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CSABA CSÁVÁS–SZILÁRD ERHART

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Are Hungarian financial markets liquid enough? The theory and practice of FX and government securities market liquidity*

(Likvidek-e a magyar pénzügyi piacok? A deviza- és állampapír-piaci likviditás elméletben és gyakorlatban)

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Contents

Summary

The subject of our study is market liquidity, which is an important element of the functioning of financial markets. Adequate liquidity of markets is of great significance from the point of view of both market participants and the central bank. On the one hand, of all market segments an examination was made of the domestic forint-euro spot FX market, which is of key importance due to the openness of the country's economy. On the other hand, an analysis was made of the market of forint denominated government bonds, which plays a crucial role in the transmission of the central bank's interest rate policy.

Several useful lessons can be drawn from looking over the literature dealing with the measurement of market liquidity. First, liquidity can unambiguously be interpreted only alongside several liquidity dimensions. The so-called tightness dimension of liquidity can be measured by the transaction costs, a typical indicator of which is the bid-ask spread. Another important dimension is market depth, and market turnover is most often used in literature as its approximation indicator. Accordingly, in the course of empirical examinations, the two main liquidity indicators, i.e. the bid-ask spread and turnover were examined not only separately, but also in terms of their relationship. Another important conclusion to be drawn is that individual liquidity indicators may often signal changes in different directions of market liquidity, and this is one of the reasons why it is important to look at individual indicators together.

Our empirical examinations suggest that there are some similar features between the liquidity of FX and government securities markets. Seasonal characteristics were observed in both market segments. In the FX market, Monday trading days may represent liquidity improving factors, while market liquidity declines on Fridays and the last days of the year. However, we reject the hypothesis that the liquidity of the FX market is much lower in summer than in other months. Year-end decline in liquidity can be observed in the government securities market as well. In addition, the seasonality of the government securities market liquidity is also influenced by the primary issue of government bonds, as trading activity and thus market liquidity increase more markedly around auction days. Another feature of the government securities market is that liquidity gradually declines as the expiry of securities approaches.

The comparison with markets of more developed countries gave the result that neither domestic market segment belongs among the most liquid ones, which is mainly explained by the smaller market size due to the size of the economy. However, in a regional comparison, in terms of turnover as a proportion of GDP, the forint-euro market is in first, while the government bond market is in second place. Based on international comparisons we also identified factors which may, over the long term, influence market turnover and thus liquidity as well: in the FX market it is the nominal GDP, while in the case of government bonds it is the outstanding amount. In our view, over the longer term liquidity in both markets will continue to improve: in the FX market joining ERM II, while in the government securities market joining EMU may represent related potential, institutional factors. The increase in the weight of electronic trading systems may also contribute to liquidity improvements in both market segments in the future.

The liquidity of the two market segments differ from each other in many aspects. In the FX market, several signs indicate that liquidity improved in the last 1–2 years slightly and continuously, and the decline in spreads was higher than what would have been justified by the moderation of volatility itself. However, the liquidity of the government securities market was rather characterised by stagnation; despite the lessening yield volatility, the spreads could not significantly decline in this same period. The underlying reason might be that the market turbulence of 2003 H2 may have had an unfavourable effect on market liquidity over the longer term as well.

As for the spot FX market, the developments in several indicators (concentration, turnover) suggest that foreign investors' role in determining liquidity may be more important than that of domestic ones, and the changes in market liquidity are also propelled rather by the activity of foreigners. In contrast, in the government securities market it was found that the weight of foreign participants and domestic institutional investors is the same, in both the turnover and the outstanding amount, which suggests that these two sectors may play a similar role in forming market liquidity. In the FX market, signs were also found that market makers behave cautiously when establishing the spread, i.e. presumably they also take into account the risks of a possible increase in volatility in the future.

As several indicators suggest, the liquidity of the government securities and FX markets is not independent, mainly in turbulent periods. This indicates that the same participants may provide liquidity in both markets. Consequently, in extreme market situations, a decline in the liquidity of a market segment may also negatively affect the liquidity of the other market segment.

JEL Classification numbers: F31, G14, G15.

Keywords: Market liquidity, financial markets, bid-ask spread, market turnover.

1. Introduction

Our study deals with the questions of market liquidity and liquidity measurement. Our aim is to prepare a comprehensive analysis of the domestic FX and government securities markets, which may provide important lessons for both economic policy decision-makers and financial market participants. The underlying reason for the timeliness of the topic is that by now enough information has been accumulated about these market segments to allow not only qualitative but also quantitative analyses. With our study, we are striving to remedy the deficiency whereby, except for the stock markets, no comprehensive studies of the liquidity of domestic financial markets have been prepared so far.

Our analysis examines three main topics:

Theoretical relationships of liquidity

Firstly, we examine the problems of market liquidity measurement, and whether there are any tested and reliable tools for this. In this respect, the most important theoretical relationships of market liquidity are presented. An overview of the theoretical literature on liquidity is essential for a more exact definition of liquidity, and at the same time it helps us understand the methodology used in empirical examinations and the findings thereof. The analysis deals mainly with the description of liquidity under 'normal' circumstances. However, due to the importance of the issue, how liquidity may change under crisis conditions is also addressed.

Empirical examination of the liquidity of domestic financial markets

Secondly, we are looking for an answer to the question concerning which are the most important factors that may have an effect on the liquidity of domestic financial markets. Therefore, in our empirical analyses we investigate the time series behaviour of the main liquidity indicators in order to test those hypotheses about the domestic markets' liquidity which are based on anecdotal information and the relevant literature.

Some of our questions are relevant for both FX and government securities markets. In view of Hungary's small size and economic openness, we examine the importance of the presence of foreign participants from the aspect of market liquidity. In addition, based on the time series data we also attempt to identify the trends of the developments in liquidity indicators and the possible seasonal effects. The common analysis of the two markets is advantageous because it also allows a mapping of liquidity relationships between individual financial market segments.

The empirical examination of the spot FX market is carried out by applying the bid-ask spread model presented in the theoretical part. On the one hand, by means of the model it is empirically tested how the different costs of providing liquidity contribute to the developments in the bid-ask spread, which is one of the most important and precisely measurable liquidity indicators. On the other hand, application of the model also helps clarify the issue of how volatility affects the bid-ask spread.

In the section on government securities a time series-based analysis is applied to investigate individual liquidity indicators. Wherever possible, a breakdown according to security series or maturity is used, which allows the identification of relationships between the liquidity of individual government bonds and maturities. In connection with the government securities market, it was also examined whether the decline in remaining maturity of government bonds influences trading activity and/or market liquidity. Finally, with regard to the analysis of calendar effects observable in the liquidity of the secondary market of government securities, there is also an attempt to identify the seasonality generated by primary auctions.

Domestic financial markets in an international comparison

In order to expand the spectrum of our analysis, an international comparison of the liquidity indicators of Hungarian financial markets is also carried out. The most important question of the analysis is whether the extent of liquidity of Hungarian financial markets can be considered adequate in an international comparison. Both global and regional comparisons are made. International comparison is also useful because it allows the identification of future development trends. As for the coming years, adoption of the euro may be the most important event, which, based on the experience of countries introducing the single currency earlier, may result in a substantial improvement of financial market liquidity also in Hungary.

The structure of our study is as follows. As an introduction, the advantages of liquid markets are reviewed. In the second chapter, in addition to describing the concept of liquidity, the most important liquidity indicators are presented. The problem of liquidity measurement is also discussed, and a model which makes empirical analyses easier is also outlined. In the chapter about the liquidity of the spot FX market the results of the model describing the developments in the bid-ask spread are presented, then the liquidity of the spot market is examined in an international comparison as well. Finally, the liquidity indicators of the government securities market are analysed, and the possible relationships between the liquidity of the two market segments are also mentioned.

1.1 WHY IS LIQUIDITY IMPORTANT?

For market participants, the liquidity of a given instrument is determined by how easily or how cheaply it is possible to trade, i.e. to carry out selling or buying orders. Therefore, liquidity raises important questions first of all for the *owners of a given financial instrument.* For example, the magnitude of the forint investment yields required by a foreign investor depends among others on the risks and costs of liquidating the position. In a market which is small in an international comparison, e.g. in the Hungarian government securities market, a large international fund buying a significant volume of bonds takes a risk, as liquidating its investments may involve extraordinary costs due to the limited size and liquidity of the market. This means that liquidity has an effect on the level of risk associated with the given instrument, i.e. of Hungarian government securities in our example, which must be reflected in the price of the instrument as well as in its expected yield. Of two financial instruments which otherwise have the same features, market participants expect a higher yield from the lower-liquidity instrument, since due to the lower liquidity the uncertainty of the expected yield of the instrument is also higher.[1] In addition, the information processing capacity of government securities markets also influences the efficiency of other financial segments, as government securities market yields serve as a compass for banks and other financial institutions for determining the interest rates for households and corporations, and also for pricing other debt instruments.

Market liquidity is also important for the issuers of financial instruments. The yield premium due to low liquidity for example, also influences the level of financing costs of the Hungarian general government. For the government debt management agency the improving liquidity of debt instruments markets improves the security of financing the general government deficit, and also reduces its costs in the long run. From this aspect, Hungary's future EMU membership is of key importance, as joining the integrated market may significantly improve the liquidity of the government securities market, which may be beneficial at a macroeconomic level as well. The same is true for the FX market; the forint-dollar spot market, which currently has subdued liquidity, will become a part of the euro-dollar market with the adoption of the euro, greatly reducing transaction costs.

In more liquid markets, the cost of trading is lower, thus the amount of transactions required for the smooth functioning of the economy can be carried out by using less resources. It is a generally accepted opinion that the improvement of market liquidity and the lessening of market frictions have an effect as *positive externalities* not only on financial markets, but also on the economy as a whole. Another advantage of higher-liquidity market segments for market participants is that in parallel with higher liquidity they are usually less concentrated, and thus partner risk is also easier and cheaper to reduce. In addition, liquid markets allow continuous trading, which shortens the time between market participants' decisions and their implementation on the market, which also involves macroeconomic advantages.

Market liquidity is also closely related to *market efficiency.* In a low-liquidity market, transactions stemming from trading may move prices easily and bring 'noise' into price developments. Improving liquidity, however, may contribute to market efficiency, as price changes stemming from low liquidity do not distort prices, or only to a lesser extent. Therefore, markets are able to more efficiently fulfil one of their main functions, the transformation of market expectations into prices.

[1] See, for example, Amihud and Mendelson (1991), Fleming (2003).

The issue of liquidity is *important for central banks from several aspects.* Market liquidity may affect the efficiency of monetary policy. In international practice, central banks strive to influence the prices of various financial market instruments in order to attain and sustain price stability. Accordingly, central banks are present in the markets to fulfil their fundamental task. Therefore, it is of key importance for central banks to have an impact with monetary policy operations on those segments of the financial market which are the most liquid, since this way monetary policy interventions may have a stronger influence on economic developments, which also determines the success of steps taken by the central bank. In practice this means that if the central bank intends to influence short-term yields with its key interest rate, then it is the market of short-term money market instruments for which adequate liquidity may be expected.

For the central bank the existence of liquid financial markets is also important because it often relies on the *information content of financial market instruments* when making monetary policy decisions. The reliability of interest rate or inflation expectations derived from the prices of financial market instruments also depends on the liquidity of the given segment.

The issue of liquidity is also *significant for central banks in terms of financial stability.* The stability and integrity of financial markets may be jeopardised when market liquidity declines drastically. In crisis situations, a decline in liquidity may amplify the effect of fundamental shocks on asset prices, and may generate adverse spillover effects. In these cases the restoration of market liquidity may even require direct intervention by the central bank in order to repair the confidence in the functioning of markets.[2] Therefore, as a general rule, liquidity of financial markets should remain relatively steady. The importance of this issue came especially to the forefront following the emerging markets' crises in 1997–1998. At that time it became evident that stronger shocks may result in an unexpected and lasting decline in market liquidity, even in developed financial and FX markets.[3]

In our analysis, we basically attempt to describe the behaviour of liquidity under *'normal conditions',* although experiences related to crisis situations are also touched upon, based on theoretical literature and the Hungarian experiences. Analysing the financial market crises of 1997–1998, Borio (2000) came to the conclusion that the current liquidity of markets is not necessarily a good forecaster of future liquidity. In his opinion, the hypothesis of permanent liquidity is an illusion: if this belief becomes a part of participants' expectations, but proves to be false in the case of market turbulence, it will exactly be these expectations that may lead to the deterioration of liquidity. Keynes (1936) had a similar opinion on the relationship between liquidity and market stress situations. He called attention to the fact that the increase in market liquidity may add to individual participants' willingness to take risks, which may cause a decline in liquidity when market conditions are turbulent. Muranaga (1999), however, believes that if a market operates well under normal conditions, that can increase both the participants' confidence in the market and the stability of the market as well, since higher liquidity may improve markets' resistance in the case of regional or global financial market turbulence.

Market liquidity also plays an important role in fulfilling other central bank tasks. In the course of foreign reserve management, the central bank carries out transactions in the market of those financial instruments which constitute the foreign reserves, e.g. trading is done in euro denominated bonds. The liquidity of traded securities has a direct effect on the cost of foreign reserve management; in the market of euro government securities even some basis points of increase in the bid-ask spread may involve several millions of euro in transaction costs (based on the foreign reserves total). Market liquidity is important from the aspect of other central banking areas as well. If the liquidity of eligible securities which are accepted as collateral for loans granted by the central bank is low, selling the given security in the market may involve risks and additional costs if the loans are not paid back. Therefore, the liquidity premium must be taken into account when pricing the securities, if there is no regular quoting for them. Accordingly, the liquidity of securities also plays a role in the central bank's decision concerning at what value it accepts collaterals.

[2] An example of interventions of this type is the rescue of the LTCM hedge fund in autumn 1998. The intervention by the New York Fed was partly motivated by the aim to reduce the systemic risks of financial markets. The near-failure of the LTCM was a result of the decline in liquidity of the markets, and without the intervention, liquidation of positions by clients which were in contact with LTCM could have caused a further fall in market liquidity (President's Working Group on Financial Markets, 1999).

[3] For this, the American bond market is considered to be the best example, where most indicators showed a persistent decline in market liquidity in the years after 1998 (Fleming, 2001).

2. Theoretical relationships in market liquidity

Interest in liquidity is not a new phenomenon: market participants and economists specialising in this issue have been interested in its measurement for a long time.[4] This chapter discusses the relationship between the individual liquidity indicators with the definition of liquidity and offers possible solutions for the elimination of problems arising in the course of measuring liquidity. On the basis of academic literature on market liquidity, we have collected the most important statements that may be useful in understanding the concepts related to liquidity.

2.1 DIMENSIONS AND INDICATORS OF LIQUIDITY

Prior to measuring and analysing liquidity, the question as to what exactly we want to measure needs to be posed. This is because market liquidity has no universally accepted definition. It is actually an extremely pliable concept that is difficult to define. In the generally accepted simple definition, a market is liquid if trading is easy and continuous, and it becomes illiquid when sales and purchases grow difficult or eventually impossible.[5]

In order to have a more accurate definition of market liquidity, it is worth starting from the one accepted by the BIS, as it is perhaps the most comprehensive and wide-spread. “A liquid market is a market where a *large volume* of trades can be *immediately* or rapidly executed with *minimum effect* on prices” (BIS, 1999). Even this simple definition reveals that liquidity is a complex concept of several dimensions. On the basis of the definition given by the BIS, liquidity is a ‘binary’ variable, i.e. a market can be considered liquid or illiquid. However, numerous studies in the relevant literature consider the different dimensions of liquidity as continuous variables, and the extents assigned to the individual dimensions enable us to measure the current level of market liquidity.

Fundamentally, the following 4-5 definitions of market liquidity can be distinguished:

- Tightness
- Depth
  - o Breadth

Static dimensions

- Resiliency
- Immediacy

Dynamic dimensions

In connection with the definition of liquidity, it is important to distinguish asset liquidity and market-wide liquidity. In the former case, in addition to the current market liquidity, an investor holding a particular asset is also interested in the amount of loss he incurs when he wishes or is compelled to sell his asset, which, in turn, depends on future market liquidity. Market-wide liquidity may be interpreted as a narrower category: dimensions are used to grasp current or short-term (intraday or daily) liquidity, as it is of more significance. Thus the former concept is related to liquidity risk, while the latter covers the risks inherent in the functioning of markets.

Each dimension stresses a different feature of liquidity. With their help, the definition of liquidity can be reformulated: the more a market meets the dimension criteria, the more liquid it is. The following is a discussion of the meaning of dimensions and an overview of the indicators used for measuring the dimensions.

[4] Carl Menger, founder of the Austrian school of economics was among the first to tackle the concept of market liquidity at the end of the 19th century. He considered market liquidity identical with the bid-ask spread (Menger, 1892).

[5] The word ‘liquidity’ derives from the Latin word ‘liquiditas’. Its original meaning is fluidity, in this case referring to the continuity and easy flowing of market functioning. The relevant literature also has extremely word-painting descriptions, like: “Liquidity is the lifeblood of financial markets” (Fernandez, 1999).

Tightness

Tightness of the market means the transaction cost of trading. This dimension describes the ability of the market to couple demand with supply at the lowest possible cost. Its characteristic indicator is the bid-ask spread, calculated from the best available prices of the market. Its name (tightness) refers to the fact that the narrower the difference, the more liquid the market. In other words, the cost of processing a transaction arises from the fact that due to the existence of the bid-ask spread, the price at which the individual transactions can be performed differs from the average market price.

Transaction cost is not directly included in the above definition of liquidity as its defining factor. However, the requirement that transactions should have an insignificant impact on market prices essentially suggests that transaction costs are low. Actually, the concept of liquidity is often identified with transaction costs. Expressions such as "liquid and deep markets" actually conceal two dimensions of liquidity, and the first part of this particular expression refers to tightness (Marès, 2002).

For the purposes of measuring the tightness dimension of liquidity, most empirical surveys apply the difference between the best bid and ask prices, the so-called bid-ask spread (Fleming 2003, Wyss 2004). In addition, it is also worth considering an indicator that marks the difference in percentage between the best bid and ask prices relative to the price of a particular asset *(relative spread).*

For the purposes of measuring spread, the so-called *effective and indicative spreads* must also be differentiated. The effective spread is the difference between the prices at which transactions are actually made. At the prices included in the indicative spread, no actual deals are transacted; this category comprises spreads by the market makers that are not actual quotes. Effective spreads are characteristically lower than indicative spreads; however, as their time series usually move together, the latter can also be useful in the analysis of liquidity (Chordia–Roll–Subrahmanyam, 2001).

Depth

In addition to tightness, another important dimension of market liquidity is *market depth.* A market is deep if there is a large volume of market bids on the bid as well as the ask side, above and below the market price. In the narrow sense of the word, depth means the largest order volume that can be performed in the form of a purchase or sale without market price changes, in other words, the marginal volume of the best prices.

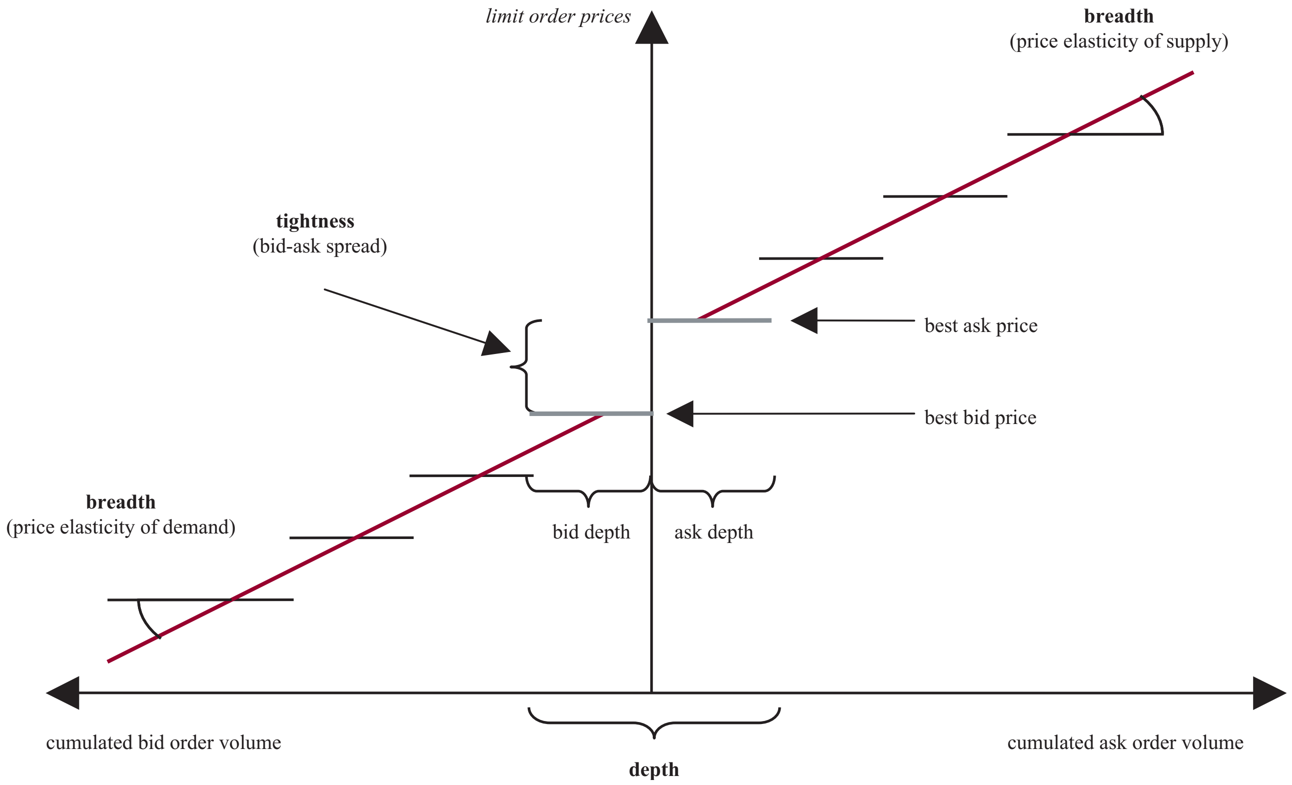
The easiest way to demonstrate the concept of market depth is by an order book (Chart 1), which may be a stock exchange trading book or an electronic order book that covers most of the market.[6] The order book specifies the order volumes coupled with the individual bid and ask prices, arranged in an order from the most to the least favourable prices. *Depth in the general sense is the order volume of the best prices.* The reason for this is that deals can be performed at the best quoted price, provided that the volume does not exceed the volume offered in the course of quoting.

Thus, depth can be easily calculated if the order book data are available for a particular market. The volumes of the best orders may be termed as quoted or as 'order depth'. In other cases, however, approximate indicators need to be applied. *Average contract size* describes depth fairly well if trading is always performed at the current best prices. In deeper markets contract sizes may rise as the risk that bid prices are not indicative in the cases of larger-volume transactions is lower.

[6] Such is the Reuters Spot Matching electronic broking system in foreign exchange markets. A common feature of order books is that they only record limit price orders, i.e. orders that comprise volumes in addition to prices.

Chart 1

Market liquidity dimensions in a stylised order book



Breadth

Numerous authors do not differentiate between breadth and depth, as they are closely interconnected dimensions. Breadth can be considered as a wider interpretation of depth: in addition to orders related to the best price, in a broader sense, market depth may also be affected by the volumes of other orders. Thus the market feature that the number of potential buyers and sellers assigned to all other prices is high as well, can be called market *breadth.*[7] In the order book this is reflected in a large aggregated volume of orders. The term refers to the fact that if the number of investors and trading participants increases, the volumes belonging to one and the same price also rise and the order book becomes 'broader'. A major characteristic feature of a broad market is that orders are 'densely' recorded in the trading book; in other words, differences between the order prices should be reduced.

An obvious feature of breadth is the slope of lines determined by the orders included in the order book: a flatter line means a larger market breadth, and consequently higher liquidity (Chart 1). The order book can be considered as the potential excess demand and excess supply which are prevented from meeting at market prices. Thus this indicator essentially measures price elasticity in demand and supply, with higher elasticity reflecting higher liquidity. Relationship with the definition is established by the fact that the higher the price elasticity, the smaller the impact transactions have on market prices (Wyss, 2004).

Market traders often use the expression 'thin market', which means low market liquidity. Liquidity dimensions may help understand the origin of this expression: the attribute 'thin' refers to the fact that market liquidity is low along the dimensions of depth or breadth.

Thus, while tightness can be considered as a *price* or cost dimension, depth and breadth stand for the *volume* dimensions in the market. These represent the static dimensions in liquidity, as they characterise the order book at a specific

[7] In our definition of breadth, we have slightly modified the one specified by Sarr and Lybec (2002) in order to clearly distinguish breadth and depth.

moment of time. Liquidity is, however, also affected by the dynamic changes of the order book. Thus we need dimensions to reflect market dynamic: these are resiliency and immediacy.

Resiliency

The literature is more divided over the definition of *market resiliency.* In most definitions resiliency is deemed to describe how quickly prices converge to their new 'equilibrium' value after they have been moved by large transactions (Borio, 2000). The equilibrium price may mean the value of a specific financial asset as defined by fundamentals. It may also reflect a state of balance between bid and ask orders in the order book. This is because the trading book continuously changes. When market participants hit the quotes in the course of trading, certain orders are cancelled from the book. This affects prices, and it takes some time for the order book to be refilled and the orders to equilibrate.

The definition of liquidity is less directly related to resiliency than to other dimensions. Assuming two markets with identical spreads and depth, the initial price effect of transactions is also identical. If, however, one of these markets is more resilient, then according to the definition, prices return to equilibrium faster than in the other, in other words, *in a unit of time* an identical transaction affects prices less, and so market is more liquid.

As it is often difficult to estimate the equilibrium price, the authors engaged in measuring liquidity approach the resiliency dimension from a practical aspect – measurability. One of these indicators suggests that resiliency is determined by the time required for the spread to return to its earlier value (Muranaga, 1999).

Another major group of indicators comprises the so-called price impact indicators, which quantify the prices change caused by a transaction of a specific size. These indicators are related to resiliency by the fact that if identical volumes trigger smaller price changes, prices are likely to return to equilibrium sooner; in other words, market resiliency is higher. It is clear that the price impact indicators are very similar to the price elasticity indicators discussed in the previous chapter. However, there is an essential difference – the latter is a static, while the price impact indicators are dynamic indicators.

Immediacy

Another significant dimension of liquidity is *immediacy.* It is expected that liquid markets provide the opportunity for the immediate processing of transactions, i.e. at any time whenever market participants wish. If investors have to wait for the execution of transactions, market liquidity is lower, as waiting involves the risk that prices may turn more unfavourable in the meantime. Moreover, immediacy means the actual, physical time requirement of the execution of transactions, as affected by the development of the applied trading system.

Due to the dynamic nature of this dimension, it is also difficult to measure. As an approximate indicator, the number of transactions executed in a specific period of time, the frequency of contracting, or the number of new trading orders are usually recommended as measures in the literature (Wyss, 2004). The number of executed transactions may be a good measure for the examination of continuity in market liquidity, as an increase in this indicator suggests that the potential sellers and buyers are continuously present in the market and ready to trade.

Table 1

Principal dimension indicators

Tightness	bid-ask spread – concentration
Depth	volumes of the best prices average trade size – turnover – concentration
Breadth	price elasticity of demand and supply
Resiliency	price impact indicators
Immediacy	contracting frequency – turnover

The indicators that can be related to more than one dimension are indicated at several places. The Appendix discusses a few more liquidity indicators of major significance.

In view of the above, it may be stated that, on the basis of its definition, *liquidity can be measured unambiguously only considering several dimensions; thus liquidity level can be assessed only with simultaneous consideration of the information provided in several indicators.* The simplest way to classify the indicators used for measuring liquidity is to group them on the basis of the dimensions measured in the indicator (Table 1).

There are, however, approximate liquidity indicators which cannot be directly related to the individual dimensions. One such frequently used indicator of market liquidity is *market turnover.* An increase in market activity raises the information content of market prices and so the risk undertaken by the owners of a particular asset may decline as their larger-volume transactions change prices. As turnover is a product of the average contract size and the number of contracts, it is related to depth and immediacy as well. When it is used, it is problematic that the wider definition of depth also includes potential demand and supply, while turnover only reflects actually performed transactions. In any case, the literature uses the turnover as an indicator approximating depth (Borio, 2000), and this is the most important indicator of liquidity next to the bid-ask spread.

Another liquidity indicator is *market concentration,* used in our empirical analyses as well. Decline in the concentration of the market participants who trade with market makers suggests an increase in liquidity, while with a decrease in the share of participants of major weight, the chance of changing prices by their large-volume transactions also declines. On this basis, concentration can be related to the depth dimension. However, it can also be related to tightness. With a decline in concentration between market makers, the costs incurred on account of asymmetric information may fall; if turnover levels out among market makers, the individual market makers may obtain similar information from the developments of transactions processed with them.

2.2 DEMAND FOR SUPPLY OF LIQUIDITY

As seen above, market liquidity is determined by several dimensions jointly. Thus simultaneous change in the indicators measuring the individual dimensions in the same direction, e.g. an increase in tightness and depth at the same time, clearly suggests a rise in liquidity. But the dimensions (and the indicators describing them) do not necessarily move together and in such cases it is difficult to decide, even in theory, whether liquidity increases or decreases. This chapter discusses a theory that can clearly demonstrate when and in what directions the two principal liquidity dimensions, tightness and depth, can move together.[8]

This theory interprets market liquidity as a market good (service), a 'product' of financial intermediation, that has its own market. Liquidity is provided by the market makers (supply), and 'consumed' by the customers trading with them (demand) (Chart 2). A unit of liquidity can be defined as a service in executing a transaction of a given amount without changing prices. In a market developed in this way, the price of liquidity as follows from the definition of liquidity is equivalent to the *bid-ask spread,* the price is therefore the *tightness* dimension. The volume of liquidity in equilibrium corresponds to the *depth* of the market. The more liquidity the market makers provide, i.e. the larger transactions the customers can perform without affecting prices, the larger is the depth by definition. *Immediacy* also appears in this theoretical framework and represents the opportunity of the prompt execution of the service in demand, i.e. liquidity. The following is a survey of the impacts of the major factors affecting liquidity on market depth and tightness, according to this model.

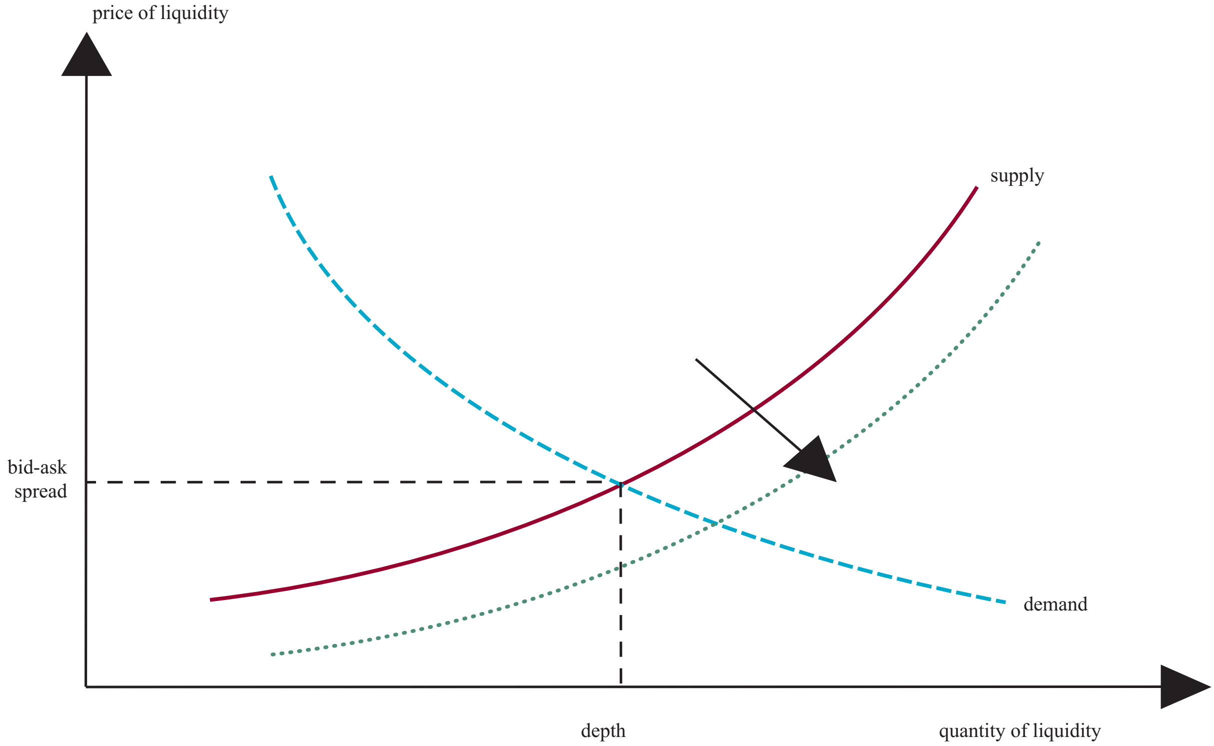
The provision of liquidity fundamentally requires a single principal production factor – capital. The provision of liquidity is a risky activity that requires the assignment of capital and the larger the provided liquidity, the more capital is required. In line with the assumptions of classical micro-economics, the marginal product of capital declines, i.e. the use of a unit of capital increases the volume of supplied liquidity at a slowing pace. Consequently, the marginal cost of liquidity is increasing and therefore supply in market liquidity can be depicted by a curve of positive slope in function of the price (bid-ask spread), similarly to corporate supply curves.

Demand for liquidity can also be deduced within the framework of neoclassical microeconomics. In the market, the investor must choose – either he immediately performs the transaction he needs, or he waits and performs it at a later

[8] The study by Marès (2002) provided the starting point for the model of liquidity demand and supply. The author only roughly outlines demand for liquidity and supply of liquidity, thus the analysis of the demand and supply functions reflects the ideas of the authors of this study.

Chart 2

Liquidity demand and supply equilibrium



date. (Perhaps the two can be combined: the intended transaction is performed in several parts.) In the former case the market participant faces a bid-ask spread reflecting the risk that large transactions may change prices. If the investor decides to wait, however, he incurs the potential cost of an eventual unfavourable change in the prices, with probability depending on volatility. The opportunity cost of the prompt execution of transactions is therefore identical with the volatility expected for the future. Thus, a choice between 'consuming' liquidity today or tomorrow is similar to the optimising activity performed by consumers. If at a given level of volatility the spread is lower, then the optimum solution for investors is to conduct more transactions in the present, i.e. consume more liquidity. Thus the demand curve has a negative slope – if the spread declines, the amount of liquidity in demand by market participants rises.

In this model, if supply increases and the supply curve shifts to the right, the *spread drops and depth increases simultaneously,* i.e. the two major dimensions of liquidity move in the same direction. Below some practical examples are given for shifts in demand and supply.

Let us assume that competition increases as new market makers enter the market, triggering an increase in supply, which reduces the spread and simultaneously increases market depth. Thus, according to this model, a reduction in the concentration of market makers clearly improves these two dimensions of market liquidity. A similar result may be achieved by the adoption of new technologies, e.g. electronic trading systems, as they also shift the supply curve to the right.

In the literature major modifications in the features of financial products (product design) are usually considered as a similarly positive supply shock. For instance, in the market of government securities the development of benchmark securities reduces marginal cost for participants supplying liquidity, as fewer kinds of securities need to be kept in store.

Another factor that may reduce liquidity is a drop in market makers' risk appetite. A well-known example of this is the situation that evolved after the 1998 Russian crisis, when market makers adopted a more prudent and tighter risk management, contributing to decline in liquidity supply in several segments of the global financial market (BIS, 2001).

Another important question concerns the impact of increased volatility on the market of liquidity. This may reduce supply, as it increases market makers' risks and, consequently, potential costs. On the assumption of this model, demand will, however, increase. It follows from the optimisation of consumption of the current and future liquidity, that at a given spread higher volatility prompts investors to perform more transactions in the present. Thus an increase in volatility shifts the demand curve to the right. A decrease in supply and an increase in demand both raise the price of liquidity, i.e. spread. However, the effect on depth is not clear, as it may either grow or drop, depending on the preferences and volatility sensitivity of the market participants.

Thus, the model described is suited for analysing shifts in static dimensions between two states of equilibrium within the framework of comparative statistics. Turbulent market conditions may, however, upset the equilibrium, and consequently the *resiliency dimension,* i.e. the time needed for the equilibrium to be restored, would attract more attention.

When persistent, such imbalances may also lead to the 'drying up' of the market liquidity.[9] This term refers to a dramatic reduction in market liquidity, which can be attributed to shifts in liquidity demand and supply as well as some market disturbance. If market makers' willingness to provide liquidity decreases as a result of market turbulence, this leads to the build-up of excess demand in the liquid market, which will simultaneously entail reduction in depth and a hike in spreads. Furthermore, it is highly likely that in such cases demand is unable to adjust. On the contrary, market participants need more liquidity despite higher spreads. This may, in turn, affect the price of the underlying product, thereby generating a high degree of volatility.

A special case of market disturbance is called a 'liquidity black hole', which comes about in crisis situations where market participants head for the same direction, i.e. the homogeneity of their expectations reaches a level that upsets the balance even between demand and supply (Persaud, 2001). In such cases neither drops nor increases in market prices translate into a shift towards a new equilibrium. Rather, they destabilise the market, tempting a significant number of additional sellers and buyers to the market, thereby generating further movements in prices. Events like this may be triggered by certain types of market behaviour of major market participants, positive feedback-based trading or herding behaviour (Kóczán–Mihálovits, 2004).

In conducting an empirical analysis, we do not intend to test the model outlined in this paper, since both the supply and demand sides of liquidity are influenced by several factors for which we do not even have proxies (e.g. data on the preferences of investors in need of liquidity). One lesson can, however, be learnt, namely that the phenomenon where various liquidity dimensions may move in opposite directions can be underpinned theoretically as well. Therefore, the individual indicators of liquidity should be tracked simultaneously.

2.3 DIFFICULTIES IN MEASURING LIQUIDITY

Market liquidity does not lend itself to direct observation. The difficulty implied in its measurement relates mainly to its definition, as liquidity is often considered as a qualitative rather than quantitative category. Furthermore, definitions contain subjective components, for example the price impact of 'major' or 'minor' transactions is a relative term, which may also generate further difficulty for measurement. As a result, developments in liquidity indicators do not enable us to draw conclusions about the extent of changes in liquidity between two different points of time. They do enable us, however, to decide about the direction of the changes, i.e. whether liquidity improves or declines.

A further common problem with the easily available indicators is that they cannot provide a perfect description of the individual dimensions, as was referred to in the case of turnover. This is further compounded by the fact that liquidity dimensions partly overlap with each other. Nevertheless, empirical analyses typically use the indicators described earlier or ones similar to them. Preference for them generally depends on the availability of data.

A further issue involves the assessment of *liquidity when various indicators move in opposite directions,* and, depending on the indicator studied, we would arrive at contrary conclusions regarding changes in liquidity. One possible way of

[9] Naturally, liquidity never fully dries up in the market, as this would mean the end of all trading at a time when quotes have no information content whatsoever. Assessing the extent of reduction in liquidity that is to be considered as dry-up is a tough challenge to meet, even theoretically.

overcoming this difficulty is to consider as more convincing those measurements that are supported by several indicators. This is indeed the method we adopt in analysing bid-ask spreads and the trading volumes of government securities. However, in examining one single indicator separately, we confirm the accuracy of our conclusions by relying on empirical literature.

In analysing the spot FX market, we opt for a different method: we seek to identify the underlying reason for the positive co-movement of spreads and trading volumes, the two most important liquidity indicators. Based on what was outlined in the previous section, it is a safe assumption that it should be related to the volatility of the exchange rate. Increasing volatility heightens the risks assumed by market makers, who can offset this by widening spreads. It also entails higher trading volumes, which are particularly common under turbulent market conditions (see Section 4). Therefore, we have chosen a model to analyse spot market liquidity that enables us to filter the impact of volatility on liquidity indicators. If we find that, after filtering volatility, trading volumes and spreads move in opposite directions, this confirms the fact that volatility is likely to be the very factor that makes the other two variables correlate. Although we lose data by filtering volatility, the advantage of this method is that we can interpret joint changes in liquidity indicators.

The role of volatility raises further issues. If the only observation that we can make is that spreads expand due to increasing volatility, this alone does not necessarily point to a reduction in liquidity. In order to be able to confirm such a reduction, we should discover the causes of increasing volatility (Grossman–Miller, 1988). Possible reasons include an increase in the volatility of the fundamentals that determine the exchange rate, a rapid change in expectations for fundamentals and the fact that information reaches the market faster. In this case, volatility is not detrimental to liquidity; rather, it suggests that the market fulfils its main task, i.e. the transformation of expectations into prices. Another possible reason underlying higher volatility is that the capability of the market of processing information improves, which also points to an improved functioning of the market.

In order to be able to explore the exact nature of the relationship between volatility and liquidity, we need methods that would enable us to 'isolate' the increasing and decreasing effect of different components of volatility on liquidity. In addition, we should know the interdependencies between liquidity and volatility, as reduction in liquidity may increase volatility; but there may exist a reverse relationship as well. In order for these issues to be tackled, an exchange rate model should be set up and tested that would be able to tell whether it is the new information on fundamentals that affects the exchange rate, or liquidity-related factors generating noise that lead to volatility. This, however, goes beyond the framework that we have set to our analysis. Although we leave the question unanswered, we will, in connection with our empirical analysis, refer to the uncertainties arising from this. One possible solution to the above problem could well be the application of price impact indicators mentioned earlier. For the derivation of such indicators one would need, however, intraday data so as to be able to estimate indicators on a daily or weekly frequency (Fleming, 2003).

The literature offers no satisfactory analysis of the relationship between volatility and liquidity. Often, liquidity is treated as identical to bid-ask spread, on the basis of which the relationship would be unequivocally negative (Chordia, 2001). Furthermore, with the time series in the literature that we have surveyed it is often the case that, as volatility increases, so indicators reflecting depth (trading volumes and quoted depth) decrease, while spreads widen (e.g. Galati, 2001). In such a case, an increase in volatility is, in reality, likely to suggest declining liquidity, as opposed to the domestic spot market, where the correlation per pair between volatility, spreads and trading volumes is positive. The fact that the literature does not focus on the relationship between volatility and liquidity may be due to the definition of liquidity. The liquidity of certain financial instruments depends on, among other things, the volatility of the instrument at the moment when investors wish to liquidate their positions; thus, volatility also affects liquidity in this broader sense. By contrast, static indicators can only capture liquidity in a narrower sense over a shorter time horizon.

The literature also cites the use of other methods of measuring liquidity. One such possible method is the calculation of composite indicators. However, there is no tried and tested method that could be used to determine the weights for the calculation of the indicator. Often, a combination of two indicators is calculated according to some simple rule (e.g. Kutas–Végh, 2005). There are more sophisticated methods which calculate weights by means of a principal component analysis (Wyss, 2004). In order to be able to use this method, however, we would need several liquidity indicators that are not available to us.

2.4 BID-ASK SPREAD MODELS

So as to perform an empirical analysis of market liquidity, we have performed a model that can manage liquidity indicators consistently and is able to eliminate the impact of volatility on liquidity indicators. First, we present the theoretical basis of the model, and then we go on to provide a brief overview of the related literature. We also offer an argument for our decision concerning the use of this model.

Bid-ask spread models are used to break down the differential between bid and ask prices in the market of a financial product into factors influencing it. Theoretically, bid-ask spreads are subject to three types of costs: inventory-holding costs, order-processing costs and adverse selection costs. These costs can be associated with various indicators, on the basis of which the following formula can be used:

$$\text{SPREAD} = \alpha + \beta_1 \bullet \text{VOLATILITY} + \beta_2 \bullet \text{TRADING\_VOLUME} + \beta_3 \bullet \text{CONCENTRATION} + \varepsilon$$

inventory-holding costs	order-processing costs	adverse selection costs

The constant is to be interpreted as the fixed costs of trading, while the remaining factors, in effect, identify variable costs. We expect the sign of trading volumes to be negative and that of volatility and concentration parameters to be positive. What follows provides an overview of the relationship between the individual indicators and the spread.[10]

Part of the costs arises from the fact that market makers assume market risks, due to the nature of their activity. The risk assumed in ensuring market liquidity is that during the period between hitting the bid and ask quotes, they take positions. The costs of potential shifts in prices are therefore reflected in bid-ask spreads. The reason why the term 'inventory costs' is used is that in the case of government securities, for instance, market makers must have an inventory of a certain size in order to be able to provide continuous liquidity. A logical indicator of this cost component is volatility, which is a suitable indicator because, if market makers want to hedge this risk, its cost is proportionate to volatility.

Order-processing costs denote actual costs arising from market makers' activity. They include, for instance, technology, labour and settlement-related costs. As these costs are, in part, fixed, or they increase at a more moderate pace than do trading volumes, with *market turnover* rising, unit transaction cost falls. Thus, rising volumes reduce bid-ask spreads. (If, for instance, trading volumes double overnight, processing orders does not require or is unlikely to require the employment of twice the number of dealers.)

Bid-ask spreads are also subject to what is called adverse selection costs, attributable to the asymmetric distribution of information. If market counterparties are better informed about current market developments and expected shifts in exchange rates than market makers, this leads to a potential cost being borne by market makers, which cost is also incorporated in spreads. One example of this is insider information, although this only bears relevance to equity markets; it affects the market segment under review only to a lesser degree. A proxy to these cost components is *the concentration of market turnover.* If few market makers manage the overwhelming part of trading, then this poses the risk of asymmetric information to other market makers. Diminishing concentration is an indication of a sharper competition among market makers; thus, it contracts spreads via this channel as well. The more fierce the competition, the smaller the amount of market participants' profit, which is proportionate to bid-ask spread in the case of market makers.[11]

Empirical findings of bid-ask spread models

An overwhelming majority of empirical studies apply cross-sectional data to test bid-ask spread models, that is asset price spreads are investigated for a certain point of time. Mostly equities give the underlying asset of the studies. It is

[10] Bollen, Smith and Whaley (2001) provide a comprehensive overview of bid-ask spread models. In outlining the theoretical foundations of our model, we follow the train of thoughts adopted by their paper. Literature on bid-ask spread models goes back as far as the 1960s (Demsetz, 1968).

[11] Other indicators, e.g. market capitalisation in the case of shares or the number of specialists in certain shares, are also used to approximate adverse selection costs. However, we find that concentration is the most suited for such purposes in the markets surveyed. Bollen, Smith and Whaley (2001) regard concentration to be a separate cost component, which is, in our opinion, more closely associated with adverse selection costs.

mainly time series-based research on spot FX market spreads that bears relevance to our paper. What follows provides an overview of such research.

Using a sample of daily data spanning 18 months, a study by the BIS (Galati, 2000) analysed bid-ask spread on the currencies of several emerging countries (South African rand, Indian rupee, Mexican peso and Israeli shekel). The coefficient of volatility was positive for each currency (the author used the GARCH(1,1) model to assess volatility). Only in the case of the Mexican peso did he find that FX market turnover exerted a significant negative partial impact on spread. (Galati divided turnover into an expected component and an unexpected one, which he incorporated into his model.)

Wei (1994) analysed bid-ask spread on the yen-dollar exchange rate on a 7-year horizon, using monthly data. An increase in one-month implied volatility widened spread. However, the coefficient of turnover was positive, with low significance. Analysing percentage changes, Wei arrived at the conclusion that volatility affected spread more than did market turnover.

Huang and Masulis (1999) tested a bid-ask spread model for the dollar-German mark exchange rate. They studied a period of one year, using intraday data with 15 minutes' frequency. Their model did not have any data on market turnover. It only included indicators reflecting volatility and market concentration in their explanatory variables. The coefficient of the volatility estimated by standard deviation was positive. The increase in the number of dealers, ceteris paribus, had a mitigating impact on the spread. The sign of another variable, which also reflects concentration, was different from what bid-ask spread models had assumed – an increase in the number of major participants tightens spread.

What the above empirical research has in common is the employment of the model on the levels of variables and use of OLS, the most simple method to estimate parameters, assuming, as a rule, a linear relationship. A review of literature reveals that various indicators are used to provide estimations for the individual cost components. Thus we are free to choose indicators that we think influence bid-ask spread to the largest possible extent.

The relationship between bid-ask spread models and liquidity

The primary aim of the bid-ask spread models is to break down spread into various components. We, however, wish to use them to draw conclusions about developments of liquidity. Towards this end, we give further thought to the above models with regard to the manner in which parameters should be interpreted.

The reason why we chose our model needs some explanation. We wanted to find a model that was able to manage all major liquidity indicators and quantify the impact of volatility. Our model meets these requirements. The dependent variable of the model is bid-ask spread. This also fits in with the framework of our analysis, because in establishing a causal link between the three liquidity variables, spread, market turnover and concentration, we think that market turnover and concentration impact spread and not the other way round, i.e. spread affects market turnover and concentration either directly or indirectly.

We interpret parameters as follows. The treatment of the coefficient of volatility is different from that of the other two variables. The fact alone that, with the values of the other variables unchanged, higher volatility widens spread does not mean that increasing volatility reduces liquidity, as this effect is, to a certain extent, natural from the perspective of the functioning of the market. We do not perceive volatility as a stand-alone liquidity indicator. Rather than interpreting the level of the parameter, we are interested how the value of the coefficient changes in time; an increase in the parameter may suggest lower liquidity.

With respect to the evaluation of the role of liquidity, a further factor that matters concerns developments in that part of the bid-ask spread which fluctuation in volatility cannot explain. If the sign of a liquidity variable (market turnover or concentration) is consistent with expectations, it confirms that shifts in that indicator point to changes in liquidity, provided that such shifts affect developments in spread significantly. A further advantage that the use of this model offers is that it filters the impact of volatility from not only the spread, but also the other liquidity variables. As the coefficients of the model can only be interpreted in a ceteris paribus manner, in interpreting the other indicators, e.g. the coefficient of market turnover, we only analyse the direct impact on spread, while assuming unchanged volatility. Although we are likely to lose information, we can compare bid-ask spread on days and during periods when the degree of volatility is different.

2.5 THE USE OF THEORETICAL RELATIONSHIPS IN PRACTICE

The most important conclusion of the section on the theoretical background serving as the basis for the practical analyses is that liquidity is a complex concept that has several characteristics. Our paper defines liquidity as continuous variable and, of the liquidity indicators presented in the literature, it focuses on static indicators.

Based on static indicators, the empirical section provides a time series-based analysis of recent developments in liquidity in the Hungarian spot FX and government securities market. Of the indicators, we primarily focus on bid-ask spreads that can capture market tightness and data on market turnover, which provides information about the depth of financial markets. We identify trends and seasonality in financial markets liquidity in Hungary and seek to explore the reasons underlying them. In analysing the FX market, we rely on the model for bid-ask spreads, which also enables us to perform time series-based analyses and to identify the relationship between the various liquidity indicators. By contrast, in the case of the government securities market, for lack of data, we perform time series-based analyses separately, i.e. outside the framework of the model. As a separate analysis of the indicators may prove misleading, we check the accuracy of our conclusions against the findings disclosed in empirical literature.

In the course of the empirical analyses, we also compare the liquidity indicators of the Hungarian financial market with global ones in the sections on both the spot FX and the government securities markets. Global and regional comparisons are useful in the perception of the current level of liquidity in the domestic markets and provide for the possibility that future trends can be identified.

In the course of the empirical analyses, a separate section is devoted to the spot FX and the government securities markets, due partly to the differing characteristics of these markets and partly to the differences in the methods applied. In order to pinpoint the relationships between the two markets liquidity, we offer a joint time series analysis of the liquidity indicators of the FX and the government securities markets in the section of government securities.

3. Empirical examination of the spot FX market

The first part of our empirical examinations deals with the forint-euro spot FX market. In the course of the analysis, the time series development in the liquidity of the FX market is examined using the liquidity indicators presented in detail in the previous chapter and the outlined bid-ask spread model. We are seeking answers to several questions at the same time. On the one hand, we want to know if the available anecdotal information about the liquidity of the FX market can be supported by our data – according to FX market rumours, liquidity in the spot market declines towards the end of the year, on Fridays and in summer months. In addition to seasonal peculiarities, it may also be interesting whether any trend-like deterioration or improvement can be observed in the liquidity of the FX market. On the other hand, we are also trying to find out whether non-resident or domestic participants play a greater role in providing market liquidity. As an example, it is also mentioned what may have happened to market liquidity in certain turbulent periods in the FX market.

The liquidity of the forint-euro FX market was also analysed in an international comparison (Chapter 3.4). In this respect, the major question concerns why bid-ask spread and market turnover of Hungarian markets may be different from that of foreign markets. In addition, the liquidity of the forint-euro spot market in a regional comparison is also mentioned, and it is touched upon whether an improvement in the forint market liquidity can be expected in the longer run.

3.1 DATA DESCRIPTION

In this sub-chapter, we describe the source and calculation method of major liquidity indicators of the forint-euro spot market, which will later be used in the time series model. The period under review is from May 2003 to July 2005 and our dataset is based on daily data.

Bid-ask spread

The forint-euro bid-ask spread was calculated on the basis of orders entered to the Reuters electronic trading system, as the difference between the best bids and offers.[12] This indicator describes most efficiently the effective spread, as it represents real market offers, although contracts are not necessarily made at these prices. In our analysis, we used the *relative spread* (spread compared to the forint-euro exchange rate) in order to receive comparable values, even if exchange rates are different. The daily average spread calculated from the two-minute frequency exchange rates was examined in the model.

Volatility

The percentage difference between the daily maximum and minimum levels of the forint-euro exchange rate was chosen as the indicator of volatility. Although this is one of the recommended indicators in the literature of bid-ask spread models, choosing this may seem rather arbitrary. Therefore, we also examined another indicator, the volatility estimated using the GARCH (1,1) model. However, it turned out that it does not have a significant effect on the bid-ask spread (see the model in the next chapter). The underlying reason may be that the cost of trading is more influenced by the intraday volatility than by an indicator which goes back several days. As market makers usually wish to close their open positions to a predetermined level by the end of the day, their risks are also more determined by the intraday exchange rate fluctuation. Unless otherwise indicated, volatility hereinafter is understood as the absolute value of the percentage difference between the daily maximum and minimum values of the exchange rate.

Volume-based indicators

The *daily spot forint-foreign currency market turnover* of domestic banks was chosen as the market depth indicator.[13] Considering that non-residents play a decisive role in forming the FX market, *the volume of transactions vis-à-vis non-*

[12] The exchange rates are from the Reuters Dealing 3000 Spot Matching electronic trading system and/or its earlier version, the Reuters D2000-2.

[13] The data source of quantitative indicators is the daily FX market report of domestic banks, which covers only the turnover of domestic banks; double recording has been eliminated from the interbank turnover of reporting banks.

residents may also be a factor which affects the spread. As we are examining the forint-euro spread, only the forint-euro transactions have been taken into account when calculating the quantitative indicators.

Another indicator which can reflect market depth is the *daily average deal size.* When calculating this indicator, again only the transactions against the euro were taken into consideration. Based on the daily average deal size and the daily turnover, another indicator, the *average daily number of deals,* can also be calculated, which can be an approaching indicator of the immediacy dimension.

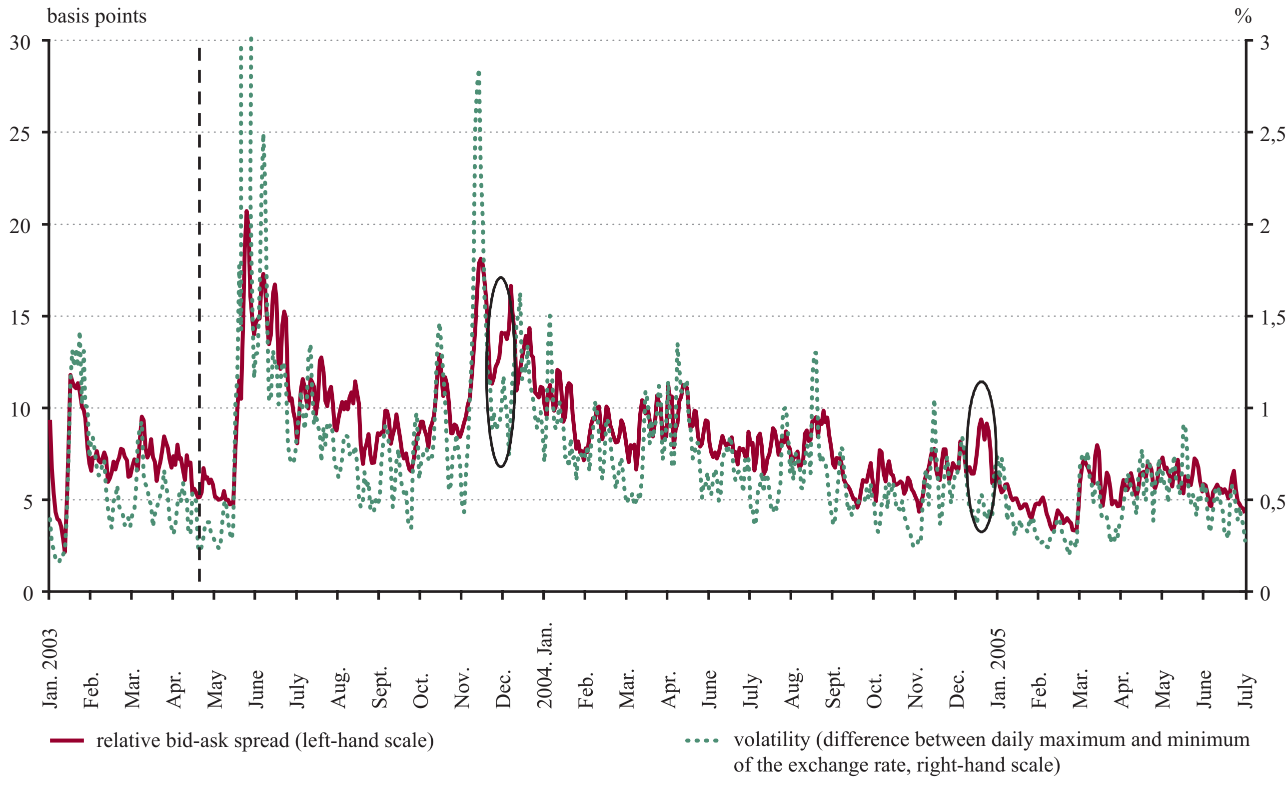
The Herfindahl index calculated from the share of individual banks within daily turnover was used *to measure domestic banks' concentration.*[14] The highest value of the index, i.e. 1 represents 100 per cent concentration, and the more equally distributed the turnover among banks, the smaller the value of the indicator becomes. In addition, in terms of liquidity, the extent of concentration of investors' doing business with market makers can also be of importance. In this case, high concentration may reflect investors' information superiority, which may represent a risk for market makers. Therefore, we have also calculated a Herfindahl index which takes account of the ratio of individual foreign banks within the turnover with all non-residents, i.e. it measures the *concentration of non-resident participants* (when calculating the index, the turnover of the 40 largest foreign banks, which cover nearly the whole market, was taken into account).

3.2 MAIN CHARACTERISTICS OF LIQUIDITY INDICATORS

In the period under review, the average value of the relative bid-ask spread stood at 0.085 per cent, i.e. 8.5 basis points. (See the descriptive statistics of the indicators in the Appendix.) Converted into forints this means that in the case of a transaction with a value of 1 euro, the average spread is approximately 0.20 forints. The highest value of the spread,

Chart 3

Forint-euro bid-ask spread and volatility (3-day moving average)



The dashed line indicates the beginning of the sample period examined in the analysis.

[14] The Herfindahl index is the sum of the squares of shares of each individual player, divided by 10,000.

exceeding 0.60 forints, was recorded on the day of the shift of the exchange rate fluctuation band, on 4 June 2003. Similarly to the spread, volatility also reached its maximum on the very same day. The question may be raised whether it is worth examining the developments in the spread, considering that it is very low. However, in absolute terms the amount cannot be neglected. On the basis of the annual spot market turnover, the existence of the bid-ask spread represents a 15 billion forint total cost for investors, and the same amount of income for market-making banks. If 2003:H2 is considered, due to the higher spread and turnover, the transaction cost amounted to 13 billion forints in just half a year.

In addition to the close co-movement, some characteristic signs can be observed in the time series developments in spread and volatility (Chart 3). Higher volatility jumps were usually immediately followed by increases in the spread, while a decline in volatility is generally followed by a gradual decline in the spread with a little delay. This observation may reflect market-making banks' cautious behaviour; being afraid of a sudden volatility jump, they reduce the spread to a perceptible extent when the decline in volatility seems to be longer-lasting. This caution is understandable, as it is usually typical of volatility that rises are rapid and great, while declines are rather gradual.

The value of the total turnover indicator and that of the indicator of the turnover only vis-à-vis non-residents was the highest on the day of the shift of the exchange rate band, while the lowest turnover could be observed on the last trading days of the years. Comparing the relative standard deviation of the two types of indicators it becomes evident that the fluctuation of the indicator reflecting the activity vis-à-vis non-residents is much bigger than that of the whole market. This means that the interbank turnover and the turnover vis-à-vis residents is relatively stable, and the changes in the turnover are mainly influenced by the activity of non-residents. As turnover is one of the important indicators of market liquidity, it indicates that *market liquidity reacts to the presence of non-residents in a more sensitive manner than to that of residents.*

The average of the daily average deal size in the sample is 320 million forints, i.e. somewhat more than 1 million euro. The daily average value of deals is typically between 1 and 2 million euros, while deals effected by non-residents are larger; their value is usually between 1 and 3 million euros. The average daily number of deals in the sample period was 340. Considering that one trading day lasts approximately eight hours, this means a deal in the forint-euro spot market is made relatively often, i.e. every 1.5 minutes on average.

In the sample period, the average value of the Herfindahl index, which reflects the concentration of domestic banks, was 0.11. To assess this level of concentration one could refer to the concentration indicators calculated for industrial branches. When competition between companies is examined, values between 0.1 and 0.2 are usually considered to reflect a moderate concentration. In terms of percentages this means that of the 25 actively trading domestic banks 60 per cent of the turnover is concentrated among the 5 largest.

The average value of the indicator reflecting foreign banks' concentration is practically identical with that of domestic ones (0.12). This indicator had an extremely high value on each Good Friday, which is a holiday in several foreign markets. Then the average or below-average turnover vis-à-vis non-residents took place with fewer-than-usual foreign participants. Despite the same averages of the two types of concentration indicators, their standard deviations are much different; that of non-residents is higher, which also indicates that non-residents play a decisive role in liquidity.

The correlations between individual variables have also been examined. It is volatility which performs the closest co-movement with the spread (Table 2). It is also interesting that the behaviour of concentration indicators is different from that of the others. The domestic banks' Herfindahl index usually moves in the opposite direction compared to that of other liquidity indicators. Intuitively, one would expect that in parallel with the increase in trading activity the competition between market makers could increase and concentration could decline. Nevertheless, in the case of the forint market, the correlation between the domestic banks' Herfindahl index and the turnover is positive. This is attributable to the fact that in the increase in trading activity usually the increase in trading of domestic banks, which otherwise also have a higher share, plays a greater role.

The correlation matrix also shows that the correlation between the spread, the turnover and the volatility is positive by pairs. Thus, regarding the dynamics in liquidity, one would come to different conclusions based on separate examinations of the spread and the turnover, which justifies the need for a model which can handle the role of volatility.

Table 2

Correlation matrix of liquidity indicators

	Average deal size	Average number of deals	Volatility	Residents' concentration	Non-residents' concentration	Turnover	Non-residents' turnover	Relative spread
Average deal size	1							
Average number of deals	**0.32**	1						
Volatility	**0.48**	**0.33**	1					
Residents' concentration	**0.33**	-0.08	0.01	1				
Non-residents' concentration	**0.12**	**-0.28**	**-0.10**	**0.63**	1			
Turnover	**0.74**	**0.81**	**0.50**	**0.18**	-0.04	1		
Non-residents' turnover	**0.74**	**0.74**	**0.50**	**0.30**	0.06	**0.94**	1	
Relative spread	**0.36**	-0.03	**0.73**	0.04	0.05	**0.20**	**0.21**	1

Bold type indicates those correlation coefficients which are different from zero at a 5 per cent significance level. See the meaning of variables in detail in the Appendix.

3.3 THE TIME SERIES MODEL OF THE FORINT-EURO BID-ASK SPREAD

In accordance with the above, the forint-euro bid-ask spread was chosen as the dependent variable of the fitted model. The traditional bid-ask spread model was modified in conformity with the characteristics of the domestic spot market. Accordingly, in the case of concentration and turnover in the equation of the bid-ask spread model, not only were variables representing the whole market taken into account, but also those ones that describe non-residents' market activity. According to empirical analyses, significant calendar seasonality is typical for the daily developments in the FX market bid-ask spreads (see e.g. Huang–Masulis, 1999). In order to test this hypothesis, dummy variables were also included in the explanatory variables of the model according to the days of the week and describing monthly seasonality. The model was also expanded with a linear trend variable. Although it cannot be expected of the bid-ask spread to follow a trend in a certain direction in the long run, since its value cannot fall below 0, it is conceivable that during the two and a half years of the sample period the spread followed a trend decline or growth.

Due to the time series behaviour of the variables, the model can be fitted to the level of the spread, i.e. there is no need for differentiation of the variables.[15] The estimation was carried out using the ordinary least squares method. However, the error term of the thus stated model contained a high degree of autocorrelation. We tried to eliminate this by inserting autoregressive terms in the model, but even after inserting a fifth-grade AR term, autocorrelation remained in the error term. In order to handle this problem, the one-day lagged value of the spread was inserted in the explanatory variables of the model, instead of the AR terms. This can also involve economic contents, provided that market makers' expectations on formulating the spread are backward-looking to some extent.

However, this alteration brings dynamics into the model, thus it cannot be considered as testing the aforesaid bid-ask spread model, but rather an econometric specification built thereon. In addition, due to the effect of the lagged depend-

[15] Based on the Dickey–Fuller and Phillips–Perron tests, it is rejected that the time series of the spread includes a unit root. In spite of this, the dependent variable is not stationary, as it includes trend and seasonality. This was handled by applying a linear trend variable and seasonal dummy variables. The explanatory variables of the model include lagged dependent variable, moving average term and other explanatory variables. Therefore, an ARMAX model was chosen, the parameters of which can consistently be estimated with the method of non-linear ordinary least squares (Greene, 2000). Because of the lagged dependent variable, the estimated coefficients are not unbiased, but they are consistent. This is sufficient for us, since, due to the large size of the sample (more than 500 elements), the parameter estimates can be considered almost unbiased. The residuum of the model is not autocorrelated, and heteroskedasticity was treated by applying White's standard errors; thus the p values can be used for the examination of the significance level of the parameters.

ent variable the parameters cannot be interpreted the same way as in traditional OLS models, as the specification postulates that the change in explanatory variables has a gradually unwinding effect on the spread. In the case of continuous variables this may not be a problem, but it may be problematic with dummy variables. The parameters here indicate multiplicators which measure the immediate effect, but in the case of a monthly dummy variable the longer-term effect must also be taken into account, just as in the case of trend variables.[16] As far as the daily dummy variables are concerned, the longer-term effect is less important, as a shock in the positive direction is followed by one in the negative direction, and thus autoregressive effects more or less neutralise each other. However, the *ceteris paribus* interpretation can still be problematic, as in the sample average it cannot be presumed that the spread of a given day is identical with that of the previous day, due exactly to daily seasonality. Therefore, parameter values should be treated cautiously, but the sign and magnitude of the coefficients may help to identify the factors affecting the spread. Hence, in the sub-chapter about robustness, the coefficients of variables which can be problematic to interpret are mentioned separately.

Those explanatory variables (turnover, concentration) were left in the final form of the model which became significant. Test statistics of the resulting model are summarised in the table below:

Table 3

The time series model of the forint-euro bid-ask spread

Dependent variable: SPREAD

Method: Least Squares

Included observations: 561

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SPREAD(-1)	0.662***	0.039	17.018	0.000
VOL	2.023***	0.269	7.606	0.000
D_RATE	0.280**	0.130	2.155	0.032
TURN_VS_FOR	-0.006**	0.003	-2.225	0.027
HI_FOR	2.856**	1.235	2.313	0.021
T	-0.002***	0.000	-4.289	0.000
C	1.980***	0.397	4.989	0.000
DUM_MO	-0.831***	0.195	-4.260	0.000
DUM_TU	-0.489***	0.171	-2.865	0.004
DUM_FR	0.947***	0.208	4.555	0.000
DUM_DEC	0.424**	0.172	2.468	0.014
DUM_YEAR_END	1.176*	0.610	1.927	0.054
MA(1)	-0.477**	0.060	-7.912	0.000
R-squared	0.800	F-statistic		183.435
Adjusted R-squared	0.796	Prob. (F-statistic)		0.000

*The parameters significant at 10 per cent are marked with *, those significant at 5 per cent are marked with **, while those significant at 1 per cent are marked with ***. The meaning of the variables:*
SPREAD: forint-euro daily average relative bid-ask spread, calculated from two-minute exchange rates; dataset includes exclusively trading time observations (basis point). VOL: daily difference of maximum and minimum of forint-euro exchange rate (per cent). D_RATE: one-day change in the forint-euro exchange rate (per cent). TURN_VS_FOR: spot forint-euro turnover vis-à-vis non-residents (billion HUF). HI_FOR: Herfindahl index (on a scale between 0 and 1) calculated from the share of foreign banks in the spot FX market turnover. T: time. C: constant. Meaning of the dummy variables: DUM_MO: Monday, DUM_TU: Tuesday, DUM_FR: Friday, DUM_YEAR_END: trading days between Christmas and New Year's Eve, DUM_DEC: month of December. Term MA(1) means that the residual variable is not white noise, but follows a moving-average process. With its application we saw that the error term does not contain autocorrelation.

[16] Long-term effect = $\beta/(1-\rho)$, where β is the coefficient of the given explanatory variable, and ρ is that of the lagged spread.

Results

In the model, with the exception of one variable all variables became significant at a 5 per cent significance level, which explain a total 80 per cent of the fluctuation of the spread (Table 3). The choice of the sample period (May 2003 – July 2005) was limited by the fact that data regarding the bid-ask spread are available only starting from autumn 2002. However, in the first months of 2003 the speculative attack against the edge of the intervention band and the MNB's presence in the market may have distorted the indicators of market liquidity. At least this is suggested by the fact that including the January–April 2003 period in the model markedly reduced the significance of several variables. Therefore, this period was omitted from the sample, and only the period between May 2003 and July 2005 was examined. In the following the coefficients of the explanatory variables are discussed in detail.

The first variable is the one-day lagged value of the spread [SPREAD(-1)]. The 0.66 value of the coefficient suggests a high degree of persistency of the spread.[17] The level of the bid-ask spread is determined by its past value to the extent of approximately 66 per cent, provided that there is no substantial change in the other variables. The question is, how can this relationship be interpreted from the aspect of liquidity. On the one hand, it may indicate what was already mentioned, i.e. market making banks behave cautiously when formulating the bid-ask spread, an interpretation of which is that market makers make the movements of spread between days smoother. (Market makers' liquidity smoothing activity is also mentioned by Marès [2002].) Consequently, sudden shifts in the extent of the spread can be observed only rarely. However, from a liquidity aspect this is not necessarily advantageous, as presumably it is 'asymmetric smoothing', which is more typical when the spread is declining than when it is increasing (see Chart 3 and the meaning of the D_RATE variable). On the other hand, as the spread is the indicator of liquidity, this also means that if there is no substantial shock, liquidity cannot 'disappear in just a moment'. *Therefore, based on the spread, liquidity is characterised by relative stability under normal market conditions.*[18]

The coefficient of the volatility indicator (VOL) selected by us became positive, as expected. The increase by 1 per cent in volatility, i.e. in the day-to-day fluctuation of the exchange rate, results *ceteris paribus* in a 2 basis-point increase in the bid-ask spread. This may be considered relatively high, as the average value of the spread was 8–9 basis points in the period under review, while its standard deviation was 3 basis points. However, based on this it cannot be decided whether the increase in the spread stemming from volatility indicates a deterioration of market liquidity. It depends on what causes the increase in volatility, as has already been mentioned in the theoretical part. Nevertheless, it can be stated that a decline in volatility can significantly reduce the spread, which is advantageous for investors and market makers due to lower trading costs and lower risk, respectively.

We also examined whether there is any effect on the spread if the exchange rate weakens or strengthens on a given day (D_RATE). As opposed to the volatility indicator, this indicator was calculated by taking the percentage change in the exchange rate during one day. Positive values indicate the forint's depreciation against the euro. A 1 percentage point extra weakening of the exchange rate increases the spread by 0.3 of a basis point. This parameter allows the comparison of spreads of those days when the value of all other variables, including that of the volatility indicator defined by us is the same. The correlation between these two variables (VOL and D_RATE) is negligible, so it makes sense to examine *ceteris paribus* effects. If on two trading days volatility is the same, but on one day the exchange rate strengthens 1 per cent and weakens 1 per cent on the other, then the spread on the latter day is 0.6 of a basis point higher. *This observation may also reflect market makers' cautiousness,* suggesting that market makers react to volatility in an asymmetric manner when forming the spread. They increase the spread to a greater extent if the jump in volatility takes place in parallel with a depreciation of the exchange rate, which might be attributable to the fact that the market may consider the increase in volatility triggered by exchange-rate depreciation longer-lasting than the decline in volatility triggered by appreciation.

The daily FX market turnover with non-resident partners proved to be the best of the FX market turnover indicators. However, the coefficient of the variable (TURN_VS_FOR) is very low: even a twofold increase in the turnover from the

[17] The omission of this variable from the model does not substantially reduce the significance of the model, so it is not the presence of the lagged variable only that causes the relatively high explanatory power of the model.

[18] In addition, autocorrelation can be caused by a technical factor as well, namely that other variables are also autocorrelated. This may play an especially important role in terms of volatility, due to its high coefficient in the model. Involving the first lagged of volatility in the model resulted in the coefficient of the lagged of the spread not declining. This suggests that it is not the persistence of volatility that plays the main role in the autocorrelation of the spread.

average 60 billion forint level, with other factors remaining unchanged, would only reduce the spread by a negligible 0.3 of a basis point. Inserting the total turnover including non-residents and residents as well into the model, its coefficient has a significantly lower explanatory power. This may indicate that *non-residents' trading activity somewhat better reflects the change in market liquidity* than the total turnover, despite the fact that non-residents account for only approximately 50 per cent of the total turnover. Due to the low value of the coefficient, one might think that the turnover is not the proper indicator of liquidity. However, the information content of the turnover is supported by the fact that the sign of the coefficient became as expected: if we only look at the correlation between the spread and the turnover, it is positive. However, the partial effect appearing in the model had an opposite direction due to inserting volatility in the model.

Apart from the turnover, we also examined the behaviour of other quantitative indicators, i.e. the average deal size and number of deals, but they were not significant. Average deal size proved to have the least explanatory power, despite the fact that it is usually considered to be a better indicator of market depth than turnover. The negligible explanatory power of these variables may reflect what was seen with the correlation matrix, i.e. turnover concentrates the joint effect of these two volume-based variables into itself.

The sign of the coefficient of the concentration indicator (HI_FOR) calculated from the share of non-resident clients in the turnover was also as expected, but the coefficient became low. A growth in concentration, e.g. a twofold increase in the Herfindahl index from its average value of 0.1 increases the spread by a total 0.3 of a basis point. The low value of the coefficient may be attributable to the same factors as with the turnover. Inserting residents' concentration into the model instead of non-residents' concentration, that of the former became much less significant. This is surprising, because according to anecdotal information domestic banks are the market makers in the spot FX market, so one would think that the competition between them is more important than the concentration of the turnover vis-à-vis non-residents. This may indicate that *in addition to domestic banks, foreign ones also play a major role in providing market liquidity;* e.g. intraday trading by non-residents and their speculative activity may represent these kinds of factors.

Volume-based variables (turnover, concentration) in sum add little explanatory power to other variables. However, a better or worse behaviour of individual indicators in the model may carry information in terms of market liquidity.

In the model, the coefficient of the time (deterministic) trend (T) became negative and significant: spread declines by a daily 0.002 of a basis point, i.e. approximately half a basis point annually. (The long-term parameter is higher, 1.5 basis points.) This itself is low, but cannot be neglected if compared to the average value of the spread. This coefficient can also be interpreted only *ceteris paribus,* examining how the spread would have changed if volatility and other explanatory variables had remained unchanged. On this basis, in the last two years the spread declined faster than would have been justified by the decline in volatility, which is one of the most important factors, and *this may indicate a continuous, slight improvement in liquidity.* One of the possible underlying reasons for the growing trend in liquidity is that, based on anecdotal information, the share of turnover performed through the Reuters electronic trading platform within the total turnover increased in the last two years. The spreads used in our analysis originate from this trading system, and based on theoretical considerations as well, electronic trading systems' gaining ground reduces the spread and increases liquidity (Barth–Remolona–Wooldridge, 2002).

Seasonality in liquidity

Important conclusions may also be drawn from the coefficient of variables which describe daily seasonality (DUM_MO, DUM_TU, DUM_FR). The *bid-ask spread is nearly 1 basis point lower on Mondays than on an average day.* Compared to the average size of the bid-ask spread, this value cannot be neglected. The *ceteris paribus* lower value of the spread on the first days of the week indicates that market liquidity is typically higher at this time. Higher Monday liquidity may reflect a kind of weekend effect: weekend news and announcements which affect the market may appear in the market in a concentrated fashion on Monday, and this may reduce the bid-ask spread. Another possible explanation is that the rate-setting meetings of the central bank are held on Mondays (except for holidays), and the disclosure of the decision and its incorporation in the prices may have a favourable effect on the spread.[19] However, the Monday effect should be

[19] This hypothesis could not be supported by econometric methods; on those Mondays when the rate-setting meetings of the Monetary Council were held the spread was lower to the same extent as on any other Monday.

treated cautiously, as in the case of another model specification the parameter lost its significance (see the analysis of robustness).

There is another day, namely Friday, which markedly influences the development in the spread. *On the last days of the week the spread is typically 1 basis point higher than the average.* The higher-than-usual Friday bid-ask spread is in conformity with the anecdotal information from market dealers, according to which liquidity of the forint market declines on Fridays. The underlying reason may be the shorter trading time or the fact that on Friday afternoons fewer items of market-influencing news are released and/or the market is more reluctant to react to them.

The seasonality of Tuesday also became significant; then the spread is half a basis point lower than at other times. *Accordingly, the liquidity of the spot market gradually declines during the calendar week.* A part of the 2 basis point difference between the Monday and Friday spreads may be explained by the fact that the effect of the Friday afternoon news usually appears in the market only on Monday, and a part of market liquidity may be 'pushed' from Friday to Monday. This may also be attributable to the time lag between trading in Hungary and in the United States, and thus, due to the shorter trading time, American investors can react to the Friday market-influencing events only on Monday.

In terms of calendar effects, it is important to mention that on Fridays neither the volatility of the exchange rate (VOL), nor the percentage change in the exchange rate (D_RATE) shows a significant difference compared to other days, thus the lower spot market liquidity on Friday is not necessarily unfavourable to the exchange rate. It is also interesting that turnover shows a seasonality, which is different from the aforementioned two variables as well: on Monday and Friday non-residents' turnover is lower by an average 10 billion forints than on other days. An underlying reason may be, for example, that most of the holidays abroad which are different from the ones in Hungary fall on Monday or Friday.

Of the monthly seasonal variables December (DUM_DEC) proved to be significant: in the last month of the year the spread is 0.4 of a basis point higher than at other times (the long-term effect is 3 times more). Based on market information, the underlying reason may be that at the end of the year investors are less willing to open new positions, and they are rather only dressing their books. However, the other variables describing monthly seasonality did not become significant. The higher spread in December is related not only to the holiday period, but it is typical of the whole month: in the period between Christmas and New Year's Eve the spread is higher by another 1 basis point than the December average (DUM_YEAR_END), although the significance level of the parameter is relatively low.

This effect is even more strongly reflected in the turnover data; in these short periods the turnover falls to half of the average. However, looking at December as a whole, there is no significant difference in the turnover compared to other months. In addition, market turnover does not show any significant difference from the average in other calendar months either, similarly to the spread. However, the insignificance of non-December monthly seasonal variables may also stem from the fact that this sample is relatively short (two years long) for examining monthly seasonality. Therefore, we examined if there was monthly seasonality in the FX market turnover in the 1999–2005 period (see the Appendix). In this period, of the summer months it was only in August when the turnover was significantly lower than in other months. However, the difference is not too big at all: the long-term effect of August on the dummy spread is –14 per cent. Consequently, our data do not support the view which often appears in market news that FX market activity declines in an excessive manner in summer, so in this respect we cannot talk about an FX market 'off season'. Accordingly, *the liquidity of the spot market is only slightly lower in summer months than in the rest of the year.*

Robustness check

The relationships between variables are not necessarily described precisely by linear functions (e.g. in the theoretical overview of the bid-ask spread model it could be seen that the turnover can reduce the spread according to a function different from linear). Therefore, the application of other function forms was also considered. However, logarithming the variables did not change the results significantly, and the sign and significance of the parameters also remained unchanged.

In order to examine robustness, some explanatory variables were replaced by variables defined in a different manner. Calculating volatility from the standard deviation of intraday exchange rate changes, no substantial differences were experienced relative to the original model, only the significance of the coefficient of the turnover declined. Replacing other variables (turnover, concentration) with variables covering the whole market also did not influence the values of other parameters.

If the lagged value of the spread is omitted from the model, its explanatory power declines only slightly, from 80 per cent to 74 per cent. By omitting another important variable, volatility, R squared also remained relatively high (60 per cent). By omitting the autoregressive term it can be tested at the interpretation of which variables the inclusion of the lagged term may be problematic. The result was that the value of most parameters grew 2–4 times higher, while that of the Friday dummy did not change. However, the Monday and Friday dummy parameter estimation declined markedly, while that of the development in the exchange rate changed sign. Consequently, the earlier interpretation of these latter parameters must be handled with care, as the concrete values partly depend on the model specification.

The model was also estimated on shorter samples (of 150–200 observations), but the explanatory power still remained strong, above 55 per cent in each case. The sign of the parameters usually remained unchanged, but due to the smaller samples several variables lost their significance. Of the variables, it is the volume-based variables and the coefficient of the exchange rate change that are the most sensitive to the choice of the sample period, and they became insignificant when the sample contained a high percentage of year 2003 data. The lagged spread and the volatility always remained significant, but the size of their coefficient changed as time went by – that of preceding spread grew, while that of volatility declined. From the aspect of liquidity, this direction of change of the variables can be considered favourable. In the last year the spread reacted to volatility in a less sensitive manner than earlier, and, as was mentioned in the theoretical part, this may indicate an improvement in liquidity. These findings confirm what was said of the trend variable, i.e. the liquidity of the forint-euro spot FX market may have increased in the last one or two years.

For a better understanding of the relationship between volatility and spread, volatility was divided into two components and then inserted in the model. That part of the volatility which was expected for the given day on the basis of information from the past was filtered, while the rest is the unexpected component.[20] Of the expected and unexpected parts of volatility only the latter became significant; therefore, shocks to volatility are reflected in the spread. This may indicate that *only newly received information has an effect on the change in the spread,* while the information effect of expected volatility is already included in the spread.

In terms of the reliability of the model it is important whether all explanatory variables can be considered exogenous. The spread, for example, may affect the turnover, if investors are less willing to trade due to the increasing spread. The ambiguity of the cause and effect relationship can be problematic mainly because of the relationship between spread and volatility. If the spread grows due to a decline in liquidity, this may add to volatility, so volatility may be an endogenous variable. In order to eliminate such endogenous effects, the model was also run using the two-stage ordinary least squares method, where the lagged of the explanatory variables were used among the instrumental variables.[21] The estimated value of most parameters remained unchanged, with the only important difference that the coefficient of the autoregressive term declined, while that of volatility increased.

Residuum analysis

Based on the model, it can be concluded that *volatility has one of the strongest effects on the forint market bid-ask spread.* The model can be used to prepare a liquidity indicator, taking the difference between the observed spread and the value fitted by the model. The interpretation of the development in the residuum is similar to how the dummy variables were examined. This indicator shows if the spread is higher than what the volatility and the liquidity variables would justify. Of course, an indicator like this must be treated cautiously, as the better a model's goodness-of-fit is, the less information the error term contains. In addition, it is also uncertain if the change in the residuum is caused by one of the non-observed liquidity factors or perhaps by independent shocks. A high value may be attributable to outliers as well.

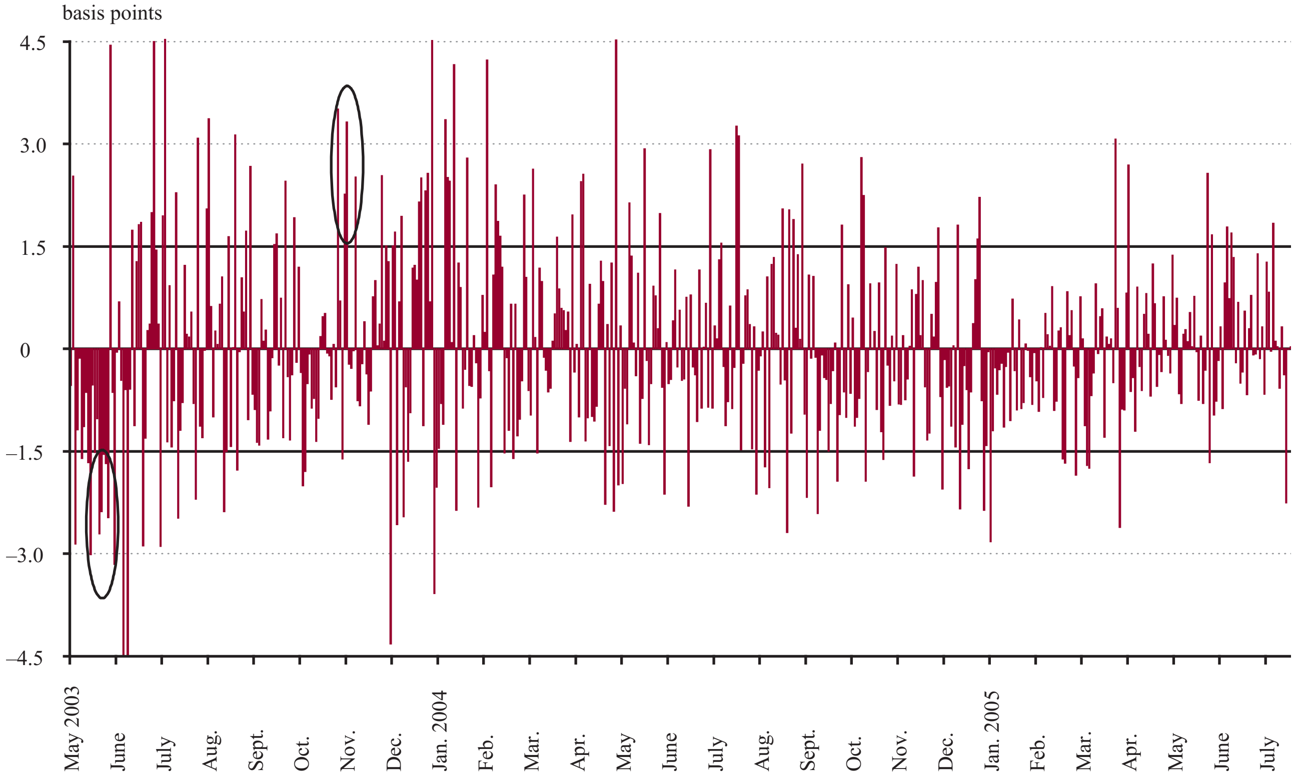
[20] Decomposing was carried out with forecasts and their errors, respectively. The forecasts were based on the simplest, well-fitting ARMA specification of volatility.

[21] As the model contains an MA(1) term, the 1-day lagged of all explanatory variables need to be put among the instrumental variables to receive consistent estimators.

Nevertheless, this indicator monitored together with the other liquidity indicators may help identify the changes in market liquidity.

Chart 4

Error term of the bid-ask spread model



Thick horizontal lines indicate the standard error of the model. Positive values mean that the spread is higher than the value estimated by the model.

Using this liquidity indicator we examined when the error term of the model was persistently higher in absolute value terms than its standard error (Chart 4). In the 1–2 weeks before the shift of the exchange rate band the spread was lower than what the variables of the model would have justified – the spread did not react to the slightly increasing volatility, the reason for which might have been that the market considered the increase in volatility temporary. On the other hand, the lower-than-average value of the residuum may also have suggested an improvement in market liquidity, which may have been attributable, for example, to the disclosure of news items substantially affecting the exchange rate in this period, and their effect on the prices may have been reflected in the relatively low value of the spread.

However, in the period between late October and early November 2003 spreads opened wider than what would have been caused by increased volatility itself, and this may have reflected a lower-than-usual liquidity of the market. This coincides with the period when, according to other information, the liquidity of the government securities market declined.

3.4 SPOT MARKET LIQUIDITY IN AN INTERNATIONAL COMPARISON

The bid-ask spread has also been analysed in an international comparison fitting a cross-sectional bid-ask spread model. In this case, the set of available information is narrower than in the case of the time-series-based analysis of the spread. For this reason, relationships have been analysed only between three variables: the spread has been regressed on the spot market turnover and volatility, and for each country a single observation has been considered for 2004.

The analysis covers spot market data for the currencies of 25 countries, most of them emerging, and seven developed economies. The sample comprises countries that participate in the triennial foreign exchange market survey conducted by the BIS, thus the sample covers the markets of the most traded currencies. The four currencies of the largest turnover (US dollar, euro, yen and the British pound) have been excluded from the analysis. The international role of these currencies (e. g. they also serve as reserve currencies) makes their comparison with the emerging currencies problematic. It is not clear, for instance, which turnover vis-à-vis which currencies should be considered for the purposes of analysing liquidity of the euro spot market.

Calculation of the analysed variables slightly differs from the ones applied in the forint market. The dataset for the international comparison includes only indicative quotes. As a result, the spreads calculated from them cannot be considered as effective spreads. For this reason, in the case of the forint its value is higher than demonstrated above: the HUF/EUR relative bid-ask spread was 17 basis points in the average of 2004, the fifth highest of the currencies included in the sample.

In respect of turnover, we relied on the April 2004 survey of the BIS, which also includes trading between non-residents in the specific currencies. Only three of the currencies included in the sample had lower turnover, while four of them had broadly the same. Volatility is measured by the standard deviation calculated from daily exchange rate changes in 2004.[22] On the basis of volatility calculated this way, the forint is placed somewhere in the middle.[23]

The question is to what extent turnover and volatility relative to the other currencies affects the spread. Regression results are the following:

The explanatory power of the model is high: 80 per cent despite the fact that only indicative spreads have been used

Table 4

Cross-section model of the HUF/EUR bid-ask spread

Dependent variable: LOG(SPREAD)

Method: Least Squares

Included observations: 25

White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(TURN)	-0.369**	0.057	-6.442	0.000
LOG(VOL)	0.588**	0.147	4.003	0.001
DUM_FIX	-0.538*	0.301	-1.789	0.088
C	4.266**	0.433	9.858	0.000
R-squared	0.812	F-statistic		31.700
Adjusted R-squared	0.787	Prob. (F-statistic)		0.000

*Parameters of 10 per cent significance are marked by *, and those of 1 per cent significance by **. Variables have the following meaning:*
SPREAD: relative spread in the average of 2004, measured in basis points and calculated from closing prices (Reuters). Exchange rates are vis-à-vis the euro in the case of European currencies and against the USD in all other cases. TURN: daily average spot FX market turnover in USD millions, April 2004. VOL: annualised standard deviation of 2004 daily exchange rate changes, in percentage. DUM_FIX: dummy variable for countries applying fixed, narrow-band exchange rate regimes.

(Table 4). Selection of a logarithmic function is justified by the fact that with this parameters have become less sensitive to the omission of certain observations than in the case of a linear function.[24]

[22] The reason for choosing the whole year of 2004 instead of April 2004 for volatility and spread was that in the case of the forint, this is a period of significantly higher than average volatility, and as such it is less representative. This modification had no impact on the parameters of the model.

[23] If volatility is calculated by different methods, e.g. on the basis of the difference between the annual maximum and minimum exchange rates, the HUF/EUR exchange rate is likely to have a more favourable place in the international ranking. When, however, the spread is modelled, reliance on short-term volatility indicators is justified.

[24] As indicative spreads are applied, actual values have been overestimated, which causes a measuring error in the dependent variable, and so the constant may be biased. With regard to minor currencies, the BIS statistics only contain the off-shore turnover transacted outside London, thus their values are underestimated. The absolute value of the turnover parameter is therefore slightly biased downward.

Similarly to the analysis based on time series, turnover has a negative, and volatility has a positive sign. Holding volatility fixed, if turnover doubles, the spread decreases by 40 per cent. If volatility doubles, the spread increases by 60 per cent. The model has also been fitted to the standardised variables. In this case there is no significant difference between the values of the two variables; in other words, the same shift in turnover and volatility in relative terms affect the spread to the same extent, although in the opposite direction.

The HUF bid-ask spread is 6 basis points higher than the average of the currencies included in the sample. This is for the most part due to a turnover below the international average, as in the reviewed period the volatility of the forint practically corresponded to the average of the sample.

The coefficients cannot be compared directly to those obtained from the time series model demonstrated in the previous chapter, as they differ in structure. The coefficient of volatility and turnover is considerably higher than the one resulting from the time-series analysis, which is mainly due to the fact that only two variables are used for explaining spread developments, and these provide a similar explanatory power. Nevertheless, the comparison of the coefficients may provide information. In this model turnover has a far higher impact on the spread in relative terms (compared to volatility) than in the time-series analysis, and turnover also has a significant effect on the spread in economic terms. The difference between the two models may be interpreted in a way that the time-series analysis describes short-term developments in market liquidity, i.e. gives reasons for the daily changes in the spread, *and an international comparison describes long-term structural differences.* Thus, this cross-sectional model can be considered as a model describing time-sequence differences, assuming that the differences between the liquidity of the individual countries' currencies have evolved as a result of long-term developments. Thus we can form an opinion as to how the spread would be affected if turnover and exchange rate volatility in the HUF market was the same as in a more developed market.

Among the currencies included in the sample, in an ascending order of turnover, the forint is followed by the Polish zloty, as its daily FX market turnover is approximately double that of the forint. The current trends do not support such an increase even in the long term. The spot-FX turnover transacted by Hungarian banks improved by roughly 50 per cent between 2000 Q1 and 2005 Q1, primarily as a result of the liberalisation of foreign exchange and the broadening of the exchange rate band. In the future no similar structural break is to be expected. To demonstrate the coefficients of the model, let us assume a 50 per cent rise in turnover. This would reduce the HUF spread by nearly 3 basis points from the current level. Although this is no major change, it might involve a more persistent fall in the spread than volatility does, which decreases only temporarily. A fall in volatility, however, has a far more powerful impact on the spread: if the 7 per cent volatility measured in 2004 would drop by 50 per cent, approaching the volatility of the Slovak koruna, the spread would be significantly lowered by 7 basis points.

In addition, we have found another variable that can affect the differences between the spreads of the individual currencies. In countries where *monetary authorities apply narrow-band exchange rate regimes, the spread is 50 per cent lower* than in other currencies, provided that volatility and turnover remain unchanged.[25] This suggests that in countries applying fixed exchange rate regimes moderate volatility is not the only reason for a low spread – the exchange rate regime itself may contribute to it. Relatively higher liquidity in the markets of these currencies may be explained by the fact that in a fixed exchange rate regime central bank interventions may directly contribute to the provision of liquidity in the foreign exchange market. Higher liquidity may also be due to the fact that these countries have been applying an unchanged exchange rate regime for more than a decade, and the resulting predictability and moderate risks are favourable for the market participants. Although significance of the parameter is relatively low, empirical research confirms that tightly managed exchange rate regimes tend to reduce the spread (Koutmos–Martin, 2005). With regard to the currencies of the region, this is relevant because this fact may theoretically have a similar impact on the bid-ask spread if these countries join the ERM II exchange rate regime. *Although the ERM II is not a narrow-band regime, its aim is to provide for the stability of exchange rates, and therefore its application may reduce the spread and increase market liquidity, assuming unchanged volatility.*

[25] The sample contains three countries applying fixed or narrow-band exchange rate regimes: Denmark, Hong Kong and Singapore. The fluctuation band of the Danish krone is ±2.25 within the ERM II, Hong Kong is operating a currency board and in Singapore the exchange rate regime is officially managed floating, and the authority targets a narrow, implicit exchange rate band. We had no chance to apply an ERM II dummy, as among the countries included in the sample, only Denmark applied the exchange rate regime of the European Union.

In other classifications of countries we have not found significant differences in this model. Thus, for example, the fact that the country of a particular currency was developed or emerging failed to provide additional information regarding the explanation of the bid-ask spread.

Table 5

Regional liquidity indicators

	Indicative spread (basis points)	Effective spread (basis points)	Volatility (%)	Turnover (billion USD)
Slovak koruna	12.2	4.9	2.7	0.17
Czech koruna	11.1	9.5	5.2	0.74
Forint	16.8	10.6	6.8	0.75
Polish zloty	11.0	6.4	8.4	1.57

The indicative spread and volatility calculated from the Reuters data are averages in 2004, while the effective spread is calculated from the 2004 Q1 spread based on central banks' estimates and on real market orders. Daily average turnover data are based on the April 2004 survey of the BIS, which, however, contains only the off-shore turnover transacted in these currencies outside London.

Liquidity in the HUF market is worth comparing to the FX markets of the region with a view to the fact that turnover in these currencies is similar in size to the turnover transacted in forints (Table 5).

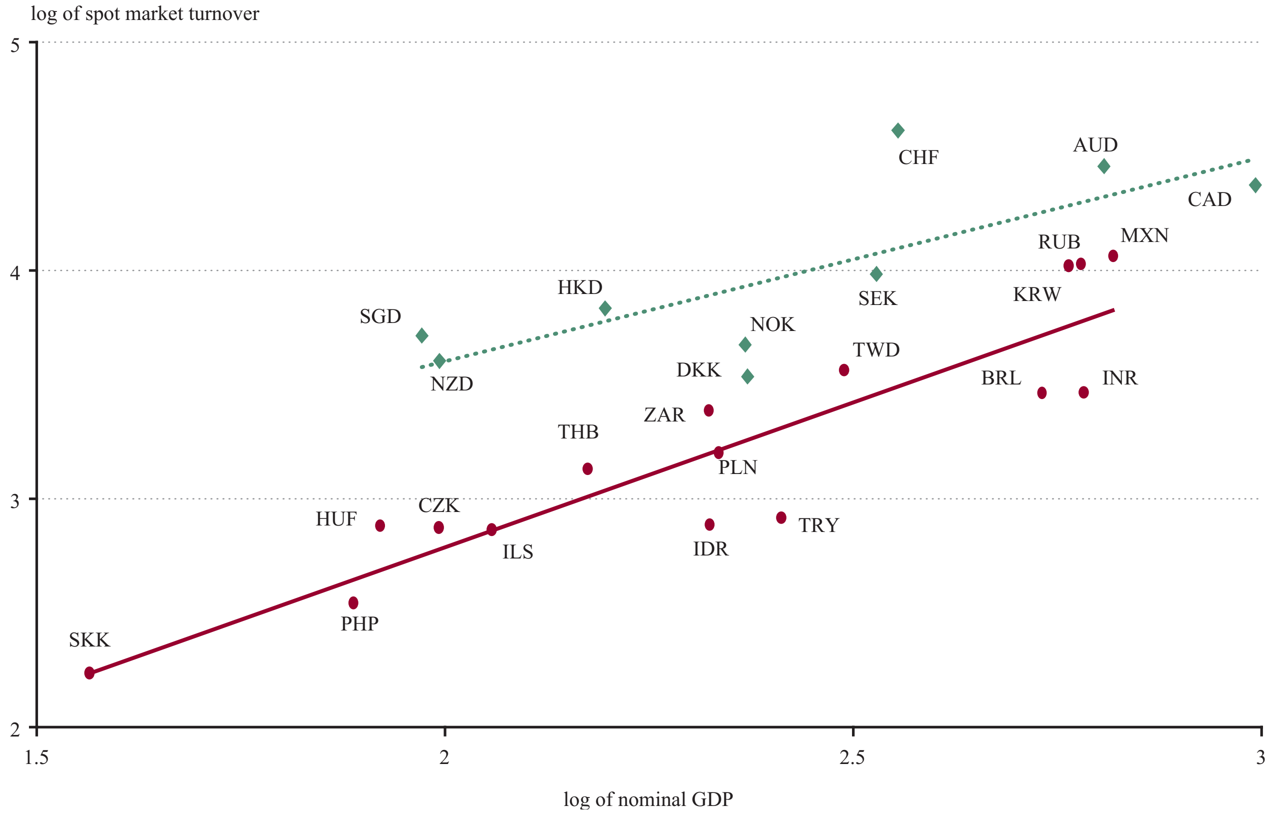
The HUF/EUR exchange rate has the highest spread of these four currencies (at least for 2004). In addition to the indicative spreads used in this model, turnover and volatility have also been compared to spreads which reflect better exchange rates related to actual transactions. In every currency these effective spreads are lower than the indicative spreads, and the spread of the forint is still the highest of all. In comparison to the Czech koruna, it is clear that at an essentially identical market turnover, the higher spread involved in the forint is due to a higher volatility. In view of this, liquidity in the forint and the koruna may not differ significantly.

Turnover of the zloty is far higher than the turnover of the above two currencies, and its impact on the spread can offset its volatility, which is the highest in the region. Despite higher volatility, the zloty spread is lower than the spreads of either the forint or the koruna. Therefore, at an identical level of volatility the spread of the zloty would be even lower. Consequently, the spread 'adjusted for volatility' and a higher turnover make the zloty market more liquid than the markets of the forint and the Czech koruna. The Slovak koruna has the lowest spread (at least in terms of the effective spreads), and its volatility and turnover are also the lowest of these four currencies. Due to the opposite effects of volatility and turnover on the spread, these three indicators are not sufficient for clarifying the relationship between the market liquidity of the Slovak koruna and the other three currency markets. As noted above, we need to know the extent to which low volatility may reflect higher liquidity in order to decide if this can offset the spread-increasing impact of low turnover.

As discussed above, one of the long-term factors significantly affecting market liquidity developments is market turnover. Therefore, it is worth finding the reasons for the significant differences between the turnovers transacted in the individual currencies. *One of the most important factors to affect market turnover can be nominal GDP.* Although market transactions are not only related to transactions in the real economy, GDP may indirectly affect the volumes of other transactions, e.g. if non-resident investors consider the ratio of GDP within a group of countries when they allocate capital.

Chart 5

Relationship between FX market turnover and GDP (2004)



Developed countries: ***AUD: Australian dollar; CHF: Swiss frank; CAD: Canadian dollar; DKK: Danish krone; HKD: Hong Kong dollar; NZD: New Zealand dollar; NOK: Norwegian krone; SEK: Swedish krona; SGD: Singapore dollar.*** **Emerging countries:** ***BRL: Brazilian real; CZK: Czech koruna; HUF: Hungarian forint; IDR: Indonesian rupiah; ILS: Israeli shekel; INR: Indian rupee; KRW: South Korean won; MXN: Mexican peso; PHP: Philippine peso; PLN: Polish zloty; RUB: Russian rouble; SKK: Slovak koruna; THB: Thai baht; TRY: new Turkish lire; TWD: Taiwan dollar; ZAR: South African rand. Source: BIS, IMF.***

In an analysis of the countries that were included in the model, the correlation between the logarithms of GDP and the turnover is 80 per cent (Chart 5). Correlation is even stronger if only emerging currencies are considered: 93 per cent. On the basis of the relationship between GDP and turnover, currencies can be divided into two clearly distinct groups: in developed countries the FX market turnover to GDP ratio is significantly higher than in emerging countries.[26] This relationship explains why economic development failed to have an explanatory power in the above model – for the most part turnover alone reflects the income differences between the countries.

In the case of the forint, the spot market turnover is low in nominal terms; however, it is higher than justified by GDP alone. The very fact that the turnover-to-GDP pair is above the trend line may result from the Hungarian economy's openness, or the percentage of government securities in non-resident ownership, which exceeds the similar indicator for other countries. As a result, *the HUF market has the highest turnover to GDP ratio of the four currencies in the region.*

The above relationships can also be used for making a conditional forecast about the forint/foreign currency market turnover. Based on this model, a 1 per cent rise in nominal GDP increases spot market turnover by 1.15 per cent. (Although the value of this parameter does not differ significantly from 1, i.e. an increase in GDP fails to affect the turnover-to-GDP ratio, this might be due to the small size of the sample.) In the case of the forint this means that, assum-

[26] Similar results have been achieved by a study of the central bank of New Zealand, which relies on the 2001 data provided by the BIS (Reserve Bank of New Zealand, 2004).

ing a potential economic growth, turnover may increase by nearly 60 per cent within 5 years. If this is fitted to the bid-ask spread model, the indicative spread may drop by 4-5 basis points, which may, in turn lower the effective spread by 2-3 basis points (assuming an identical proportional drop). (As the data included in the model are from 2004, the 5-year projection refers to 2009.[27]) *Thus, with an increase in turnover, HUF market liquidity still has room for improvement in the long term.* This is confirmed by the example of Portugal from among the earlier acceded Member States of the EMU. In the 2-3 years prior to the adoption of the euro, spot market turnover increased rapidly despite the fact that the exchange rate fluctuated in a relatively narrow band (Banco de Portugal, 1999).

To sum up the above, it may be said that in an international comparison, HUF market bid-ask spreads are high; however, this is due primarily to low turnover. With regard to turnover to GDP, the forint is placed first among the currencies of the region. In an assessment of the nominal volume of turnover, it is worth considering the fact that the forint is one of the 25-30 most traded currencies of the world, and as such it may be able to attract HUF market trading for non-residents in the future, thus ensuring appropriate liquidity for the market.

[27] Calculating with 3.5 per cent potential increase in real GDP and a 3 per cent GDP-deflator [$(1.035 \times 1.03)^5 \times 1.15 \approx 1.6$]. As the estimation is based on indicative spreads, the quantified value of the forecast has a high degree of uncertainty.

4. Empirical analysis of the government securities market

We have examined the liquidity of Hungarian government securities on the basis of indicators similar to those described in the section on the foreign exchange market. As the information required to estimate the intraday volatility for the formulation of the bid-ask spread model is not available to us, we investigated the liquidity of government securities with the help of two important liquidity indicators: the bid-ask spread and the turnover. The section on theory showed that the separate study of different liquidity indicators could lead to contradictory conclusions. In order to avoid this problem we intend to check the accuracy of our conclusions regarding liquidity against the findings disclosed in empirical literature.

From the government securities market we analyse the bond market and if our information allows we also conduct the research according to maturity breakdown.[28] In addition, we review briefly what effect primary issues of government bonds may have on the liquidity of the secondary market. The last section of our analysis contains the international comparison of the liquidity indicators on the Hungarian market.

4.1 LIQUIDITY INDICATORS ON THE GOVERNMENT SECURITIES MARKET

Bid-ask spreads, measurement conventions and historical development

One of the most important indicators of the liquidity of the Hungarian government securities market is the bid-ask spread calculated from the difference between bid and offer prices, as this is a good way to measure the costs and risks of market making. In the case of debt securities – in addition to the difference between the bid and offer price usually applied in the foreign exchange market – the spreads may also be expressed in yield terms. Therefore, first we briefly summarise the relationship between the two types of bidding/spread.

In Hungary quotes for government securities are usually expressed in yield terms – when making a transaction sellers and buyers primarily agree on the yield.[29] One of the reasons for this market standard may be that the ÁKK (Government Debt Management Agency) defined the maximum market making spread for primary dealers in yields which is 50 basis points in the case of Hungarian fixed rate government securities.

On the basis of all the sources of information available to us, the spreads expressed in yields are significantly narrower than the maximum spread defined by the ÁKK (see Charts 6-7). Nevertheless, spreads with different maturity vary significantly in the various sources of data. The Bloomberg system has the narrowest spread (5-8 basis points), which is due to the fact that this system indirectly also contains effective trading data. Based on Reuters (HUBEST) figures, which in contrast only include indicative quotes, spreads are somewhat broader (10-16 basis points). Finally, based on the Central European Bond Index introduced by Dresdner Kleinwort Wasserstein (DrKW), the spread between buy and sell orders expressed in yield terms is approximately 16-18 basis points for each maturity.[30]

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[28] For the breakdown by maturity (d) the bonds were divided into 5 groups:
$1< d <= 3$,
$3< d <= 5$,
$5< d <= 7$,
$7< d <= 10$,
$10< d$.

[29] The international government securities market is characterized by *market orders* in contrast to most equity markets where *limit orders* are more frequent (Gravelle, 1999). Based on anecdotal information, the Hungarian government securities market is also characterised by market order. For this reason, of the two markets the government securities market may satisfy the immediacy criterion of liquidity better, as here transactions may be completed following the placing of orders.

[30] The CEBI has been published by the Research Department of the DrKW since February 2004. For more details see the analysis of the research institute on the introduction of the CEBI (DrKW Research, 2004).

Chart 6

Government securities market spreads and volatility according to various sources of data by maturity expressed in yields (July 2005)

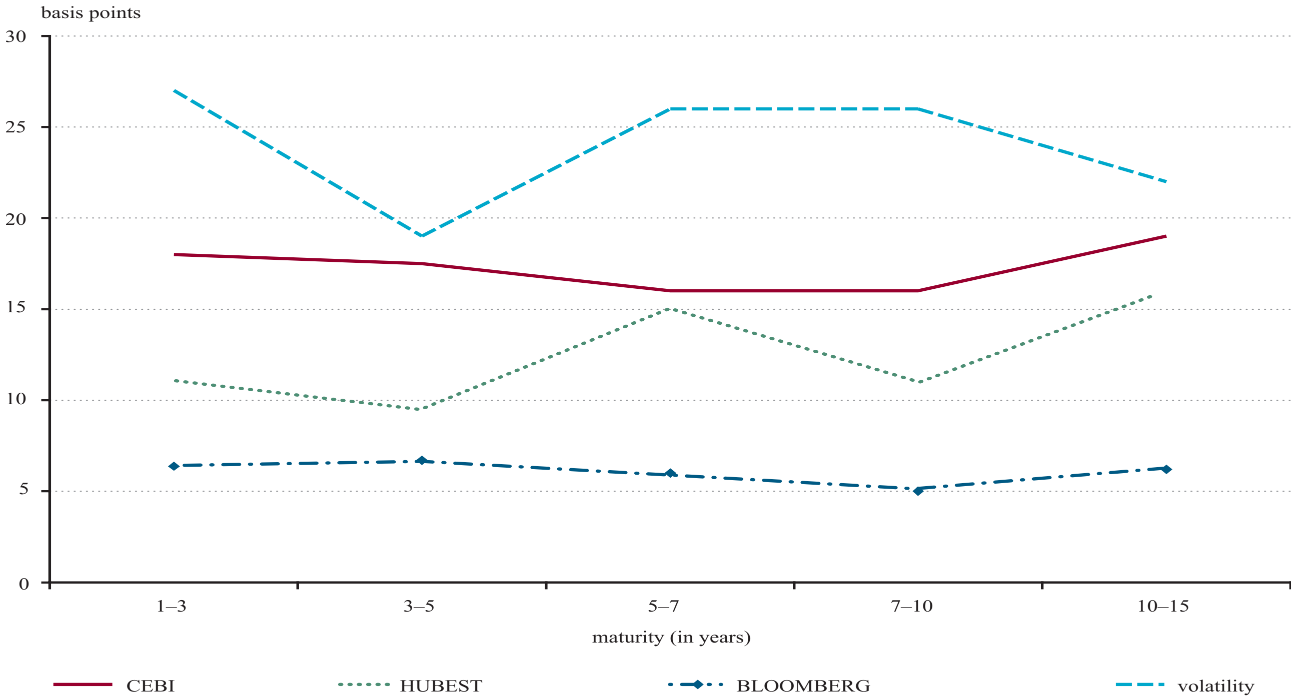
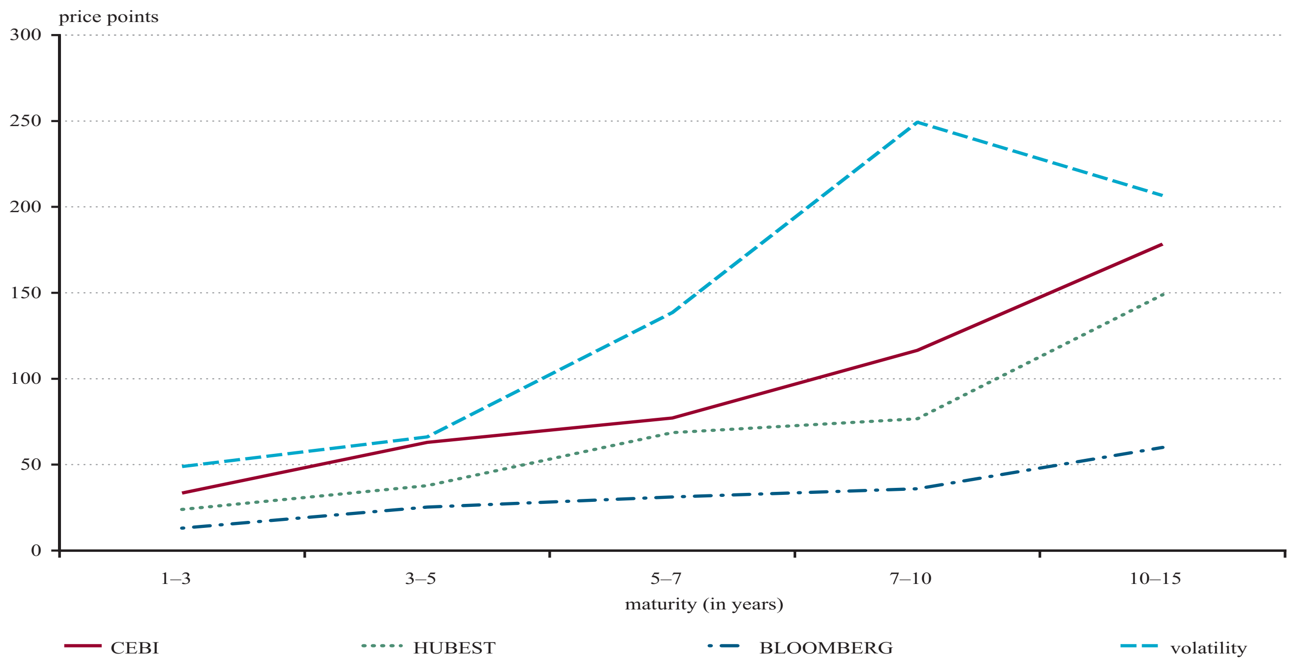


Chart 7

Government securities market spreads and volatility according to various sources of data by maturity expressed in the price of bonds (July 2005)



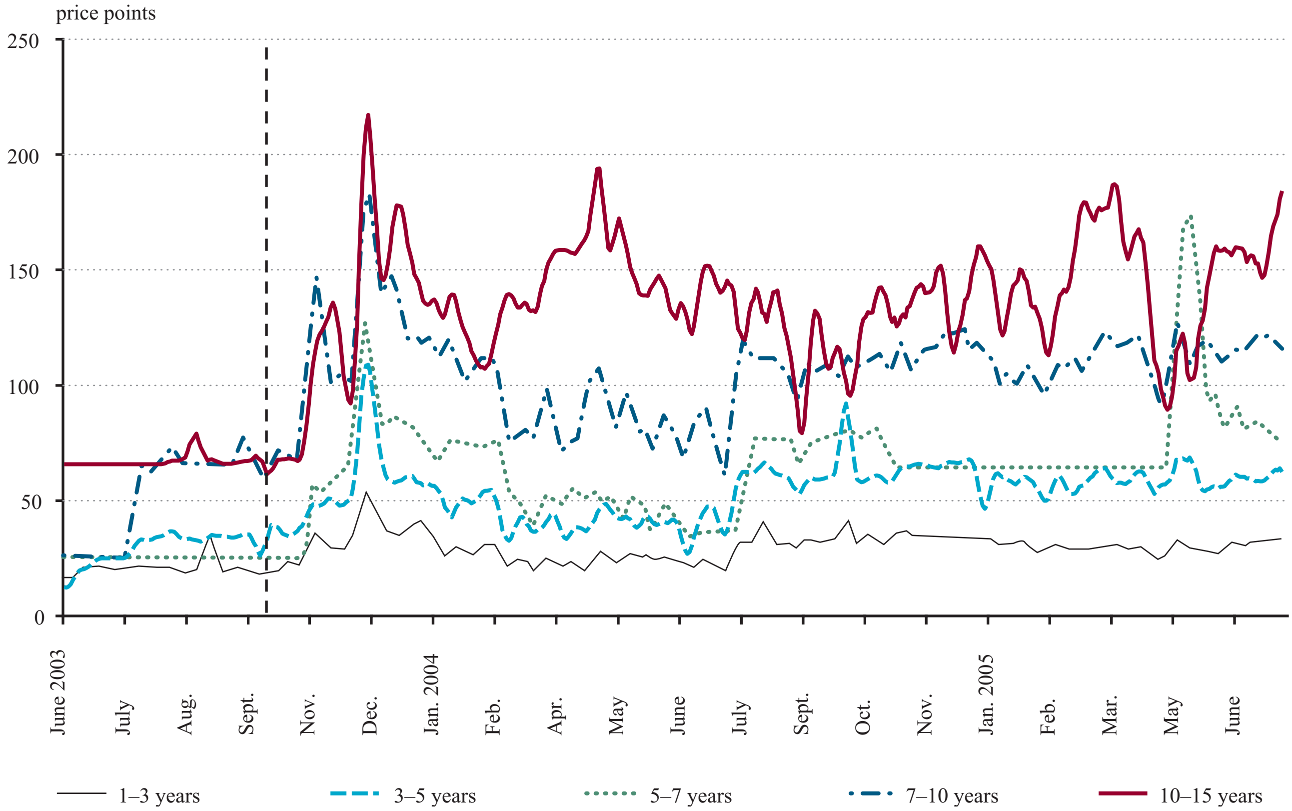
The spread figures in the chart are given as a percentage point of the bond's nominal value (price point). If, for example, the bid and ask price is 100.15 per cent and 100 per cent, respectively, then the spread is 15 price points. This index differs from the relative spread in that the spread is divided by the nominal value instead of the average bid-ask price.

In view of the spreads expressed in yields the information gained from the various data sources are consistent, as they do not vary significantly by maturity. As a result, however, the spread expressed in price terms is a growing function of maturity in the case of each data source. This is because, due to the similar cash flow structure of the securities (typically the annual payment of interest and repayment at redemption), the longer the maturity of a security, the more sensitively the price reacts to a unit change in the yields.

In accordance with our above analysis, bid-ask spreads partly serve as a cushion against volatility for market makers. In this respect it may be interesting to examine how the historical volatility varies by different maturities. In Hungary yield volatility proved stable in the period under review regardless of maturity (October 2003 – July 2005). This could explain why spreads expressed in yields is constant irrespective of the maturity.

Chart 8

Hungarian government securities market bid-ask spreads for different maturities based on CEBI (5 day moving average)

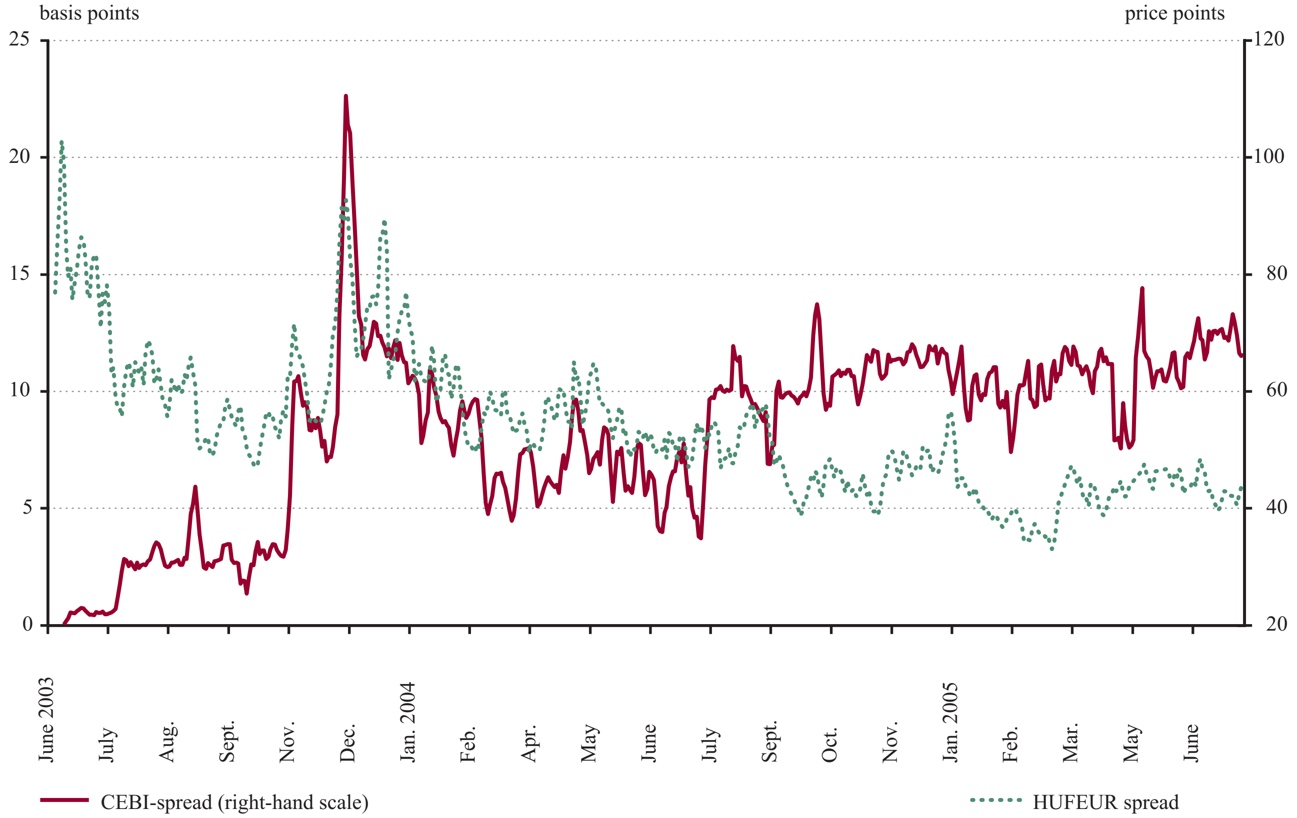


We have historical data on spreads only in the case of CEBI and for this reason we based our time series analysis on this index. For our analysis we used the time series starting from October 2003, as the figures in the preceding period had frequently remained flat for days. The reliability of earlier data is also questioned by the fact that at the time of the band shift spreads had practically not reacted to growing volatility (see Chart 8).

Government securities market spreads remained flat in the previous periods and a significant rise can only be identified following financial market turbulences at end-2003. Although the spreads rose simultaneously with the temporary increase in volatility, the stabilization of the spreads at a high level indicates that liquidity may have permanently declined. This permanent increase in spreads following financial market turbulence is especially clear in the case of longer maturities. In the case of securities with maturities of more than 10 years, for example, the difference between bid and offer prices rose from around 70 price points to 150 price points and has been fluctuating around this level since.

Chart 9

Government bond and forint-euro spot foreign exchange spreads (5 day moving average)



Our analysis based on time series also revealed that it was not only the level of spreads that increase in line with maturity, but also the variance of the spread (see related international comparisons). Based on our earlier findings, this may be connected to the fact that the prices and spreads of longer maturities react significantly more sensitively to an increase in volatility than those with shorter ones.

Although the bid-ask spread level of instruments vary according to maturity, the spreads often move closely together. The correlation coefficient among the different maturities was 0.7-0.9 in the period under review, which may be related to the correlation of the liquidity of instruments.

When analysing liquidity it is important to emphasise that not only the liquidity of financial market instruments with different maturity may correlate, but also that of different types of instruments which may be linked by their denomination. This relationship is well demonstrated by the correlation of bid-ask spreads of government securities and forint-euro markets.

Based on the evidence of the last few years, spot foreign exchange market and government securities market spreads moved closely together mainly in turbulent periods. The financial market turbulence in the autumn of 2003 resulted in a fast depreciation of the foreign exchange rate, a rise in yields and an increase in volatility in both markets. This led to a widening of spreads both in the government securities market and the foreign exchange market (see Chart 9). In the period between October 2003 and July 2004 the correlation coefficient between these two liquidity indicators was 0.65, while in the following year there was no significant correlation. This suggests that under normal market circumstances the liquidity conditions of the two markets do not closely correlate with each other, while under turbulent conditions they may move more closely together, which is very likely to be related to the decreasing heterogeneity of foreign investors' expectations.

Hungarian bond market turnover

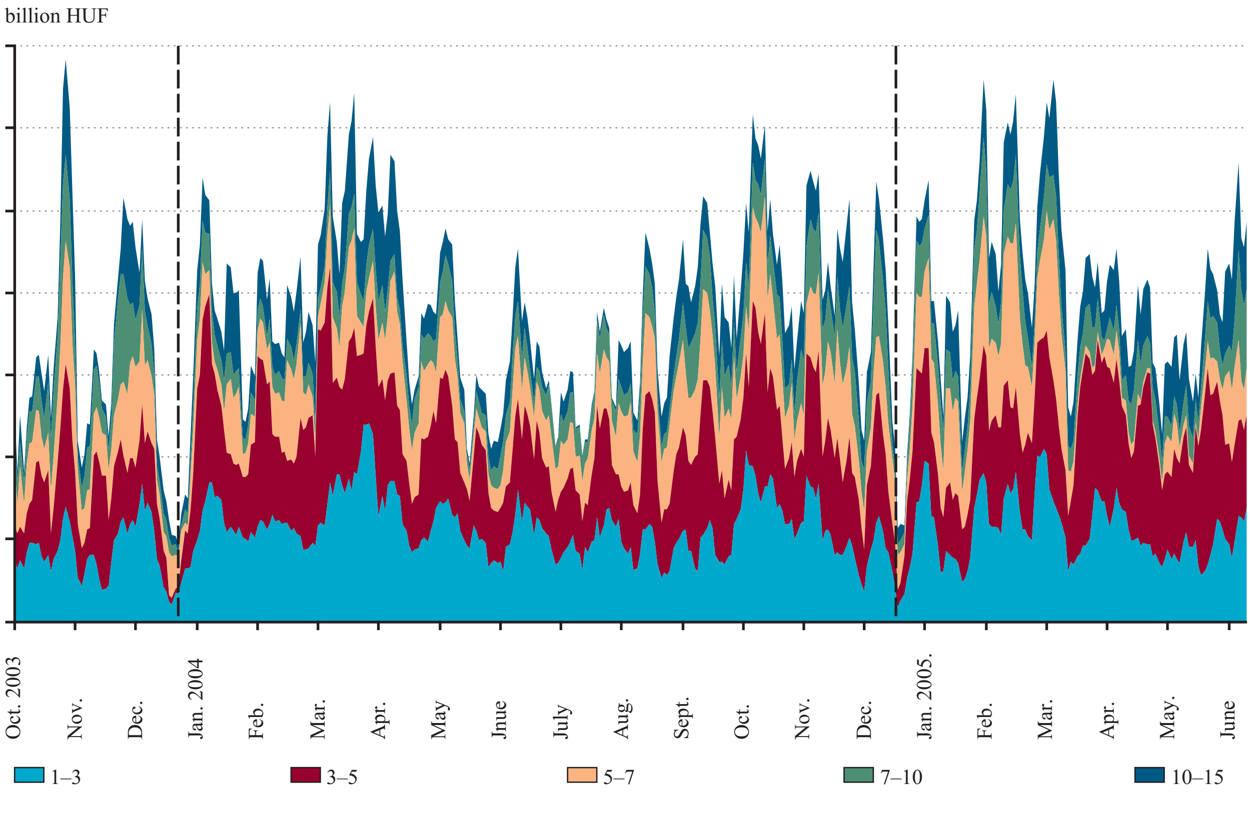
When analysing the liquidity of the government securities market the use of volume-based indicators is indispensable for measuring market depth. As in the case of the Hungarian government securities market, the dominant part of trading is conducted on the OTC market, we have no information on the actual order books of trading. Following the practice in the literature, we have used turnover data to measure market liquidity.

The average daily turnover of Hungarian government bonds is around HUF 70-80 billion (see Chart 10). The turnovers of government securities with maturities between 1-3 years, 3-5 years and over 5 years have approximately the same weight at 30 per cent each.

The turnover of securities with different maturities often correlates. This confirms the hypothesis based on spreads, according to which the liquidity of debt securities with different maturities often moves in the same direction. As a result the liquidity of the whole government securities market and the liquidity of individual securities comprising the market may be interdependent.

Chart 10

Turnover of Hungarian government bonds by maturity (5 day moving average)



Sources: Central Clearing House and Depositary (KELER) settlement turnover statistics.

The breakdown of turnover by sector provides information about the activity of the different types of market participants on the government bond market (see Table 6). According to 2005 Q1 data, professional government securities market participants (resident financial market institutions and non-residents) account for most of the turnover (96 per cent), while the weight of households and government sectors is minimal. Among professional financial market participants non-resident investors have the largest weight (40 per cent), while non-bank financial investors (mainly insurance companies and pension funds, 37 per cent) and resident banks (19 per cent) also play an important role.

Table 6

Government bonds, their turnover and turnover ratios in 2005 Q1

	MNB	Banks	Households	Non-residents	Non-bank financial interme-diaries	Non-fiancial corporations and other investors	Govern-mental sector
I. Outstanding amount							
a. value (billion HUF)	208	1566	215	2521	2316	108	45
b. in percentages of the total outstanding stock	3%	22%	3%	36%	33%	2%	1%
II. Turnover							
a. value (billion HUF)	0	797	16	1657	1548	86	30
b. in percentages of the total turnover	0%	19%	0%	40%	37%	2%	1%
Turnover ratio (II.a/I.a)	0%	51%	7%	66%	67%	79%	68%

Source: Government Debt Management Agency, turnover data refers to the volume of secondary market transactions conducted by primary dealers.

The secondary market turnover of different sectors is approximately proportional to their weight as investors in a given sector, i.e. to the amount of government securities held by them. Based on turnover ratios, which also take into account the weight of each sector, non-resident and non-bank financial investors are the most active. The activity of enterprises and other investors is surprisingly strong (their turnover rate is 79 per cent), while they only have a moderate impact on market liquidity, due to their limited role on the market. In contrast, the weight of banks in the government securities market is large, but on the basis of the turnover ratio (51 per cent) they represent a significantly more passive group of investors than those in the other sectors.

When discussing the liquidity of government securities markets it is often stated that liquidity decreases as the remaining maturity gets shorter (Amihud-Mendelson, 1991). The closer the maturity date of the security, the less likely it is that the selling/buying will be profitable. Consequently, depending on the maturity date, market activity and liquidity are likely to decline. Hungarian government bond market figures confirm the above hypothesis. The monthly average turnover of a security transacted by primary dealers is around HUF 30 billion twelve months before redemption, which decreases gradually to HUF 5 billion in the last month preceding the redemption date (see Chart 11).

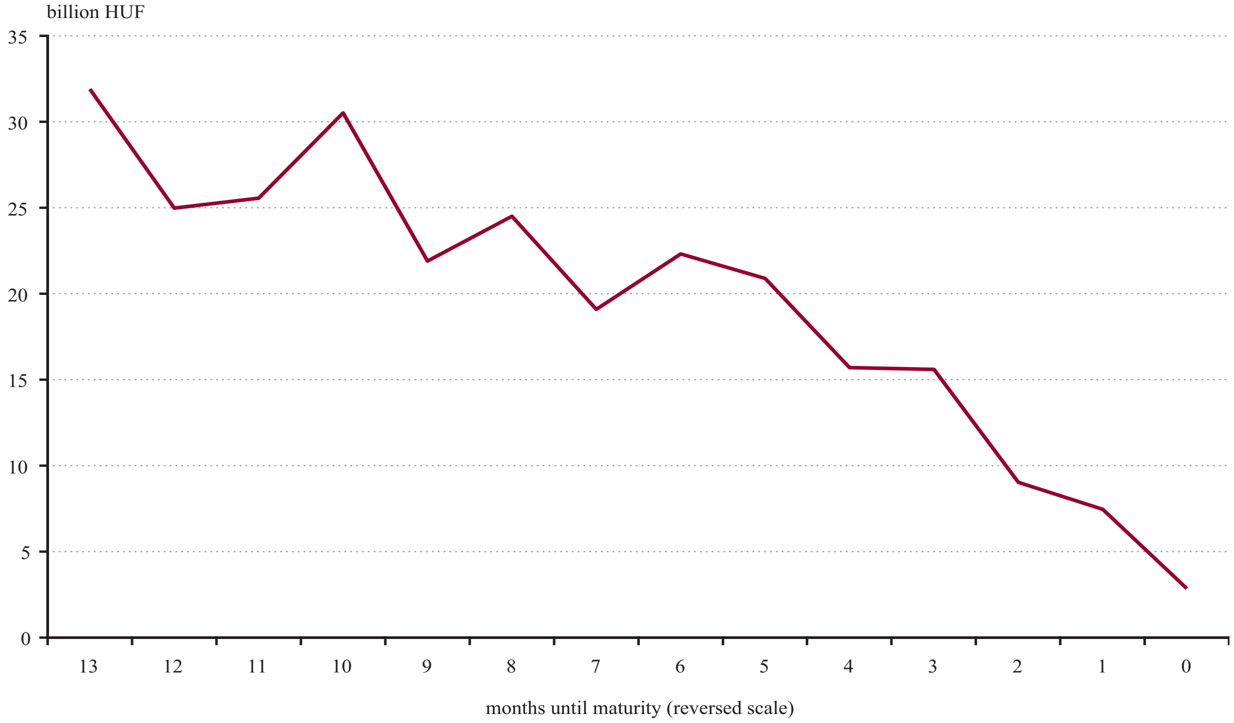
In addition to the above mentioned reasons, weaker trading activity may also be due to technical factors. Treasury bills represent an alternative to trading in bonds in the last year of maturity. Furthermore, according to the market making rules of the ÁKK, the market making obligation of primary dealers is terminated 90 days before maturity, which may also play a role in the fall in turnover in the last few months.

We also compared the turnover of the government securities market with that of the spot foreign exchange market. We found that the turnover figures of these two segments are clearly moving in the same direction most of the time. On the one hand, the turbulent financial market events of 2003 (January, June, October, December) can be clearly identified in both time series, as was the case with the changes in bid-ask spreads. On the other hand, it was also noticeable that the turnover declines significantly on both markets in the last days of a given year. The typical narrowing of liquidity on the government securities market at year end can be identified clearly in the case of every maturity. Turnover data move closely together in other periods as well. This confirms the hypothesis that the liquidity of those market segments may be mostly interdependent where the key participants are the same. In the case of the forint market, this is partly due to the fact that a major part of government securities market investors can be constituted by actively trading non-resident market participants. These participants buy forint-denominated government securities and finance it by taking FX positions in order to gain profits from the interest rate differential, a possible drop in yields and the appreciation of the exchange rate.

The relationship between the government securities market and the spot foreign exchange market is also confirmed by the structural similarities of the two markets. The primary dealers in the government securities market are not only of key importance on that market itself, but also on the foreign exchange market, as they conduct nearly three-quarters of the Hungarian spot foreign exchange market turnover.

Chart 11

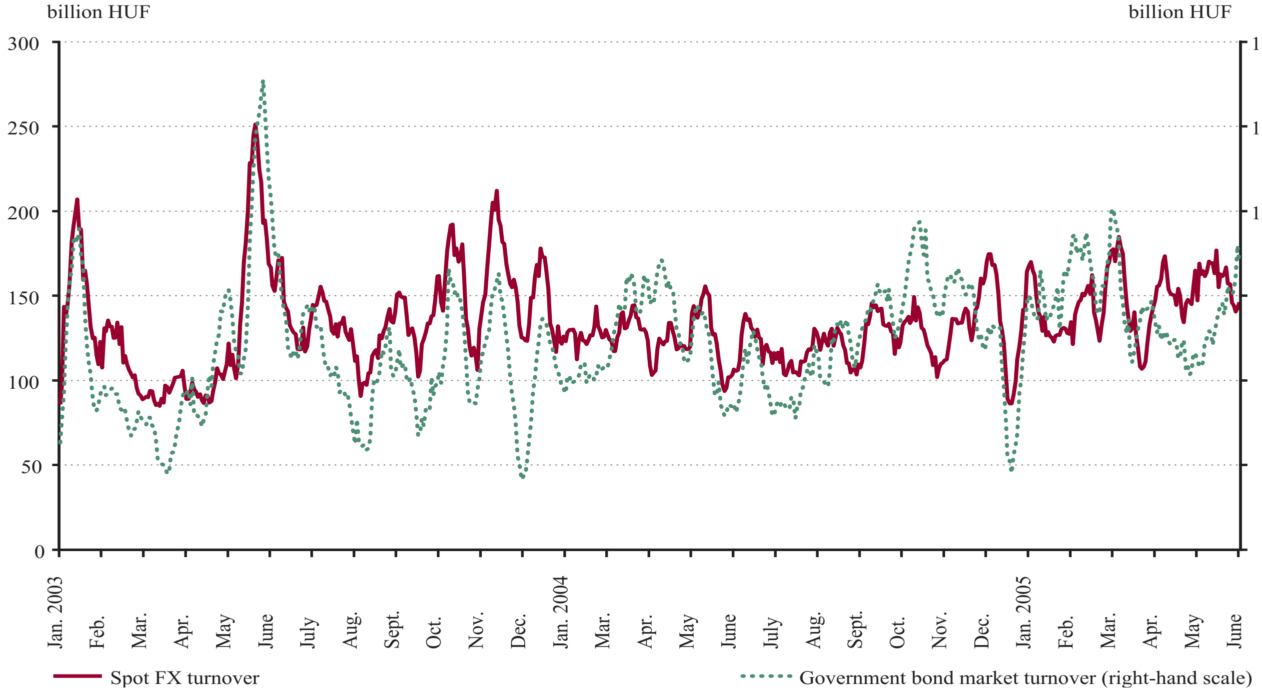
Government bond turnover on the secondary market in relation to remaining maturity (2002-2004)*



** Source: Government Debt Management Agency.*

Chart 12

Spot turnover on the foreign exchange and the government bond markets (5 day moving average)



The impact of auctions on the liquidity of the government bonds market

The liquidity of financial assets is affected by the total outstanding amount of a given instrument. In the case of foreign exchange markets this has less or indirect significance, while in the case of securities the relationship between outstanding amount and liquidity can be clearly identified. The larger the size of a given government security or maturity, the larger the liquidity of the given instrument may be.

Taking into account that the total outstanding amount of a given bond is a result of a series of auctions, a study of primary auctions and their effects on the secondary market may also expand the set of information related to market liquidity. When analysing the impact of auctions first we examined the hypothesis according to which liquidity indicators significantly change on the days of auctions. We analysed the time series of the most recently auctioned bonds with maturities of 3, 5, 10 and 15 years. As we had no disaggregated spread figures for each bond, we only examined the turnover data of the government securities market.

As the first step of our analysis, we tested a hypothesis on the data of the auctioned bonds – whether there is a significant auction day effect on the amount of the secondary market turnover. To this we estimated the following simple regression for each maturity:

$$turn_{i,t} = \alpha+\beta_{i,1} \bullet dum\_auction_{i,t} + \beta_{i,2} \bullet dum\_security\_swich_{i,t} + \beta_{i,3} \bullet turn_{i,t-1}+\varepsilon_{i,t},$$

where the dependent variable ($turn_{i,t}$) contains the secondary market turnover data of the auctioned bond of a given maturity derived from the data of the settlement-turnover statistics of KELER, adjusted for the auction volume. The $dum\_auction_{i,t}$ stands for auction settlement days, while the $dum\_security\_switch_{i,t}$ binominal variable indicates the days on which new government securities were introduced. Taking into account the autoregressive nature of the dependent variable, the lag of the variable is also shown on the right-hand side of the equation. The time series included 863 observations from the period between January 2002 and June 2005.

The most important advantage of the estimated equation is that it tests the above hypothesis unambiguously (do auctions affect secondary market liquidity) and the parameters can be easily interpreted. The constant measures average turnover, while dummy variables do the same with the impact of auction days and security switches.

Based on the results, the parameters differ from zero at a 99 per cent confidence level in the case of each maturity and regressor. Thus we have not shown the p values in our table that summarises the estimation results. Based on the constant, the average turnover is similar in the case of maturities of 3, 5 and 10 years, at around HUF 6-7 billion a day (on non-auction days). The turnover of securities with a maturity of 15 years, at HUF 0.75 billion, is somewhat lower than this, which may be associated with lower issue volumes and smaller outstanding amount.

Table 7

Statistics of the estimated regressions on the government bond market by maturity

	3 years	5 years	10 years	15 years
Regressors				
C	7.11	7.44	5.92	0.75
DUM_auction	41.80	38.94	30.28	14.48
DUM_security_switch	–11.28	0.00	–20.36	–7.62
AR(1)	0.34	0.40	0.42	0.11
Other statistics				
R^2	0.56	0.55	0.51	0.56
Adjusted – R^2	0.55	0.55	0.51	0.55
DW-statistics	2.13	2.11	2.17	2.02
F-statistics	357.99	351.99	299.33	358.38

The meaning of variables: DUM_auction: dummy variable for auction settlement days; DUM_security_switch: dummy variable for auctioned security switches; AR(1): lagged dependent variable.

According to the estimation, the parameters of the *DUM_auction* are positive, which means that the secondary market turnover rises significantly on auction days. The increase in turnover is around HUF 30-40 billion in the case of maturities of 3, 5 and 10 years, and HUF 14 billion in the case of the maturity of 15 years. Here too, the interpretation of the level of estimated parameters is made more difficult by the fact that the right-hand side of the equation contains the lagged dependent variable, but this could cause a smaller problem than in the case of a spot market bid-ask spread model.[31]

The rise in the secondary market turnover on auction days may be attributable to two factors. On the one hand, when accounting for auction days auctioned securities are partly redistributed by primary dealers, which could be considered a technical factor. In addition to this, however, the turnover of participants taking positions directly before or after the issue, speculating on the difference between the prices of the auctioned issue and the secondary market, may also be concentrated on the settlement day of auctions. On the other hand, the turnover of securities with maturities that had not been auctioned on the given day also often increases, suggesting that auctions have an impact on the actual market activity.

When interpreting our findings we must take into account that the focussing of the turnover on auction settlement days does not necessarily mean the concentration of liquidity on auction transactions days. Trading activity and market liquidity are spread over the period between the auction day and the settlement day. In order to estimate the precise form of their distribution over time we would need transaction level data, which was not available to us. On the whole, however, higher trading activity due to a new issue increases the liquidity of auctioned securities. This observation coincides with the findings of Fleming (2003), who compared the prices of bonds under issue (on the run bonds) with the price of not auctioned bonds with the same maturity (off-the-run bonds). According to empirical evidence, off-the-run bonds are traded at higher yields (at lower prices) and have a liquidity premium compared to on-the-run bonds (the 'on-the-run/off-the-run' premium).[32]

Based on the estimated regressions, the turnover falls by HUF 7-20 billion in the case of securities switches *(DUM_security_switch)* during the first issues, except for securities with a maturity of 5 years. This may suggest that in the course of auctioning new securities market participants are less willing to take speculative positions. Furthermore, lower turnover may also be related to the fact that the total outstanding amount and the number of participants holding these securities are much lower at the time of the first auction, and this may also decrease market liquidity.

4.2 THE LIQUIDITY OF THE GOVERNMENT SECURITIES MARKET IN AN INTERNATIONAL COMPARISON

Government securities market turnover

It is often stated in connection with government securities markets that large countries may make better use of their domestic bond market than small ones. According to Turner and Van't Dack (1996), for example, a smaller market is often coupled with much lower efficiency due to the low number of market participants and the slow pace of market development. Development is most often hindered by the high fixed costs of investments. This theory is also supported by experience in the EMU, as the liquidity of bond markets has sharply increased since the introduction of the euro, compared to the liquidity of former national markets.

Comparing the government securities market turnover and the total government securities portfolio on an international level may help to form conclusions as to whether the Hungarian market is small or not by international standards. In addition, the analysis of international data helps us understand the relationship between the size of the market and market liquidity.

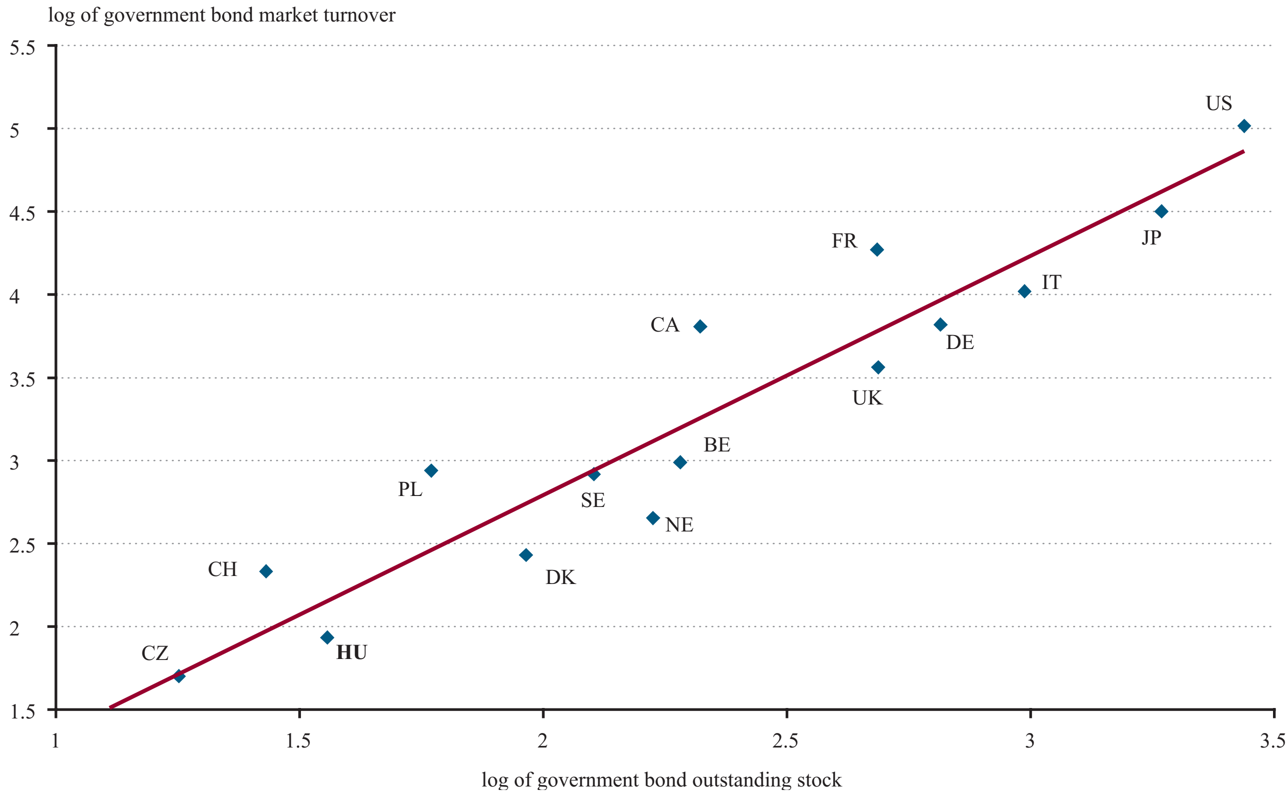
According to the analysis by BIS in 2000 and the ECB's survey of the bond markets in 2004 the secondary market turnover of government securities is clearly dependent on outstanding amount (see Chart 13).

[31] The *ceteris paribus* interpretation of the variables is made easier here by the fact that the 1 values of the dummy variables fall further away from each other than in the case of daily dummies, and thus the autoregressive effect almost entirely peters out until the appearance of the new dummy.

[32] Hungarian data do not allow for the estimation of this premium as Hungarian government debt securities are concentrated around much shorter maturities than government securities in the US.

Chart 13

The relationship between the size of the government securities portfolio and the secondary market turnover*



Source: BIS 2000, ECB 2004.

The result for Hungary fits into the international picture, although the data point for Hungary is slightly below the regression line. Nevertheless, the difference is statistically not significant and thus it does not indicate that the liquidity of the Hungarian market would be low compared to the size country's government securities portfolio.

Due to the application of log variables, the steepness of the regression line expresses the relationship between the dependent and independent variables in percentages. A 1 per cent increase in the government securities portfolio is accompanied by a 1.4 per cent rise in the secondary market turnover.[33] The estimation results also show that the turnover rate, another important indicator of the liquidity of the government securities market, increases in line with the growth of the outstanding amount. On the bond market of the US, for example, the turnover rate is 38 which means that US government bonds change holders this many times per year on average. In contrast to this, the same indicator in Hungary is only 2.

It is primarily the Central European government bond market and the Polish market in particular that constitutes the relevant basis for comparison of the Hungarian government bond market with foreign ones.[34] It is Poland that has the largest government securities market in Central Europe, partly due to the large size of the country itself. The average daily

[33] The hypothesis relating to the connection between outstanding amount and the secondary market turnover was also confirmed by the analysis of Hungarian bonds. Pointing out the higher uncertainty surrounding the results of our findings due to the lower number of observations, it can be stated that, in the case of most recently auctioned securities with maturities of 3 and 5 years, the secondary market turnover increases in line with outstanding amount, while the steepness of the regression lines is lower (0.35 and 0.75 per cent) than the line drawn according to international data. This can partly be attributed to the fact that the international survey also reflects the effect of other (e.g. institutional) factors on the government securities market liquidity, in addition to the size of the issues.

[34] According to the ECB's survey, the turnover of the Czech and the Slovak government securities markets in the region is significantly lower than that of the Hungarian market, amounting to approximately half and one third, respectively, of the Hungarian turnover. The turnover of other new Member States that joined the EU in 2004 is even lower.

turnover of its bond market amounted to around EUR 3 billion in 2004, which is approximately ten times larger than that of the Hungarian government bond market. The two markets are similar in that the turnover of the Polish government bonds also fell sharply at year end by around 50 per cent.

A major part of the turnover is attributable to bilateral interbank transactions in both countries. There are, however, electronic trading systems in both countries[35] and although their present weight is low they could contribute to the improvement of trading activity and government securities market liquidity over the medium term.

Bid-ask spreads

By international standards the Hungarian government securities market is of low liquidity based on bid-ask spreads. In 2005 the spread of 10 year government bonds calculated in price terms was around 4-5 price points in the US (the largest government securities market) and in the EMU Member States, while the spread in Hungary reached even 53 price points.

Table 8

10 year government bond spread by country in price terms

	US	UK	CAN	JP	EMU	MEX	DEN	BR	AUS	NZ	HU	PL
2005*	5	9	5	22	4	13	8	56	12	36	53	20

Reuters quotes for benchmark securities.

When examining spreads it is important to note that in contrast to turnover the size of the spread is not necessarily dependent on the size of outstanding amount, as the liquidity of small markets (e.g. Denmark and Canada) does not lag behind that of larger countries based on bid-ask spreads expressing the costs of trading.

Spreads and the costs of trading have decreased significantly, especially in euro area countries recently, where segmented markets operating in a national framework were replaced by integrated bond markets. Prior to EMU accession the spread of 10 year government bonds was around 5-10 basis points in certain Member States, while in July and August of 2005 in every country this fell to approximately 2-5 price points, which is considered especially low.

Table 9

Spreads of 10 year benchmark bonds in EMU Member States (price point)

	AT	BE	DE	ESP	FI	FR	GR	IE	IT	NE	PT
1999*		5.0	6.0			10.0			6.0		
2005**	5.4	2.4	4.7	3.5	4.7	4.4	5.5	4.3	4.1	2.9	5.3

** BOJ 1999, **Reuters 2005.*

In Hungary the approximately 50 price points spread in the 10 year maturity is significantly higher than the spread of euro area Member States. In the light of this, Hungary's EMU accession could significantly reduce the indirect economic burdens of the government debt. Based on a GDP of approximately HUF 20 thousand billion in 2004 and a secondary market securities turnover on a similar scale, Hungary's immediate entry into the euro area would reduce government securities trading costs by around 0.1 of a percentage point relative to GDP.[36]

By regional standards the spreads are 2-3 times larger for each maturity in the Hungarian market than in the Polish one. In addition, the standard deviation of spreads is also significantly larger, which may be due to Hungarian interest rate conditions and indirectly the greater volatility of government security prices.

[35] The MTS has been operating in Poland since 2002 and trading in Bloomberg's bond trading system also started in February 2005 in Hungary.
[36] Based on the approximately two and a half years average remaining maturity of Hungarian government bonds, the spread is around 11 basis points expressed in yields which could fall to 2 basis points following accession to the euro area.

Table 10

CEBI spreads and the maximum spread prescribed for primary dealers by maturities in Hungary and Poland (price point, January-June 2005)*

	1–3	3–5	5–7	7–10	10–15	Total
I. Average						
Poland	11	13	21	21	29	15
Hungary	30	59	103	111	146	63
II. Standard deviation						
Poland	2	3	5	4	11	2
Hungary	4	10	48	21	42	9
III. Maximum spread allowed for primary dealers						
Poland	20	30	60	60	60	
Hungary	94	179	257	343	462	

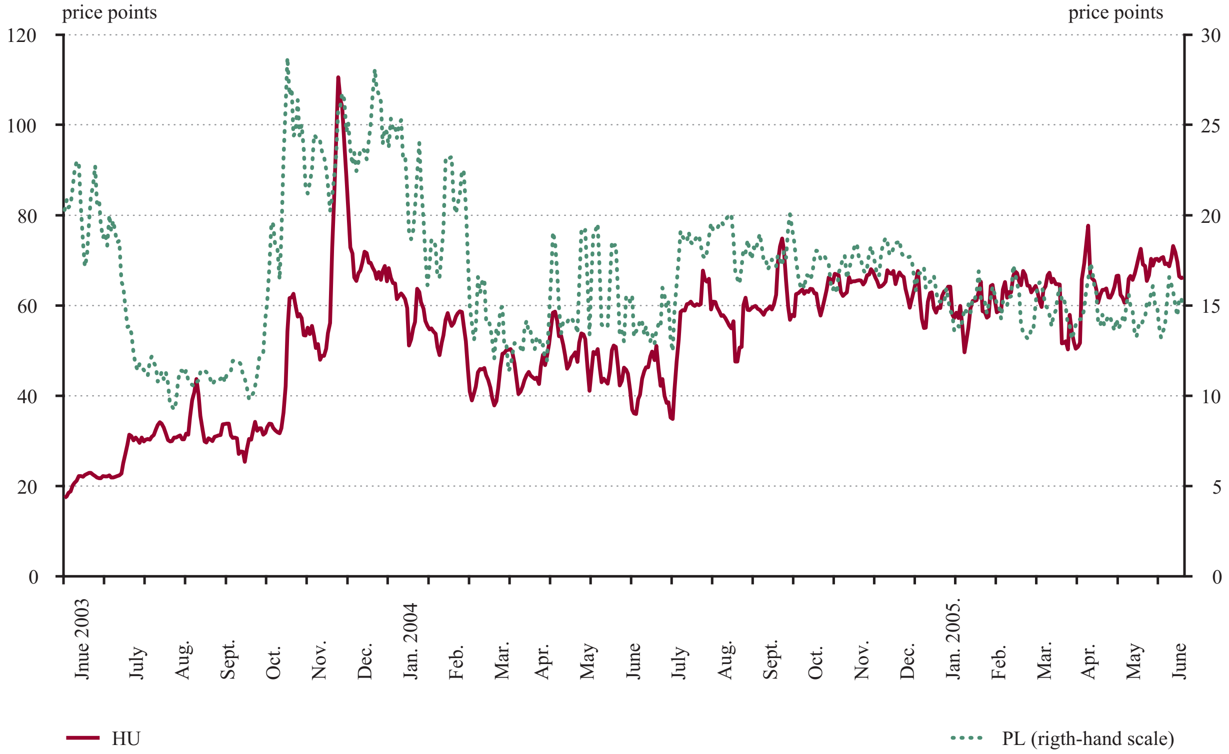
** In the case of Hungary we estimated the required maximum market maker spread from the 50 basis point yield spread prescribed by the ÁKK for the average term of maturity intervals.*

The maximum spread required for market makers provides information about the institutional settings of the government securities market. It is an important difference between the two countries that while the maximum level is specified in price in Poland, the same is done in yields in Hungary. When converting the 50 basis point yield spread into price points, independent of maturity required for Hungarian market makers, it is clear that regulations allow much more room for manoeuvre for Hungarian market makers. On the whole this could harm the efficiency of market making, which could have contributed to the appearance of wider bid-ask spreads and lower liquidity in Hungary.

Another good reason for analysing the developments in regional government securities markets is that foreign investors active in the other countries of the region, in Poland in particular, may play a key role in Hungarian govern-

Chart 14

CEBI spreads (5 day moving average)



ment securities market demand. When looking at the time series of Polish and Hungarian government securities market data it is interesting to note that there is a strong positive correlation between the spreads, which supports the above hypothesis. The correlation coefficient for the nearly two years of daily data is around 0.5. The correlation was the strongest in the turbulent period of 2003 Q3, but the longer-term trend also indicates a strong positive correlation (see Chart 14).

In the autumn of 2003 the spreads first widened as a result of pressure by sellers on the Polish government securities market, which soon after induced an increase in volatility and spreads also in the market of Hungarian debt securities at the end of October. Naturally, in addition to regional contagion, the unfavourable assessment of Hungarian economic fundamentals could also have contributed to this strong pressure by sellers.

The 'black hole in liquidity' described by Persaud (i.e. weaker heterogeneity of market expectations) could also have contributed to lower market liquidity in the Hungarian government securities market, as the assessment of key foreign investors in the bond market simultaneously became unfavourable. This led to a sudden rise in yields and high volatility, to which market makers reacted by widening the spreads.

In this financial market situation the outright bond purchases of the MNB in October 2003 could have contributed to ensuring market liquidity and maintaining the stability of financial markets. On the one hand, these purchases created demand in a market characterised by strong pressure on the part of sellers, causing a direct rise in market liquidity supply, while on the other, these transactions may have had an indirect favourable impact on liquidity through the announcement of the purchases. It became clear for market participants that the market still had several participants as a large institution created demand. On the whole, this could have eased the pressure from sellers and increased the heterogeneity of market expectations, thus creating liquidity.

Following the developments in autumn 2003 the spreads narrowed both in Poland and in Hungary in line with lower volatility. Spreads have remained flat since 2004 Q2 in both countries. On the whole, however, current levels exceed those prior to the events in the autumn of 2003, which may suggest that market liquidity decreased following financial market turbulence.

5. Conclusions

From the overview of the literature of market liquidity we may draw the important conclusion that liquidity can unambiguously be assessed only alongside several dimensions (tightness, depth, width, resiliency, immediacy). Accordingly, in the course of the empirical examinations the major liquidity indicators describing individual dimensions, the bid-ask spread and the turnover were analysed not only separately, but also in terms of their relationships.

Major findings of our empirical examinations are as follows. The time series of the spot FX market bid-ask spread and volatility can lead us to conclude that market makers, being afraid of an increase in volatility, behave cautiously when forming the spread. Based on the analysis of the spot market turnover and concentration, we can draw the conclusion that non-residents' liquidity determining role may be more significant than one would think on the basis of non-residents' share in market turnover. This was also confirmed by the tested bid-ask spread model; the indicators reflecting non-residents' activity had more explanatory power than the indicators covering the whole market. Our model can also lead us to conclude that spot market liquidity improved continuously and slightly in the last one or two years. We also found that market liquidity is higher on Mondays than on other days, which might be attributable to the timing of the central bank's rate-setting meetings or the time-lag between trading hours in Hungary and in the United States. However, our data do not support the hypothesis that FX market activity declines excessively in summer; the turnover of the FX market in summer months is only slightly lower than in the rest of the year.

In a regional comparison, spot FX markets are characterised by the equal importance of the impact of turnover and volatility on the bid-ask spread. The differences between individual foreign currencies' spreads can also be affected by the exchange rate mechanism applied. Therefore, joining ERM II may be a potential factor improving market liquidity. Although of the four main currencies of the region the forint is less liquid than the Polish zloty, the forint market turnover is the highest in the region as a proportion of GDP.

Based on the analysis of the government bond market, we can ascertain that the bid-ask spread and turnover of instruments with various maturities are characterised by strong correlation, which may indicate the relationship between the liquidity of the instruments. Based on the developments in the turnover of government securities, we accepted the hypothesis that liquidity is declining as a function of residual maturity. In addition, seasonal effects are also typical of market turnover; and secondary market turnover shows significant increases on auction days.

Cross-sectional examinations suggest that the secondary market turnover has a clearly positive relationship with the outstanding amount of government securities. Therefore, liquidity is also influenced by the development in the outstanding amount of a given instrument in the market. Based on the bid-ask spread, the Hungarian government securities market can be considered a low-liquidity one in an international comparison. However, joining the EMU in the future is expected to significantly reduce the costs of trading in government bonds, which may contribute to favourable developments in market liquidity as well.

We have also found signs indicating that the liquidities of the government securities market and of the FX market move in the same direction, which was mainly typical of turbulent periods. This indicates that the same participants may provide liquidity in both markets, thus in extreme market situations a possible decline in the liquidity of one of the market segments may negatively affect the other as well.

Appendix

Indicators capturing transactions costs		
Indicators	**Definition**	**Formula**
S_t	Bid-ask spread	$S_t = p_t^A - p_t^B$
Rel_S_t	Relative bid-ask spread	$Rel\_S_t = \frac{(p_t^A - p_t^B)}{(p_t^A + p_t^B)/2} = \frac{(p_t^A - p_t^B)}{p}$
Notations: p_t^A = the best ask price	p_t^B = the best price	

Volume-based indicators		
Indicator	**Definition**	**Formula**
n_t	Frequency of entering into transactions	$n_t = N_t / T$
Q_t	Order volume	$Q_t = (q_a + q_b)/2$
$Turn_t$	Turnover	$Turn_t = \sum_{i=1}^{N_t} p_t^i \cdot q_t^i$
$Turn\_rate_t$	Turnover ratio	$Turn\_ratio_t = Turn_t / Outstandingamount_t$
Av_deal_t	Transaction size	$Av\_deal_t = Turn_t / N_t$

Notations

n_t = number of transactions executed in the T period

q_b and q_a = the average bid/ask quantity in the order book in the t^th^ period

p_t^i = the price of the i^th^ transaction effected in the t^th^ period

q_t^i = the quantity of the i^th^ transaction effected in the t^th^ period

$Outstandingamount_t$ = Outstanding amount in the market at the end of the t period

Price-basedi ndicators		
Indicator	**Definition**	**Formula**
γ_t	Price impact indicator I	$\gamma_t = \frac{\lvert\Delta(p_t)\rvert}{\text{transaction\_size}_t}$
δ_t	Price impact indicator II	$\delta_t = \frac{\lvert\Delta(\text{spread}_t)\rvert}{\text{average\_deal}_t}$
ε_t	Spread resiliency indicator	$\varepsilon_t = \frac{\lvert\Delta(\text{spread}_t)\rvert}{\text{spread\_convergence\_time}}$

Notations

p = price of traded instrument

Table

Descriptive statistics of spot market liquidity indicators

	AV_DEAL	DEAL_NUM	VOL	HI_DB	HI_FOR	TURN	TURN_VS_FOR	SPREAD
Mean	0.32	340.17	0.73	0.11	0.12	132.82	66.93	8.45
Median	0.31	329.00	0.61	0.10	0.10	122.92	60.87	7.86
Maximum	0.80	683.00	5.77	0.38	0.82	417.21	258.16	22.84
Minimum	0.12	103.00	0.14	0.07	0.06	29.28	0.65	2.56
Std. Dev.	0.07	84.85	0.52	0.03	0.06	50.33	34.17	3.26
Rel. Std. Dev.	0.23	0.25	0.71	0.32	0.54	0.38	0.51	0.39
Skewness	1.24	0.88	3.66	3.90	5.24	1.37	1.47	1.22
Kurtosis	6.92	4.69	26.64	25.93	45.17	6.29	6.62	5.17

AV_DEAL: daily average size of forint-euro deals (billion HUF).
DEAL_NUM: daily number of forint-euro deals.
VOL: daily maximum and minimum difference of forint-euro exchange rate (per cent).
HI_DB: Herfindahl index (on a scale between 0 and 1) calculated from the share of domestic banks in the spot FX market turnover.
HI_FOR: Herfindahl index (on a scale between 0 and 1) calculated from the share of foreign banks in the spot FX market turnover.
TURN: daily forint/foreign currency spot market turnover (billion HUF).
TURN_VS_FOR: turnover vis-à-vis non-residents (billion HUF).
SPREAD: forint-euro daily average relative bid-ask spread, calculated from two-minute exchange rates; only values within trading time (basis point).

Table

Test of the error term of the spot market bid-ask spread model

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	1.085		P-probability	0.339
Obs*R-squared	2.221		P-probability	0.329
Test Equation:				
Dependent Variable: RESID				
Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
SPREAD(-1)	–0.002	0.028	–0.083	0.934
VOL	0.010	0.119	0.081	0.935
D_RATE	–0.009	0.174	–0.052	0.958
TURN_VS_FOR	0.000	0.002	0.071	0.943
HI_FOR	–0.092	1.077	–0.085	0.932
T	0.035	0.306	0.114	0.910
C	0.000	0.000	–0.127	0.899
DUM_MO	0.007	0.179	0.040	0.968
DUM_TU	0.008	0.195	0.043	0.966
DUM_FR	0.011	0.198	0.055	0.956
DUM_DEC	0.016	0.152	0.107	0.915
DUM_YEAR_END	–0.040	0.382	–0.104	0.917
MA(1)	0.220	0.175	1.260	0.208
RESID(-1)	–0.216	0.175	–1.239	0.216
RESID(-2)	–0.133	0.091	–1.473	0.141
R-squared	0.004	F-statistic		0.155
Adjusted R-squared	–0.022	Prob. (F-statistic)		0.999

Table

ARMA specification of volatility

Dependent variable: VOL
Method: Least Squares
Included observations: 561
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.193	0.040	4.805	0.000
VOL(-1)	0.477	0.074	6.400	0.000
VOL(-2)	0.251	0.090	2.778	0.006
DUM_TU	–0.085	0.033	–2.580	0.010
DUM_TH	0.107	0.043	2.505	0.013
R-squared	0.449	F-statistic		113.126
Adjusted R-squared	0.445	Prob. (F-statistic)		0.000

Table

ARMA specification of non-residents' turnover

Dependent variable: TURN_VS_FOR
Method: Least Squares
Included observations: 561
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TURN_VS_FOR(-1)	0.307	0.055	5.638	0.000
TURN_VS_FOR(-2)	0.131	0.056	2.342	0.020
C	43.927	4.391	10.005	0.000
DUM_MO	–12.012	3.624	–3.315	0.001
DUM_FR	–12.027	3.574	–3.366	0.001
DUM_YEAR_END	–30.904	4.453	–6.940	0.000
R-squared	0.182	F-statistic		24.633
Adjusted R-squared	0.174	Prob. (F-statistic)		0.000

Table

Seasonality of spot market turnover between 1999 and 2005

Dependent variable: LOG(TURN)
Method: Least Squares
Included observations: 1638
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.244	0.137	9.057	0.000
LOG(TURN(-1))	0.712	0.033	21.259	0.000
DUM_MO	–0.072	0.024	–2.959	0.003
DUM_FR	–0.262	0.023	–11.418	0.000
DUM_JAN	0.042	0.018	2.365	0.018
DUM_JUN	0.029	0.016	1.846	0.065
DUM_JUL	0.007	0.017	0.411	0.681
DUM_AUG	–0.040	0.018	–2.229	0.026
DUM_DEC	0.041	0.019	2.136	0.033
DUM_YEAR_END	–0.418	0.089	–4.698	0.000
T	0.000	0.000	7.493	0.000
MA(1)	–0.419	0.047	–8.958	0.000
R-squared	0.485	F-statistic		89.879
Adjusted R-squared	0.480	Prob. (F-statistic)		0.000

Of the seasonal variables, besides the summer months only those dummy variables were left in the regression which became significant at least at 5 per cent. The point estimation of long-term parameter of the month of August is: –0.04/(1-0.712)≈–14%

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