

# Analysis methodology of interbank reference rates – International trends and the results of the first Hungarian annual statistical analysis for 2014\*

Dániel Horváth – Eszter Makay

*The importance of interbank rate quotations is enormous from the aspect of pricing loans, deposits, and financial instruments, and in general for the efficiency of resource allocation mechanisms in the economy. Consequently, it is crucial to ensure that interest rate quotations are defined in a transparent, authentic, and reliable way, and that they reflect true market conditions and the widest possible information base without any distortion. In recent years, following the manipulation experienced on international financial markets, the regulatory environment has been made stricter, and the mechanism of determining key interbank reference indicators has been transformed. Adjusted to international trends, the quoting practice of BUBOR has been reconsidered, and the control has been transformed. Apart from official and internal banking audits offering direct insights in the checking of interbank rate quotations, more emphasis has been laid in recent years on statistical analyses that belong to the scope of indirect analysis methods, and our article will focus on this new method of examination. The article reviews the methods used so far in international and domestic statistical examinations, and presents the Hungarian analysis framework compiled on the commission of the Quotation Committee of the Hungarian Forex Association (MFT), as well as the results of the first analysis regarding 2014. The article contributes to the international technical literature on the subject mainly by building an analytical frame based on the example of the Hungarian interbank reference rate, using various statistical approaches, which will demonstrate the key aspects of the conduct of individual panel banks and the development of the reference rate.*

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## 1. Introduction

In recent years, following the manipulation experienced on international financial markets, the regulatory environment has been made stricter, and the mechanism of determining key interbank reference indicators has been transformed. In addition to the United States, reference rates were reviewed in the United Kingdom, the euro area, Canada, Denmark, Sweden and Japan, as a number of deficiencies were discovered in relation to the global financial crisis. In parallel with the audits conducted by national supervisory bodies, international institutions have also formulated some guidelines for the definition, checking, and supervision of reference rates. For instance, the “Wheatley Review” produced in the wake of the manipulation of LIBOR (*Wheatley Review 2012*) included several relevant proposals for the future of interbank rate quotations. Among other things, in order to improve transparency, this review recommended that the audits by the supervisory bodies be more transparent and quotations be subject to regular statistical examinations.

Adjusted to international trends, the quoting practice of BUBOR has been reconsidered as well. The revision of the BUBOR quoting methodology and regulations, as well as the quotations themselves have been going on in parallel with the international re-working of the principles related to reference rates.<sup>1</sup>

The code of conduct strengthening the control process of rate quotations is presently being developed in Hungary and might offer some guidelines for panel banks on the consideration of factors potentially influencing quotations and an organisational structure that allows for prudent quotation activities, as well as the controlling and supervisory processes.

The importance of BUBOR is enormous in many respects, and therefore it is important that it is defined in a transparent, authentic, and reliable way. On the Hungarian markets, a significant portion of financial products use the 3-month BUBOR as reference rate, and therefore even small changes may have a significant impact, and the general public may also pay close attention to its development.<sup>2</sup> It also needs to be pointed out that the possibilities of substituting BUBOR with other reference rates are limited, and thus strengthening the reliability of the existing quoting process and BUBOR is of special importance. From the aspect of the financial market and financial stability monitoring activities of the central bank, it is also important that BUBOR reflects true market conditions and the widest possible information base without any distortion.

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<sup>1</sup> International experiences, the Hungarian attempts and other issues related to BUBOR are reviewed in detail by *Erhart–Mátrai (2015)* and *Erhart et al. (2013)*.

<sup>2</sup> In the case of corporate loan products, traditionally, it is variable interest rates adjusted to BUBOR that have been typical (see *Walter 2014*), and their weight has also recently increased in the retail segment.

In connection with the reform of BUBOR, it is also necessary to strengthen the control functions and external control. This is why there is a need for regular, annual statistical analyses, which allow the BUBOR-related processes to be captured with annual frequency and reasons for possible changes to be detected. Another objective of examinations related to BUBOR is that possible signs of manipulation activities, mistypings, and in general non-market-conform price quotations can be identified, and, as a result, the credibility of BUBOR and the information contents of interbank rate quotations can improve.

It is important to note that international experience indicates that several methods are required to test the reliability of reference rates: official audit methods (e.g. checking e-mails and other communication channels), internal audits in banks (compliance), and statistical analysis. These audits complement one another. The statistical approach is suitable for the identification of certain signs of the intention of manipulation and for the detection of systematic behaviour patterns, but these can be considered as indirect instruments only, which are unable to capture all forms of manipulation. Official audit methods and internal bank audits provide a direct insight into the activities of panel banks; therefore they are also useful in specific evidentiary procedures, and are able to detect the intention of manipulation even in cases when statistical instruments are not able to do so, or when it does not seem to be significant. However, the main advantage of statistical examinations is that they are able to detect the intention of manipulation even when no specific proof is available. The publication of analyses has a deterring effect on such conduct as well, as the affected institutions would run a serious reputation risk with any manipulation.

In this article, we first present the international experiences and results of statistical analyses related to key reference rates, and then provide a brief overview of the features of the Hungarian unsecured interbank market. Following that, we present the objectives of regular analysis and the Hungarian statistical analysis framework developed on the commission of the Quotation Committee of the Hungarian Forex Association, as well as the results of the first examination regarding 2014, sorted by the six key analysis considerations.

## **2. Methods of statistical analysis used in international practice**

At the end of 2012, the experts of the European Banking Authority (EBA) and the European Securities and Markets Authority (ESMA) jointly analysed the EURIBOR quoting process,<sup>3</sup> using the following key considerations:

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<sup>3</sup> EBA–ESMA (2013)

- In the course of the examination of EURIBOR quotations, they found that identical interest rate quotations submitted on several consecutive days were rather frequent. In one case, the quoting bank listed the same interest rate levels permanently, for 67 days, for several tenors.
- The analysis pointed out the importance of identifying quoting banks that permanently divert from the average. The observation of most frequently trimmed panel banks on both the low and the high side may facilitate the identification of one-sided quoting behaviour that often differs from the average.
- In order to identify deviating quoting behaviour, the development of interbank reference rates of different countries were compared. The comparison of EURIBOR and LIBOR quotations shows that these two rates were very close to each other before the crisis, but since the end of 2009, EURIBOR has been significantly higher than LIBOR, by approximately 10 basis points. The lower level of LIBOR may be explained by the fact that in the stricter interbank rate environment during the crisis, the banks may have felt an urge to conceal their own financing problems with lower quotations (stigma effect).

In addition to the retrospective examination of EURIBOR quotations, it is worth mentioning that EURIBOR rate quotations are also subject to preliminary checking. Thomson Reuters, which accepts, records and then publishes the quotations, conducts a preliminary check before publication, in the course of which outliers are reconciled with the quoting banks. In spite of the preliminary examination (“sanity check”), the analysis of EURIBOR identified presumably incorrect quotations which, in the course of trimming, were removed from quotations used for the calculation of the average, but if they had been filtered out during the preliminary checking by Thomson Reuters, the EURIBOR fixing would have had a different value. This highlights the need for the refinement of preliminary checking as well.

*Fouquau–Spieser (2014)* examines LIBOR quotations in the period 2007–2012, looking for structural breaks and cartelling behaviour:

- *Identification of structural breaks:* The authors used two different methods<sup>4</sup> to examine the time series of LIBOR quotations, depending on whether or not there was a structural change in the level or dynamics of indicators. Both methods applied identify 9 October 2008 as the date of the significant structural break for the time series of LIBOR rates. Looking at the quotations of individual banks, most models indicated 9 October 2008 as well, but there was an exception (Barclays) where the behaviour changed 2–3 weeks earlier. As a result of further investigation and based on direct evidence (correspondence, etc.), the authorities defined the primary responsibility of this bank (“the organiser of the cartel”),

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<sup>4</sup> For details see *Zivot et al. (1992)*, and *Perron (1997)*.

which indicates that it might be really worthwhile to examine the time series from this aspect, using statistical approaches.

- *Identification of cartels*: The authors carried out hierarchic cluster analysis on the whole sample and on the two parts of the sample determined by the structural break. This method allows for the grouping of banks that follow similar quotation strategies, and for examining the behaviour of groups one by one. The results suggest that in the whole time series, as well as in the sample taken before the structural break, Barclays bank followed a special strategy, while the rest of the banks belonged to two large groups. However, between the groups and inside the groups, only relatively loose relations were identified. In the sample taken after the structural break, Barclays is already part of one of the larger groups, and within the group, the strategies of banks were moving closer to each other, which means the strengthening of coordination. All in all, the results of the cluster analysis indicate events similar to those detected by the official investigation.

*Monticini–Thornton (2013)* examined whether or not LIBOR rate quotations distorted downwards significantly influenced the development of LIBOR. In the course of the examination, they tested the statement that if LIBOR quotations were really and deliberately diverted downwards, there had to be a statistically significant reduction in the difference between LIBOR and the banks' CD rates<sup>5</sup>, as a result of the LIBOR manipulation. The authors were looking for the presence of structural breaks in the spread among the examined rates, using the Bai-Perron test. The econometric examination carried out on the difference between the rates of 1-month and 3-month LIBOR and bank deposit certificates identified structural breaks. The results of both tenors indicated that LIBOR quotations significantly diverted downwards by some banks had a significant impact on the LIBOR rate.

In February 2013, the Hungarian Financial Supervisory Authority published a detailed study<sup>6</sup> on the statistical analysis of portfolios related to BUBOR and BUBOR quotations. The results of the examination of potential problems occurring during the BUBOR quotation process and the methods used for the identification of signs of manipulation were as follows:

- *Relation between interest rate derivative positions and BUBOR quotations*: The institution-level development of net positions originating from forint FRA, IRS and CIRS transactions related to 3-month and 6-month reference rates were compared with the BUBOR quotations. Following the examination of significant net position changes that occurred in the period from the beginning of 2009 to the middle of 2012, and the development of the quotations of the given bank, it was found that

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<sup>5</sup> The CD or Certificate of Deposit is a financial instrument which helps credit institutions collect funds.

<sup>6</sup> *Hungarian Financial Supervisory Authority (2013)*.

there was no relation between the BUBOR-related derivative positions of banks and the quotations, and no signs of manipulation were detected.

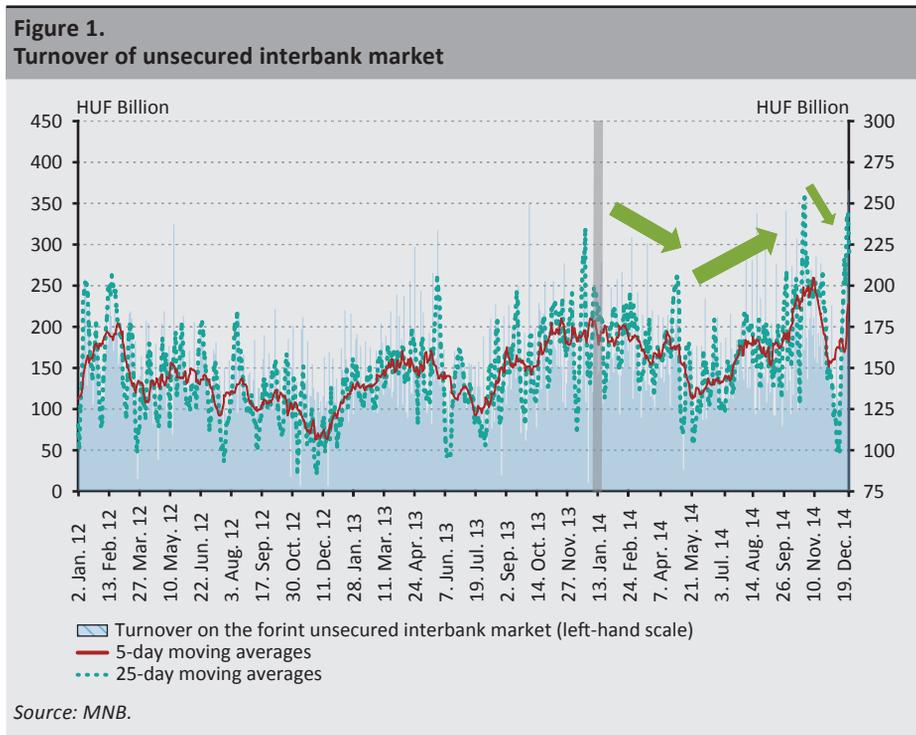
- *Identification of data errors:* Incorrect quotations were identified in the time series of O/N, 1-month, 3-month and 6-month individual BUBOR quotations of banks, indicating deficiencies in data quality.
- *Standard deviation of interest rate quotations:* The examination of the standard deviation of quotations may be a suitable method for the identification of possible anomalies that can be observed in the quoting behaviour of banks. According to the supervisory examination, between the beginning of 2004 and June 2012, the standard deviations of quotations remained low in the tenors of 1, 3 and 6 months, and only increased in turbulent periods.
- *Comparison of BUBOR with reference rates:* BUBOR quotations primarily follow the course of the base rate, but are influenced by other reference rates as well, although this relationship changes in time, which indicates that BUBOR values cannot be derived from any other market benchmark rate.
- *Cluster analysis:* The supervisory study carried out a cluster analysis for 3- and 6-month BUBOR quotations in order to identify any potential systematic behaviour in the quoting activities of banks. Based on the cluster analysis, it can be stated that some institutions tend to drive BUBOR downwards, while others tend to drive it upwards. However, no joint distortion in the same direction was found, which would imply harmonised behaviour by banks.

In addition to the above methods, the literature describes a number of other alternative approaches. *Haaker (2013)* uses game theory methods to analyse the LIBOR manipulation case, and points out the role of punishments and long-term reputation risks. *Bariviera et al. (2015)* use information theory methods for the examination, also in connection with the LIBOR case. Based on the results, the applied information theory indicators (entropy and statistical complexity) seem to be useful in the examinations, because they point out “suspicious” patterns in the conduct of panel banks. Another relevant and related research subject is the cooperative game theory, which can be used to model the background of community decisions and the formulation of interest groups (see e.g. *Bachrach et al. 2011*). In the future, these approaches may serve as a basis for the further improvement of the Hungarian analysis methodology described in the article.

### 3. Unsecured interbank market in 2014 in Hungary

From the aspect of the development of BUBOR, the market of unsecured bank transactions is of key significance, because in optimal cases the interest rates of unsecured interbank loans provide guidance for panel banks quoting the rates for the determination of rate quotations.

In terms of the major scenes of bank liquidity management, the unsecured interbank market is one of the smaller markets, as it still has a relatively moderate turnover, even after the restoration of the trust that was lost during the global financial crisis. On the other hand, it needs to be pointed out that at the beginning of 2014 the turnover of the unsecured interbank market exceeded the average volume which was typical in previous years, suggesting rising activity. In the first half of the year, depo market turnover followed a slightly decreasing trend and fell to a more significant extent in May, but historically it was still not low. In May, with the narrowing of interbank forint liquidity, depo market turnover temporarily dropped, which may have been caused by seasonal factors related to the Hungarian banks' keeping their reserves and the expected negative liquidity shock. At the end of May, depo market activity started to increase again, and by the end of October it surpassed the higher level experienced at the beginning of the year. All in all, in view of these processes, we can say that the turnover of the unsecured interbank



market in the examined period was driven by factors that generally characterise the market, and thus the impacts of the changes in the market did not really influence the quotation of BUBOR. On the other hand, it is a favourable development that the slow and gradual increase in the annual average turnover after the crisis also continued in 2014 on the depo market (*Figure 1.*).

Another important feature of the unsecured interbank market – in addition to the fact that this market has the lowest turnover among the key domestic money markets – is that significant activity can only be observed in tenors of less than 1 month, and most of the transactions are made by the banks in the shortest, one-day segment.

In 2014, most of the deals were also concluded with the shortest O/N tenor by the market players. In the case of longer maturities, turnover was lower and gradually decreased with the increase in the term. While deals with overnight tenors were concluded on each trading day, 3-month unsecured interbank deals were only concluded on 47 days, for a total of 49 such transactions in 2014. All of this implies that in spite of the moderate increase in interbank market turnover, the frequency of deals with longer tenors is still low, and for lack of real market transactions, this makes the quoting practice of interbank reference rates difficult, as the panel bank involved in quoting has to consider other data sources as well, instead of transactions observed on the reference value market. Compared to previous years, the annual amount of contracts with tenors of 3 months declined slightly in 2014, but the frequency of transactions increased, while annual turnover with tenors of 6 months increased significantly, just like the frequency of transactions.

All in all, we can say that similarly to previous years, activity remained low in the 3-month and 6-month segments of the unsecured interbank market in 2014, and the liquidity of the 6-month tenor is still below that of the 3-month tenor, in spite of the increase.

#### **4. Considerations in Formulating the Analytical framework**

As we already noted, the importance of BUBOR quotations is very significant from a number of aspects, and therefore it is important that the quotations are defined in a transparent, authentic, and reliable way, and reflect real market conditions and the widest possible information base without distortion. For this purpose, we considered five key considerations in the formulation of the analytical framework.

##### **4.1. Checking the adjustment of quotations to market prices**

Although there are usually no transactions behind banks' quotations, it is a key objective to ensure that quotations correspond to market conditions. That can guarantee that BUBOR is defined on the basis of the latest information base, in

such a manner that increases market efficiency and that financial products are priced in a way that is reassuring and “fair” for the general public as well. In this respect, it is a good idea to compare BUBOR quotations with yield levels emerging on other markets.

*Duffie–Stein (2014)* demonstrated that, as interbank reference rates gain ground, their use has also become widespread on a number of other markets which are not directly related to the costs of interbank fund placement. All of this means, for instance, that reference rates based on the interest rates of less liquid interbank market transactions also serve as a benchmark on the derivative market with much higher turnover. In the case of a large derivative portfolio, a slight modification of the reference rate may result in a significant change in cash flows related to the derivative portfolio, which might be an incentive to divert the reference rate.

#### **4.2. Identification of panel banks that regularly divert from the average**

In respect of diversions from the average, naturally the focus may be on diversions that last longer and that are significant and one-way, but it is difficult to draw the line for the term and the extent. During the examination, this consideration should be used in relation to other analytical methods (e.g. examination of interest rate derivative positions).

There may be several reasons why individual quotations are different from the official BUBOR quotation. The “natural” factors include the following:

- different rate expectations of banks;
- difference between the risk premiums of banks;
- if the liquidity position of the given bank is permanently unfavourable, or it can collect funds at a higher cost, it will probably offer funds to other banks at higher cost, and thus it will quote higher rates;
- on the other hand, the stricter internal rules of the bank may also be the reason for its lending with yields higher than the average;
- experience shows that the standard deviation of quotations increases in an uncertain money market environment.

It is important to note that the code of conduct strengthening the control process of rate quotations is presently being elaborated, and that may offer some guidelines to panel banks for the consideration of factors that influence quotations.

Therefore, quotations that permanently differ from the average may have several justified reasons. The objective is to separate natural reasons from intended

manipulation. While manipulation distorts the market, the above mentioned factors are natural characteristics of rate quotations and facilitate the integration of information.

#### **4.3. Improvement of data quality**

In international practice, examples were found when quotations were submitted unchanged for a longer period of time.<sup>7</sup> Quotations that get stuck indicate that the quoting bank does not reflect the information collected from the changes in the market environment in its rate quotations, which is against the objectives of the functions to be served by BUBOR. For the improvement of the information contents of interbank fixing, it is important to filter out unchanged or stuck quotations, as well as incorrectly submitted rate quotations.

#### **4.4. Support for bank treasury staff involved in quotation**

The production and publication of regular examinations related to BUBOR quotations and the strengthening of communication among the parties may facilitate the work of panel banks, and, in connection with the previous point, may encourage them to improve the quality of data submitted.

#### **4.5. Audits should not jeopardise the existence of BUBOR**

In the establishment of the regular analysis and checking of BUBOR quotations, one important consideration is that these activities should not punish panel banks and should not reduce the motivation of banks to submit quotations. If the range of active quoting banks is wide, the BUBOR fixing provides a wider scope of information on interbank lending conditions; therefore, the objective is to make sure that the number of panel banks does not drop after the strengthening of external control. This consideration is especially important for the trimmed average used for the establishment of fixing, as a reduction in the number of data points may have a negative impact on the robustness of fixing.

At the end of 2012, 16 banks were participating in the quoting of BUBOR, while presently only 9 are involved. The higher number of active quoting banks reduces the possibility of manipulating BUBOR, because the highest and lowest values are ignored, and extreme or “diverted” values are not included in the average. However, in the case of fewer quoting banks, the extent of trimming is lower as well, which might give a chance to consider possible manipulating quotations.

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<sup>7</sup> *EBA–ESMA (2013)*.

## 5. The Hungarian framework and the results of the examination in 2014

In the following, we describe the six key methods used in the Hungarian analysis framework and demonstrate their use on the example of the examination of 2014. In our analysis, we focus on the 3-month BUBOR only, but it is important to note that we also conducted analyses for the equally important 6-month maturity and obtained similar results.

Based on theoretical considerations and international experience, several signs should be checked in quotations; some of these may be related to data errors and others to possible manipulation. Patterns to be examined from the aspect of data errors include stuck or extreme quotations. In respect of manipulation, it is worth examining individual extreme quotes, quotations that permanently differ from the average, the relations between individual quotations, the time series features of quotations and the relations with interest rate positionings. We tried to enforce these considerations in formulating the framework.

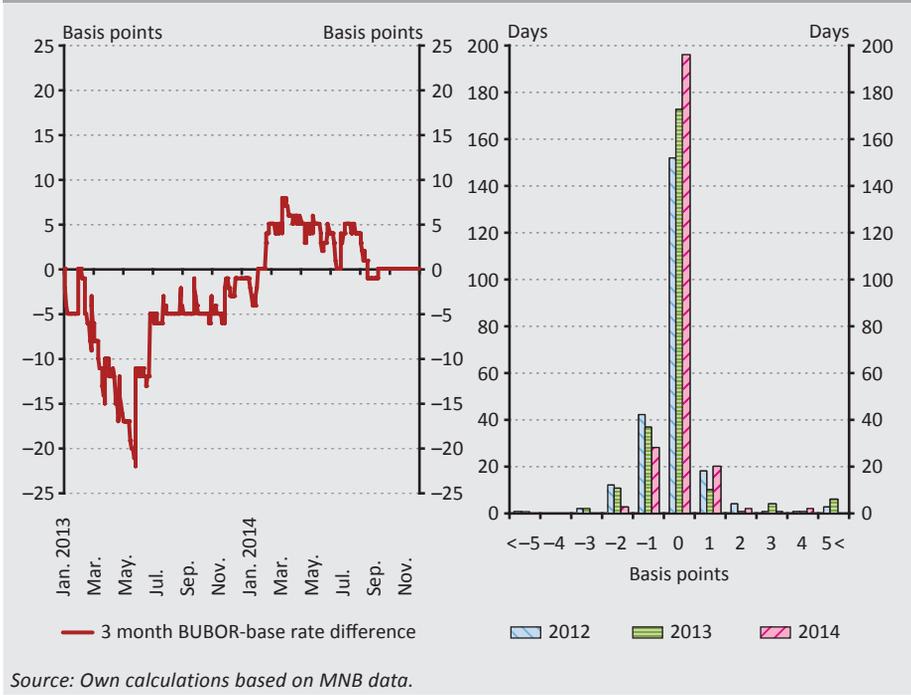
### 5.1. Identification of stuck quotations

International reference rate analyses show that the unchanged nature of quotations (when they get stuck) may be a problem. For the improvement of the information contents of interbank fixing, it is important to filter out unchanged or stuck quotations and to identify incorrectly submitted quotations.

In 2014, the banks quoted BUBOR on 252 days. In the first 7 months of the year, 10 quoting banks listed BUBOR, and then for the rest of the year, the number of quoting banks dropped to 9. Within the 252 daily fixings, the 3-month BUBOR changed overnight on 57 occasions, and in other cases, a value corresponding to the value of the previous day became the daily BUBOR fixing, which means that in 77% of the cases, the 3-month BUBOR fixing was identical to the previous day's value. In this respect, there seems to be a sharp difference between the first and second half of the year: in the first half of the year, the fixing was unchanged in 68% of the cases, while in the second half, this ratio climbed to 87%. The change observed in the development of 3-month BUBOR quotations may have been supported by the end of the rate-cutting cycle and expectations of rates being maintained, and with the unchanged nature of the base rate, these factors may have reduced the volatility of BUBOR quotations as well.

Based on the daily fluctuations of the 3-month BUBOR, it can be said that in the past 3 years, the fixing was more and more closely related to the base rate (*Figure 2.*). This implies that compared to the base rate, BUBOR has not offered any additional information lately. This historic trend was present in 2014 as well, in the development of the Hungarian reference rate: the longest period in which the 3-month BUBOR fixing did not change was 58 days. At that time, the emerging

**Figure 2.**  
**Development of the difference between 3-month BUBOR and the base rate (left panel), and distribution of the daily changes of the differential in the past 3 years**



fixing remained at 2.1%, the level of the central bank base rate from the beginning of October to the end of the year.

At the level of individual banks, we evaluated the volatility of bank quotations on the basis of three considerations. First, we examined how many times a bank modified its submitted quotation, and then we checked the maximum length of possible stuck periods. Finally, with the length of the average stuck period, we tried to show the average number of days for which the quotations submitted by panel banks remained unchanged during the year.

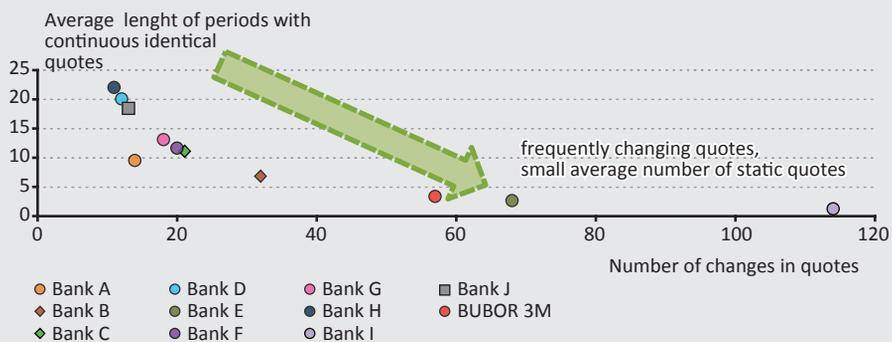
The results indicate that 7 among the 10 rate quoting banks submitted a quotation different from the previous day's on maximum 20 occasions, which indicates low volatility, but this cannot be considered as general, because two banks modified their BUBOR quotations fairly often.

The maximum lengths of stuck periods also show different pictures in the case of various panel banks: the length of unchanged quotations exceeded 50 trading days in the case of 6 banks, but in the case of banks that frequently modified their

quotations, the lengths of stuck periods were effectively shorter. It is interesting to note that from October until the end of the year, i.e. the end of the examination, 6 banks quoted BUBOR at unchanged levels. This resulted in the BUBOR fixing also remaining at 2.1% in the period from 8 October to 31 December.

Based on the average length of stuck periods, the banks moved in a wide spectrum, and the picture of the conduct of individual panel banks seems to be identical to the picture given by the other two “getting stuck” indicators (*Figure 3.*). At Banks I and E on the edge of the spread, long stuck quotations were less frequent, as they often modified their quotations. However, the high value of the average length of stuck periods at some banks indicate that long-lasting unchanged rate quotations happened not only on a few occasions, but are a fairly frequent phenomenon. The high number of quotations stuck at the same time indicates that most of the banks did not make any change in their quotations, and this may imply the stability of market conditions or the improper channelling of market information.

**Figure 3.**  
Length of average unchanged quotations of quoting banks and the number of modifications



Source: Own calculations based on MNB data.

Although it is rather difficult to define how often BUBOR quotations should change on average, when the central bank base rate changes, it is usually justified to modify the quotations, so these cases can be examined separately.<sup>8</sup> In the 3-month term, we found stuck quotations in the case of 5 banks in the rate-cutting environment. Owing to the calculation methodology of the BUBOR, these individual stuck quotations did not influence the official quotation in 2014. In the quoting of the 6-month BUBOR, it happened slightly more frequently that the banks did not immediately reflect

<sup>8</sup> In the autumn of 2013, the individual rates stuck after the base rate changes resulted in a situation that the 3-month BUBOR was adjusted downwards only with delays of a few days, after the interest rate cuts.

the base rate change in their quotations, but we did not experience a significant difference in the conduct of the banks regarding these two terms.

In general, we can say that the reduced volatility of the BUBOR fixing, the low frequency of the modifications of individual bank quotations, and the length of stuck periods imply the fact that interbank market conditions were not reflected at all in the BUBOR quotations in certain periods, or only to a limited extent. Looking at the indicators of stuck periods together with stuck rates following the base rate changes, two banks acted differently from other active quoting banks: Bank H seldom modified its rate quotation, even compared to other banks, and submitted unchanged quotations already from July, while Bank I was on the other edge of the spectrum with its activity.

## 5.2. Relation to alternative market benchmarks

BUBOR quotations reflect money market information which may appear in other reference rates as well, and thus it may be worthwhile to review their relations and their changes in time, as this may also be indicative for the explanation of the development of BUBOR. We compared the BUBOR quotations to the development of 4 alternative indicators. The *base rate* influences interbank rates – including the BUBOR level reflecting costs of funds by definition – through the various channels of monetary transmission. The comparison of *FRA yields* with BUBOR is relevant because the parties to the agreement make a bet on the future value of the reference rate, i.e. the FRA yields reflect market expectations regarding rates. The advantage of FRA yields is that it is a liquid market, but in comparison with BUBOR, one disadvantage is that the capital amount does not change hands, i.e. credit risk is not reflected in the rates.<sup>9</sup> The *FX swap market implied HUF yield* reflects the rate of the secured FX market transaction interest rate. Similarly to BUBOR, both interest rate and liquidity risk factors can be detected in the development of the *3-month discount Treasury note*, but apart from the interbank market processes, other impacts such as the default risk of the state are also reflected in T-bill yields.

In examining the relation with other benchmarks, the analysis of correlation data is also an option, but as a result of the low volatility of BUBOR (see *Figure 2.*), this method is not informative under the Hungarian conditions. Therefore, we examined the difference between BUBOR and alternative yield indicators.

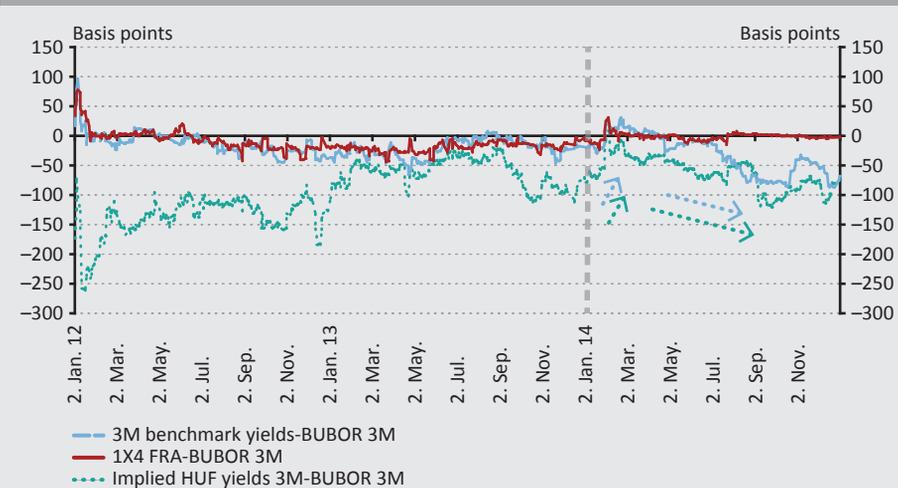
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<sup>9</sup> It is important to add that in the pricing of FRA deals, the parties use the expected future value of BUBOR as a base, and therefore the FRA rates also partly include the information reflected in BUBOR, and thus it is not a benchmark that is independent of BUBOR. On the other hand, the comparison of BUBOR and FRA quotations might still be justified, considering the fact that, owing to the higher turnover, the FRA market offers more information on the market rate expectations than the depo market and thus renders the picture of the financial market rates more complex. The relation of BUBOR to rate expectations is analysed in more detail by e.g. *Horváth et al. (2013)*.

The deviation of base rates and FRA yields from BUBOR did not really change during the year, as it stagnated around zero (*Figure 4.*). It is worth noting that at the beginning of the year, during the emerging market turbulence, interbank rates effectively increased, and thus the 1X4 FRA quotations increased by 43 basis points, and the EUR/HUF exchange rate rose from 305 to over 313 in 4 days. In the meantime, the 3-month BUBOR increased by 4 basis points to the level of the base rate, and then steadily tracked the central bank policy rate.

In the case of the three-month T-bill, an effective decline in yields started at the beginning of July, which continued even after the closing of the rate-cutting cycle of the end of July, but this was not reflected in BUBOR quotations. The low level of short-term government securities market yields was remained in place, all the way until the end of the year. This can be explained partly by the transformation of the set of MNB tools and the related change in the liquidity management of the banking system, and partly by the reduced issues by the Government Debt Management Agency. In addition to a number of other seasonal and individual factors, another aspect which was also partly related to the change in the set of central bank tools was that the HUF liquidity released after the transformation of MNB bonds into deposits may have increased the HUF supply on the FX swap market, which may have contributed to a reduction in the implied HUF yield, and thus to its deviation from BUBOR.<sup>10</sup>

**Figure 4.**  
**Difference between reference rates and BUBOR**



Source: MNB; Bloomberg

<sup>10</sup> The development of the FX swap market implied HUF yields is influenced among other things by the position of foreign players and the HUF liquidity of banks. The latter is influenced by a number of factors, for example the end-of-quarter impact or deposits and withdrawals related to the treasury account. In 2014, the central bank introduced its self-financing programme, which may have further influenced implied HUF yields, in addition to the factors already mentioned and observed in earlier years.

All in all, in the course of 2014, BUBOR quotations were close to the key benchmarks, which means that BUBOR changed in harmony with other market indicators. The occasionally different dynamics were explained by individual factors affecting the benchmarks, i.e. the reason was not a change in the dynamics of BUBOR.

### 5.3. Outlier quotations

From the aspect of the reliability of the BUBOR fixing, the identification and examination of outlier rate quotations is of special importance. A quotation that is effectively different from the average rate quotation may indicate a data error, a shock affecting the individual bank, or even deliberate manipulation.

#### 5.3.1. No significant data quality problems originating from mistyping in 2014

The time series of individual bank quotations moved together in 2014, and quotations differed from the average, i.e. from the BUBOR fixing, to a small extent only. It is a positive phenomenon, that in the case of quotations submitted in 2014, no outliers suggesting data errors can be identified, which means that problems of data quality nature originating from mistyping did not deteriorate the reliability of BUBOR in the last year.

#### 5.3.2. No outliers found in individual bank quotations

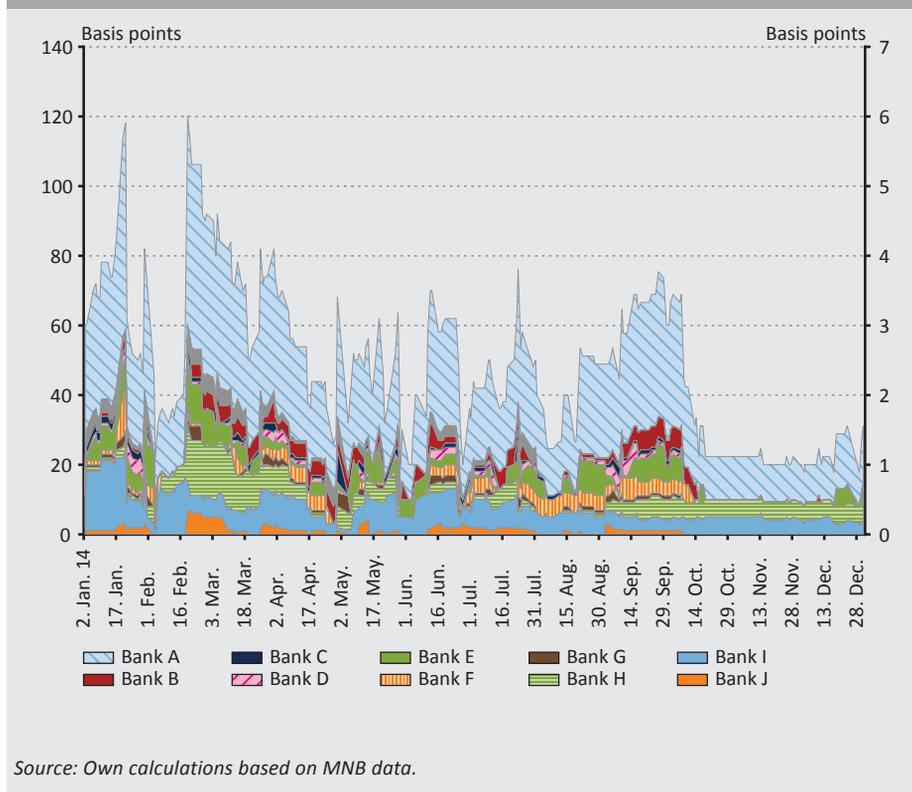
The value of the absolute difference calculated from the 3-month BUBOR of active quoting banks moved in a narrow band in 2014, between 1 and 6 basis points on an average (*Figure 5.*).<sup>11</sup> The differences compared to BUBOR were extremely high on two occasions, both times in connection with the drop in the central bank base rate, but the difference was not caused by an outlier value but by stuck quotations, because in the environment of the February base rate cut, one of the banks did not modify its quotation.

Individual quotations which are different from the official BUBOR quotation can be explained by several natural reasons, such as the different rate expectations of banks, the difference between the risk premiums of banks, the stricter internal rules of the banks, or their changed liquidity position. Therefore, quotations permanently different from the average may have several reasons, which is measured in the examination with the average of the absolute difference from BUBOR. A significant difference compared to the average may mean that other effects may have driven the rate quotation as well, in addition to natural factors. In the respect of 3-month BUBOR quotations, a difference from the average by more than 10 basis points was observed in the case of 3 banks last year, but outlier individual bank quotations were not the reason for any difference.

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<sup>11</sup> The absolute differences are the differences in absolute values between the individual quotations of quoting banks and the official BUBOR of the given day. Therefore, we did not consider the direction of the difference, only its rate. The average absolute difference refers to the average of differences experienced at the panel banks.

**Figure 5. Absolute differences of rate quotations of banks from the 3-month BUBOR in 2014**

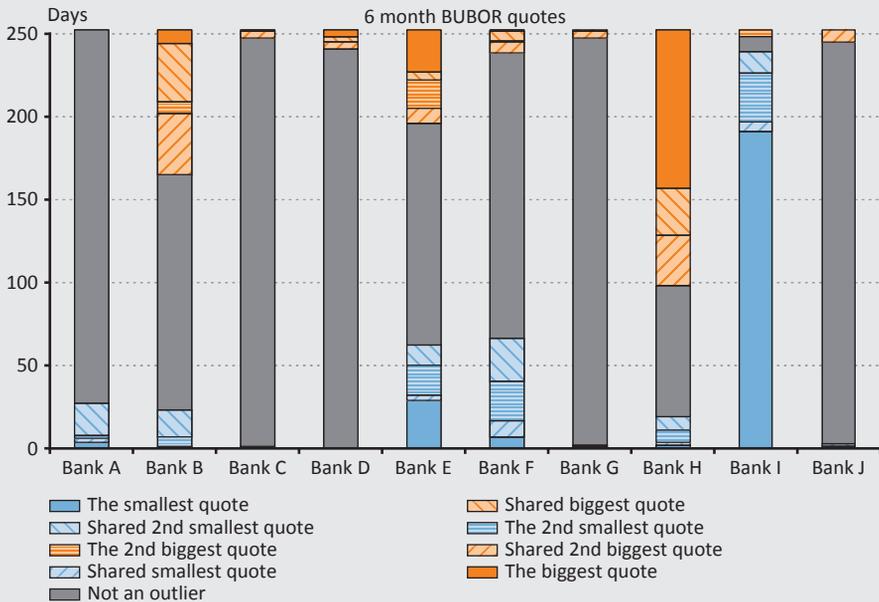
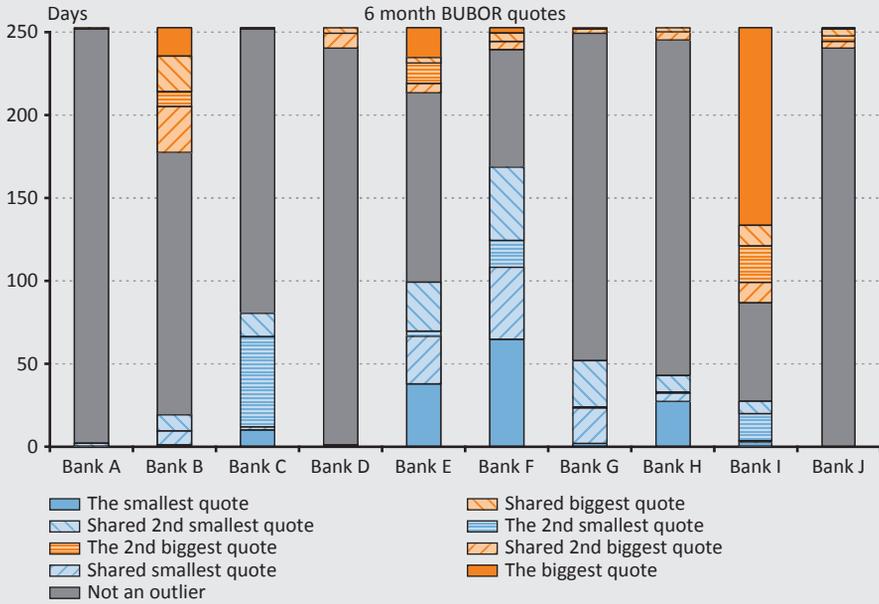


### 5.3.3 Quotations to be eliminated

The effects of outlier values can be mitigated by the trimmed averages used in the generation of interest rate fixing, when in the case of certain quotation number the upper and the lower values are ignored in a certain proportion. A different rate quotation activity may be indicated when a bank's rate quotations are regularly excluded from the trimmed average, but it is also possible that the difference can be explained with natural reasons. In the definition of the quotations to be eliminated, it may be a problem that several banks submitted the same quotations at the tails of the dispersion. In that case, the extreme value to be eliminated is not considered to be an outlier. (In the examination, we applied the rule that when more than two banks submitted the same value, the quotation was not included as an outlier.)

Last year, the 3-month BUBOR quotation of Bank I proved to be the lowest quotation in more than three quarters of the cases, which means that it did not only regularly deviate downwards from BUBOR, but that it also provided the smallest quotation among the panel banks. Bank I was often at the bottom of the range not only as

**Figure 6.**  
**Frequency of potentially ignored quotations of panel banks**

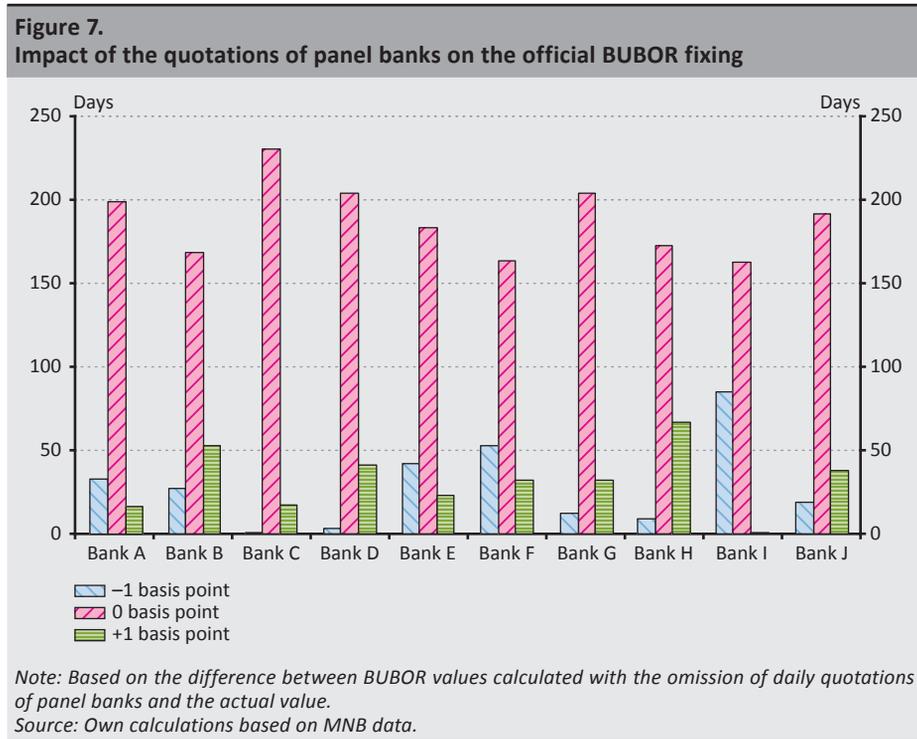


Note: Cases when the number of identical rate quotations was more than two were not considered as outliers, while the two identical extreme values were put into the divided category.

Source: Own calculations based on MNB data.

the lowest value, but as the second lowest value as well. Similarly to the smallest quotation, the highest quotations were concentrated in the quotations of one bank. In more than 50% of the cases, Bank H quoted the highest BUBOR value among the panel banks, which can be explained with the quotations stuck at a level higher than the average in the second half of the year (Figure 6. ).

However, it can be stated that during the year the quotations of individual banks did not affect the official BUBOR fixing (Figure 7.), and when it did, it was by a maximum of 1 basis point, which is a negligible extent.



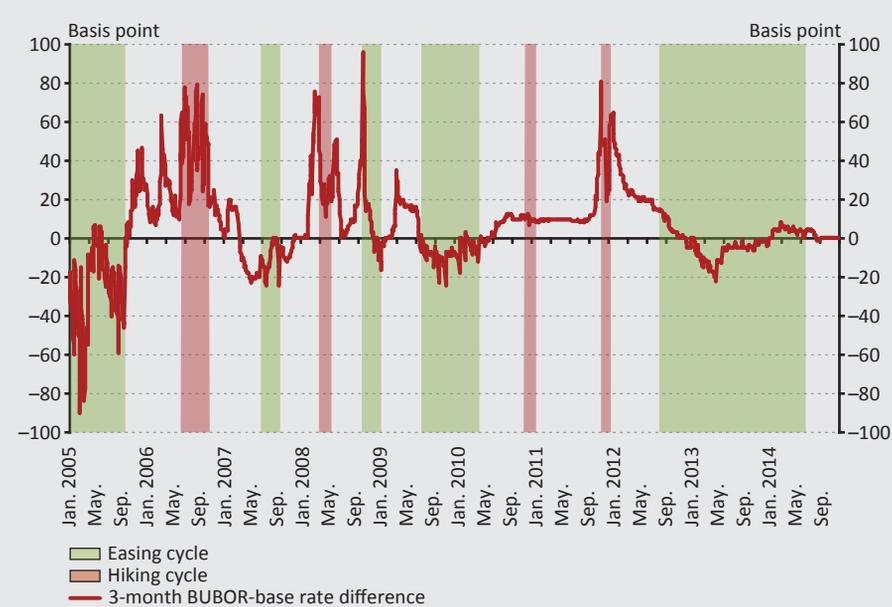
All in all, it can be stated that the differences of individual bank quotations from BUBOR are of a moderate extent, and the differences refer to stuck quotations, and not to outlier rate quotations. In some cases, the turbulent market environment at the beginning of the year and the slowdown and end of the MNB rate cycle may have contributed to the difference between individual bank quotations and BUBOR. Based on the quotations to be eliminated in the calculation of the trimmed average, there were banks which behaved differently from the average, but individual quotations had no effective impact on the official fixing. The individual differences should be examined together with other considerations.

#### 5.4. Identification of structural breaks

From the aspect of the examination of the quotations, it is also a relevant issue whether there is a turning point in the development of BUBOR quotations which indicates a serious change in conduct. First, we examine the official 3-month BUBOR quotation and then turn to the conduct of individual panel banks.

As BUBOR shows a strong relation to the base rate, we primarily examine this relationship, which gives us a chance to analyse the changes justified by general market trends. Based on the observations from the past 10 years (Figure 8.), we can say that the relation of the 3-month BUBOR and the base rate is effectively defined by the rate cycle the MNB is currently in: in increasing cycles and at times of unchanged base rate, the 3-month BUBOR is usually over the level of the base rate, and in decreasing cycles, it moves below that. The background to this phenomenon consists of several related factors. On the one hand, the expectation regarding the two-week interest rate may appear in BUBOR, which can explain the observed relation. On the other hand, the rate cycles are related to the changes in the risk premium, which may affect the BUBOR level as observed. Thirdly, the 3-month BUBOR may contain premium factors as well (e.g. maturity premium<sup>12</sup>), which justify

**Figure 8.**  
Development of the difference between 3-month BUBOR and the base rate in the MNB rate cycles



Note: The positive values mean a 3-month BUBOR level higher than the base rate.  
Source: Own calculations based on MNB data.

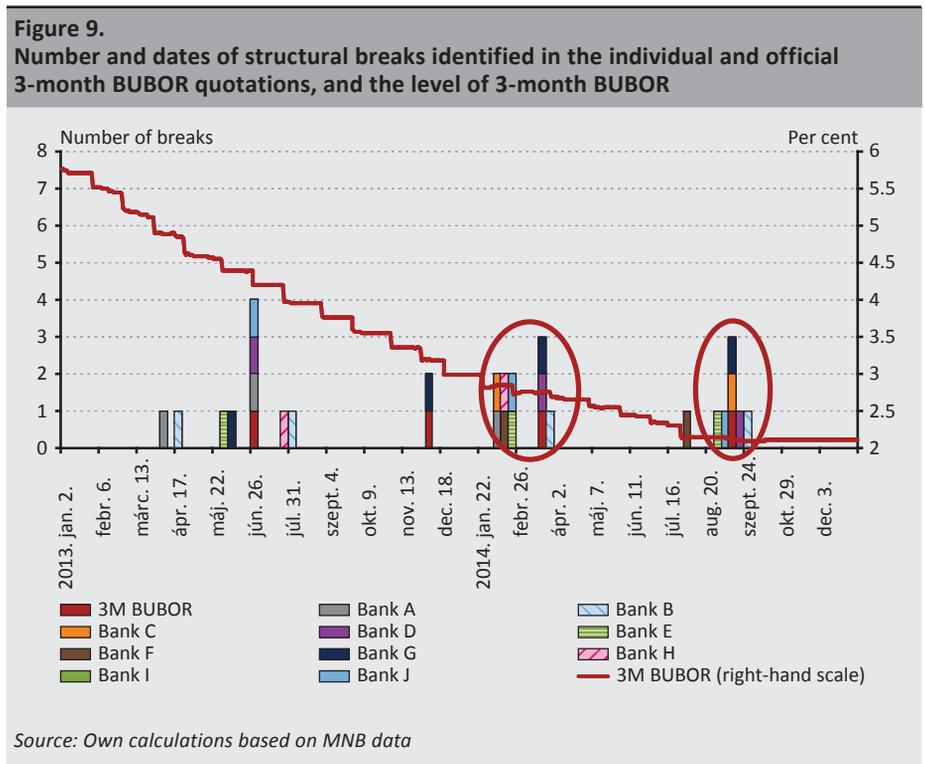
<sup>12</sup> See e.g. Horváth et al. (2013).

the fact that in calm periods and at times of an unchanged central bank rate, BUBOR is over the base rate level.

In 2014, at the time of the slowdown and then the end of the MNB rate-cutting cycle, changes corresponding to the pattern of previous years took place in the BUBOR-base rate differential: in the last months of the cycle, the difference started to increase, and then it entered the positive range that is a feature of maintaining periods. By the end of the year, the difference stabilised at 0 level, which can be partly explained by the forward guidance of the MNB in relation to leaving the level of the base rate unchanged. The 3-month BUBOR tied to the base rate also means that in the second half of 2014, BUBOR did not present any additional information compared to the base rate.

All in all, we can say that in 2014, the change experienced in the development of the 3-month BUBOR corresponds to the pattern observed at the time of closing base rate cycles in the past, and is in harmony with the course justified by theoretical considerations.

Based on the statistical analysis of the official 3-month BUBOR time series, two major breaks can be identified in the time series in 2014 (*Figure 9.*): early spring and



end of summer. The change in the behaviour of individual quoting banks is related to these two dates, although there may be a difference of a few weeks. It is important to point out that it is possible to identify an event for both dates which may explain the change in the conduct of panel banks. In the case of the early spring time, the slowdown in the MNB rate-cutting cycle, and in the case of the end of the summer, the end of the rate cycle may have been important background factors, which can explain the change in the behaviour of the BUBOR quotations.

#### Methodology description: Structural breaks

We looked for the structural breaks of time series with the so-called Bai-Perron test.<sup>14</sup> Technically, the test determined the break points of the linear trend adjusted to the time series of the difference between individual quotations and BUBOR. Thus, with this method, the changes in the conduct of the panel bank are identified on the basis of the relation to the official BUBOR quotation. For the sake of more precise estimates, we carried out the test for the period of 2013–2014, but the analysis focused on the break points of 2014 only. In the case of the official BUBOR quotation, the BUBOR-base rate differential was used.

### 5.5. Cluster analysis

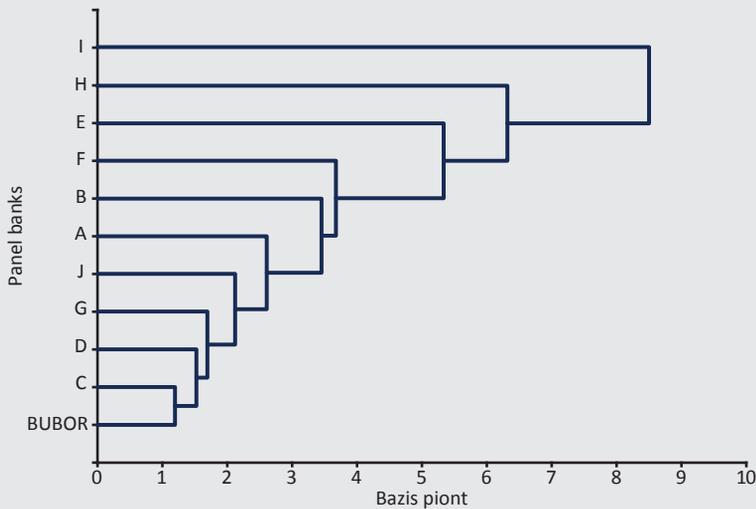
The cluster analysis can be used to examine the relation of individual quoting strategies, allowing us to answer the question of whether it is possible to identify some groups among market makers who behave in a different way. Based on the results (*Figure 10.*) we can say that there is no separate group among the BUBOR quoting banks whose conduct is effectively different from the others, and thus there is no sign of coordination between panel banks.<sup>14</sup> Based on the dendrogram summarising the results of cluster analysis, the [A, J, G, D, C] group followed the official BUBOR quotation more closely than the others. Among the panel banks which followed the official quotation more loosely, Bank I was different. It is an important result that this structure suggests that every entity adjusted primarily to BUBOR, and not to another player or group of players.

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<sup>13</sup> Bai et al. (2003).

<sup>14</sup> We obtained similar results in the case of 6-month quotations.

**Figure 10.**  
**Dendrogram of hierarchic cluster analysis produced on the basis of 3-month BUBOR quotations**



*Note: The distance of market makers and clusters on the horizontal axis may be interpreted as daily average base point difference. Clusters created at a lower level indicate the closer relation of elements. Source: Own calculations based on MNB data.*

**Methodology description: Cluster analysis**

In the course of the hierarchic cluster analysis, we examined the similarities between the individual quotations and BUBOR time series. In the first step of this process, the “distance” of the time series per pair is defined, which in this case is interpreted as the square median of the difference of daily quotations (“Euclidean distance”) which can be interpreted as the daily average basis point difference. Then we define the two closest time series and combine them in one cluster. In this case, this meant the official BUBOR quotation and the time series of bank C, at the basis point level of 1.2. After that, we find the shortest distance again, but instead of the already combined two time series, we use the average difference from these. If the shortest difference is between two “intact” observations, we will create a new cluster from them, but if the difference between an existing cluster and a new time series is the smallest, this cluster is extended with a new time series. This process goes on until all constituents have been put into a group. Based on the dendrogram, the sequence of combinations and the distance among groups can be examined. In our case, in each step, a new time series was added to the already existing cluster, i.e. the time series of each panel bank was around the BUBOR (common average), in a way that they effectively differed from each other in pairs.

### 5.6. Relation between interest rate derivative positions and BUBOR quotations

The relation between individual BUBOR quotations and the interest rate derivative positions (FRA, IRS and CIRS) was examined using multi-variable regression. For the analysis, we estimated for each bank to what extent the difference between individual BUBOR quotations and the official BUBOR can be justified by the Hungarian CDS spread, the EUR/HUF exchange rate, the base rate and the individual interest rate derivative position (Table 1.). In the regression, the use of the first three common financial variables allows that we take into consideration the fact that the panel bank defines its new individual BUBOR quotation related to these indicators. We tested the analysis with similar results on several partial samples; we analyse the results for the whole sample only.

According to the results, the interest rate derivative positions of Banks G, J and D show significant positive correlations with the BUBOR quotation. In these cases, we examined the development of positions and quotations in more detail as well. Based on the examination, two independent factors may have played a role in the fact that there seems to be a significant relation between the interest rate derivative position and BUBOR quotations. One of the factors is the end of the rate-cutting cycle of the MNB and the message that the rate level would be left unchanged, as a result of which banks submitting higher BUBOR quotations started to submit quotations corresponding to the base rate. The other factor is that as a result of the MNB CIRS tenders related to the conversion of FX loans to HUF, the net CIRS portfolio of banks has fallen. In the second half of the year, these two factors together resulted in the concurrent reduction in the interest rate derivative portfolio tied to the 3-month BUBOR and the BUBOR quotations. This concurrent move is identified by our regression as a relation of positive direction, but there is probably no manipulation intent behind this relation.

*All in all, we can say that the BUBOR quoting practice of banks does not show any relation with the individual interest rate derivative positions in addition to the extent justified by external factors.*

**Table 1.**  
**Results of regressions explaining the difference between individual quotations and BUBOR, by bank**

	B	D	E	F	G	H	I	J
c	-0.13 (-0.5)	-0.57 (-3.46)	-0.06 (-0.15)	1.27 (4.13)	-0.05 (-0.33)	-1.06 (-3.29)	-1.1 (-5.61)	-0.41 (-2.38)
CDS	5.52 (0.7)	19.55 (3.9)	1.17 (0.1)	-34.66 (-3.97)	3.94 (0.85)	35.73 (3.65)	33.53 (5.65)	11.07 (2.1)
EURHUF	-0.04 (-2.37)	-0.02 (-1.58)	0.16 (5.28)	0.11 (5.69)	0.01 (1.11)	0.14 (5.55)	0.16 (10.93)	0.04 (3.46)
base rate	3.45 (1.33)	-2.48 (-1.37)	-11.65 (-3.16)	-14.97 (-4.99)	-6.66 (-4.26)	-11.41 (-3.6)	-14.08 (-7.83)	-1.46 (-0.92)
position	-0.04 (-1.04)	1.91 (6.71)	0.07 (1.19)	-0.2 (-3.74)	0.25 (12)	0.03 (1.26)	-0.36 (-14.11)	0.11 (5.79)
R <sup>2</sup>	0.05	0.23	0.18	0.21	0.39	0.28	0.66	0.24

*Note: In brackets behind the regression coefficients: t-statistics. c: constant; CDS: 5-year Hungarian CDS-spread; EURHUF: euro/forint exchange rate; base rate: MNB base rate; Position: the institution's daily interest rate derivative position tied to BUBOR (FRA, IRS, CIRS).*  
*Source: Own calculations based on MNB data.*

## 6. Conclusion

The statistical approach presented is suitable for the identification of certain signs of manipulation and the detection of systematic behaviour patterns, but it can be considered as an indirect instrument only, which has its limitations. Direct insight into the activities of panel banks is provided by official examination methods and internal bank audits only, but statistical analyses may compliment other audits, and may have a favourable impact on the quality of BUBOR quotations.

All in all, we can say that on the basis of the statistical analysis of BUBOR quotations in 2014, there is no condition that would require the further examination of the official BUBOR fixing or the individual bank quotations.

The reduced volatility of the BUBOR fixing, the low frequency of the modification of individual bank quotations, and the length of stuck periods indicate that in certain time periods, market conditions are not reflected in the BUBOR rate quotations, or only to a limited extent. On the other hand, it can be seen that in the course of 2014, the occasionally stuck individual quotations in the environment of the changes to the base rate did not really influence the BUBOR level, owing to the calculation methodology. In connection with the conduct of individual banks, several analysis methods show that Banks I and H follow a quotation strategy that is effectively different from the strategies of the other panel banks. However, while Bank I differs from other quoting banks with its activities, Bank H differs with its inactivity and often stuck quotations.

In the course of 2014, the BUBOR quotations were close to the key benchmarks, and the occasionally different dynamics can be explained with individual factors affecting the benchmarks. All in all, it can be stated that the differences of individual bank quotations from BUBOR are of a moderate extent, and tend to suggest stuck quotations, and not stem from outliers in rate quotations. The structural change observed in 2014 in the time series of individual quotations and the fixing corresponds to the pattern observed in the past at the time of ending rate-cutting cycles, and is in harmony with the dynamics justified by theoretical considerations. The individual quotation strategies are significantly different, and the methodology used found no signs of coordination. The BUBOR quoting practice of banks does not show any relation with the individual interest rate derivative positions in addition to the extent justified by external factors.

With further processing of the findings of the Hungarian analysis methodology, the methodology may change in the years ahead. Our findings collected so far are summarised in the table below.

**Table 2.**  
**Summary table related to the Hungarian examination methodology**

Method	Description	Advantages	Drawbacks
Identification of "stuck" quotes	Identification of stuck quotes and other "obvious" errors	Strengthening the information content of BUBOR	It is an ex post tool, it can not prevent errors
Analysis of benchmarks	Analysis of the connection between BUBOR and other benchmark rates	Development of other benchmarks can shed light on the factors influencing BUBOR	Noisy connection
Outlier detection	Identification of the most frequently trimmed panel banks	Capable of identifying banks with significantly different strategy	Different strategy often reflects different conditions ("natural causes")
Cluster analysis	Identification of banks with similar strategy	It can indicate cooperation	It is quite difficult to define what "similar" means
Structural breaks	Identification of structural breaks in the time series of individual quotes and of the fixing	Identification of behavioral changes	A number of "natural" causes can trigger a behavioral change
Analysis of derivative positions	Linear regression between the derivative position and the quotes	It can reveal manipulation motivations in connection with the BUBOR exposure	A number of "natural" causes can be in the background

Source: Own compilation based on the results.

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