ECONOMY AND FINANCE • VOL. 10. ISS. 2 • JUNE 2023 • DOI: 10.33908/EF.2023.2.1

QUANTITY ADJUSTMENT ON THE UNSECURED INTERBANK FORINT DEPOSIT MARKET[1]

Zoltán Pollák – Erika Jáki[2]

ABSTRACT

On the unsecured interbank markets, if a bank perceives that a counterparty has an increased default risk, it can respond by raising the interest rate (price adjustment) and reducing the amount of loan available (quantity adjustment). In the interbank deposit market, the most important factor is clearly quantity adjustment rather than price adjustment. For a deeper explanation of the quantity adjustment, we examined the concentration of lending and borrowing in a database covering all interbank transactions between 2012 and 2015. Both the Gini and Herfindahl-Hirschman indices showed that borrowing was more concentrated than lending in terms of both volume and number of transactions. Loans were provided by an average of 10-15 active banks typically to only 5-8 borrowers in the period examined. We tested this observation by using a two-sample z-test to compare expected values and confirmed a significant difference in concentration between the borrowing and lending sides of the interbank market. The more even distribution of the lending transactions can be explained by the fact that structural liquidity surplus was typically experienced in the Hungarian interbank market. The high concentration of the borrowing transactions derives from the partner limits.

JEL codes: G15, G21

Keywords: unsecured interbank deposit market, quantity adjustment, partner limits, concentration analysis

1 This research was supported by the New National Excellence Programme of the Ministry for Innovation and Technology and National Research, Development and Innovation Fund.

2 *Zoltán Pollák* college associate professor, Budapest Business School, Faculty of Finance and Accountancy, Department of Finance. E-mail: pollak.zoltan@uni-bge.hu.
Erika Jáki associate professor, Budapest Business School, Faculty of Finance and Accountancy, Department of Finance. E-mail: jaki.erika@uni-bge.hu.

1 INTRODUCTION

The platforms of the banks' liquidity management are the unsecured interbank HUF deposit market and the forint repo market, where the more important goal of the participants is usually to smooth out the imbalances in their net liquidity position with short-term borrowings and deposits or repo transactions. Excess liquidity reduces the profitability of a credit institution, and, on the other hand, a lack of liquidity can jeopardise solvency. At the same time, liquidity risk is an asymmetric risk for banks. Not investing excess liquidity – especially in the current low-yield environment – is nowhere near as much of a problem as failing to obtain extra funds (or only very expensive). In Hungary, the most important platform for banks' liquidity management is the unsecured interbank forint deposit market, so we focused our research on this market.

In *Chapter 2*, we describe the most important characteristics of unsecured interbank credit transactions, of which the lack of financial collateral together with the significant volume may create significant risk. In the unsecured interbank forint deposit market, the most important factor is quantity adjustment rather than price adjustment. Quantity adjustment is mostly achieved through partner limits.

In *Chapter 3*, we first examine the evolution of monthly aggregated transaction amount, and for a deeper explanation of the quantity adjustment, we compare the concentration of lending and borrowing.

The relevance of the analysis and our choice of topic lies in the concentration-related connections published in the academic literature. We compare the obtained results with the *Berlinger–Michaletzky–Szenes* (2011*)* study. The authors studied the network dynamics of the Hungarian unsecured interbank HUF deposit market for the period between December 2002 and March 2009. Their study found that the different network metrics and the general features of the market were stable until 2006–2007, after which – as if forecasting the crisis –, part of the indicators began to change. We partly considered this study the preamble of the present study when we examined the data series of the same market between 2012 and 2015.

2 THE HUNGARIAN UNSECURED INTERBANK DEPOSIT MARKET

The inherent feature of banks' activities is that their liquidity position is constantly changing. The primary platform for eliminating their possible liquidity shortage and disbursing their temporary excess liquidity is the unsecured interbank deposit market.

First, we review the main features of interbank loans, then we focus on the limits that determine the market as a whole.

2.1 Characteristics of the interbank loans

As a result of their activities, banks may generate excess liquidity or a lack of liquidity on a daily basis (or even more frequently). Excess liquidity is disbursed and liquidity is mainly obtained on the unsecured interbank HUF deposit market or the forint repo market. The main difference between the two markets lies in counterparty risk.

Repos are backed by securities as collateral, which almost completely eliminates counterparty risk. In some countries (such as Turkey or Australia), the interbank market typically suffers from a structural lack of liquidity, so local banks continue to lend in some form (usually through repos) to their central bank. In these countries, repo transactions can be considered the main monetary policy instrument in most cases (*Kollarik–Lénárt-Odorán*, 2017).

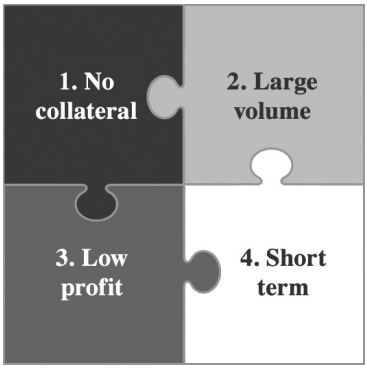
In contrast, the typical excess liquidity banking systems, such as the Hungarian one, encounter much larger loan volumes in the interbank deposit market than in the repo market (Berlinger–Michaletzky–Szenes, 2011). The average daily turnover of the latter unsecured HUF deposit market amounts to seven times the turnover of the repo market (*Erhart–Mátrai*, 2015).

Besides interbank markets in the region, not only the Hungarian one but also the Polish (*Smaga* et al., 2018), the Czech, the Lithuanian and the Estonian banking sectors typically have structural liquidity surplus (*Hryckiewicz*, 2021).

The low weight of the repo market in bank liquidity management can be explained mainly by legal obstacles and the low limits between the participants. The MNB's survey of banks highlighted this, and a repo working group was also set up with market participants to solve the problems. The most important obstacles hindering market participants were the lack of a standard repo framework contract and the shortcomings of the settlement system of KELER Central Depository and ÁKK (Government Debt Management Agency) *(Kolozsi–Horváth, 2020)*.

Thus, the most important platform for banks' liquidity management is clearly the unsecured interbank HUF deposit market, which is similar in many respects to other financial markets, but has some special features (or rather a combination of these special features) that create different patterns than any other market.

Figure 1
General characteristics of interbank lending transactions



Source: own edition

Figure 1 shows the main features of interbank lending transactions. In the figure, the interlocking puzzle pieces symbolise that these features appear in other markets separately, while their co-occurrence forms a unique image to the interbank deposit market.

One of the most important features of the interbank deposit market is that the transactions (1) are unsecured, i.e. in the event of the counterparty's default, there is no credit collateral behind them from which even partial satisfaction could be obtained. In addition, this lack of collateral is often coupled with tens of billions of (2) large loan volumes, which induces significant risk (*Veres–Gulyás*, 2008). With such a high risk, (3) the profit margin for a provider of funds in the interbank market is very low, but access to funding from the other side is usually the cheapest here.

In addition to the above characteristics, it is worth noting that (4) the maturity of interbank loans is typically short compared to other markets. As the primary function of the market is liquidity management, one-day transactions are concluded in the vast majority of cases. A typical example is the overnight (O/N) loan, where the starting date of the transaction is the same as the date of concluding the contract, and the transaction closes on the next trading day.

2.2 The market as a whole is driven by limits – partner limits in the foreground

Moving from the characteristics of interbank loans to the characteristics of the market as a whole, an unsecured and significant exposure brings to the fore coun-

terparty risk in the interbank market. The actors constantly monitor and rate each other. If a bank perceives that a counterparty has an increased default risk, it can respond by raising the interest rate (price adjustment) and reducing the amount of loan available (quantity adjustment) (Berlinger, 2017).

It can be seen from the above that the presence of information asymmetry is very significant in this market (it is difficult to get real-time, reliable information about the current asset quality, profitability, capital adequacy and liquidity position of the partner), and the stake is high due to significant credit volumes and lack of collateral. This information asymmetry raises the possibility of adverse selection and moral hazard, so lenders then respond to the perceived increase in counterparty risk less by raising interest rates than by reducing the amount of loan provided. The literature calls this phenomenon credit rationing (*Tirole*, 2006). This phenomenon is a problem especially in the case of high concentration on the lending side of the interbank market, where banks with a lack of liquidity are more likely to be exposed to a liquidity supply concentrated at a small number of participants (*Nyborg–Strebulaev*, 2004).

The phenomenon referred to in the literature as short squeezing has a similar effect on the interbank market as credit rationing. The information asymmetry mentioned above exists not only between banks, but also between banks and the duo of the central bank and the state. The central government generates shocks in the liquidity of the interbank market through the Treasury Single Account, and the central bank is also an actor capable of influencing the behaviour of banks with its toolset. If, as a result, market participants feel that the liquidity available on the interbank market is uncertain in the short term, the banks with excess liquidity may adopt a reasonable decision to retain (leave it on the balance sheet as a kind of buffer) excess liquidity[3] (*Kolozsi–Horváth*, 2020).

Due to these phenomena, the most important tool for managing counterparty risk in the interbank deposit market is not price adjustment (as in many other markets) but the containment of the amount lent. The participants set a partner limit against each other, which means the amount of maximum exposure they wish to hold against a given bank.

The work of *Homolya* et al. (2013), who examined the limit setting practices of Hungarian banks with the help of questionnaires and interviews, is particularly interesting and relevant in relation to partner limits. This is highly sensitive information for a bank, which is why this article is so valuable; the interviews revealed information that greatly helps to understand the mechanisms of influence of the interbank market.

3 It is especially true in a low-yield environment, where they do not lose significant interest income.

According to their study, the practice of setting limits largely depends on the role of a given credit institution within their banking group. Some of the banking groups operating in Hungary perform global risk management. The domestic subsidiaries and branches of these banking groups receive the limits "from above" from their parent bank; they usually have no say in the specific limit levels or the methodology of their determination, as this is done centrally in all cases. For the other credit institutions, the parent bank only sets the guidelines and methodological frameworks, so the limit is set in a multi-level decision, giving space to the local subsidiary in smaller decisions with a local impact.

In the interbank market, lending transactions usually take place in established relationships, as unused limits are cut back over time, which can prevent the re-establishment of the relationship and close a previously live lending relationship between two participants.

From the perspective of interbank lending, the partner limit is clearly a bottleneck and is also the most commonly used type of limit. Berlinger (2017) examined the relevance of partner limits (more precisely, the implicit partner limits estimated by her in the absence of their knowledge) and the interest rate (as a financing cost) of interbank unsecured forint transactions on transaction data between 2003 and 2012. The findings are in line with the results of the research mentioned earlier. The interbank market is more driven by quantity factors (partner limits), while price components – in this case, the interest rate on transactions – are less important in this market.

A similar result has been obtained by the authors *Geršl–Lešanovská* (2014) when examining the Czech interbank market during the crisis of 2008. They established that, in reaction to an increase in counterparty risk during the crisis, banks decided not to change interest rates but rather to reduce counterparty limits and introduce maturity limits. According to their analysis, interbank interest rates were affected almost exclusively by the spillover effect coming from parent banks from abroad rather than by credit relationships in the interbank market.

Thus, in light of the literature, the interbank deposit market seems to be driven mainly by partner limits. However, the setting of partner limits is also the result of a multivariable (and, as we presented earlier, multi-level) decision-making process for some banks. From the perspective of understanding the market, it is worth looking behind the limits on the surface and going a level deeper by exploring the elementary factors that shape it.

As a result of their qualitative research, Homolya et al. (2013) found that limits are fundamentally shaped by three factors, (1) the counterparty's (or country's sovereign) credit rating, (2) its CDS spread, and (3) certain financial ratios. In general, financial ratios are intended to numerically involve the profitability, asset quality,

capital adequacy and liquidity of the partner credit institution in the limit setting process.

Relying on the implicit rating indicator used by her, Berlinger (2017) found that after the 2008 crisis, the most active banks became the most creditworthy players in the market, and therefore they were able to access funds under the best conditions.

3 THE ANALYSIS OF QUANTITY ADJUSTMENT ON THE HUNGARIAN INTERBANK DEPOSIT MARKET

Our research hypothesis examined in the study is:

> *The concentration of borrowing is significantly higher than the concentration of lending, both in terms of volume and the number of transactions.*

The relevance of our hypothesis lies in the concentration-related connections published in the academic literature. We compared the obtained results with the Berlinger–Michaletzky–Szenes (2011) study. The authors studied the network dynamics of the Hungarian unsecured interbank HUF deposit market for the period between December 2002 and March 2009. Their study found that the different network metrics and the general features of the market were stable until 2006-2007, after which – as if forecasting the crisis –, part of the indicators began to change.

3.1 General characteristics of the examined database

We performed the analysis on the highly detailed database compiled from the regular reports of the Hungarian banks provided by MNB for research purposes, which contained every unsecured interbank lending transaction performed between 2 January 2012 and 31 December 2015. As these pieces of information are deemed strictly confidential, the different banks are included anonymously with random sequence numbers in a directly unidentifiable manner. The purpose of our study is not the linking of the results to a given credit institution. The goal is clearly the examination of the whole market, the exploration of the structure of connections.

The transactions of the database (records) contain the following information: fictitious code of borrowing (data supplying) bank, identifier of the lender partner, contract amount of the credit, (annualised) interest rate paid for the transaction, date of contracts, the start and end date of the transaction and the direction of

the transaction (which, in every case, is borrowing to avoid duplication in the data table[4]).

3.2 Changes in the monthly aggregated transaction amount

If the market shocks were less reflected in the price adjustment, the quantity adjustment is worth examining in detail by all means. In addition to examining the aggregated transaction amount, we will also attempt to shed light on the structure of the quantity adjustment in *Section 3.3*.

Let us first look at the changes in the aggregated volume and number of transactions in the given period for the overnight unsecured HUF loans. We have reached an important question here, namely the definition of the size of the examination window, in other words, the selection of the length of the period in which we aggregate the transactions.

The most obvious solution on the market of overnight loans would be the one-day time window. In this case, the daily transaction volumes would show fluctuations, which would completely cover the tendencies in the time series. The use of moving average could partly counterbalance this, but this type of "smoothing" the time series would lead to distortions exceeding a certain extent.

An even more powerful argument against one-day aggregation is the low activity of the Hungarian interbank market at international level. There were so few contracts in average on one day in the examined period (37 contracts) that by choosing this option, the interbank network would fall apart, it would consist of smaller or bigger separate islands, which would make the use of methodologies presented in our study later, and the interpretation of the results impossible.

So it seems certain that the examination window should be selected for a period longer than one day, but the longer the period is the stronger the aggregation "conflates", conceals diversity in data and the fewer the number of data points will be. This latter problem can be eliminated, for example, by "pushing" a time window of one quarter on every month, but in this case, approximately one-third[5] of the elementary data aggregated in every data point will match the content of the previous and the following data point.

In order to find the "optimal" solution, the literature is worth looking at. The different articles examining the interbank market are not uniform either regard-

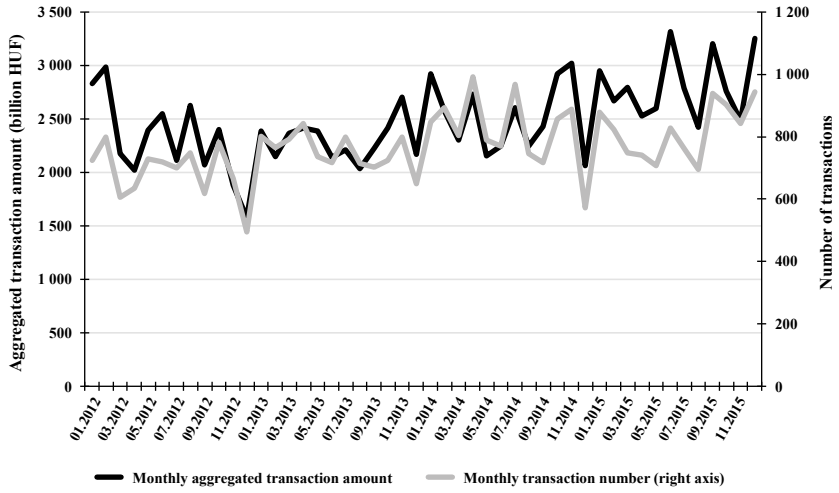
4 Both the lender and the borrower must report every transaction to MNB but duplication resulting from this has previously been filtered from the data table.

5 If the transactions are distributed among the different months uniformly.

ing the level of aggregation over time. Some authors use a one-day time window (*León–Machado–Sarmiento*, 2018), others analyse monthly data (Berlinger et al., 2017), but there are often quarterly (*Veld–van Lelyveld*, 2014); *Craig–von Peter*, 2014; *Fricke–Lux*, 2015), or even half-yearly (*Langfield–Liu–Ota*, 2014) examinations, too.

The Berlinger–Michaletzky–Szenes (2011) study used as a starting point for this chapter uses weekly and monthly time windows alternately. As the weekly time window is not frequent in the foreign literature, we will uniformly work with the monthly aggregation level, which we will keep "pushing" on every month. By doing so, we will have 48 (monthly) data points between 2012 and 2015. The August 2015 network, for example, will consist of the sum of overnight interbank transactions initiated between 1 August and 31 August 2015.

Figure 2
The monthly aggregated transaction amount of overnight unsecured interbank HUF deposit market and the monthly number of transactions (axis on the right) (2012–2015)



Source: Own editing based on MNB data

Examining the order of magnitude of the market based on *Figure 2*, it can be stated that at around monthly HUF 2-3 thousand billion aggregated transaction amount (black line and the belonging axis on the left), between 700 and 1,000 overnight credit transactions (gray line secondary axis on the right) were contracted in the examined period on the Hungarian unsecured interbank market.

The monthly aggregated transaction amount and the number of transactions moved together very closely in a relatively narrow band. The two indicators separated from each other only in the first half of 2012 and in 2015; in both cases aggregated transaction amount grew more than the number of transactions.

In the first such period, the reason for this must have been the events of the end of 2011 and the beginning of 2012, when Hungary's long-term credit ratings fell at the three major credit rating agencies (S&P, Moody's and Fitch) in the junk, speculative category and the transformation of the central bank toolbox in the second period. One possible explanation of the phenomenon is that the banks significantly cut the limits of partners deemed less reliable due to the shocks on the interbank market. In contrast, the volume of loans extended to the best partners grew (as financing requirements still had to be satisfied from somewhere, while the central bank instruments were less and less attractive). Changes in the aggregated transaction amount exceeding the number of transactions and the scissors opening between them may point to the presence of quantity adjustment.

3.3 Analysis of the concentration of lending and borrowing

After examining the aggregated transaction amount, we will examine how quantity adjustment was performed structurally between 2012 and 2015. The different indicators of the concentration, such as the Lorenz curve, Gini index and the Herfindahl-Hirschman index, as well as the effective number generated from them, will help us in this.

Concentration is the focusing of the majority of the total amount (e.g. transaction amount in the present case) in few observation units (market participants) (*Hunyadi–Vita*, 2008a).

Concentration has two types fundamentally: absolute and relative concentrations. Absolute concentration is present on a market if the number of participants is very low. In this case, a large percentage of the total amount will be concentrated in few units – due to the small number of active market participants in itself. What is small and what is large multitude is difficult to define, and the literature does not give any general guidance either, but the measures of relative concentration can already be used and interpreted well if there are 30-40 active credit institutions present on the interbank market.

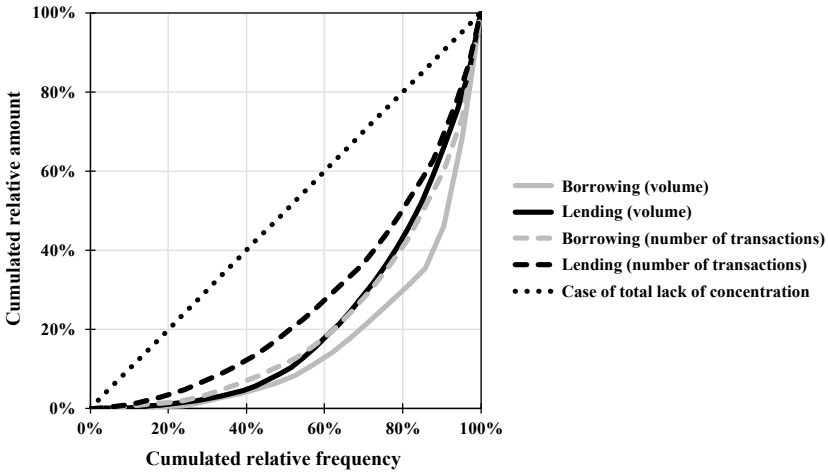
The volume of concentration in the relative sense can be defined in some way by the comparison of relative frequencies (one group of banks constitutes what percentage of all active banks on the market) and the relative amounts (loans granted by one group of banks in the proportion of the total market credit volume).

3.3.1 Lorenz curve and Gini index

At the beginning of the 20th century, Max Otto Lorenz American economist prepared a special chart to show the Prussian asset concentration, which was named Lorenz curve in his honour (*Kerékgyártó–Mundruczó*, 1998).

The Lorenz curve shows the cumulated relative amounts subject to the cumulated relative frequencies, where cumulation begins from the smallest observation and goes on to the larger ones.

Figure 3
Lorenz curve



Source: Own editing based on MNB data

The concentration of the interbank market transactions on the borrower and lender sides according to volume (continuous curves), on the one hand, and number of transactions (dashed curves), on the other hand, in December 2015[6] is seen in Figure 3. The diagonal of the square (dotted black line) is the case of total lack of concentration, as the participation in the total volume and total number of transactions of the given banks is uniform. The farther the Lorenz curve is from

6 The choice for the aggregate data of December 2015 was made because it is the most recent available monthly time window, and it is excellent for presenting that if two Lorenz curves intersect, then it will not be possible to determine a clear order in terms of concentration. Therefore, concentration indicators will be used to draw meaningful conclusions, and the Lorenz curve is used only for illustrative purposes here.

the diagonal (and the closer it is to the lower and right sides of the square), the larger is the concentration it indicates.

According to *Figure 3*, taking the borrowed credit volumes as a basis, the concentration on the borrowing side (continuous gray line) was the highest, while the lowest concentration was on the lending side with the number of granted loans taken into account (dashed black line). The Lorenz curves indicated with continuous black line and dashed gray line intersect each other in the chart. If two Lorenz curves intersect each other in one or several places, they cannot be compared clearly.

Different concentration indicators are worth calculating in order to eliminate this problem. Although the Lorenz curve is a very illustrative method of showing the concentration, unfortunately, it is not suitable for the examination of the dynamics over time (this is why we depicted only the last observations from December 2015). The latter's disadvantage makes the use of concentration measures necessary and justified for the Lorenz curve, too.

Gini index (G) is one of the indicators used most frequently to measure the degree of concentration. Its value can be defined as the quotient of the size of the area bordered by the diagonal and Lorenz curve, and the size of the area bordered by the diagonal and the axes.

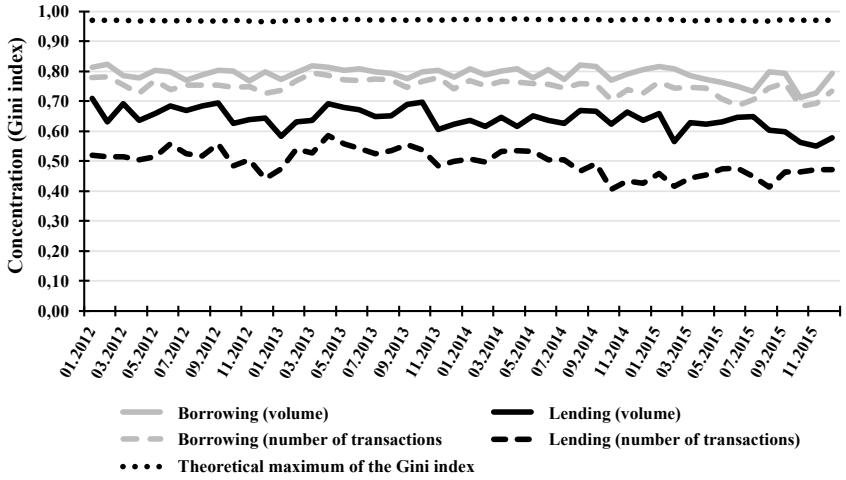
$$\mathrm{G} = \frac{t_c}{1/2} = 2 \cdot t_c \tag{1}$$

Where t_c is the so-called concentration area bordered by the diagonal and Lorenz curve. The diagonal divides the square with unit-size side length into two parts. Therefore it is easy to see that the size of the area bordered by the diagonal and the axes is ½ (denominator of formula 1).

The Gini index takes its smallest value (0) when the market share of every bank is identical. This is the case of the total lack of concentration. In the case of limited number (n) of banks, if one bank extends all loans (or one market participant borrows all on the other side), it is seen that the value of the Gini index is $G = 1 - \frac{1}{n}$, i.e. the more participants are on the market (the bigger n is), the closer the value is to 1 (*Ross*, 2017).[7]

7 The number of active banks fluctuated between 30 and 40 in the examined period, therefore the upper limit of the Gini index is around 0.97.

Figure 4
Gini index of the borrowing and lending transactions in the given months according to the amounts and number of transactions (2012–2015)



Source: Own editing based on MNB data

In *Figure 4*, we see that examining the interbank market from the lender side Gini index shows medium size concentration (values typically between 0.4 and 0.7) and strong concentration from the borrower side (values between 0.7 and 0.8).[8]

Additionally, it can be observed that regarding both the volumes (continuous lines) and the number of transactions (broken lines), borrowing is significantly more concentrated than lending, which means that a relatively small number of participants borrow the majority of interbank credits, and they do not obtain financing from individual bigger market participants, but almost every one of the market participants contributes to the maintenance of market liquidity.

3.3.2 Herfindahl-Hirschman index and the effective number

Another index frequently used to measure concentration is the Herfindahl-Hirschman index (HHI), which can be described according to the following:

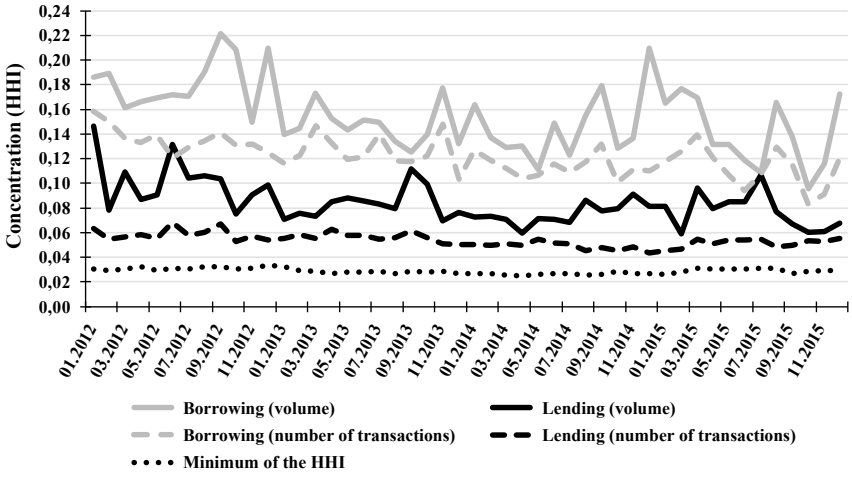
$$\mathrm{HHI} = \sum_{i=1}^{N} Z_i^2 \qquad (2)$$

8 The precise value, from which the size of concentration is deemed strong, is difficult to define. We used the categorisation of Harangi-Rákos (2013) in the present case.

where Z_i is the market share of bank i, and N is the number of participants present on the market. The minimum of the index is $1/N$, when the market share of every participant is identical (total lack of concentration), the maximum of the index is 1, which indicates the presence of the highest degree of concentration (one participant owns the entire market). The lower limit depends on N, which means that if there is a total lack of concentration on a market, then on a market of 5 participants, we obtain ceteris paribus higher HHI value than on a market of 30 participants. Meaning that this indicator can take both the relative and absolute projections of the concentration into account simultaneously.

Additionally, the reciprocal value of the Herfindahl-Hirschman index is also a very frequently used indicator, which is known by the literature as effective number and which, if applied to the interbank market, can be interpreted as the number of active banks on the market (Berlinger–Michaletzky–Szenes, 2011).

Figure 5
HHI index of the borrowing and lending transactions in the given months according to the volume and number of transactions (2012–2015)



Source: Own editing based on MNB data

Figure 5 shows the changes in the borrowing side (continuous gray and dashed gray lines) and the lending side (continuous black and dashed black lines) concentrations of the interbank market (HHI) in the given months, and the $1/N$ lower limit (dotted black line).

According to the thumb rule, the market cannot be considered concentrated in HHI values under 0.15, values between 0.15 and 0.25 indicate moderate concentra-

tion, and the interbank market can be deemed highly concentrated over the value of 0.25. (U.S *Department of Justice & FTC, 2010)*.[9] It means that the interbank market loans cannot be deemed concentrated (HHI values are under 0.15 every month), but the borrowing transactions show moderate concentration, especially in terms of the borrowed credit amounts (continuous gray line).

Two phenomena can furthermore be observed in *Figure 5*. The first is that – similarly to measuring concentration with the Gini index – both in terms of the volumes and the number of transactions, the borrowing transactions show significantly higher concentration than the lending transactions. It means that proportionally more market participants finance fewer market participants.

The more even distribution of the lending transactions can be explained by the fact that structural liquidity surplus was typically experienced on the Hungarian interbank market in the past one and a half decades. The high concentration of the borrowing transactions derives from the partner limits and the quantity adjustment being stronger on the interbank market. Only a few large (or rather actively transacting, reliable)[10] market participants have more significant limits at their partners, limiting the number of market participants who can receive funds on the interbank market.

This result is identical with the findings of Berlinger–Michaletzky–Szenes (2011); moreover, the picture is further tinged by the fact that the number of lenders is relatively stable in a crisis, while the number of borrowers drops significantly (the concentration of borrowing grows drastically).

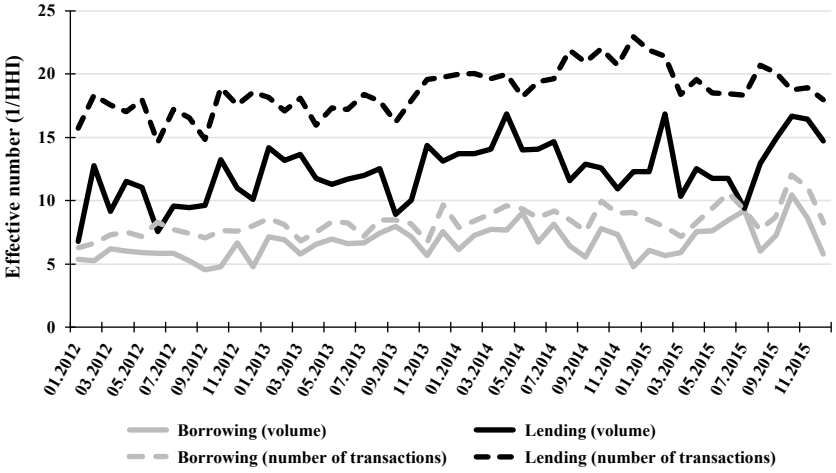
Minoiu–Reyes (2013) examined cross-border interbank transactions using the exceptionally rich time series of BIS (Bank for International Settlements) from 1978 to 2010, covering 184 developed and developing countries (including the Visegrad states). The network they analysed contains data for individual resident banks as aggregated at the level of countries. Their analysis of a global interbank network of states also shows clearly that the concentration of borrowing was significantly higher than that of lending throughout the 32 years under review. In addition, the authors observed increasing concentrations over time on both sides.

The effective numbers derived from the borrowing and lending HHI indicators are to quantify the average number of active banks on the two sides of the interbank market.

9 It is interesting that the line was drawn at 0.1 and 0.18 values in their 1997 publication.

10 The literature is not uniform in this, as we pointed to it earlier (see for example Berlinger (2017)).

Figure 6
Effective numbers generated on the basis of the concentration of the borrowing and lending transactions and according to the number of transactions (2012–2015)



Source: Own editing based on MNB data

Based on the effective numbers of *Figure 6*, it can be stated that the loans were granted by 10-15 banks on average[11] while there were only 5-8 active borrowing banks on the market. The same numbers were 17-21 and 7-10 respectively, based on the number of transactions.

Another phenomenon, which is clear from *Figures 5* and *6*, is that the fluctuation, volatility of the volumes (continuous lines) is higher than those of the number of transactions (dashed lines).

This phenomenon can unfortunately not be verified by a formal test as the preproposition of F-test (aimed at the identity of the standard deviation of the two populations) is that the distribution of both populations is normal and that we have two independent samples (Hunyadi–Mundruczó–Vita, 2001). This latter condition is not met at all; examining the same transactions, there is a (expectedly positive and strong) connection between the volume and the number of loans granted by the given bank.

The first observed phenomenon is worth testing with the help of a formal hypothesis test. The phenomenon to be tested is that borrowing is significantly more

11 The limits are roughly the lower (D_1), and higher deciles (D_9) of the monthly effective numbers.

concentrated both in terms of the volumes and the number of transactions. This assumption can be tested with a two-sample *z*-test for comparing expected values. According to our alternative hypothesis, the average concentration of borrowing *(B)* (μ_B) is larger than the average concentration of lending *(L)* (μ_L), and according to our null hypothesis, the expected value of the HHI index of lending is minimum the size of that of borrowing, in other words, formally:

$$\begin{aligned} H_0&: \quad \mu_B - \mu_L \leq 0 \\ H_1&: \quad \mu_B - \mu_L > 0 \end{aligned} \tag{3}$$

If we assume that the standard deviation of the two populations is limited and if we have a sufficiently large sample[12], if the null hypothesis is met, the test statistic written in

$$z = \frac{\overline{B} - \overline{L}}{\sqrt{\frac{s_B^2}{n_B} + \frac{s_L^2}{n_L}}} \tag{4}$$

form is of standard distribution with good approximation, where the numerator contains the arithmetic average of the HHI indexes of borrowing and lending, and s^2 in the denominator indicates the variance of the different samples, and n the number of sample elements (Hunyadi–Vita, 2008b).

Based on the calculations of *Table 1*, the value of the test statistic is much higher than the upper critical value both in terms of the volumes and the number of transactions. It is in the critical (or rejection) range, therefore the null hypothesis can be rejected at 99% confidence level, which means that the average concentration of the borrowing transactions was significantly higher than that of the lending transactions. The p-value is extremely close to 0, so the null hypothesis can be rejected not only at 1% significance level, but also at any generally used significance level. Thereby, the hypothesis (formulated in the introduction of this chapter) is successfully proven through a formal test.

12 Sample of 48 elements can already be considered a large sample.

Table 1
Examination of the average HHI difference of borrowing and lending with two-sample z-test

	Volumen	Tranzakciószám
Sample mean of lending ($\overline{L}$)	0.0844	0.0540
Sample mean of borrowing ($\overline{B}$)	0.1542	0.1220
Standard deviation of lending (s_L)	0.0178	0.0054
Standard deviation of borrowing (s_B)	0.0286	0.0157
Sample size of lending (n_L)	48	48
Sample size of borrowing (n_B)	48	48
Test statistic (z)	**14.3331**	**28.4172**
Upper critical value	**2.3263**	**2.3263**
p-value	**0.0000**	**0.0000**

Source: Own editing based on MNB data

Kolozsi–Horváth (2020) also examined the concentration of interbank loans and found that by the increase of additional liquidity (the saturation of the market with liquidity), the concentration of liquidity decreases. The authors also showed that in addition to the quantity of interbank liquidity, the distribution (concentration) of liquidity also significantly affects the average interest rate. The relative price was significantly higher in the case of higher concentration (the majority of liquidity is concentrated in few banks).

Furthermore, by the increase of additional liquidity, the aggregated transaction amount of the interbank market decreased, as due to the lower relative price of liquidity, the banks were less motivated to place their liquidity surplus on the interbank market.

4 SUMMARY

We described the most important characteristics of unsecured interbank credit transactions, of which the lack of financial collateral together with the significant volume (up to tens of billions of HUF) may create significant risk. This is due to the strong information asymmetry on the interbank market, credit rationing and short squeezing. Taken together, these phenomena may explain that in the interbank deposit market, unlike in many other markets, the most important factor is quantity adjustment rather than price adjustment (raising interest rates due to higher risk). Quantity adjustment is mostly achieved through partner limits.

Examining the database, the aggregate volume of transactions increased more than the number of transactions. One possible explanation for this phenomenon is that, in response to shocks to the interbank market, participants decided to reduce partner limits considered less reliable and to obtain the necessary funds from the few, most reliable players on the market.

For a deeper explanation of the quantity adjustment, we examined the concentration of lending and borrowing. Both the Gini and Herfindahl-Hirschman indices showed that borrowing was more concentrated than lending in terms of both volume and number of transactions. Loans were provided by an average of 10-15 active banks typically to only 5-8 borrowers in the period examined. We tested this observation by using a two-sample z-test for comparing expected values and confirmed a significant difference in concentration between the borrowing and lending sides of the interbank market, as expressed in our hypothesis.

The more even distribution of the lending transactions can be explained by the fact that structural liquidity surplus was typically experienced on the Hungarian interbank market in the past one and a half decades. The high concentration of the borrowing transactions derives from the partner limits and the quantity adjustment being stronger on the interbank market.

REFERENCES

Berlinger, Edina – Michaletzky, Márton – Szenes, Márk (2011): A fedezetlen bankközi forintpiac hálózati dinamikájának vizsgálata a likviditási válság előtt és után [An analysis of the network dynamics of the unsecured interbank forint market before and after the liquidity crisis]. *Közgazdasági Szemle*, 58(3), 229–252, http://unipub.lib.uni-corvinus.hu/403/1/Kszemle_CIKK_1227.pdf.

Berlinger, Edina – Daróczi, Gergely – Dömötör, Barbara – Vadász, Tamás (2017): Pénzügyi hálózatok mag-periféria szerkezete. A magyar bankközi fedezetlen hitelek piaca, 2003–2012 [The core-periphery structure of financial networks, The Hungarian interbank unsecured market, 2003–2012]. *Közgazdasági Szemle*, 64(11), 1160–1185, https://doi.org/10.18414/ksz.2017.11.1160.

Berlinger, Edina (2017): Implicit rating: A potential new method to alert crisis on the interbank lending market. *Finance Research Letters*, 21 May, 277–283, http://dx.doi.org/10.1016/j.frl.2016.11.010.

Craig, Ben – von Peter, Goetz (2014): Interbank tiering and money center banks. J*ournal of Financial Intermediation*, 23(3), 322–347, https://doi.org/10.1016/j.jfi.2014.02.003.

Erhart, Szilárd – Mátrai, Róbert (2015): The most important steps of BUBOR reforms led by the Central Bank of Hungary in an international comparison. *Financial and Economic Review*, 14(1), 139–165, http://epa.oszk.hu/02700/02758/00002/pdf/EPA02758_financial_economic_review_2015_1_139-165.pdf.

Fricke, Daniel – Lux, Thomas (2015): Core-periphery Structure in the Overnight Money Market: Evidence from the e-MID Trading Platform. *Computational Economics*, 45(3), 359–395, https://doi.org/10.1007/s10614-014-9427-x.

Geršl, Adam – Lešanovská, Jitka (2014): Explaining the Czech interbank market risk premium. Economic Systems, 38(4). 536-551. p. https://doi.org/10.1016/j.ecosys.2014.10.001

Harangi-Rákos, Mónika (2013): A társas vállalkozások és az egyéni gazdaságok gazdasági szerepének változása, különös tekintettel az állattenyésztésre (PhD-értekezés) [The economic role of partnerships and individual farms. Changes in the agricultural sector with special reference to livestock production (PhD thesis)]. Debreceni Egyetem, https://dea.lib.unideb.hu/dea/bitstream/handle/2437/172155/Harangi-RakosM_ertekezes-t.pdf.

Homolya, Dániel – Lakatos, Melinda – Mátrai, Róbert – Páles, Judit – Pulai, György (2013): Magyarországi bankok limitállítási gyakorlata. Előtérben a partnerlimitek [Limit setting practices of Hungarian banks. Focus on counterparty limits.]. *MNB-szemle*, 8(3), https://www.mnb.hu/letoltes/homolya-lakatos-matrai-pales-pulai-1.pdf.

Hryckiewicz, Aneta (2021): There is no smoke without a fire: The effect of government interventions in less advanced economies. *Economic Systems*, 45(1), 1–19, https://doi.org/10.1016/j.ecosys.2020.100776.

Hunyadi, László – Mundruczó, György – Vita, László (2001): *Statisztika* [Statstics]. Budapest: Aula Kiadó.

Hunyadi, László – Vita, László (2008a): *Statisztika I.* [Statstics I.]. Budapest: Aula Kiadó.

Hunyadi, László – Vita, László (2008b): *Statisztika II.* [Statstics II].. Budapest: Aula Kiadó.

Kerékgyártó, Györgyné – Mundruczó, György (1998): *Statisztikai módszerek a gazdasági elemzésben* [Statistical methods in economic analysis]. Negyedik kiadás, Budapest: Aula Kiadó.

Kollarik, András – Lénárt-Odorán, Rita (2017): A jegybank helye a pénzügyi rendszerben [The role of the central bank in the financial system]. In Vonnák Balázs (szerk.) (2017): *Modern jegybanki gyakorlat* [Modern central banking practice]. Budapest: MNB, 239–286, https://www.mnb.hu/letoltes/mnb-modern-jegybanki-gyakorlat.pdf.

Kolozsi, Pál Péter – Horváth, Gábor (2020): Mennyit ér a likviditás? A magyar bankrendszer likviditáskeresleti függvényének becslése [How much is liquidity worth? Estimating the liquidity demand function of the Hungarian banking system]. *Közgazdasági Szemle*, 67(2), 113–139, https://doi.org/10.18414/ksz.2020.2.113.

León, Carlos – Machado, Clara – Sarmiento, Miguel (2018): Identifying central bank liquidity super-spreaders in interbank funds networks. *Journal of Financial Stability*, 35, 75–92, https://doi.org/10.1016/j.jfs.2016.10.008.

Minoiu, Camelia – Reyes, Javier A. (2013): A Network Analysis of Global Banking: 1978–2010. *Journal of Financial Stability*, 9(2), 168–184, https://doi.org/10.1016/j.jfs.2013.03.001.

Nyborg, Kjell G. – Strebulaev, Ilya A. (2004): Multiple Unit Auctions and Short Squeezes. *Review of Financial Studies*, 17(2), 545–580, https://doi.org/10.1093/rfs/hhg038.

Ross, Sheldon M. (2017): *Introductory Statistics*. Fourth Edition. Cambridge: Academic Press, https://doi.org/10.1016/b978-0-12-804317-2.00031-x.

Smaga, Paweł – Wiliński, Mateusz – Ochnicki, Piotr – Arendarski, Piotr – Gubiec, Tomasz (2018): Can banks default overnight? Modelling endogenous contagion on the O/N interbank market. *Quantitative Finance*, 18(11), 1815–1829, https://doi.org/10.1080/14697688.2018.1438641.

Tirole, Jean (2006): *The Theory of Corporate Finance*. Princeton: Princeton University Press.

U.S. Department of Justice & the Federal Trade Commission (2010): Horizontal Merger Guidelines, https://www.justice.gov/atr/horizontal-merger-guidelines-08192010#5c (letöltve: 2020.02.12.).

Veld, Daan – van Lelyveld, Iman (2014): Finding the core: Network structure in interbank markets. *Journal of Banking & Finance*, 49 December, 27–40,https://doi.org/10.1016/j.jbankfin.2014.08.006.

Veres, Judit – Gulyás, Éva (2008): *Bankszámvitel* [Bank accounting]. Budapest: Alinea Kiadó.