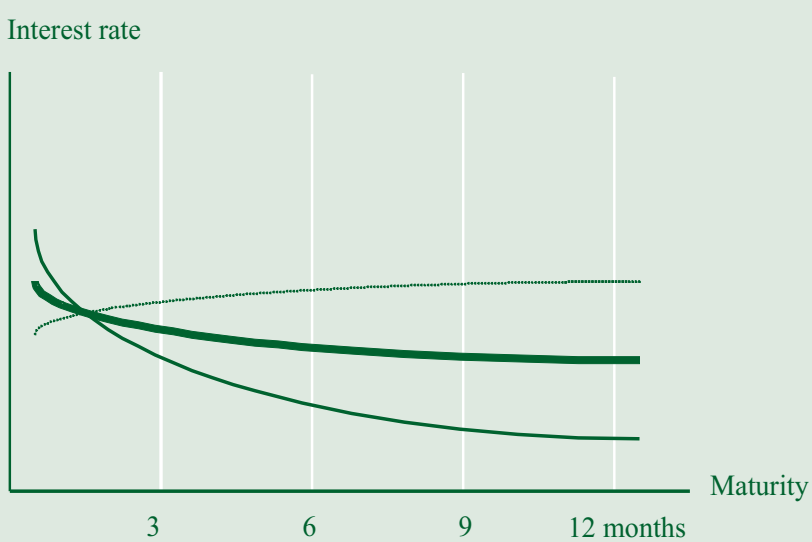
If the market assigns a high probability to a rate cut, then the yield curve usually turns around the maturity that corresponds to the expected time of the rate cut. This is called *pivoting*. If the central bank is using a standing facility with a maturity that exceeds the expected time of the rate cut, then the pivoting occurs around the date

corresponding to the expected time of the rate cut *plus* the maturity of the central bank's instrument.[4] The reason behind the pivoting is that market participants are trying to exploit the price reactions that follow the change in the policy rate. If the yield curve is expected to shift downwards after a rate cut, then the price of assets with long duration will increase the most. The longer the duration of a portfolio, the higher the gain it yields after a parallel downward shift in the yield curve. Knowing that, when a rate cut is expected, market participants try to purchase fixed-income securities with longer maturities, which leads to a drop in long-term rates even before the rate cut occurs. The efficiency of this speculation strategy can be increased if someone uses short-term – e.g. interbank – loans to finance its purchases, knowing that after the rate cut occurs, short-term yields will decrease as well and he/she will be able to finance his or her long-run investments by cheap, short-term loans. Thus when the market expects a rate cut, the demand for short-term loans increases, pushing short- term rates upwards. When a rate increase is expected instead of a rate cut, similar moves occur, but in the opposite direction.

All in all, an expected rate cut leads to the pivoting of the yield curve as longer-term rates decrease before the actual rate cut. If the

Chart 3

Yield curve moves when the main policy rate is expected to change (pivoting)



[4] For theoretical models about the pivoting see *Schnadt and Whittaker* (1993).

central bank does not decrease the key policy rate, but expectations about a rate cut occur from time to time, volatility of both the short-term and the long-term rates might increase.

pivoting in itself is not harmful...

It is important to emphasise that while in the previous subsection we assumed that moves in the interest rates were caused by exogenous liquidity shocks (e.g. changes in the government's current account balance), the variability caused by pivoting originates in the expectations of the market participants. Interest rate variability caused by pivoting is not necessarily harmful; on the contrary, it reveals the market's expectations to the central bank. Furthermore, if the market expectations are fulfilled and the central bank changes its main policy rate, the pivoting vanishes automatically. If in such cases the central bank attempts to diminish the moves in the overnight rates by "ordinary" means – e.g. a narrow interest rate corridor or by injecting (withdrawing) liquidity to (from) the interbank market – such a move only gives further opportunity to market participants for speculation: they gain cheap access to short-term liquidity that can be used to increase the duration of their asset portfolio. If the central bank wishes to reduce the volatility caused by pivoting, the adequate method is to provide clear information about the goals of the central bank and also about the expected policy measures.

...only if it comes together with excessive speculation

Pivoting in itself is not harmful, nevertheless excessive speculation on expected central bank rate changes can cause permanent liquidity shortages. Such a situation occurs when the banks, when carrying out their speculative strategy, do not take into consideration that speculation affects their future liquidity position. The resulting liquidity shocks, contrary to the simple pivoting, do not die out after the central bank rate change. In this case, although the "original" move in the overnight interest rate was caused by pivoting, the lasting disequilibrium of the market is caused by excessive speculation. Such excessive speculative behaviour contributed significantly to the variability of overnight interest rates from September 1998.

Overnight targeting

main policy rate at the overnight maturity

Reducing the volatility of overnight interest rates is not a goal in itself. It is necessary only if moves in the overnight rate prove to be persistent, as overnight rate volatility reduces the efficiency of the monetary transmission mechanism only in that case. However, some central banks are attempting to reduce the variability of the overnight interest rate for a different reason, namely because their main policy rate is announced at the overnight maturity (e.g. in the USA, Canada, Australia etc.).

In such an instrumental framework the central bank influences market expectations through overnight interest rates. Variability of the rates at the shortest maturity therefore spoils the signalling effect of the monetary policy measures, as the market cannot precisely segregate the intended effects of an official rate change and the rate changes caused by liquidity shocks. Thus these central banks are attempting to reduce the variability of overnight rates, minimising in this way the chance that the market misinterprets the changes in the policy rate. Within such an instrumental framework speculation caused by pivoting disappears, as the short maturity of the central bank instrument does not allow profitable speculation on changes of the yield curve's short end.

Central bank instruments aimed at reducing the variability of overnight interest rates

reserve averaging

An instrument that is widely used to reduce the volatility of the short-term interest rates is *reserve averaging*. Averaging allows the banks to not fulfil their mandatory reserve requirement on a daily basis, but only on the average of a certain period of time (averaging period or maintenance period). As a result, on days ending with shortage in liquid reserves the bank does not have to ask for (interbank or central bank) credit, but by maintaining a higher reserve balance in the remaining days of the averaging period the bank can compensate for the earlier shortages. Thus, despite temporary shortages and surpluses, on average the bank is able to fulfil the mandatory reserve requirement. Averaging is therefore able to smooth temporary liquidity shocks, and as a consequence these shocks are not manifest on the interbank market in higher overnight interest rate volatility.

Smoothing with reserve averaging is more effective when the reserve ratio is higher and the averaging period is longer. The reason behind the former is that if the interbank clearing and settlement system does not allow current account overdrafts (negative balances), then large positive deviations from the mandatory level of reserves cannot be offset by similar negative deviations, as it would lead to negative current account balances. Therefore if the reserve ratio is low, then large positive liquidity shocks cannot be smoothed out by the averaging, and as a result these shocks are transmitted to the interbank market causing a drop in interest rates.[5]

[5] A similar argument can be asserted against those regulations that impose a ceiling to positive deviations from the mandatory reserve balance. Similarly to the zero level of current account balance, ceilings on positive deviations are constraining the use of reserve averaging.

The length of the reserve averaging period is also important. The longer the averaging period, the larger is the puffer that can be used by the banks to absorb liquidity shocks. A longer reserve averaging period, therefore, allows the absorption of longer and/or larger liquidity shocks. As an example, a liquidity shock that lasts for ten days is unlikely to be handled by an averaging period of two weeks, while there is a good chance that the banks can compensate the missing liquidity in a system with a maintenance period of one month. Of course there is always a possibility that the banks are out in their liquidity plans by the end of the period; this is why the last one or two days of the reserve averaging period are characterised by intensive trading on the interbank market and by extremely low or high overnight interest rates. This variability is not considered to be harmful though, as the market participants are aware of its cause and also of its transitory feature. This end-of-period variability is therefore unlikely to affect longer-term interest rates, and as a result the central banks do not make efforts to smooth out these deviations.

overnight interest rate corridor

Another instrument that serves the stabilisation of overnight interest rates is the *overnight interest rate corridor*. Besides playing a prudential role as one of the key instruments of the central bank's lender-of-last-resort function, the interest rate corridor defines a floor and a ceiling for the overnight interest rates by trimming the extreme fluctuations in these yields. The smoothing effect of the interest rate corridor is constrained by the fact that a narrow corridor presents an opportunity for speculation on central bank rate changes through pivoting. If the banks expect a rate cut, they can increase their deposits in the central bank's main instrument with longer maturity, while financing these deposits from the central bank's marginal lending facility representing the ceiling of the overnight rate corridor. The narrower the interest rate corridor, the lower the interest rate of the marginal lending facility, and as a result, the lower is the cost of such a speculation. For a given maturity of the central bank's main (deposit) instrument there exists a minimal width for the overnight interest rate corridor at which the banking system can effectively speculate for expected rate changes. When designing the framework of monetary policy instruments, central banks have to take that into consideration.

active liquidity management

A third tool which can be used for smoothing short-term interest rates and interbank liquidity is *active liquidity management*. When necessary, the central bank can affect the amount of overall liquidity available on the interbank market through open-market operations (usually through tenders) in order to counterweight the effect of liquidity shocks. While the instruments presented formerly – the reserve averaging and the interest rate corridor – work through market automatism, active liquidity management needs discretion-

ary steps from the central bank. Furthermore, active liquidity management requires accurate forecasts of interbank liquidity.

the NBH currently uses all the aforementioned instruments

The NBH currently uses all the instruments mentioned above. The primary instrument of liquidity smoothing is the reserve averaging: the one-month maintenance period introduced in September 1998 allows a rather flexible liquidity management for the banks. However, as was mentioned previously, some banks (or sometimes the banking system as a whole) are often unable to take advantage of the opportunities offered by the system of reserve averaging. The reasons behind this originate in the lack of efficiency in the interbank money market, resulting from certain institutional and regulatory deficiencies.

Besides reserve averaging, the overnight interest rate corridor is used for limiting extreme changes in the overnight rate. The ceiling of the corridor is defined by the interest rate charged on the central bank's overnight active repo facility, while the floor is given by the one-day NBH deposit rate. The interest rate corridor is symmetric around the key policy rate. It has to be mentioned that in extreme cases the overnight active repo rate does not provide a ceiling for overnight rates, as the NBH imposes limits on the individual banks (the limit size is proportional to the balance sheet size of the given bank). In January 1999 some banks exhausted these limits, and as a consequence the interbank overnight rates rose well above the corridor. In an efficient market the overnight rates should have stayed near the level defined by the marginal lending facility until all the banks exhaust all of their limits. Those banks which still had unused marginal lending quotas could have reallocated these funds to banks whose stock of overnight loans had reached the limit size in exchange for a minimal margin. The fact that the overnight interest rate could significantly exceed the ceiling of the interest rate corridor also indicates that the interbank money market does not work efficiently.

In January 1999 the NBH introduced a flexible instrument called quick tender which can be used for active liquidity management. Until September 1999 the quick tender was only used twice. Both times occurred in January 1999 in order to alleviate the shortage in liquidity and to channel the overnight rates back to the interest rate corridor.

4 The link between the variability of overnight interest rates and the monetary transmission mechanism in Hungary: an empirical analysis

did permanent deviations of the overnight rate weaken the monetary control between August 1998 and February 1999?

The main message of the previous chapter can be summarised as follows: those changes in overnight interest rates which prove to be persistent can be considered as harmful from the point of view of the monetary transmission mechanism. These changes might affect those longer-term (3–6 months) interbank rates and yields on government securities that are of primary concern for monetary policy. Between August 1998 and February 1999 overnight rate changes on the Hungarian market were characterised with such persistency: the one-day interest rate often showed deviations from the key policy rate which lasted for two-three weeks (see Chart 1). It is reasonable to assume that such long-lasting deviations could affect the 3 to 6 month rates as well, weakening therefore the central bank's control on these maturities which are important from the viewpoint of monetary transmission.

The validity of our conjecture can be tested by analysing the data by econometric methods. The empirical analysis can be divided into two steps. Firstly we have to define two variables: one that measures the disturbances of the liquidity situation and another that quantifies the imperfection of the central bank's control over the essential maturities. As a second step, we have to examine the whether a causal relation exists between the two variables.

empirical analysis showed that overnight rate changes were reflected in the 3-month BUBOR rate

A detailed description of the empirical analysis can be found in the Appendix. We used vector-autoregression techniques to explore the relation between the deviations of the overnight rates and the moves in the rates at those maturities considered to be important for the transmission mechanism. To quantify these latter we used the 3-month BUBOR[6] rates. The results fully support our conjecture. While during the first part of 1998 the variability of the overnight interest rates did not affect the BUBOR rates, from Autumn 1998 until Spring 1999 there existed a link between persistent deviations in the overnight rates and the 3-month BUBOR. When the overnight interest rate remained at the edge of the interest rate corridor for a relatively long period, it resulted on average in an approximately 10 basis point deviation of the 3-month BUBOR.

[6] Budapest Interbank Offered Rate

5 | The factors behind the permanent liquidity shortages and surpluses

the four primary factors behind permantent liquidity shocks

In the following we will attempt to discover the factors that led to the high variability of the overnight interest rates and to the persistency of liquidity anomalies. Four primary factors could be identified. The first one is the modification of the framework of monetary operations: the timing of the changes in the central bank's instruments temporarily hampered commercial banks' liquidity planning. Another major cause was the capital market crisis in September 1998, which led to a robust withdrawal of liquidity through the channel of central bank intervention on the foreign exchange market. The other two factors that led to the hectic liquidity situation can be related to the seemingly irrational behaviour of bank treasuries. On the one hand, banks did not properly react to the abolition of the central bank's one-week deposit facility. On the other, excessive speculation on the central bank's rate changes heavily exacerbated the anomalies of liquidity.

Changes in the framework of monetary operations

a new framework of monetary operations

The turbulence of the interbank money market is partly due to a comprehensive restructuring of the framework of monetary operations which took place at the end of August 1998. The main goal of the modifications was to make the instruments of monetary policy more simple and market-oriented than they had been previously. The new instrumental environment gave larger leeway for the liquidity management of the individual banks, inducing them to handle liquidity shocks through the interbank market and not through central bank instruments. The emphasis on the development of the interbank market aimed to strengthen competition between bank treasuries: competition could improve the overall efficiency of the banking system and it could also serve to prepare the treasuries for the tougher market environment they would face after the country joins the European Union.

Among other changes, the central bank's one-week deposit facility was suspended, while in the case of the one-month deposit the permanent standing facility was replaced by a "sequential" standing facility, available only twice a week. In the meantime, the reserve av-

eraging period was increased from two weeks to one month, and measures were taken to establish a symmetric and relatively narrow interest rate corridor.

two-week deposit facility available only twice a week

The introduction of the sequential standing facility with respect to the one-month deposit instrument represented a move towards a tendering system from the previously applied permanent standing facility. The fact that the banks had access to *the deposit facility only twice a week* modified slightly the instrumental environment of the bank treasuries, though in practice it did not represent a major change, as the sequential feature of the standing facility could be compensated through reserve averaging.

longer reserve averaging period

Lengthening the reserve averaging period from two weeks to one month allowed greater flexibility when handling liquidity shocks. A longer maintenance period leaves more time to offset the unexpected liquidity surpluses or shortages, thus enhancing the banking system's ability to accommodate liquidity shocks. Problems can arise, however, if the system is hit by shocks of similar direction during the averaging period, or if some institutional feature constrains the operation of reserve averaging. In such cases large imbalances can accrue by the end of the maintenance period, which, together with the exhaustion of interbank lending limits result in extreme moves in the overnight rates. However, on a well-functioning interbank market the probability of the emergence of such situations is low.

abolition of the one week deposit facility

The abolition of the one-week deposit facility was necessary, as the central bank wanted to abandon its previous practice of determining the level of interest rates at two distinct points on the short end of the yield curve. Fixing two interest rates with different maturities can easily lead to inconsistency, which can hinder the signalling effect of changes in the main policy rate on one hand, while presenting an opportunity for speculation on the other.

Furthermore, the NBH deemed that within the new framework of monetary instruments the treasuries would be able to perform efficient liquidity management without the one-week deposit instrument. When the reserve averaging period was two weeks long, banks used the one-week deposit facility to transfer liquidity between the two averaging periods of the same month. This was necessary as the income and the expenditure of the government show a strong seasonality within calendar months, and fluctuations in the State Treasury Account heavily influence the amount of liquidity on the interbank market. After the introduction of the one-month reserve averaging period, the cycle length of the State Treasury Account fluctuations and the averaging period became equal. As a result, fluctuations of the State Treasury Account could be handled fully with the averaging facility. Nothing justified, therefore, the maintenance of the one-week deposit facility.

It was obvious from the beginning that it would take some time for the banks to accommodate to the new market conditions and that the

variability of the interbank rates might increase during the period of transition. However, it was also rational to assume that bank treasuries got to know the principles of the new framework in a couple of months, which could have resulted in a more efficient interbank market and in monetary control that takes full advantage of market forces.

Capital market crisis

the Russian crisis

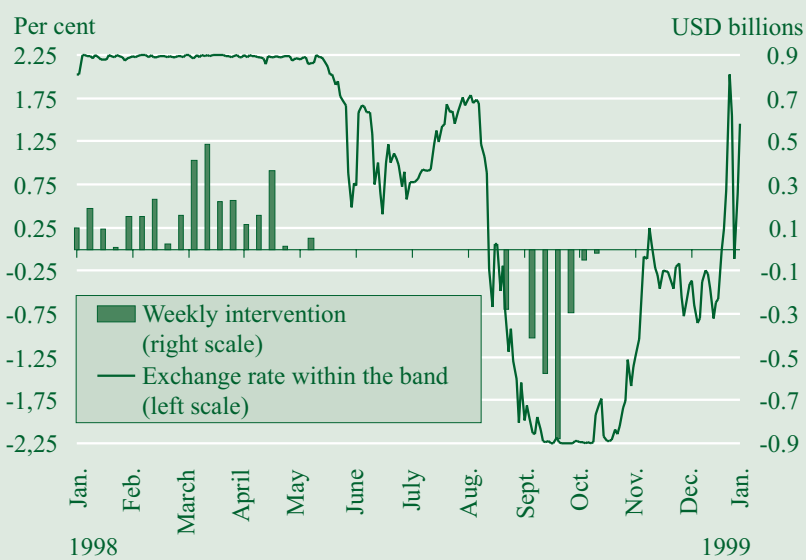
Since the second half of August 1998, together with the emergence of the crisis on the international capital markets, the direction of the capital flows induced by interest rate and exchange rate speculation has changed. From the beginning of September until the end of October the NBH had to intervene on the foreign exchange market to prevent the exchange rate from falling below the weak side of the fluctuation band. During these two months operations on the foreign exchange market reduced the overall liquidity of the banking system by approximately Ft 500 billion.

the banks' liquidity management faced a new and unknown situation

As a result of these two effects – changes in the framework of monetary instruments and the liquidity consequences of the intervention – the banks' liquidity management faced a new and unknown situation. The banking system, which rolled its liquidity surplus mainly in one-month deposits, was shocked by the liquidity shortage caused by the foreign exchange operations. As the pace of the liquidity drain resulting from the intervention was faster than the expiry of the bank's

Chart 4

The exchange rate of the forint within the band and the foreign exchange intervention



deposits with the central bank, the banking system as a whole was short of liquidity and the overnight rates skyrocketed to the upper edge of the corridor. The sequential pattern of the intervention spoiled the original evenly distributed schedule of the one-month deposits: on some days the banks did not renew their deposits at all, while on other days exceedingly high quantities of new deposits were observed. Due to the entanglement of the "natural" expiration schedule of the deposits, the shocks that were hitting the interbank market were able to spread to the following months as well.

long FOREX positions could not be used as a liquidity buffer any more

Prior to the Russian crisis the intervention on the strong side of the fluctuation band provided a continuous and rather steady increase in liquidity. By wisely timing their currency sales, banks could manage their domestic liquidity position in a flexible manner, using their long foreign exchange position as a buffer. Therefore they did not fall back on funds from the interbank market or from the central bank. The reversal in the direction of foreign exchange intervention changed this comfortable position of the banks and forced them to learn new techniques to manage their liquidity.

The effect of the abolition of the one-week deposit facility

the length of both the reserve averaging period and the maturity of the main deposit instrument became one month

The abolition of the one-week deposit facility made the banks' liquidity management somewhat more difficult compared to the previous times. The maturity of this instrument was shorter than the length of the previously applied reserve averaging period of two weeks. As a result, the one-week deposit facility allowed the banks to invest their liquidity surplus in such a way that in case of emergency it could be used for reserve accumulation within the same maintenance period. Following the changes in the monetary instruments in August, the length of both the reserve averaging period and the maturity of the main deposit instrument became one month. Thus if the banking system tied down a certain share of its liquidity in central bank deposits, those funds were no longer available within the same maintenance period. As a consequence, if the banks underestimated their liquidity needs and tied down too much of their funds in the central bank deposit instrument, they could not correct this miscalculation at a later point of the averaging period. Additional liquidity could have been obtained only with high costs through the central bank's overnight active repo facility.

the role of the one-week deposit facility was to smooth the monthly seasonal pattern of the State Treasury Account

In spite of that, the central bank was expecting that bank treasuries would be able to manage their liquidity position efficiently even without the one-week instrument. Historical data suggested that the bulk of the deposit stock be tied up in the one-month deposit instrument anyway. The stock of the one-week deposit was low, but

showed high variability within the months. The result of this was that the banks used the one-week deposit to transfer liquidity between the two reserve maintenance periods of the same calendar month (and sometimes also to speculate on changes in the policy rates). The transfer of funds was necessary because of the monthly seasonal pattern of the State Treasury Account. As tax payments are due in the second half of each month, the first maintenance period was characterised by higher liquidity, while the second was usually more tight because of the tax payment outflows.

the liquidity transfer was not necessary anymore

It seemed that the role of the one-week deposit was bound to the smoothing of the liquidity cycles caused by the State Treasury Account. Since in the newly introduced framework the length of the reserve averaging period was one month – the same as the cycle length of the State Treasury Account fluctuations – the liquidity transfer was not necessary anymore. The logical reaction of the bank treasuries would have been to increase their reserve balances by the average amount of their previous stock of one-week deposit. With proper liquidity planning the fluctuations of this increased amount of liquidity on the reserve account could have compensated the intra-month seasonality of the State Treasury Account. Taking all these factors into account, the central bank assumed that the abolition of the one-week instrument would hinder liquidity management only for a short period of accommodation. To promote forward-looking liquidity management, the NBH started to publish the reserve position of the banking system (the overall reserve requirement, the aggregate amount of the reserve accounts and cash holdings) on a daily basis. The dissemination of this data was aimed at giving individual banks an overview of the reserve position of the market as a whole.

The banking system's reaction to the abolition of the one-week deposit facility was not in line with the NBH's expectations. The liquidity which become available from the suspension of the one-week deposit was not treated separately on the reserve accounts of the banks, nor were the fluctuations of the State Treasury Account taken into account by the treasuries when formulating liquidity plans. As a consequence, shocks resulting from the State Treasury Account cycles were unexpected. All these components contributed to the extreme overnight interest rate fluctuations in the period examined.

Speculation on the changes in the main policy rate

the speculative activities of the banks and the pivoting

The fourth component contributing to the hectic liquidity situation was related to the speculative activities of the banks. When the market expects a change in the policy rate it is natural to incorporate this expectation into liquidity management strategy. This means

that in the case of an expected rate cut treasuries try to increase the duration of their portfolio in order to maximise the gains resulting from the yield changes which follow a rate cut. As a consequence of the expectations of a rate cut the short end of the yield curve switches: longer rates fall, while the very short ones increase. This is the so-called pivoting, discussed earlier in this paper. As the central bank accepts unlimited amounts of deposits at fixed rates and given maturities, the price of the central bank instrument does not change with the market assets. This presents an arbitrage opportunity for the banks. To make it simpler, it is worthwhile for the banks to increase their deposit holdings before the rate cut, as by doing so they can earn a higher yield on their liquidity surplus compared to the yield which is effective after the rate cut.

how does speculation affect liquidity?

When a bank's treasurer makes decisions about increasing the deposit holdings, he or she has to take into account how such an action affects the bank's future liquidity position. If the treasurer expects a rate cut and increases the amount of the bank's deposits with the central bank, this move will also lower by the same amount the liquidity available for a period equal to the maturity of the deposit instrument. Let us assume that the bank at a given moment has just enough liquidity to fulfil its mandatory reserve requirement, and all of its liquidity surplus has already been invested into central bank deposits that expire evenly in time. If the treasurer increases the bank's deposit holdings just *before* a rate cut, he or she also has to decrease its deposit holdings just *after*, in order to maintain a sufficient liquidity position. The treasurer's other choice is to obtain the missing money from the interbank market. However, if the whole banking system chooses this latter option, it can lead to an overall shortage in liquidity and permanently high overnight interest rates. Thus if all market participants increase their deposit holdings for speculative reasons and they do not compensate the missing liquidity from the expiring deposits, the overnight interest rates can easily stick to the ceiling of the corridor. In such a situation the speculation can easily turn out to be unprofitable for some banks or even for the whole banking system, as the cost of financing the necessary liquidity – high interbank rates or the central bank's marginal lending rate – can overly exceed the gains earned on the higher interest rates of the central bank deposits.

Speculation on central bank rate changes – a numerical example

The costs and benefits of the speculation on rate cuts can be illustrated through a numerical example. Let us assume that the reserve requirement of the banking system for a given month is Ft 400 billion. The closing balance of the banks at the previous month was also Ft 400 billion. Furthermore, the banking system also has a stock of Ft 200 billion tied down in one-month central bank deposit instruments, with Ft 50 billion expiring each week. We also assume that the banks are aiming to maintain the even distribution of the expiring deposits.

The market expects a rate cut (with 100 percent probability) during the first week of the month. The banks have two options. They either maintain the evenly distributed deposit structure or they can speculate on the rate cut by increasing their deposits in the first week, tying down additional funds at the higher interest rate.

Strategy I.: Evenly distributed deposit structure

		Interest rates			Account volumes (HUF billion)					Interest revenues and expenses (HUF billion)		
		Overnight deposit facility	1-month deposit	Overnight repo (marginal lending)	Current account	1-month deposit maturing that week	1-month deposit invested that week	Overnight deposit facility	Overnight repo (marginal lending)	1-month deposit	Overnight deposit facility	Overnight repo (marginal lending)
Period I	week 1	17.50	20.00	22.50	400	50	50	–	–	0.83	–	–
	week 2	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
	week 3	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
	week 4	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
Period II	week 1	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
	week 2	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
	week 3	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
	week 4	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
										Profit:		**6.30**

Strategy II.: Speculative deposit increase

		Interest rates			Account volumes (HUF billion)					Interest revenues and expenses (HUF billion)		
		Overnight deposit facility	1-month deposit	Overnight repo (marginal lending)	Current account	1-month deposit maturing that week	1-month deposit invested that week	Overnight deposit facility	Overnight repo (marginal lending)	1-month deposit	Overnight deposit facility	Overnight repo (marginal lending)
Period I	week 1	17.50	20.00	22.50	350	50	100	–	–	1.67	–	–
	week 2	16.25	18.75	21.25	400	50	0	–	–	0.00	–	–
	week 3	16.25	18.75	21.25	450	50	50	–	50	0.78	–	–0.22
	week 4	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
Period II	week 1	16.25	18.75	21.25	400	100	50	50	–	0.78	0.17	–
	week 2	16.25	18.75	21.25	400	0	50	–	–	0.78	–	–
	week 3	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
	week 4	16.25	18.75	21.25	400	50	50	–	–	0.78	–	–
										Profit:		**6.30**

The above table describes the two strategies assuming a rate cut of 125 basis points and an interest rate corridor with a width of 250 basis points. When applying Strategy I the banking system invests the same amount – Ft 50 billion – into the one-month deposit instrument. Its current account balance remains Ft 400 billion for the whole period. The banks do not use the overnight deposit and lending (repo) facility; therefore its interest balance equals the revenue from the one-month deposit.

When choosing Strategy II, the banks are trying to speculate on the rate cut, therefore in the first week they put Ft 50+50 =100 billion to the one-month central bank deposit instrument, instead of the Ft 50 billion that expires that week. The current account of the banking system therefore diminishes to Ft 350 billion, and the reserve deficit of Ft 50 billion has to be financed either from the banks' expiring deposits or from central bank credit. Let us assume that the

banking system does not place any deposit in the second week, therefore the banks' current account balance returns to the level of Ft 400 billion. However, the daily reserve deficit of Ft 50 billion which occurred in the first week has to be compensated: the banking system has to maintain a daily credit stock of Ft 50 billion in the central banks' overnight repo facility for one week. The cost of this credit operation appears among interest expenses.

The consequences of the speculative deposit strategy affect the next reserve maintenance period as well. If the banks want to restore their original deposit structure with similar amounts maturing each week, they have to renew only half of the one-month deposit stock of Ft 100 billion which expires in the first week of second maintenance period. The remaining Ft 50 billion can be rolled in the overnight deposit instrument for one week and can be re-invested into the one-month deposit facility one week later. This move restores the original deposit structure.

The above table shows the interest revenue and expenses for both strategies. On the one hand, Strategy II yields some extra profit as the Ft 50 billion increment in the deposit stock in the first week earns higher interest rates for a whole month. On the other hand, there are additional expenses, too: the banking system looses the spread between the central bank's overnight deposit and lending facility, using both instruments for one week. The extent of the rate cut and the width of the interest rate corridor determine whether the additional revenue exceeds the costs. With the assumptions used in this example the speculation is profitable if the expected rate cut is higher than one quarter of the spread between the marginal overnight lending and deposit facilities. (The table shows the break-even point: by assuming an interest rate corridor of +/–250 basis points and a rate cut of 125 basis points the yield on both strategies was the same.)

This example simplifies some important aspects of the true market environment. The banking system has other alternatives to compensate for the missing liquidity apart from the overnight repo facility, for example by not renewing the one-month deposits on the third week. This reduces somewhat the financing expenses of the speculative strategy: instead of the interest rate paid on the overnight repo facility, in that case the opportunity cost would be that interest rate earning that was not realised on the one-month deposit facility for one week. However, this alternative strategy would further jam the evenly distributed deposit structure, and the return to the original structure would invoke additional costs later. Furthermore, in the example we assumed that the banks know with certainty the extent and the timing of the rate cut. In reality uncertainty is always present, thus further reducing the expected profit of the speculation.

Although above upper numerical example is far from being realistic, it still shows that the costs of eliminating the liquidity deficit caused by rate cut speculation can be rather high and might largely exceed the earnings. Furthermore, in this example we dealt with the banking system as a whole, and as a consequence the cost of additional liquidity was the spread between the central bank's marginal lending and deposit facility. If the speculation is carried out by an individual bank, generally it may obtain cheaper liquidity from the interbank market, reducing therefore the costs of the speculative strategy. As a result speculation might seem more profitable from the viewpoint of an individual bank. However, if all the banks start to speculate, then the interbank market quickly gets tight in liquidity, pushing up overnight interest rates and the costs of the additional liquidity necessary for speculation.

irrationally high levels of speculative deposit

Irrationally high levels of speculative deposit positions occurred several times during the period examined. At the end of October a consensus developed on the market about a likely rate cut within some days. The banks, having significant excess reserves at the end of the maintenance period, largely increased their deposit

holdings within few days. As a consequence, a bulk of liquidity was drained from the reserve maintenance period of November. In the first days of the new maintenance period it became obvious that the costs of obtaining the additional liquidity needed would highly exceed the gains that might be earned from a rate cut to any realistic extent. As a consequence of the liquidity shortage, the overnight rates stuck to the ceiling of the interest rate corridor for the whole month, pushing up the cost of short-term liquidity.

the banks did not take full advantage of the reserve averaging facility

The situation was further exacerbated by the fact that the banks did not take full advantage of the reserve averaging facility. Those banks which had excessive deposit holdings due to expire at the end of the month did not provide interbank credit for the others with a shortage of liquidity, although they could have done so. Consequently, in the final days of the reserve maintenance period the liquidity situation switched, and the expiring excessive funds were placed into the central bank's overnight deposit facility.

cyclical patterns in reserve accumulation

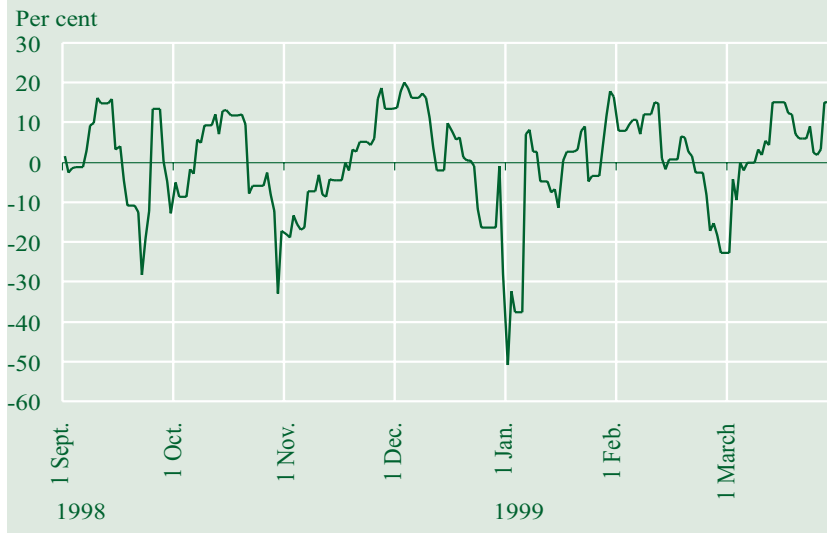
In December the same process could be observed, but in the opposite direction. After facing severe problems in November, banks significantly reduced their one-month deposit volume. Concerns about scarce liquidity were further intensified by the worries about the traditionally volatile cash demand around Christmas. As a result of the low deposit volume the banking system had excessive reserves throughout December. Then in January the scenario of November repeated itself. Expecting another rate cut, banks started to increase their deposit holdings, which mopped up excess liquidity. When in the second half of the month an unexpected increase in the volume of the State Treasury Account drained additional funds from the system, the overnight rates rose again and stayed high until the end of the month.

the short memory of the market

By examining the evaluation of the banking system's current account balance, it can be seen that speculation on rate cuts contributed to the liquidity anomalies. The large deposit increases at the end of October that led to the liquidity shortage in November are clearly observable. A similar phenomenon can be seen in the first part of January, although the unexpectedly high tax payments also contributed to the tightness of the money market. It can also be concluded from the chart that the market had a rather short memory: typically the treasuries wanted to avoid the mistake they made the month before. After the liquidity shortage in November banks got more cautious in the following month and as a result they accumulated excessive reserve balances. In January, on the contrary, they returned to the speculative strategy of November, while February was again characterised by caution and a liquidity surplus on the interbank market.

Chart 5

Deviation of the banking system's current account balance from the reserve requirement



6 | Inefficiencies in the banks' liquidity management

the low efficiency of the banks' liquidity management...

In the previous chapter we presented four primary reasons which significantly contributed to the liquidity imbalances on the interbank money market between September 1998 and March 1999. These four reasons included the changes in the framework of monetary operations, the market turbulence due to the Russian crisis, the inappropriate reaction to the abolition of the one-week deposit instrument and excessive speculation. In the following we attempt to discover the deeper causes lying behind the last two of these four reasons. Several facts suggest that the banks' liquidity management did not work efficiently within the period observed; they did not fully exploit either the profit opportunities on the interbank market or the reserve averaging facility.

...weakens the efficiency of the transmission mechanism

From September 1998 several signs could have been observed supporting the view that the interbank money market in Hungary lies far from the theoretical construction of perfect markets. Sometimes participants did not seem to behave in a profit-maximising way; arbitrage opportunities that seemed to be obvious for an outside observer remained unexploited. These imperfections of the market are important for the central bank as they might weaken the efficiency of the transmission mechanism.

...and decreases the banks' profitability

On the other hand, aside from the transmission mechanism argument, an efficient interbank market is important for other reasons as well. By taking full advantage of the opportunities of the interbank market, banks are able to reduce the cost of funding, which leads to an increase in profits. In a competitive environment this might result in lower margins and more favourable lending and deposit facilities for the economy as a whole. Furthermore, market efficiency and a competitive environment are also necessary to prepare domestic banks for the tough market conditions which will appear after Hungary joins the European Union.

Efficient operation of liquidity management

the banks' liquidity management has to secure the whit the resserve requirement fulfilment of payment liabilities and to provide compliance

The banks' liquidity management has to secure the accurate fulfilment of payment liabilities and to provide compliance with the central bank's reserve requirement at a lowest possible cost. In practice this means that a bank's current account balance has to be sufficient for payment operations on the one hand, and its balance, on the average of the maintenance period, has to be higher than the reserve requirement. When necessary, short-term liquidity credits and deposits of the potential surpluses are available on the interbank market and also by using central bank instruments.

liquidity planning

The basic time horizon for liquidity planning is the reserve maintenance period: this is the shortest interval for which a treasury has to have a concept about the expected evaluation of the bank's current account balance. A significant part of the changes in the current account balance can be forecast with precision: debt redemption and interest payments are known in advance. Another part of the current account fluctuations can be estimated: the evaluation of the current account balances of companies and individuals usually show a seasonal pattern within the month due to tax payments and other regular payment items. Therefore, by analysing either the aggregate current account balance or the payment operations of the largest clients with time series techniques a significant share of the fluctuations in liquidity demand can be estimated.

strategy of financing

Taking all these factors into consideration, on each day of the reserve maintenance period a forecast for the exogenous components of liquidity demand can be made. Naturally, such a forecast will contain uncertain elements. The endogenous components of liquidity, such as interbank operations, use of central bank instruments etc., can be determined with respect to the forecast in such a way that minimises the costs of obtaining the necessary amount of liquidity. The optimal path of the endogenous elements can also be influenced by the expectations about the central bank's key policy rate (speculation on rate changes) or by the expectations about the banking system's aggregate liquidity position (effects of tax payments, expected interventions on the foreign exchange market, etc.) Furthermore, the liquidity plan has to deal with the effects of uncertainty: it must contain a sufficient buffer stock for unexpected liquidity shocks. By approaching the end of the maintenance period the uncertainty diminishes. As new data arrive, the plan can be revised and modified if necessary.

the use of some simple rules of thumb is often sufficient

Liquidity planning needs significant resources and efforts from a treasury: the methodology has to be developed, the flow of data between the treasury and other departments has to be provided, etc. In banks where it is not possible or worthwhile to develop such a planning system, the use of some simple rules of thumb can also significantly improve the efficiency of liquidity management. An example of such a rule is when the treasury does not let the current account balance to fall below a level defined as the average daily reserve requirement for the rest of the maintenance period minus the amount of the central bank's overnight credit facility available for the bank. This strategy ensures that the cost of meeting the reserve requirement *ceteris paribus* cannot exceed the interest rate paid on the central bank's marginal lending facility.

Mistakes in liquidity management: some examples

From September 1998 the banks revealed several times that their interbank money market activity does not always follow the rules of market rationality.

use of the central bank's overnight deposit facility on the first day of the reserve maintenance period

One of the "mistakes" was the banks' use of the central bank's overnight deposit facility on the first day of the reserve maintenance period. On the first day of December 1998, January 1999 and April 1999 a significant stock of overnight deposits was placed. It can be shown that such a move is always sub-optimal, as there exists a strategy that leads to a similar result from the viewpoint of liquidity, while being more profitable. Consider the case when the main policy instrument is the two-week deposit facility. The first strategy is to put an amount x to the overnight deposit facility. The other strategy is to place $1/14$ of x in the two-week deposit, while leaving the rest on the bank's current account. With respect to profit the second strategy is superior, as the yield on the two-week deposit exceeds the yield of the overnight deposit facility. On the other hand, as to the liquidity position the effect of the two strategies are basically the same. Although with the second strategy $1/14$ of x is tied down for two weeks, by the second day of the reserve maintenance period the bank's reserve requirement is diminished by $13/14$ of x. All in all, the liquidity that is tied down for two weeks is compensated by the reduced reserve requirement for the rest of the month.

the central bank's overnight deposit facility and the active repo facility is effective within the same reserve maintenance period

Another sign of the treasuries' inaccurate liquidity planning and the inefficient performance of the interbank money market is when both the central bank's overnight deposit facility and the active repo facility is effective within the same reserve maintenance period. As the banks have to comply with the reserve requirement only on the average of the maintenance period, a bank which used the deposit facility and another which obtained overnight credit could offset their liquidity mismatch by an interbank money market transaction. The two banks could share the gain that they could have earned by not paying the rather wide gap between the yield of the deposit facility and the active repo. It has to be mentioned that there were some extreme cases when the same bank used the overnight deposit facility and the overnight repo within the same maintenance period. It also occurred that on the same day one bank used the overnight deposit instrument while another obtained overnight credit through the central bank's repo facility.

excess reserve accumulation

The inaccuracy of liquidity management can also be seen from the fact that the banking system as a whole ended up with excess reserves in most of the maintenance periods. As the central bank pays interest only on the mandatory reserves, excess reserve accumulation leads to losses. For some smaller banks excess reserve accumulation is natural, as the minimum current account balance necessary for payment transactions exceeds their relatively small reserve requirement. However, for larger banks more efficient liquidity planning could diminish the excess reserve accumulation.

only few market participants incorporate market information into their liquidity management decisions

The cyclical pattern of the banking system's liquidity position and of the overnight interest rates that was observed from October 1998 has already been mentioned. The banks' deposit strategy resulted in liquidity shortages in one period, leading to high overnight rates, while in the next period the banks became more cautious, hence the market was characterised by excess liquidity and low overnight interest rates. The fact that the banks did precisely the opposite in one period to what they had done in the previous one, and did it several times, shows that the individual banks do not follow the established practice; they do not try to go against the flow in order to increase their profits. Market behaviour could be deduced from the banking system's overall reserve position (the total reserve requirement and the aggregate current account and cash balance are published daily by Reuters). However, apparently there are only few market participants who incorporate this information into their liquidity management decisions.

The effects of the legal and institutional framework[7]

inappropriate regulation

It some cases it is the treasuries' inappropriate regulation and control that lies behind the irrational behaviour of the interbank money market participants. Most of the treasuries are over-regulated in some respects, while the control is too loose in some other aspects. The banks' management usually compensates the lack of treasury control by administrative constraints.

the treasuries represent a "black box" for the management

On the one hand, the treasuries are a sort of unknown "black box" for the management, on the other they must comply with too many administrative constraints. These two factors lead to a significant loss in efficiency. Firstly, inappropriate regulation might create incentives that are not in line with the profit-maximisation of the bank as a whole. A good example of such a case is when, in times of scarce liquidity, some bank treasuries were bidding with lower amounts on the Treasury bill auctions instead of obtaining overnight repo from the central bank. The reason behind that lies in inefficient control: overnight borrowing from the central bank has to be reported to the controlling bodies, while nobody is interested in the opportunity cost of not participating in a Treasury auction. Furthermore, in such cases the daily liquidity shortage is reflected in the auction demand and in the longer maturities of the yield curve, which is undesirable from the point of view of monetary transmission. As a result of the inadequate regulation, in some cases market participants cannot take advantage of straightforward profit opportunities. On the interbank market security-backed transactions are not common, and as a consequence the banks are imposing rather narrow limits on their positions against each other. Naturally, such limits are hindering the market's possibilities for efficient allocation.

inadequate incentives

As the performance of the treasuries is seldom evaluated by the profits they earn, but generally by some other measures, there is no incentive to apply techniques that increase efficiency, e.g. forward-looking liquidity management. This might be a reason behind the sub-optimal use of the reserve averaging facility, and the lack of techniques to forecast liquidity. In one bank the controlling manager ordered dealers to comply with the reserve requirement on a daily basis. In this case it is obvious that the controlling body is not aware of the purpose and function of the reserve averaging facility, and that is why daily deviations are "punished". In such an environment it is not surprising that the know-how necessary for the forward-looking liquidity planning and for the conscious preparation for unusual situ-

[7] Some of the statements of this chapter are based on anecdotal evidence and market rumours which must be taken into account when considering the conclusions. However, the author had to use these sources, as in the time of writing no reliable resource was available on the subject.

ations is not developed. On the other hand, inefficient control gives room for abuses as well: treasury dealers might act according to their personal interests instead of the interests of the bank.

minimisation of liquidity risk

Nevertheless it is possible that the current practice of liquidity management is "rational" from the viewpoint of the banks as a whole. It is possible that it is the minimisation of liquidity risk that lies behind the limited use of the reserve averaging facility. It is also likely that in the Hungarian banks' current phase of development investments in both infrastructure and human resources have higher return in fields other than liquidity management, e.g. credit risk assessment, etc. This is another factor which might restrain the development of the interbank money market.

the effective reserve rate as a constraint

For some smaller banks there are other considerations that explain their limited ability to exploit the advantages of the interbank market and reserve averaging. A significant part of these banks use foreign funds as the main source of financing. During the period in question the reserve ratio for foreign funds was zero per cent, and as a result the amount of required reserves for these banks was rather small compared to their average current account turnover. This is a factor that limits the use of reserve averaging, as over-accumulation could be offset only with a current account balance close to zero, which does not provide enough liquidity buffer for daily transactions.[8]

maintaining a fully equipped treasury is costly

A certain segment of the banking system – some small, specialised financial institutions – has the policy of withdrawing itself from the interbank market. Because of their size, for these banks – at least for the moment – it is not profitable to maintain a complete treasury infrastructure. Thus they limit their liquidity management to operations with the central bank. Although their cost of financing might be higher, this loss is still smaller than the cost of maintaining a fully equipped treasury.

the slow development of the domestic repo market

The efficient functioning of the interbank market is also constrained by some features of the regulatory environment. A good example of this is the slow development of the domestic repo market. When performing outright operations on the interbank market, limits that banks impose on positions against each other often become binding, both with the overnight and the longer maturities. In many countries repo operations (sale and repurchase agreements) are used to circumvent such limit constraints, as they provide collateral against credit risk. A more widespread use of repo operations could significantly deepen the Hungarian interbank money market.

Current legislation and accounting rules do not promote the development of the repo market. For the hold-in-custody repo, when the ownership of the securities serving as collateral remain the prop-

[8] The NBH is introducing reserve requirement on foreign funds from July 2000.

erty of the borrower, they are only deposited on a separate depository account. Litigation rules not allow the creditor to enforce the pledge. In the case of the delivery repo, on the other hand, current accounting rules require the underlying securities to be marked to market when opening and closing the repo transaction. This might reallocate the profit between different points of time and between the money market desk and the bond desk of a treasury, creating an incentive for not using repos.[9]

these factors weaken the monetary transmission mechanism

The phenomena described above bring a bias to the behaviour of the interbank money market, reducing its ability of efficient liquidity allocation. The market cannot fully alleviate the effects of liquidity shocks, which might result in the variability of overnight interest rates. Market imperfections also contribute to the spread of this variability to the longer maturities. From this respect these market imperfections cause an additional noise in the monetary transmission mechanism, hence limiting its efficiency.

It is reasonable to assume that in the long run banks will allocate additional resources to both the technical and human infrastructure of liquidity management, and also to the regulation and control of treasuries. This would certainly improve the monetary transmission mechanism and also the profitability of the banks. A significant potential improvement would be if the bank treasuries were profit centres and if the performance of individual dealers could be evaluated on a daily basis. Of course, initiating such improvements is not a task of the central bank.

[9] About the factors that constrain the development of the Hungarian repo market see *Szakály and Tóth* (1999).

7 | The introduction of the two-week deposit instrument

March 1999 : introduction of the 2-week deposit facility

In March 1999 the NBH reduced the maturity of its key policy instrument from one month to two weeks. This change significantly modified the environment of the banks' liquidity management. The experiences of this new instrument show that it significantly alleviated the previous liquidity anomalies.

the new instrument reduced the risk of emergence of liquidity anomalies

Liquidity management can be carried out much easier with the two-week deposit instrument than before, when the key policy instrument's maturity was one month. The new framework has an important feature: the funds placed into the key policy instrument at the beginning of the month become available within the same reserve maintenance period. This enables the correction of the potential mistakes in liquidity planning which were made in the first half of the month. If a bank expected a higher-than-actual liquidity inflow in the second part of the month, and its current account balance is insufficient to fulfil its reserve requirement, it can be corrected by using the expiring deposits. The one-month instrument did not allow such a correction; deposits placed at the beginning of the month could not be used for reserve accumulation within the same maintenance period. Furthermore, with the two-week deposit instrument speculation on the central bank's rate changes became less profitable, reducing the risk of the emergence of speculative bubbles that might create liquidity troubles for the banking system as a whole. All these features allow us to assume that permanent deviations of the overnight interest rates are less likely in this new regime. Experience so far supports this assumption.

It is natural to ask what would have happened if the NBH had introduced the two-week instrument in September 1998. It is probable that it could not have helped to alleviate the overnight interest rate variability in September and October, which was due to foreign exchange market turbulence and to the intervention on the weak side of the exchange rate band. However, it is also likely that the extreme deviations which characterised November 1998, December 1998 and January 1999 would not have occurred (or would have been much smaller) if the maturity of the key policy instrument had been shorter.

8 | Summary and conclusions

The period between September 1998 and spring 1999 was a very useful period from the viewpoint of the evaluation of the Hungarian interbank money market. The effects of the Russian crisis and the environment created by the monetary policy instruments enable us to uncover some malfunctions of the market, which would be hidden within "normal" conditions. It is likely that the liquidity imbalances experienced during that time would not occur on an efficient market.

Beyond the Russian crisis, liquidity anomalies were due to the changes in the instruments of monetary policy, and also to the low allocating efficiency of the interbank market. The long-lasting turbulence of the money market affected the transmission of monetary policy as well.

The efficiency problems of the interbank money market were caused mainly by deficiencies of the institutional and legal environment. Better monitoring of treasury activities and the modification of some regulations which constrain the development of the market would enhance the central bank's control over those interest rates which are crucial for the monetary transmission mechanism. They would also increase the competitiveness of the banking sector. The introduction of the two-week deposit instrument of the NBH alleviated the problems, but it could not correct the intrinsic deficiencies of the banks' liquidity management.

References

Borio, Claudio E. V. (1997), 'The Implementation of Monetary Policy in Industrial Countries: A Survey', *BIS Economic Papers # 47*.

Granger, C. W. J. (1969), 'Investigating Causal Relations by Econometric Models and Cross-Spectral Methods', *Econometrica* 37: 424–38.

Hamilton, James D. (1994), *Time Series Analysis*, Princeton University Press, Princeton, New Jersey.

Kasman, Bruce (1993), 'A Comparison of Monetary Policy Operating Procedures in Six Industrialized Countries', in *Reduced Reserve Requirements: Alternatives for the Conduct of Monetary Policy Reserve Management*, Federal Reserve Bank of New York.

Pesaran, M. H., Y. Shin és R. J. Smith (1999), 'Bounds Testing Approaches to the Analysis of Long Run Relationships', University of Cambridge, *mimeo*.

Schnadt, Norbert és John Whittaker (1993), 'Optimal Money Market Behaviour and Sterling Interest Rates', *Financial Markets Group, London School of Economics, mimeo*.

Szakály, Dániel és Henrik Tóth (1999), 'Repo Markets: Experiences and Opportunities in Hungary', *NBH Occasional Papers No. 5*

Appendix

Vector-autoregression analysis of the effect of the overnight interest rate variability on the yields of longer maturities

The data

To measure the imbalance of the interbank liquidity, the difference between the daily average overnight interbank rate and the NBH's key policy rate was used (*ONGAP*). In order to ensure comparability between the levels of these two rates, we transformed the raw time series into effective yields. We presumed that *ONGAP* reflects well the liquidity shocks that hit the interbank market. In equilibrium the yield of a continuously renewed overnight interbank deposit has to be equal to the yield of the one-month (from March 1999 two-week) central bank instrument. Therefore, in equilibrium the difference between the two rates has to be zero. However, if the system is hit by a shock, this might increase or decrease the value of an overnight deposit or loan, pushing the overnight interest rate away from its long-run equilibrium level.

To create a good measure of the imperfections in the monetary transmission, we choose the relation between the key policy rate and the central bank's operative target – the 3 to 6 month yields – as a starting point. When the transmission is "perfect", the key policy rate exactly determines the level of the operative target: the two yields have to be equal. In practice, of course, this almost never happens. The difference can be considered as the noise of the transmission.

Taking these factors into account we used the difference between the 3-month BUBOR and the key policy rate (*BUBGAP*) as a measure of the imperfection of the transmission mechanism. *BUBGAP* can be considered as the component of the 3-month BUBOR, which is not explained by the monetary policy.[10]

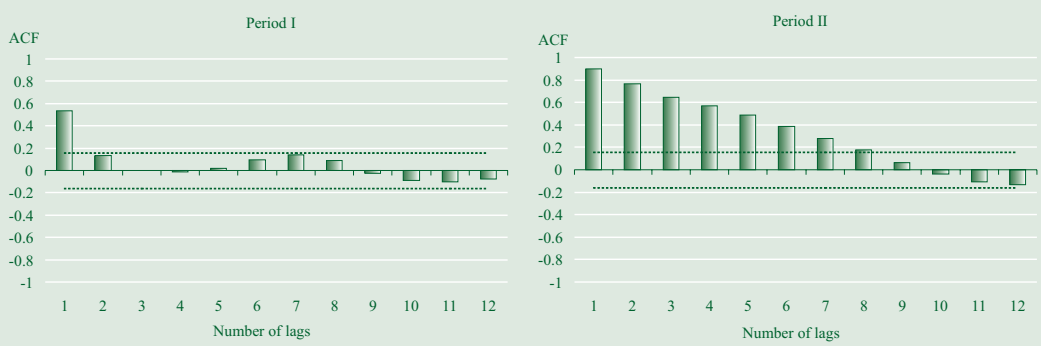
[10] The difference between the 3-month BUBOR and the NBH's key policy rate might contain, beyond the noise of the transmission mechanism, some premia (risk premium, maturity premium etc). We assumed that these premia are constant ocer time, therefore they influence only the level of *BUBGAP*, but not its short-term dynamics.

We divided the full time series into two sub-periods. Period I lasts from 1 January 1998 to 15 August 1998, and Period II lasts from 1 November 1998 to 30 April 1999. We omitted the observations between 15 August 1998 and November 1998, as the market turbulence and the effect of the foreign exchange intervention would have biased our results.

Table I: Descriptive statistics

	Full sample		Period I (5 Jan. 1998– 15 Aug. 1998)		Period II (1 Nov. 1998– 30 Apr. 1999)	
Variable	*ONGAP*	*BUBGAP*	*ONGAP*	*BUBGAP*	*ONGAP*	*BUBGAP*
Mean	–0.120	–0.420	–0.303	–0.745	0.178	–0.241
St. dev.	1.906	0.633	1.071	0.253	2.338	0.352

Chart I: Autocorrelation function (ACF) of ONGAP for Period I and II



Descriptive statistics (Table I) show that the standard deviation of *ONGAP* was much higher in Period II than in Period I. This reflects the higher volatility of the overnight interest rates observed from September. Autocorrelation functions (Figure I) describe the stochastic interdependence between *ONGAP* and its own lagged values. It shows that while in Period I only the first-order autocorrelation is significant, in Period II the autocorrelation is significant for all lags between 1 and 8. This signifies that deviations of the overnight interest rate proved to be more persistent in Period II than in Period I.

Vector autoregression

We used a bivariate vector autoregression (VAR)[11] to discover the effect of the deviations of the overnight interest rates (*ONGAP*) on the monetary transmission – on the component of the 3-month BUBOR that is not explained by the key policy rate (*BUBGAP*), to be precise. We expect that in Period I the deviations of the overnight rates did not have a significant influence on the transmission mechanism, while in Period II the overnight rate deviations are reflected in the 3-month BUBOR.

Table II: Results of the Granger-causality test

Null hypothesis: *ONGAP* does not Granger-case *BUBGAP*

Period I (5 Jan. 1998–15 Aug. 1998)			Period II (1 Nov. 1998–30 Apr. 1999)		
Lag	*F-Statistics*	*p-value*	*Lag*	*F-Statistics*	*p-value*
1	0.340	0.561	1	7.037**	0.009
2	0.228	0.796	2	3.192**	0.045
3	0.078	0.972	3	2.637*	0.052
4	0.063	0.993	4	2.246*	0.068
5	0.055	0.998	5	2.337**	0.046
6	0.048	0.999	6	1.921*	0.083

* The null hypothesis can be rejected at a 5% significance level.
** The null hypothesis can be rejected at a 10% significance level.

Null hypothesis: *BUBGAP* does not Granger-cause *ONGAP*

Period I (5 Jan. 1998–15 Aug. 1998)			Period II (1 Nov. 1998–30 Apr. 1999)		
Lag	*F-Statistics*	*p-value*	*Lag*	*F-Statistics*	*p-value*
1	0.550	0.459	1	1.159	0.284
2	1.674	0.191	2	1.176	0.312
3	1.088	0.356	3	0.882	0.453
4	0.832	0.507	4	0.886	0.474
5	0.683	0.637	5	0.810	0.545
6	0.645	0.694	6	0.910	0.491

As a first step we performed a Granger-causality test[12] (Table II). Results suggest that in Period I the deviation of the overnight interest rates from the key policy rate (*ONGAP*) did not carry any

[11] About time seris analysis with vector autoregression see eg. *Hamilton* (1994), Chapter 11.
[12] The Granger test examines whether the past (lagged) values of variable *A* help to forecast the current value of variable *B* (*Granger* 1969).

additional information about the dynamics of the 3-month BUBOR. However, for Period II the Granger test suggests a significant and stable relationship between *ONGAP* and *BUBGAP*: the lagged values of the former variable help to forecast the latter.

The impulse response functions calculated from the vector autoregression model show how an exogenous shock of one variable affects the dynamics of the other variables in the model. Impulse responses of the bivariate VAR on *ONGAP* and *BUBGAP* (Chart II) give similar results to the Granger-causality test. The charts in the lower left corners represent the effect of the overnight interest rate shocks on the 3-month BUBOR. It can be seen that in Period I the shocks of *ONGAP* did not influence significantly the variations in *BUBGAP*. In Period II, on the contrary, the overnight interest rates affected the lagged values of the 3-month BUBOR. This effect was significant for the lags from 5 and 15 days. All in all, liquidity shocks influenced the 3-month interbank yields, with a delay of few days.

By taking the standard deviation of the *ONGAP* measured in Period II we are able to estimate the scale of this bias. According to the impulse response function, a shock of one standard deviation (2.338 percentage points) in the overnight rates deviated the 3-month BUBOR by 5–6 basis points. This means that from November 1998 to February 1999, when the overnight interest rate fluctuated between the two sides of the interest rate corridor, the result was a fluctuation of +/–10 basis points in the 3-month BUBOR.

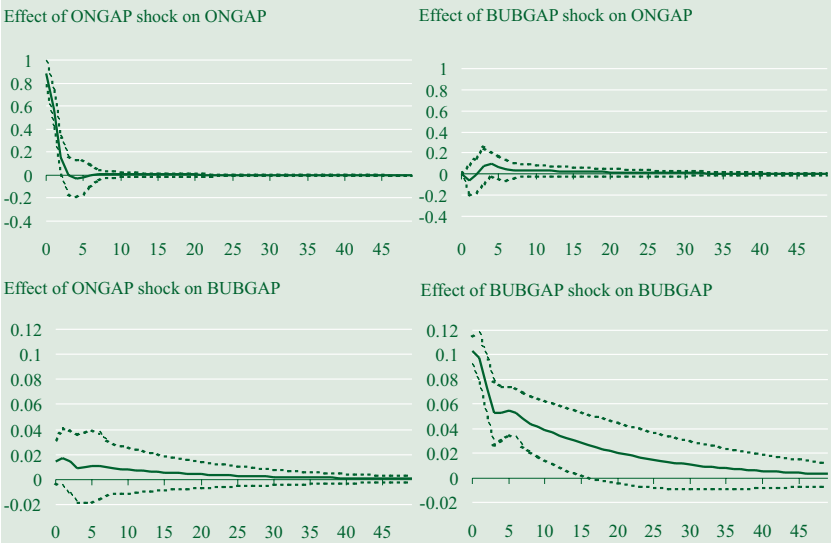
Variance decomposition provides information about what extent of the variance of one variable can be explained by the past values of the other variables in the VAR model. Results of the variance decomposition can be seen in Chart III. The charts are in line with our previous findings.

In Period I almost 100 per cent of the variance of the 3-month BUBOR residuals is due to its own shocks. However, in Period II deviations of the overnight interest rates explain around 40 per cent of the variance of *BUBGAP*. Therefore, according to our VAR model, deviation of the overnight interest rate was a major factor behind the "noise" of the transmission mechanism.

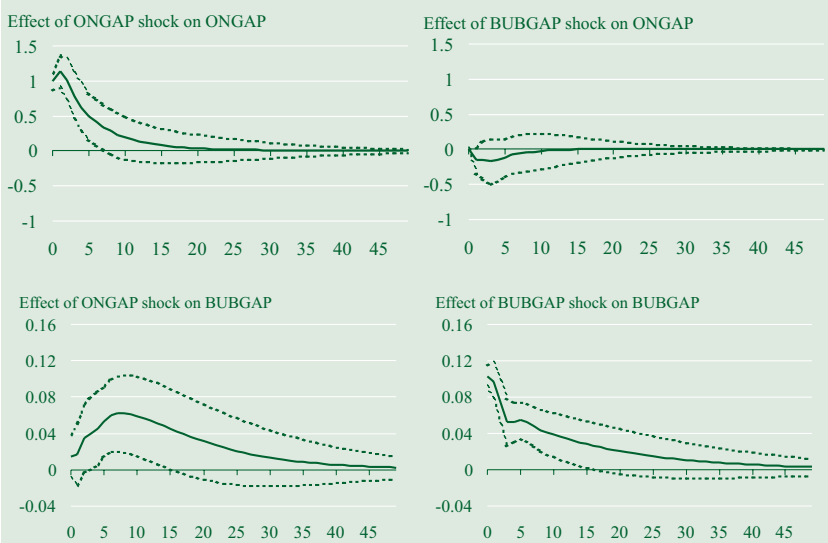
The above analysis can also performed by replacing the 3-month BUBOR with the benchmark Treasury bill yield of the same maturity. In this case the VAR model gives similar results, although the statistical inference between the two variables was not as significant as for the interbank yield. A possible explanation is that while on the interbank market the banks are the only players, the participants of the Treasury bill market cover a much broader range of investors. Non-bank participants of the T-bill market are not affected directly by interbank liquidity. The "shal-

Chart II: Impulse response functions

Period I (5 Jan. 1998 – 15 Aug. 1998)
Responses to shocks of one st. deviation
(50 periods, 95% confidence intervals)



Period II (1 Nov. 1998 –30 Apr .1999)
Responses to shocks of one st. deviation
(50 periods, 95% confidence intervals)



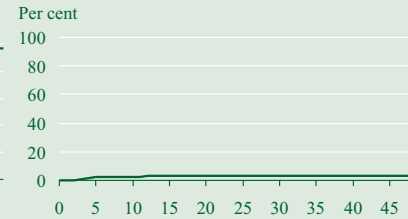
We estimated a VAR with 4 lags. The lag length was chosen with likelihood ratio test. When calculating the impulse response functions, the (ONGAP, BUBGAP) ordering was used, however, changing the ordering did not affect significantly the results. Confidence intervals were calculated analytically. The correlation of the VAR residuals (correlation coefficients of 0.136 and 0.108 for Period I and II respectively) was not significant.

Chart III: Variance decomposition

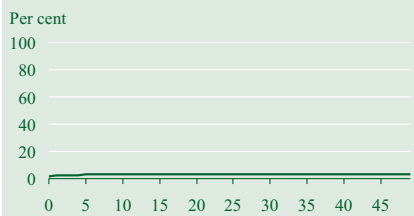
Period I (5 Jan. 1998–15 Aug. 1998)

ONGAP variance due to ONGAP

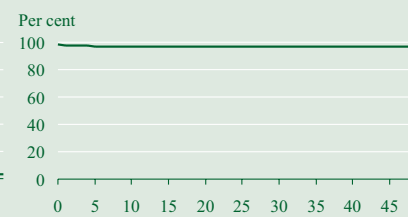
ONGAP variance due to BUBGAP



BUBGAP variance due to ONGAP



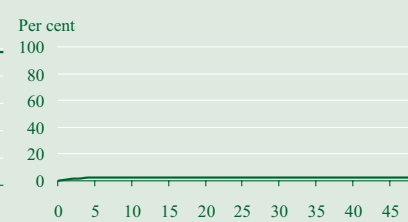
BUBGAP variance due to BUBGAP



Period II (1 Nov.1998–30 Apr. 1999)

ONGAP variance due to ONGAP

ONGAP variance due to BUBGAP



BUBGAP variance due to ONGAP

BUBGAP variance due to BUBGAP

lowness" on the interbank market, especially at the longer maturities, can also contribute to the difference between the two markets: the lack of turnover does not enable the arbitrage of the yield difference.

We can conclude that the empirical analysis supported our findings that from November 1998 liquidity anomalies of the interbank market and the subsequent volatility of the overnight interest rates affected the yields that are pivotal from the viewpoint of monetary transmission, corrupting therefore the efficiency of the transmission mechanism. This effect was obvious for the interbank yields, but the T-bill market was also affected to some extent.

Long-run co-movement of the time series used in the empirical analysis

We used the VAR technique to analyse the inference between the dynamics of the overnight rates and the 3-month BUBOR. Before estimation we subtracted the value of the NBH's key policy rate from both variables. This was necessary firstly to create variables that contain only the noise over the monetary transmission, and secondly to make our variables (covariance) stationery. As a result we obtained the variables *ONGAP* and *BUBGAP*.

When subtracting the key policy rate from the 3-month BUBOR and from the overnight interest rate we implicitly assume that both the overnight rates and the 3-month BUBOR move together with the NBH's key policy rate in the long run: the central bank's rate changes are fully reflected in the long-run path of both variables. The existence of this long-run relationship – our assumption – has to be tested econometrically.

Long-run relationships between the levels of variables are usually tested by co-integration technique. These techniques assume that the variables are integrated at order one (difference-stationarity). For one of our three variables the unit root test indicated trend-stationarity instead of first-order integration (Table III). This might be explained by the fact that within the period examined the interest rate level was permanently diminishing (the key policy rate was moved upwards only once). We needed therefore a technique that was able to test the long-run co-movement, no matter what the level of integration of the variables.

As opposed to the traditional co-integration tests, the technique of *Pesaran, Shin and Smith* (1999) is able to test the existence

Table III: Unit root tests for the 3-month BUBOR, the NBH's key policy rate and the overnight interbank rate[13]

Variable	*Trend*	*Constans*	*Lag*	*ADF*	*Critical value (5%)*
3-month BUBOR	no	no	3	–1.37	–1.94
Key policy rate	yes	yes	0	–2.08	–3.42
Overnight rate	yes	yes	1	–6.21	–3.42

Period covered: Jan. 1998 – Apr. 1999.
Number of observations: 334.
Results of the Augmented Dickey-Fuller (ADF) test.
Null hypothesis: The variable contains unit root.

of a long-run relationship between two variables, even in the case when the level of integration of the variables is not known. In the case of two variables the test requires the estimate of the following equation:

$$\Delta x_t = \alpha + \beta_1 x_{t-1} + \beta_2 y_{t-1} + \Sigma_{i=1}^{p} \gamma_{x,i} \Delta x_{t-i} + \Sigma_{i=1}^{p} \gamma_{y,i} \Delta y_{t-i} + \delta \Delta y_t, \quad \text{(A1)}$$

where x and y are the two variables in question. The parameters of the long-run relationship can be derived from β_1 and β_2. Pesaran, Shin and Smith propose two test statistics for the existence of the long-run relationship. The first one is an F-test with the restriction of $\beta_1=\beta_2=0$, the other is the t-statistics of the parameter β_1. Both tests have two critical values. The lower critical value was calculated with the assumption of both variables being stationary, while the upper is valid if both are integrated at order one. If the value of the test statistics is less than the lower critical value, then the null hypothesis of the non-existence of the long-run relationship is accepted. If the test statistics lies between the two critical values, then it is not possible to decide about the long-run relationship without knowing the order of integration of the two variables. If the test statistic exceeds the higher critical value, then the null can be rejected. Hence there is co-movement between the level of the two variables. Pesaran, Shin and Smith calculated the critical values for both the F and the t-test.

Table IV contains the OLS estimate results for equation (A1). The overnight interest rate and the 3-month BUBOR was substituted into variable x, while the key policy rate was substituted into y.

[13] For the unit root tests we started with a broad model with a lag length of 15, and reduced the number of lags until the last lag became significant. Similarly, we first assumed that the model contains a trend and a constant term. If the trend component had proven to be insignificant, we omitted it from the model. If in the re-estimated, reduced model the constant term had also been insignificant, then the model form without trend and constant was used.

Table IV: Estimated parameters of Equation (A1)

Coeff.	*Est. value*	*St. error*	*T-value*
α	0.102	0.121	0.841
β_1	–0.062	0.016	–3.787
β_2	0.056	0.016	3.359
$\gamma_{x,1}$	0.399	0.055	7.172
$\gamma_{x,2}$	–0.174	0.060	–2.900
$\gamma_{x,3}$	–0.116	0.058	–1.976
$\gamma_{x,4}$	0.036	0.057	0.620
$\gamma_{x,5}$	0.064	0.056	1.139
$\gamma_{x,6}$	0.010	0.055	0.170
$\gamma_{x,7}$	0.072	0.051	1.399
$\gamma_{x,8}$	0.157	0.048	3.262
$\gamma_{y,1}$	0.071	0.078	0.909
$\gamma_{y,2}$	0.531	0.078	6.797
$\gamma_{y,3}$	0.083	0.084	0.980
$\gamma_{y,4}$	0.485	0.084	5.748
$\gamma_{y,5}$	0.156	0.088	1.752
$\gamma_{y,6}$	–0.463	0.088	–5.210
$\gamma_{y,7}$	0.006	0.091	0.066
$\gamma_{y,8}$	–0.032	0.091	–0.359
δ	0.098	0.076	1.284
R^2: 0.503	R^2(a): 0.47	D-W:1.998	F: 16.32

x: 3-month BUBOR
y: NBH key police rate
Period covered: Jan. 1998–April 1999
number of obs: 327

Coeff.	*Est. value*	*St. error*	*T-value*
α	0.227	0.678	0.334
β_1	–0.207	0.037	–5.470
β_2	0.192	0.051	3.766
$\gamma_{x,1}$	0.288	0.056	5.094
$\gamma_{x,2}$	–0.051	0.054	–0.939
$\gamma_{x,3}$	0.016	0.054	0.300
$\gamma_{x,4}$	0.060	0.053	1.129
$\gamma_{x,5}$	0.052	0.052	0.990
$\gamma_{x,6}$	0.055	0.051	1.080
$\gamma_{x,7}$	0.103	0.049	2.083
$\gamma_{x,8}$	0.098	0.050	1.960
$\gamma_{y,1}$	0.566	0.434	1.303
$\gamma_{y,2}$	–0.313	0.435	–0.718
$\gamma_{y,3}$	0.359	0.439	0.817
$\gamma_{y,4}$	–1.301	0.439	–2.958
$\gamma_{y,5}$	–0.603	0.444	–1.355
$\gamma_{y,6}$	–0.131	0.444	–0.295
$\gamma_{y,7}$	1.042	0.442	2.355
$\gamma_{y,8}$	–0.178	0.445	–0.401
δ	0.372	0.436	0.854
R^2: 0.233	R^2(a): 0.18	D-W:2.07	F: 4.91

x: overnight rate
y: NBH key police rate
Period covered: Jan. 1998–April 1999
number of obs: 327

Taking the information criteria and the results of the autocorrelation tests into consideration, a lag length of p=8 was used.

Table V: Result of the Pesaran-Shin-smith test

x: 3-month BUBOR y: NBH key policy rate	*Test statistic*	*Lower critical value*	*Upper critical value*
F-test	7.24	4.94	5.73
T-test	–3.78	–2.86	–3.22

x: overnight rate y: NBH key policy rate	*Test statistical*	*Lower critical value*	*Upper critical value*
F-test	15.04	4.94	5.73
T-test	–5.47	–2.86	–3.22

Critical values for a 5% significance level. The F-test value was calculated as a Wald test with restrictions. The t-test is the t-value of the β_1 parameter.

Table VI: Unit root tests for the variables BUBGAP and ONGAP

Variable	Trend	Constans	Lag	ADF	Critical value (5%)
ONGAP	no	no	8	–5.59	–1.94
BUBGAP	no	no	8	–2.55	–1.94

Period covered: Jan. 1998–Apr. 1999.
Number of observations: 334.
Results of the Augmented Dickey-Fuller (ADF) test.
Null hypothesis: The variablecontains unit root.

According to the Pesaran-Shin-Smith test, the co-movement with the key policy rate can be accepted for both the overnight rate and the 3-month BUBOR. The test statistics for both the *t* and the *F* test exceeded the upper critical values, hence our assumption can be considered as valid no matter what the level of integration of the variables.

For both the overnight rate and the 3-month BUBOR the sign of β_1 and β_2 are opposite, but the absolute value of the two parameters are not statistically different. This means that a *z* basis point change in the key policy rate results in a *z* basis point change in both market rates.

Finally a unit root test was carried out to see whether the variables obtained after subtracting the key policy rate – *ONGAP* and *BUBGAP* – are stationary. According to the results the presence of a unit root can be rejected for both variable. Therefore we can rule out the problem of "spurious regression" for the estimated VAR model.